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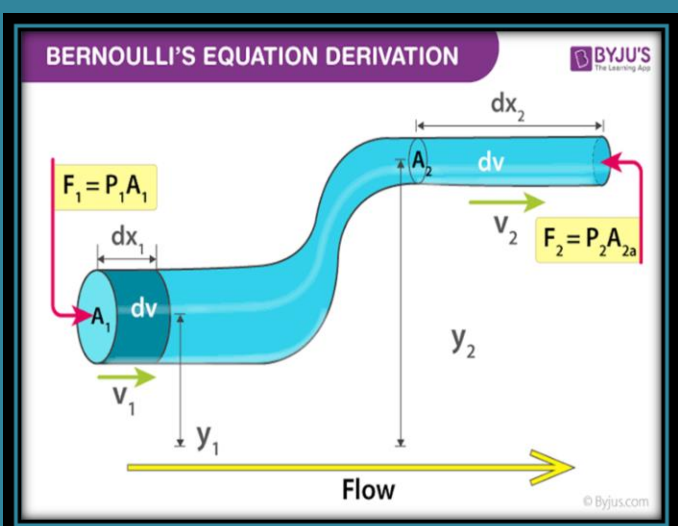
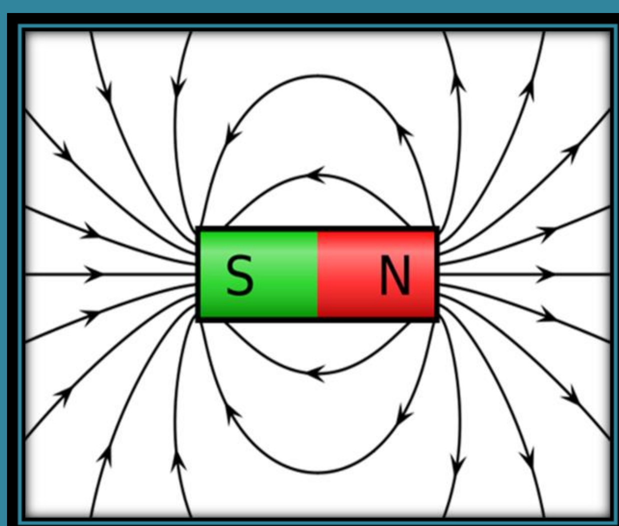
PHYSICS

GRADE 12





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Unit 1

Application of physics in other fields

It is the union of these fields that helps us to understand the world in which we live

all scientific disciplines, and their contribution to society and the environment.

1.1 Physics and other sciences

- Physics is the most essential field of science and it has a strong influence on most scientific developments.
- We can find different concepts of physics in many of the modern sciences.

Physics and chemistry

- Physics and chemistry may overlap when the system under study involves matter composed of electrons and nuclei.
- Fundamental laws that govern the behavior of matter apply to both chemistry and physics
- Both physics and chemistry are concerned with matter and its interaction with energy.
- Chemists and physicists use similar method to study the interaction of large number of particles which have complicated interaction beyond the capacity of any computer, and the capacity of the human mind.
- The physics of energy related to heat tells chemists
- Spectroscopy is the study of the interaction between matter and electromagnetic radiation as a function of the wavelength or frequency of the radiation.

Physics and biology

Physics can explain the human body like the mechanics of human motion, the energetics of metabolism, the fluid dynamics of blood flow through vessels, the mechanisms for speaking and hearing, and the optical imaging system we call the eye.

The combination of knowledge of physics and biology help to explain how athletes run fast and why the fastest animal in the world, cheetah, runs fast.

Physics of Newtonian mechanics:

- tells us that a body is in stable equilibrium under the action of gravity
- if its center of mass is directly over its base of support. Under this condition, the reaction force at the base of support cancels the force of gravity and the torque produced by it.

Physics of fluid flow and biology

The physics of fluid flow, like viscosity, equation of continuity and turbulent flow, is very important in understanding the circulation of blood and blood pressure in the multicellular.

Physics of sound wave and biology Sound

- It is a mechanical wave produced by vibrating bodies.
- The vocal cords produce sound when they come together and then vibrate as air passes through them during exhalation of air from the lungs.
- This vibration produces the sound wave for your voice.
- eardrum to vibrate; this produces nerve impulses that are interpreted by the brain.

Physics of electricity and biology

Many life processes involve electrical phenomena.

- The nervous system of animals and the control of muscle movement
- The are very important electrical phenomena in living organisms are found in the nervous system of animals.
- Specialized cells called neurons form a complex network within the body which receives, processes, and transmits information from one part of the body to another.
- The center of this network is located in the brain, which has the ability to store and analyze information.
- Based on this information, the nervous system controls various parts of the body.
- The messages are electrical pulses transmitted by the neurons.

Optical physics and biology

- Light is the electromagnetic radiation in the wavelength region between about 400 nm and 700 nm.
- Although light is only a tiny part of the electromagnetic spectrum, it is very important in both physics and biology.
- Light has fundamental roles in living system because of its paramount importance.
- In photosynthesis, plants use light to convert carbon dioxide and water into organic materials, which are the building blocks of living organisms.

- Animals have evolved light-sensitive organs, like the eyes, which are their main source of information about the surroundings.
- Some bacteria and insects can even produce light through chemical reactions.
- Optical physics, which is the study of light, includes topics such as microscopes, telescopes, vision, color, pigments, illumination, spectroscopy, and lasers, all of which have applications in the life sciences

Physics and astronomy

Astrophysics is the study of the physics of heavenly objects, called astronomical objects, in the sky like the solar system and its constituents, the properties, birth, life and death of stars, interstellar gas and dust, galaxies and clusters of galaxies,

Newton's laws of motion and astronomy

Newton's law of gravitation is used to describe the motion of the moon around a planet and the motion of the planets around the sun.

Newton was able to explain why Kepler's Laws described planetary motion using his laws of motion and gravity.

The knowledge of centripetal force and centrifugal force from our physics knowledge greatly help as to understand what keeps objects in orbit around others.

This applies to planets orbiting the Sun, moons orbiting planets, and artificial satellites in Earth's orbit

Physics of electromagnetic wave and astronomy

- Astronomers collect information about the radiation from space objects to study the birth and death of stars, how hot objects are, how far away they are, even how the universe was formed.
- Astronomers use telescopes that detect different parts of the electromagnetic spectrum.
- Each type of telescope can only detect one part of the electromagnetic spectrum.
- There are radio telescopes, infrared telescopes, optical (visible light) telescopes and so on.
- We can't see most of the radiation detected, so computers turn data into images we can see.
- distant objects we can measure distances by using brightness of objects since objects will appear fainter if they are at larger distances than identical nearby object.
- Measuring the apparent brightness of an object gives its distance if we know its true brightness

- .A light year is the distance that light travels in one year.

Physics of atoms and astronomy

Atomic astrophysics is concerned with performing atomic physics calculations that will be useful to astronomers and using atomic data to interpret astronomical observations.

The astronomers' only information about a particular object comes through the light that it emits, and this light arises through atomic transitions.

The physics that explains emission and absorption of radiation is closely related to the structure and energies of individual atoms that form the astronomical objects.

When electrons of atoms jump from higher to a lower atomic orbit, photon is emitted.

Photon is absorbed if electron jumps from lower electron orbit to higher electron orbit .

The emission and absorption of radiation depends on the characteristics of individual atoms, and helps to measure something about the compositions, temperatures, and motions of stars by studying their spectra.

These electrons fall down to lower energy orbits emitting light of precisely the wavelength that corresponds to the energy change between the two orbits.

The nature of the emitted light depends on the temperature. Thus, emitted light can be used to determine both compositions and temperatures of astronomical objects

Physics and geology

The study of different parts of Earth is called Earth science.

Earth Science deals with all aspects of the Earth including molten lava, icy mountain peaks, steep valleys and towering waterfalls, the atmosphere high above the earth as well as the Earth's core far beneath the surface.

Geology is a branch of Earth science that studies the solid and liquid matter that makes up Earth and the different processes on these matters.

The understanding of geological processes demand the understanding of the

In geo physics concepts used to study the following properties of rocks and minerals:

- electrical properties,
- density,
- magnetization,

- ☞ radioactivity,
- ☞ elasticity and more.

To study these properties of rocks and minerals the geologist take samples from different layers of the earth through excavation.

They can also study different properties of rocks and minerals by sending different types of waves from the surface of the earth without excavation.

Geology has so many branches that most geologists become specialists in one area.

- ✓ example, a mineralogist studies the composition and structure of minerals such as halite (rock salt), quartz, calcite, and magnetite.

Geological knowledge is also used to detect or infer the presence and position of economically useful geological deposits, such as

- ☞ ore minerals
- ☞ fossil fuels and other hydrocarbons,
- ☞ geothermal reservoirs
- ☞ , groundwater reservoirs.

1.2 Physics and engineering

Physics generates fundamental knowledge that can be used by different branches of engineering such as

- ❖ Mechanics,
- ❖ Thermodynamics,
- ❖ Electromagnetism
- ❖ Atomic Physics
- ❖ Molecular Physics
- ❖ Optics
- ❖ Nuclear Physics etc. are important knowledge inputs in different engineering branches. such as civil, mechanical, electrical, etc.

Civil engineering

Civil engineering concerns designing and building skyscrapers, roads, bridges, dams, and railways using our physics knowledge of forces, fluid pressure, gravity.

Civil engineering has been known since ancient civilizations in Ethiopia, Egypt and others where large buildings were built such as temples, pyramids and palaces with engineering designs.

Mechanical engineering

Mechanical Engineering need the concepts of physics like mechanics, dynamics, thermodynamics, materials science, structural analysis, and electricity to design aircraft, watercraft, engines, robotics, weapons, cars, pneumatics, hydraulics and others

Mechanical engineering uses knowledge of mathematics, science mostly physics and materials science to create mechanical systems like ,engines, manufacturing equipment and vehicles.

mechanical engineer takes one or more of these concepts to create a mechanical system that operate without failure.

Electrical engineering Electrical

Electrical engineers need understanding of physics concepts like mechanics, thermodynamics, integrated circuits, transistor logic and Electromagnetism engineering involves designing electrical circuits including motors, electronic appliances, optical fiber networks, computers, and communication links

Chemical engineering

Chemical engineering involves the production of products through chemical processes.

This includes designing equipment, systems, and processes for refining raw materials and for mixing, compounding, and processing chemicals.

The laws of physical chemistry and physics govern the practicability and efficiency of chemical engineering operations.

Particularly, chemical engineering requires an understanding of the physical properties of molecules, the chemical bonds between atoms as well as the molecular dynamics which are dealt by molecular physics.

1.3 Medical physics

Medical physics is a branch of physics that concerns the applications of principles of physics to medical diagnosing and treating abnormal tissues.

The modern medical equipment like X-ray, MRI, CT scan, ultrasound and others are developed by the application of physics knowledge.

The MRI technique yields detailed visualization of soft tissue structures with a resolution of about 0.5 mm.

Magnetic resonance is absorption or emission of electromagnetic radiation by electrons or atomic nuclei in response to the application of certain magnetic fields.

Getting an MRI image depends upon the presence of protons in the body. Protons are free hydrogen atom (proton without electrons).

X-Ray computerized tomography (CT) scan

An X-ray imaging is based on the absorption of X-rays as they pass through the different parts of a patient's body.

Differences in the densities of body tissue allow us to see inside the body by creating a shadow gram. The body is composed of tissues containing many different elements, which vary by atomic number (the number of protons in the nucleus).

The higher the atomic number, the denser the element and the more effectively the X-ray is blocked.

For example, when X-ray strikes the calcium in cortical bone, it is blocked, and on the radiographic image the bone will appear white. When an X-ray strikes less dense element like nitrogen, it passes all the way through.

Therefore the air-containing lung will appear darker, approaching black on the radiographic image. When a fracture extends through the bone the fracture line will be dark while the intact bone will remain white.

During a regular X-ray procedure, a stationary machine sends X-rays through the body to make a single shadow picture.

A computed tomography (CT) scan uses computers and rotating X-ray machines to make many successive images (called tomograms) of the inside of body along different directions.

In CT scan the X-ray source and the detectors rotate simultaneously in opposite direction

- ❖ As the patient passes through the CT imaging system a source of X-rays rotates around the inside of the circular opening while the detectors on the other side of the patient record the X-rays exiting the section of the patients body being irradiated.

The Maine different between difference between conventional X-ray and CT scan?

- ❖ The CT scan images provide more detailed information than normal X-ray
- ❖ both X-ray and CT scan use X-rays for diagnostic purpose.

- The image formation in both cases depend on the blockage and transmission of X-rays by the tissues of the body.

X-ray	CT Scan
X-ray Creates 2D images	
Used primarily to see bones and to detect cancer and pneumonia	*More powerful than X-ray*
Most common and widely available	*Take 360-degree image*
Use radiation to produce image	*Has Used primarily to diagnose conditions in organs and soft tissues rotating detector*
Has fixed detector	*Creates 3D images*
	More powerful than X-ray

Clinical uses of sound: stethoscope and ultrasound

- The most familiar clinical use of sound is in the analysis of body sounds with a stethoscope

This instrument consists of a small bell-shaped cavity attached to a hollow flexible tube.

The bell is placed on the skin over the source of the body sound (such as the heart, intestines, or lungs). The sound is then conducted by the pipe to the ears of the examiner who evaluates the functioning of the organ.

A stethoscope can be used to listen sounds made by the heart, lungs or intestines, as well as blood flow in arteries and veins.

A stethoscope can detect sound waves with frequency ranging from tens to thousands of Hertz.

Ultrasound

- If the frequency of sound is higher than 20 KHz (0.02 MHz), it is called ultrasonic or ultrasound.
- Typical frequencies used in medical ultrasound are 3.5-10 MHz.
- Ultrasonic waves penetrate tissue and are reflected, scattered and absorbed within it.
- The scattered and reflected ultrasound contains information about the form and structure of the tissue.
- An ultrasound machine sends an ultrasound wave into a body tissue and detects the reflected wave.
- The detector generates a tiny electric current that is amplified to generate an ultrasound image on the monitor

- An ultrasound image is commonly described by three words:
  - anechoic,
  - hypoechoic
  - hyperechoic

Anechoic These areas appear black on ultrasound because they do not send back any sound waves (echoless region).

Anechoic regions are resulted from fluid-filled regions.

Hypoechoic Gives off fewer echoes These areas appear dark gray because they don't send back a lot of sound waves (echoes).

Hyperechoic These areas bounce back many sound waves.

They appear as light gray on the ultrasound image.

Radiation therapy

- The photons of X-rays and gamma-rays and the particles emitted by radioactive nuclei all have energies far greater than the energies that bind electrons to atoms and molecules.
- As a result when such radiation penetrates into biological materials it can rip off electrons from the biological molecules and produce substantial alterations in their structure.
- In the treatment of certain types of cancer an ampul containing radioactive material such as radium or cobalt 60 is implanted near the cancerous growth.
- By careful placement of the radioactive material and by controlling the cancer cell can be destroyed without greatly damaging the healthy tissue

Radar technology

- The word RADAR is an acronym derived from the phrase RAdio Detection And Ranging.
  - ships,
  - vehicles
  - aircraft,
  - missiles, etc

  which are at certain distances from the location of the radar.
- It collects the information related to the object or target like its range (R) and location by radiating electromagnetic signal and examining the echo received from the distant object.
- . The range can be calculated using the speed-distance formula with the speed equal to the speed of light(c).
- speed = distance/ time

- distance = speed∗time; $2R = c*t$ and $R = ct/2$.

Military

- Radar is mostly used for military purpose and is one of the most important parts of the air defense system.
- Its major function is to detect target and guiding the defensive and offensive weapons.
- Radar can also be utilized in civilian applications particularly in controlling air traffic, observation of weather, navigation of ship, environment, sensing from remote areas, observation of planetary, etc.

Missiles

A missile is a rocket-propelled or jet-propelled weapon designed to deliver an explosive weapon with great accuracy at high speed.

types Missiles.

- cruise missile
- ballistic missile.

Cruise missiles : are jet-propelled throughout their flights.

Ballistic missiles: are rocket-powered only in the initial phase of flight, after which they move under the influence of gravity and air resistance following an arc trajectory to the target

A missile is a combination of many electronic, digital and mechanical subsystems that perform many operations to guide the missile from its launcher to its target.

There is continuous radio communication between the internal missile controlling unit and the launch controller to track the target and the proper functioning of each unit of the missile.

Infra-red wave detection for night vision

- ✓ Human eyes are sensitive to visible light: red, orange, yellow, green, blue, and violet light.
- ✓ Infrared, is just out of range of what the human eye can detect.
- ✓ It is detected by infrared detecting devices.

- ✓ Infrared (IR) devices will typically use heat emissions to identify objects that cannot be detected using available light sources.
- ✓ Infrared vision is used extensively by the military for various purposes like night vision, navigation, hunting, hidden-object detection and targeting.
- ✓ Infrared imaging systems like infrared imaging goggles create an electronic image based on the temperature differences in the radiating object; hotter objects appear brighter than cooler objects.

1.4 Physics in communication

Communication is transferring of information from one point to another using wire or without wire

Most of the communication technology uses the electromagnetic radiation physics like Reflection, refraction, diffraction, interference, rarefaction, propagation, transmission and compression.

very difficult without the use of the communication technologies like telephone, cell-phone, mobile and computers.

- ❖ Communication is transferring of information (message) from one point to another.
- ❖ To transfer the information to the receiver, medium of transmission is required.

Depending on the communication medium ,the communication system is classified as

- ☞ wired
- ☞ wireless communication system.

Wireless communication systems: use radio waves, microwaves and infrared waves. Satellite communication and ground wave communication are common examples of wireless communications.

The wire communication system : uses wire and optical fiber.

All forms of communication technologies demand the knowledge of physics.

End of unit questions

1 Explain the following biological process in terms of some physics knowledge

- ☞ How our brain receives information from the whole body and send information to other body?

An s delivered to the spinal cored through the axon terminals of sensory neurons

Which part of our body tells us the temperature of our environment?

Ans: the part of the body that tells as the temperature of our environment is skin

- What instrument is used to measure the exact value of our body temperature?

***Ans** :Thermometer uses the thermal physics and reads temperature of a body*

- What physics knowledge is needed to understand how a sound is created and transmitted to the listener?
  Ans :to understand how a sound is created and transmitted to the listener one needed to have knowledge of several key concepts in physics the first understanding of waves specially sound wave is essential .
- What energy transformation occurs in human body?
  Ans: The human body converts energy stored in foods into work thermal energy and /chemical energy that is stored fat tissue
- What energy transformation occurs in photosynthesis?
  Ans: the main energy transferred that occur in photo synthesis in green level is light energy to chemical energy

2 List as many concepts of physics that can be used in designing modern vehicles

Ans: motion and kinematics fluid mechanics thermodynamics and electrical circuit

3 How physics of light is important to study the astronomical objects?

When the light emitter is moving through spaces we can determine important physical properties of astronomical objects such us temperature density and chemical composition

- Ans: *The astronomers' only information about a particular object comes through the light that it emits, and this light arises through atomic transitions*.
- Astronomers use the physics of light, atomic physics and Newtonian mechanics for the study of astronomical objects.

4. As physics is the basis for the development of many technologies, how technologies contribute for the development of science particularly physics?

Ans: enable experiment data analyses visualization in communication

- Advanced technology such us the LHC computer simulation and power full computer have revolized scientific research and contribute important discovery.

5. What major physics knowledge is used in defense radar system to detect the enemy target?

Ans : radar system used major physics concept like EMW propagation the Doppler effect and wave reflection and refraction to detect enemy target

6. List at least three modern medical devices and explain their working principles.

Ans :

MRI , automatic blood pressure manometer and portable pulse ox meter are the three modern medical device

Working principle

automatic blood pressure manometer: measure blood pressure using an inflatable cuff and the pressure sensor producing an accurate and convent ways to measure blood pressure

portable pulse ox meter :utilize a light sensor to measure oxygen saturation and heart rate by clamping on the finger or earlobe

- *Stethoscope use the physics of sound wave and reads the heart beats.*
- *Otoscope uses physics of optics as it uses magnifying lens and examines the condition of the ear canal.*
- X-*ray uses physics of electromagnetic wave (X-ray) and examines the injuries in the tissues. Ultrasound uses the physics of sound wave and examines the nature of the sound reflected by different tissues.*

Many medical instruments also use electronic physics for displaying the results and controlling the instruments.

7. List as much physics knowledge and engineering as possible to build a modern building for residence.

Ans: An understanding of power pressure heat and electricity

8. Identify the difference between the diagnostic and therapeutic medical device.

Ans: diagnostic used to identify diagnoses a medical condition or dieses example x-ray mechanics MRI sincere and thermometer

therapeutic medical used to treat or manage medical conditions or daises

Example pace marks ,dialysis and insulin pumps

9. What are the possible applications of radar system?

Radar is used to helpful in detecting incoming signals during ware and also using geologist for Earth quake detection

Applications using radar given below

- Military

- Space
- Remotsinsing of environment
- Air craft navigation
- Ship navigation

Radar can also be utilized in civilian applications

particularly in controlling air traffic, observation n of weather, navigation of ship, environment, sensing from remote areas, observation of planetary, etc

Unit 2

Two-dimensional motion

2D motion is motion in a plane (This means object moving along two coordinate axis simultaneously, and

its position can be described by two coordinate).

Example Two-dimensional motion

- ✓ Projectile motion
- ✓ Circular motion

Example of Projectile motion, A ball kicked by a football player

Example of Circular motion.

- ❖ the orbital motion of planets,
- ❖ bicycle rounding a curve,
- ❖ the rotation of wheels of a car

2.1. Projectile Motion

Projectile motion is motion of an object in a plan under the infuelence of gravity alone, regardless of its initial motion(neglecting air resistance).

Examples: A ball kicked from the horizontal ground. The path followed by projectile motion is trajectory and downward.

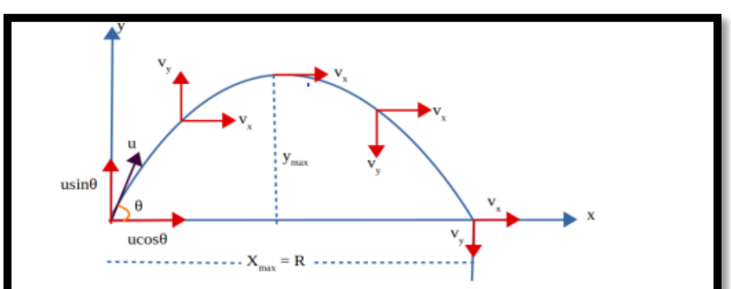


Fig 2.

Inclined projectile motion

This is a type of motion in which an object is projected with an initial velocity v_0 which makes an angle θ with the horizontal.

The initial velocity can be resolved into two components, vertical and horizontal component.

The vertical component of the velocity changes with time as a result there is acceleration due to gravity

- Horizontal projectile motion
- Vertical Projectile Motion

Horizontal projectile motion

It is uniform motion (velocity constant, $a_x = 0$). Because no net force act on horizontal motion of projectile motion.

$v_{0x} = v_0\cos\theta$ this is horizontal component of initial velocity.

$v_x = v_{0x} = v_0\cos\theta$ = constant and $x = v_{0x}t = v_{xt} = v_0\cos\theta\, t$

The horizontal distance traveled by the projectile at a time t is given by the equation $\Delta x = v_{0x}\, t$

Vertical Projectile Motion

Vertical motion of projectile motion is uniformly accelerated motion. It is motion with constant gravitational acceleration of $g = 9.8 m/s^2$ toward the center of the earth. At the origin

$v_{0y} = v_0\sin\theta$

Where V_{0y} is the initial vertical velocity. (v_{0y}=0). From the kinematics equations, the vertical displacement, Δy has a form:

$$\Delta y = v_{0y}\, t + \frac{1}{2} g\, t^2 \text{ But } v_{0y} = 0, \text{ therefore}$$

$$\Delta y = \frac{1}{2} g\, t^2$$

- When you use equations to answer questions on vertical motion, upwards motion is positive (+) and downwards motion is negative (-) gravity

Time of flight

The time of flight is the time taken by the projectile to hit the ground. We know that the flight of the projectile, use the equation v = u + at. But at the maximum height

$v_{vert} = 0$ and $a = -g$.: So $0 = u_{vert} - gt$

$gt = u_{vert}$

$t = u_{vert}/g$ but $u_y = u\sin\theta$

$t = \frac{u\sin\theta}{g}$

total flight Time = $t_{up} + t_{down}$

- $t = \frac{u\sin\theta}{g} + \frac{u\sin\theta}{g}$
- $t = \frac{2u\sin\theta}{g}$

Range (R)

The range is the maximum horizontal distance traveled by the projectile. Once we find the time of flight t, we can solve for the horizontal displacement

- $R = v_{0x}\, t$ but $v_{ox} = u\cos\theta$ and $t = \frac{2u\sin\theta}{g}$

$R = u\cos\theta\ t = u\cos\theta \frac{2u\sin\theta}{g}$

$R = \frac{2u\sin\theta \times u\cos\theta}{g}$

$R = v_0 \cos\theta\ t_{total}$

$R = \frac{v_0^2 \sin 2\theta}{g}$ b/c $2\sin\theta\cos\theta = \sin 2\theta$

maximum height(H)

- It is the maximum vertical distance traveled by the projectile.
- The maximum height of a projectile trajectory occurs when the vertical component of velocity, v_y equals zero.
- As the projectile moves upwards it goes against gravity, and therefore the velocity begins to decrease

$v_y^2 = u_y^2 + 2as$, at the maximum height but $v_{0y} = v_0\sin\theta$ and $u_y = 0$ $s = R$

$(v_0\sin\theta)^2 = 0 + 2as$

$(v_0\sin\theta)^2 = 2aR$

$H = (v_0\sin\theta)^2 / 2g$

$H = \frac{v_0^2 \sin^2\theta}{2g}$

Relation between range and maximum height

- The initial velocity of the projectile is v_0, H is the maximum height and R is its horizontal range.
- We know that the maximum height of the projectile H is given by the equation:

$H = \frac{v_0^2 \sin^2\theta}{2g}$

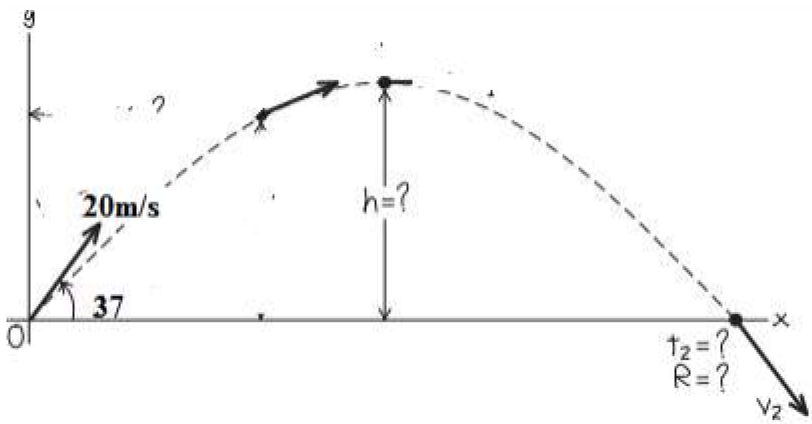
And horizontal range is given by the equation

$R = \frac{v_0^2 \sin 2\theta}{g}$ Divide the maximum height of the projectile by the horizontal range. (In the equation, $\sin^2\theta$ can be written as $\sin\theta\sin\theta$, and $\sin 2\theta$ can be written as $2\sin\theta\cos\theta$).

$$\frac{H}{R} = \frac{\sin\theta}{4\cos\theta}$$

$$H = \frac{R\tan\theta}{4}$$

Example A player kicks a football from ground with initial velocity of 20m/s at an angel of 37° , above the horizontal. Find A) The maximum height B. Total time of flight C. The range D. The velocity when it strikes the ground



A. $Y_{max} = \frac{u^2(\sin^2\theta)}{2g}$

$$Y_{max} = \frac{20^2 * \sin^2 37}{20} = 7.24\text{m} \text{ Above the ground}$$

B. $t_{tot} = \frac{2u\sin\theta}{g} = \frac{2*20*\sin(37)}{10} = 2.41\text{sec}$

C. $R = \frac{u^2 \sin(2\theta)}{g} = \frac{20^2 \sin(2*37)}{10} = 38.45m$

D. $V = \sqrt{V_x^2 + V_y^2}$

But $V_x = u\cos\theta = 20\cos(37) = 15.97\text{m/s}$

$V_y = u\sin\theta - gt = 20\sin 37 - 10 * 2.41 = -13.12ms^{-1}$

$\boldsymbol{V = \sqrt{15.97^2 + 12.06^2} = 17.7m/s}$ to find the direction let's use the tan inverse function

$$\boldsymbol{\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{13.12}{15.97}\right) = -43.78°}$$

Thus $\vec{V} = 13.12$ m/s at an angel of $\theta = -43.78°$ note the minus sign indicate the angel is below the x axis.

For the above problem the equation of trajectory is given as

$$\mathrm{Y = xtan\theta - \frac{1}{2}\frac{gx^2(1 + tan^2\,\theta)}{u^2}}$$

$$Y = xtan37 - \frac{1}{2} * 10 * x^2(1 + \tan^2 37)$$

$Y = 0.57x - 7.157x^2$ these is quadratic equation with coefficient $a = -7.157, b = 0.57$

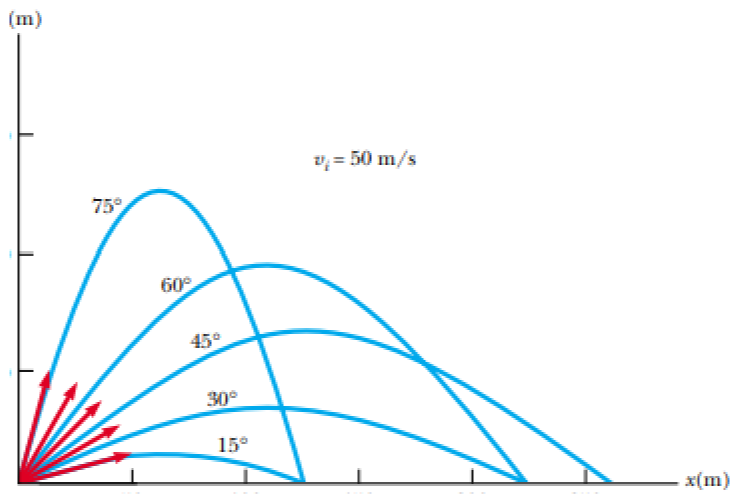
Example find the maximum range, total flight time and the maximum height for each angle for the following graph use g=10m/s^2.

Example Two projectiles are thrown with the same initial velocity, one at an angle Φ and the other at an angle of (90-Φ)

(a) Can both projectiles strike the ground at the same distance from the projection point?
Ans *Yes see in the* graph

(b) Can both projectiles be in air for the same time interval?

Ans *no see in the following solutions below*



solution

θ (o)	sin2θ	U(m/s)	U^2 (m^2/s^2)	a(m/s^2)	Range(m) $R=\frac{v_0^2 \sin 2\theta}{g}$	h_{max} (m) $H=\frac{v_0^2 \sin^2 \theta}{2g}$	Flight time(s) $\frac{2u\sin\theta}{g}$
15	0.5	50	2500	10	125	8.37	2.58
30	0.87	50	2500	10	216.5	31.25	5
45	1	50	2500	10	250	62.5	7.07
60	0.87	50	2500	10	216.5	93.75	8.66
75	0.5	50	2500	10	125	116.62	9.659

Discussion question 2.1 Which motion is different from the others? Explain Why? a) A ball thrown horizontally into the air. b) A bullet fired from a gun. c) A javelin thrown by an athlete. d) A bird flying in the air

Answer: d) A bird flying in the air The motion of a bird flying in the air is not projectile motion. This is because atmospheric pressure exerts an upward force (lift) which supports the bird, and thrust (a forward force) help them to move forward by Newton's third law. However, the only force acting on projectile motion is gravity.

Discussion question 2.2 Assume that an airplane flying horizontally drops a package to a remote village. What kind of motion is performed by the package?

Draw the trajectory of the package. As the package hits the ground at the village, where is the aircraft?

Answer : This is a type of horizontal projectile. When the package is dropped, it has a horizontal initial velocity equal to the horizontal velocity of the aircraft.

Thus, it performs horizontal projectile motion. As the package hits the ground at the village, the aircraft travels the same horizontal 46 distance as the package.

Because the aircraft is travelling with a constant velocity so both have the same horizontal velocity. Therefore, at the moment the package hit the ground the aircraft is found vertically above the package.

Discussion question 2.3 Balls A and B are kicked at an angle of 37^0 and 53^0 with the horizontal respectively, with the same initial velocity v_0. Which ball has: a) the maximum horizontal displacement? b) the maximum height?

Solution The relation between angle of projection with maximum height and horizontal range is demonstrated in the above example When the angle of projection increases the maximum height increases.

a) If the angle of projections of two balls sum to 90^0 the horizontal range is the same

b) As the angle of projection increases, the height also increases. Thus, the ball with 53^0, travels the maximum height. You can verify these by maximum height and horizontal range formula.

$$R = \frac{V_0^2 \sin 2\theta}{g} \quad \text{and} \quad H = \frac{V_0^2 \sin^2\theta}{2g}$$

Discussion question 2.4 1 A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. What is the angle of projection?

solution 3H = R $R = \frac{v_0^2 \sin 2\theta}{g}$ and $H = \frac{V_0^2 \sin^2\theta}{2g}$ $2u^2\sin\theta\cos\theta = u^2\sin 2\theta$

$$\frac{V_0^2 \sin 2\theta}{g} = \frac{3V_0^2 \sin^2\theta}{2g}$$

-

$\tan\theta = 4/3$

$\theta = \tan^{-1}4/3$

$\theta = 53^0$

2. A ball is kicked into the air from the ground at an angle θ with the horizontal. When the ball reaches its highest point, which statement is true ?

(a) Both the velocity and acceleration of the ball are zero.

(b) Its velocity is not zero, but its acceleration is zero.

(c) Its velocity is perpendicular to its acceleration.

(d) Its acceleration depends on the angle at which the ball was thrown.

Ans (c)

3. One ball is thrown horizontally. At the same time, a second ball is dropped from the same height. Ignoring air resistance and assuming the ground level, which ball hits the ground first? Explain why.

Ans Both reach at the same time as they are covering the same height.

Discussion question 2.5 1.

As a projectile moves in its parabolic path, is there any point along the path where the velocity and acceleration vectors are

(a) perpendicular to each other (at right angles)?

(b) parallel to each other?).

- ***At maximum height the only velocity is in the horizontal direction. This velocity is perpendicular to the acceleration due to gravity.***
- ***There is no any point along the path where the velocity and acceleration vectors are parallel to each other***

2. Which of the following statements about projectile motion are true? (ignoring air resistance).

(a) The horizontal and vertical motions are independent.

(b) The force on the projectile is constant throughout the flight.

(c) The acceleration of the projectile is constant throughout the flight.
(d) The path depends upon the initial velocity, but not upon the mass of the projectile.
(e) All of the above statements are true.

Answer: e

3. A projectile is fired on Earth with some initial velocity. Another projectile is fired from the surface of the Moon with the same initial velocity.

If air resistance is ignored, which projectile has the greater range? Why?

Which reaches the greater height? Why? (Note that the free-fall acceleration on the Moon is about 1.6 m/s^2

Answer *Both the range and maximum height vary inversely with acceleration due to gravity. Therefore, the projectile fired on the moon has the greater range and height.*

Exercise 2.1

Use $g=10m/s^2$ where necessary.

1. At which position in its flight will a ball experience its minimum speed during inclined projection? A. at the beginning B. at maximum height C. at the end D. the same speed at all positions
   Answer *The velocity is minimum at maximum height because there is only horizontal velocity at this height.*

2. A gun with a muzzle velocity of 500 m/s shoots a bullet at a target 50 m away. To hit the target the gun should be aimed:
A. directly towards the target along the line joining the gun and target.
B.10 cm high above the target.
C. 5 cm high above the target. D. 5cm below the target. ***Answer C***

3. A ball is thrown horizontally with a velocity of 20m/s from a top of building 90 m high. Calculate:

a) the time taken to reach the ground.

Solution ***given***

- =***h*** = $\Delta y = v_{0y}\, t + \frac{1}{2} g t^2$ But $v_{0y} = 0$, therefore

$$\Delta y = \frac{1}{2} g t^2$$

h = 90m v_h ***=20m/s g =10m/s***^{2}

$90m = \frac{1}{2} 10\, t^2$ $.180m = 10\, t^2$

$t^2 = 18$ $t = \sqrt{18}$

$\underline{t = 4.24 seco}$

b) the horizontal displacement.

$R = v_{0x}\, t$

$R = 20m/s * 4.24s$

$\underline{R = 84.8\ m}$

c) The resultant velocity with which it strikes the ground

v = gt but downwards motion is negative gravity

$v = -10m/s^2 * 4.24s$

$v = -42.4\ m/s$

. 4. A long jumper leaves the ground at an angle of 20^o above the horizontal and at a speed of 11.m/s.

a) How far does he jump in the horizontal direction?

$$R = \frac{V_0^2 \sin 2\theta}{g}$$

$$R = \frac{121 sin 40}{10}$$

$$R = \frac{77.77}{10}$$

$\underline{R = 7.777m}$

b) What is the maximum height reached?

$$H = \frac{V_0^2 \sin^2 \theta}{2g}$$

$H = 121 sin20 * sin20/20$

$H = 121 * 0.116964/20$

$H = 14.152/20$

$\underline{H = 0.70761m}$

5. An object projected at an angle θ with velocity 30 m/s reaches its maximum height in 1.5 s. Calculate its range.

$Sin\theta=0.5\ \theta=30^0\ \ cos30=0.866$

$R= v\ cos\theta t$

R = 30 m/s *0.866*1.5 s

R =$38.97m$ *but* t is the total time which 2x1.5s=3s

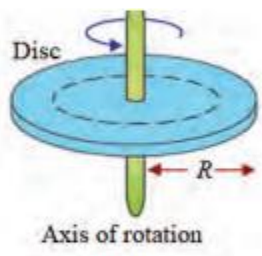
R = 2 x$38.97m$ $R = 77.94m$

2.2 Rotational Motion

Rotational motion: is when an object moves about an axis and different parts of it move by different distances in a given interval of time.

Example of rotational Motion:

- ✓ the rotation of Earth around its axis,
- ✓ the rotation of the flywheel of a sewing machine,
- ✓ rotation of a ceiling fan,
- ✓ rotation of wheels of a car, and so on.



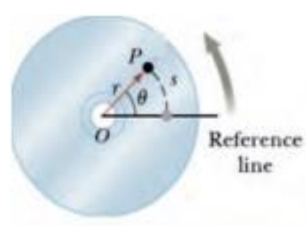


Figure 2.7 Rotation of a disc of mass M around a fixed axis. Figure 2.8 A CD rotating about a fixed axis through O perpendicular

The disc in Figure 2.7 is performing rotational motion because all of its particles are rotating around a fixed axis, called its axis of rotation.

Angular displacement(Δθ)

Angular displacement*: is the change in the angle (θ) of rotation of an object with respect to a fixed axis*

- ✓ *In one complete revolution an object will travel a distance equal to 2πr (where r is the radius of the circle).*

- ✓ *Its tangential displacement will be zero as it is back where it started.*
- ✓ *If we consider part of this motion, between two points, we can see that the object has an angular displacement equal to θ.*
- ✓ *This is just the angle the object has subtended.*
- ✓ *One full revolution is 360°, half a circle would be 180°, and so on.*
- ✓ *Radian (rad) is SI unit of angular displacement*

- ➢ *The relation between revolution (rev), degree(deg or ^{0}) and radian (rad) $2\pi rad = 360^0 = 1rev$*

Angular velocity(ω)

- ✓ *It is the rate of change of the angular displacement of an object with respect to time.*

Its represented by Greek letter ω.

It is measured in radians per second or (degrees per second or revelation per second) and is equal to the ratio of the change in the angular displacement of the object to the time interval over which the change occurred.

- ❖ *The rate at which angular displacement occurs can vary.*

$$\omega_{av} = \frac{\theta_f - \theta_0}{t_f - t_0} = \frac{\Delta\theta}{\Delta t}$$

- ❖ Angular velocity has units of radians per second (rad/s).

Angular acceleration

- Average angular acceleration (α_{av}): is the ratio of angular velocity to time interval Δt during which the change occur
- *If the angular velocity of an object changes from ω_0 to ω_f in the time interval Δt, the object has an angular acceleration.*
- *The angular acceleration α (Greek letter alpha) of a rotating rigid object is defined as the ratio of the change in the angular speed to the time interval Δt during which the change in the angular speed occurs*

$$\alpha = \frac{\omega_f - \omega_0}{t_f - t_0} = \frac{\Delta\omega}{\Delta t}$$

- Angular acceleration has units of radians per second squared (rad/s^2).

Centripetal Acceleration

Any object moving in a circular path has an acceleration directed toward the center of the circular path, called a centripetal acceleration.

Centripetal Acceleration Any object moving in a circular path has an acceleration directed toward the center of the circular path, called a centripetal acceleration. Its magnitude is given by

$$a_c = \frac{v^2}{r} = r\omega^2$$

Kinematic equations for rotational and linear motion

The kinematics for rotational motion is completely analogous to linear (or translational) kinematics. Many of the equations for the mechanics of rotating objects are similar to the motion equations for linear motion.

When solving problems involving rotational motion, we use variables that are similar to linear variables (distance, velocity and acceleration) but take into account the curvature or rotation of the motion.

We defined: the angular rotation $\Delta\theta$, which is the angular equivalence of distance, Δs; the angular velocity ω, which is the angular equivalence of linear velocity v the angular acceleration α, which is the angular equivalence of linear acceleration, a.

Linear motion with constant acceleration	Angular motion with constant angular acceleration
$v_f = v_0 + a\Delta t$	$\omega_f = \omega_o + \alpha\Delta t$
$V_{av} = \frac{v_f + v_0}{2}$	$\omega_{av} = \frac{\omega_f + \omega_0}{2}$
$\Delta s = \left(\frac{v_f + v_0}{2}\right)\Delta t$	$\Delta\theta = \left(\frac{\omega_f + \omega_0}{2}\right)\Delta t$
$\Delta s = v_0 t + \frac{1}{2}a\Delta t^2$	$\Delta\theta = \omega_o\Delta t + \frac{1}{2}\alpha\Delta t^2$
$v_f^2 = v_0^2 + 2a\Delta s$	$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

Period (T):- Time required for one complete revolution For a particle moving in a circle of radius r with a constant speed

Relationship between angular motion and translational motion

- some useful relationships between the angular quantities θ, ω and α of a rotating rigid object and the corresponding linear quantities s, v, and a of a point in the object.
- To do so, we must keep in mind that when a rigid object rotates around a fixed axis as in Figure every particle of the object moves in a circle whose center is on the axis of rotation.
- As the particle moves along the circle through an angular displacement of θ, it moves through an arc length s.

The arc length s is related to the angle θ through the equation:

When a rigid object rotates about a fixed axis, the angular position, angular speed, and angular acceleration are related to the translational position, translational speed, and translational acceleration through the relationships

$s = r\theta$, $v = r\omega$, $a = r\alpha$ $= r\,\omega^2$, $= v^2/r$

Example *What is the centripetal acceleration of the Earth as it moves in its orbit around the Sun?* $the\ radius\ of\ the\ Earth's\ orbit\ around\ the\ Sun, which\ is.\ 1.4963\ x10\ 11\ m$

$What\ is\ the\ angular\ speed\ of\ the\ Earth\ in\ its\ orbit\ around\ the\ Sun?$

$$a_c = \frac{v^2}{r} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{4\pi^2 r}{T^2}$$

$$a_c = \frac{4\pi^2(1.496 \times 10^{11}\text{ m})}{(1\text{ yr})^2}\left(\frac{1\text{ yr}}{3.156 \times 10^7\text{ s}}\right)^2 = 5.93 \times 10^{-3}\text{ m/s}^2$$

$$\omega = \frac{2\pi}{1\text{ yr}}\left(\frac{1\text{ yr}}{3.156 \times 10^7\text{ s}}\right) = 1.99 \times 10^{-7}\text{s}^{-1}$$

Example What is the angular speed of the second hand of a clock? What is the direction of ω as you view a clock hanging vertically?

For one complete rotation t = period = 60s The angular displacement is Δθ = 2π rad

$\omega = \frac{\Delta\theta}{T} = \frac{2\pi\, rad}{60s} = \frac{6.28\, rad}{60s}$ $\pi = 3.14$

$\omega = 0.104\frac{rad}{s}$

When a wheel of radius R rotates about a fixed axis, do all points on the wheel have
(a) the same angular speed? (b) the same linear speed?

- ✓ *They have the same angular speed but the linear speed depends on radius of the particles from the axis of rotation.*

Exercise 2.2

1. When a wheel of radius R rotates about a fixed axis, all points on the wheel have the same angular speed. True or False. Ans True

2. Which of the following can not be a unit for angular displacement ? A. deg B. rad . rev D. rpm Ans D.

3. A rope is wrapped many times around a pulley of radius 20 cm. What is the average angular velocity of the pulley if it lifts a bucket to 10 m in 5 s?

s = 10m ,r =20cm=0.2m ,t = 5s

$\theta = \frac{s}{r} = \frac{10}{0.2}$ $\theta = 50rad$ but $\omega = \frac{\Delta\theta}{T} = \frac{50rad}{5s} = 10\frac{rad}{s}$

4. A particle moves in a circle 1.50 m in radius. Through what angle in radians does it rotate if it moves through an arc length of 2.50 m? What is this angle in degrees?

$\theta = \frac{s}{r} = \frac{2.5}{1.5} = 1.667rad$

$360^o = 2\pi rad$

$X = 1.667rad$ use $\pi = 3.14$

$600^o = 2\pi rad\ X$

$X = \frac{600}{6.28} = 95.54$

$\underline{\Theta = 95.54^o}$

5. A wheel is under a constant angular deceleration of 5r ad/s ^{2} . Its initial speed is 3 rad/s. What angular distance will it travel just before coming to rest?

Solution $\omega^2 = \omega^2_o - 2a\ \theta$ *the mines sine indicates the acceleration down ward*

$0 = 9\ rad^2/s^2\ -2\ x5r\ ad/s^2\ \theta$

$-9\ rad^2/s^2 = -10r\ ad/s^2\ \theta$

$\theta = \frac{-9}{-10}$

$\theta = 0.9\ r\ ad$

6. A wheel initially turning at 200 rpm uniformly increases its speed to 600 rpm in 8s. Calculate: (a) the angular acceleration of the wheel in r ad/s ^{2} .

<u>*Solution;*</u> $\omega_{o=}\ 200rpm = 2\pi\frac{(200)}{60} = 6.667\pi rad/s$ $\omega = 60pmr = 2\pi\frac{(600)}{60} = 20\pi\frac{rad}{s}$

$.a = \frac{\omega - \omega o}{t}$ $a = \frac{20-6.667}{8} = \frac{13.333\pi}{8s}$

$\underline{a = 1.6667\pi rad/s^2}$

2.3 Rotational Dynamics

Torque(τ): is defined as rotational effect of force ie (it is measure of force that cause an object to rotate around an axis.

- ✓ Torque is represented by symbol (greek letter) τ .
- ✓ Torque is vector quantity with both magnitude and direction.
- ✓ It is calculated by the product of force and perpendicular distance from its axis of rotation.
- ✓ Its SI unit is Nm.
- ✓ $\tau = I\alpha$
- ✓ $\tau = r\,F\sin\theta$

Moment of inertia (I)

- ❖ Inertia is the property of a body that resist s a change in its state of motion
- ❖ It is the property of a rotating body that resist s a change in rotational motion

The moment of inertia of a rotating body depends on

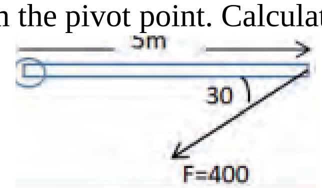
- ➢ *the mass of a rotating body*
- ➢ *axis of rotation of the body.*
- ➢ *The shape of the body*
- ➢ *The moment of inertia is given the symbol I.*
- ➢ *The moment of inertia of point of mass* $I = mr^2$
- ➢ *the SI unit of moment of inertia is* kgm^2 .
- ➢ *Moment of inertia is a scalar quantity.*
- ➢ *The moment of inertia for more than one particle around a fixed axis is:* $I = m_1r^2{}_1 + m_2r^2{}_2 + m_3r$

Example : The moment of inertia of a body does not depend on:

A. the angular velocity of the body. B. the position of axis of rotations of the body.
C. the position of the body from the axis of rotation. D. the shape of the body. Ans A

Exercise 2.3

1. A force of 400 N is applied to a beam at a distance of 5 m from the pivot point. Calculate the magnitude of the torque which turns the bar around pivot the .



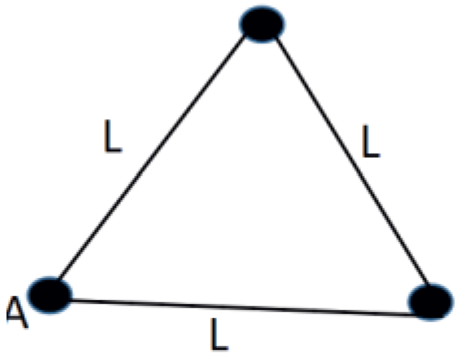
$\theta = 180^0 - 30^0 = 150^0$

$\tau = Fr\sin\theta$

$\tau = 400N \times 5m \sin 150^0$

$\tau = 1000Nm$

2. Three point masses, each of mass m, are placed at the corners of an equilateral triangle of side L. Find the moment of inertia of the system about an axis passing through one of the corners perpendicular to the plane of the triangle.



Let us choose axis of rotation through A, Therefore, the moment of inertia of mass at A is zero only the other masses produce moment of inertia about A. $I = mL^2 + mL^2 = 2mL^2$

3. A disc with moment of inertia 2 kgm^2 changes its angular speed from 3 rad/s to 8rad/s by a net torque of 50 Nm. How long will the disc take to change its angular speed?

$$\alpha = \frac{\tau}{I}$$

$$\alpha == \frac{50\text{Nm}}{2\text{ kgm2}} \qquad \alpha = 25\frac{rad}{s2}$$

$$a = \frac{\omega - \omega o}{t} \qquad = 25\frac{rad}{s2} \quad = \frac{8\text{rad/s} - 3\text{ rad/s}}{t} \qquad 25\frac{rad}{s2}\text{t} \ = 5rad/\text{s}$$

$$t = \frac{5rad/s}{25\frac{rad}{s2}}$$

$\underline{t\ =\ 0.2s}$

2.4 Planetary motion and Kepler's laws

Planetary motion is a type of curvilinear motion. The path of the motion is called orbit

Kepler formulated three laws those are

- *Kepler's First Law (Law of Orbits) States that the orbit of each planet in the solar system is an ellipse, the Sun will be on one focus*
- *Kepler's Second Law (The Law of Areas) States that the radius vector connecting the centers of the Sun and the Planet sweeps out equal areas in equal intervals of time.*

- *Kepler's Third Law (The Law of Harmony)* ***States that "the square of the orbital period of a planet is proportional to the cube of the average distance between the centers of the planet and the sun."*** $\frac{GM_S}{r^2} = \frac{(2\pi r/T)^2}{r}$
- *The speed of the planet increases as it nears the Sun and decreases as it recedes from the Sun. The period for a planet to orbit the Sun increases rapidly with the radius of its orbit.*

Exercise 2.4 1.

1 According to Kepler's laws of planetary motion, a satellite increases its speed as it approaches the Sun and decreases its speed as it moves away from the Sun. True or False. Ans True

2 Given that the Moon orbits Earth every 27.3 days and that it is an average distance of 3.84×10^8 m from the center of Earth, calculate the period of an artificial satellite orbiting at an average altitude of 1,500 km above Earth's surface. (Radius of Earth is 6380 km.) . an artificial satellite

use Kepler's third law to calculate the period

$$\frac{T2}{R3} = \frac{T2}{R3}$$

$(27.3)^2 /(3.84x10^5)^3 =T^2/(1500+6380)^3$ $T^2= 6.48x10^{-3}$

$745.29/56.623x10^{15} =T^2/489.3x10^9$ $T=0.0805day$

$T^2 =3.6467x10^{14}/5.62x10^{16}$

3. How would the period of an object in a circular orbit change if the radius of the orbit doubled?

A. The period would increase by a factor of 2.

B. The period would decrease by a factor of 4.

C. The period would increase by a factor of $2\sqrt{2}$.

D. The period would decrease by a factor of 2√2. *Answer c*

2.5 Newton's Law of Universal Gravitation

Newton's universal law of gravitation states that every particle in the universe attracts every other particle with a force along a line joining them.

The force is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$\vec{F} = \frac{GmM}{r^2}$$

- ✓ *The gravitational force is always attractive,*
- ✓ *it depends only on the masses involved and the distance between them.*

Centripetal Force

- ➢ A force that pulls an object towards the centre of a circle is called centripetal force
- ➢ The source for the centripetal force in the Solar System is the gravitational force of the Sun.
- ➢ Without the centripetal force from the Sun the planets would travel in a straight line.
- ➢ centripetal force the net force needed to make a body follow a circular path

factors affect the size of the centripetal force

- ❖ The mass of the object,
- ❖ its velocity,
- ❖ the radius of the curved path followed by the object affect the centripetal force.

To calculate the centripetal force we use the equation below: $F = mv^2/r$ *where F = centripetal force, m = mass of the object, v = velocity of the object, and r = radius of the curved path.*

Exercise 2.5 1

1 . The gravitational force between a 60 kg man and Earth is not equal because Earth is more massive than the man therefore, it exerts the greatest force. True or False. *Ans False*

2. Two objects are attracted to each other by a gravitational force F. If the distance between the objects is doubled, what is the new gravitational force between the objects in terms of F ?

A. 4 F B. 1/4F C. 16F D. 1/16F *Ans B*

3. Newton's law of gravitation applies to:

A. Small bodies only. B. Plants only. C. All bodies irrespective of their size. D. Moon and satellites only *ans C*

4. Suppose the gravitational force between two spheres is 30 N. If the magnitude of each mass doubles, what is the force between the masses?

$$\vec{F} = \frac{GmM}{r^2} = 30N$$

$$30 = \frac{GmM}{r^2}$$

$$X = \frac{4Gmm}{r2}$$

$$F = 2*2*30N = 120N$$

5. Calculate the mass of the Sun, noting that the period of Earth's orbit around the Sun is 3.156 x 10^7 s and its distance from the Sun is 1.496 x 10^{11}m.

$$T = 3.156*10^7 \quad r = 1.496*10^{11}$$

$$\omega = \frac{\theta}{T} \qquad \omega = \frac{2\pi\ rad}{3.156*107} \qquad \omega = 1.98986*10^{-7}\ rad/s$$

$$v = r\,\omega \qquad = 1.496*10^{11} \quad *1.98986*10^{-7} = 2.97683*10^4$$

$v = 2.97683*10^4$ m/s , $f_c = f_g$

$mv^2/r = \frac{GmM}{r^2}$

$m = rv^2/G$

$m = 1.496*10^{11} *8.861516*10^8 /G$

$m = 13.2568*10^{19} /6.67*10^{-11}$ $\underline{m = 1.987*10^{30}\ kg}$

6. A hypothetical planet has a mass of four times that of the Earth and radius of twice that of the Earth? What is the acceleration due to gravity on the planet in terms of the acceleration on Earth?

Ans The acceleration due to gravity is directly proportional to the mass of the planet and inversely proportional to the square of the radius of the planet. From this mathematical relation, the hypothetical planet has the same acceleration due to gravity as the earth.

End of unit Problems

1 A ball is thrown horizontally from the top of a building 45 m high. Calculate:

A the time taken to reach the ground.

We can use the equation of $h = \frac{1}{2}gt^2$

$90m = 10t^2$

$9 = t^2$,

$\underline{\mathbf{t = 3s}}$

(b) the horizontal displacement from the foot of the building to the strike point.

$\mathbf{R = v_0\, t}$

$\mathbf{R = 3Vox}$

The resultant velocity with which it strikes the ground.

v = gt but downwards motion is negative gravity

$v = -10m/s^2 * 3$

$V = 30m/s$

2. A football is kicked at angle 30^0 with the horizontal with an initial velocity of 20 m/s. Calculate:

(a) the horizontal and vertical component of initial velocity.

a) $V_{ox} = V_o Cos\theta$

$V_{ox} = 20m/s \times \cos 30^0$

$V_{ox} = 17.4m/s$

$V_{ox} = V_o Sin\theta$

$Vox = 20m/s \times 0.5 = 10m/s$

the time of flight

$$t = \frac{2V_0 \sin\theta}{g}$$

$$t = \frac{2x20m/sx0.5}{10m/s}$$

$t = 2s$

the range

$$R = \frac{V_0^2 \sin 2\theta}{g}$$

$$R = \frac{(20)^2 \sin 60^0}{10}$$

$R = 34.8m$

the horizontal displacement at t=1.5 s.

$\Delta X = V_{ox} t = V_o \cos\theta t$

$\Delta X = 20m/s \times 0.87 \times 1s = 17.4m$

3 *The launching speed of a certain projectile is five times the speed it has at its maximum height. Calculate the elevation angle at launching.*

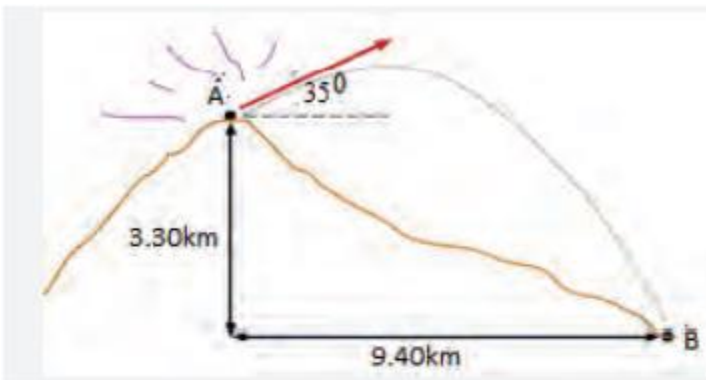
$Vo = 5Vocos\theta$

$Cos\theta = 1/5$

$\theta = cos\text{-}11/5 = 78.46^0$

4 *During volcanic eruptions, pieces of solid rock can be blasted out of a volcano; these projectiles are called volcanic bombs in the Figure below*

(a) At what initial speed would the bomb have to be ejected, at 35^0 to the horizontal, from the hole at A in order to fall at the foot of the volcano at B? (Ignore the effects of air resistance on the bomb's travel.



The vertical displacement is: $\Delta y = V o \sin\theta t - gt^2/2$

$-3300m = Vo\sin35^0\ t + (-10)\ t^2/2$

$-3300m = Vo \times 0.573\ t - 10\ t^2/2$

$-3300\ m = Vo \times 0.573\ t - 5t^2$

$-5t^2 + 0.573tv_o + 3300 = 0$

From the horizontal displacement

$\Delta x = Vo\cos\theta t$

$\Delta x = Vo\cos35^0\ t$

$9400 = Vo \times 0.82t$

By combining the two equations (from horizontal and vertical displacement)

$0.82\ (-5t^2 + 0.573tv = -3300m)$ $\quad$ $0.82\ vot = 9400$

$-0.573\ (0.82vt = 9400)$ $\quad$ $0.82 * 44.46\ vo = 9400$

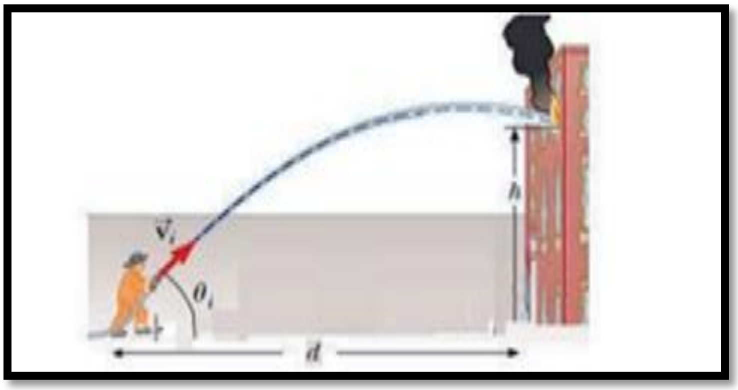
$-4.1t^2 = -8092.2$ $\quad$ $36.4572v = 9400$

$.t^2 = 1973.707$ $\quad$ $v = 9400/36.4572$

$t = \sqrt{1973.707}$ $\quad$ $\underline{v = 257.83m/s}$

$\underline{t = 44.46s}$

5 A firefighter, a distance $d = 24m$ from a burning building, directs a stream of water from a fire hose at angle of 53^0 above the horizontal, as shown in Figure . If the initial speed of the stream is $20m/s$, at what height h does the water strike the building?



$d = 24m \quad \theta_i = 53^0 \quad V_i = 20m/s$

$\Delta X = V0\cos\theta t \quad t=2s$

$h = V0\sin\theta t + \frac{1}{2} gt^2$

$h = 20m/s \times 0.8 \times 2s + \frac{1}{2}(-10m/s) \times (2s)^2$

$h = 32m - \frac{1}{2}40$,$32m - 20m$

$h = 12m$

6. A rotating fan completes 1200 revolutions every minute. Consider a point on the tip of a blade, at a radius of 0.15 m. (a) Through what linear distance does the point move in one revolution?

Solution $\Delta\theta = 1200rev = 7536rad$

$r = 0.15m$

$t = 1minute = 60s$

$S = r\Delta\theta = 0.15m \times 7536\ rad = 1130.4m$

(b) *What is the linear speed of the point?*

$v = r\,\omega$

$\omega = \frac{\Delta\theta}{T}$

$\omega = \frac{7536}{60}$

$\omega = \underline{125.6 rad/s}$

$v = r\,\omega$

$v = 0.15m * 125.\underline{6}$

$v = \underline{18.84 m/s}$

7 A car traveling at 80 km/h has wheels with a 40 cm radius. If the car can be brought to stop within 30 revolutions, what is the angular acceleration of the wheels?

$V_o = 80km/h = 22.2m/s$

$V_o = r\,\omega_o$

$\omega_o = \frac{v}{r}$

$\omega_o = \frac{22.2m/s}{0.4m}$

$\omega_o = \underline{55.5\ rad/s}$

$V_f = 0$

$\omega_f = 0$

r = 40cm = 0.4m

$\Delta\theta$ = 30rev = 188.4 rad

α =? $\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

$0 = (55.5)^2 + 2\,\alpha 188.4$

$-3080.25 = 376.8\,\alpha$

$\alpha = \frac{-3080.25}{376.8}$

$\alpha = -8 rad/s^2$

8. The angular velocity of the belt of a grindstone is 40 rad/s. To what angle does the belt rotate in one minute. Given your answer

a) in rad

$t = 1minute$ $\Delta\theta = \omega t$

$\Delta\theta = ?$ $\Delta\theta = 4\ 0rad/sx60s$

$\Delta\theta = 2400rad$

in rev

$1rev = 2\pi rad$

$x = 2400rad$

$\Delta\theta = 382rev$

in degree.

$1rev = 360^0$

$382rev = x$

$\underline{\Delta\theta = 137,579.6^0}$

9. A cyclist rides a bicycle with a wheel radius of 0.50 m across campus. If the wheel completes 320 rotations between her apartment and the cafeteria, how far has she traveled?

solution $r = 0.5m$ $S = \Delta\theta r$ $\theta = 2\pi rad$ *one full cycle*

$\Delta\theta = 320rev$ $\underline{S = 0.5m \times 320 \times 2\pi rad = 1004.8m}$

10. A spinning wheel is slowed down by a brake, giving it a constant angular acceleration of 5.60 rad/s^2 . During a 4.20 s time interval, the wheel rotates through 62.4 rad. What is the angular speed of the wheel at the end of the 4.20 s interval?

$\alpha = -5.60rad/s2$

$t = 4.20s$

$\Delta\vartheta = 62.4rad$

$\omega f = ?$

. $\vartheta = \omega_o t + \frac{1}{2}\alpha t^2$

$62.4rad = 4.2\omega_o + \frac{1}{2}(4.2)^2\ (-5)$

$62.4 = 4.2\omega_o\ -44.1$ $\omega_f = \omega_o + \alpha t$

$62.4 + 44.1 = 4.2\omega_o$ $\omega_f\ = 25.35rad/s\ + (-5.60rad/s2)(\ 4.20s)$

$106.5 = 4.2\omega_o$ $\omega_f\ = 25.35 - 23.52$

. $\omega_o = \ _o\frac{106.5}{4.2}$ $\omega_f\ = \underline{1.83rad/s}$

. $\omega_o = \ \underline{25.35rad/s}$

11. Titan, the largest moon of Saturn, has a mean orbital radius of 1.22×10^9 m. The orbital period of Titan is 15.95 days. Hyperion, another moon of Saturn, orbits at a mean radius of 1.48×10^9 m. Use Kepler's third law of planetary motion to predict the orbital period of Hyperion in days.

$T^2/r^3 = T^2/r^3$

$(15.95)^2\ /(1.22 \times 10^9 m)^3 \quad = \quad T^2/(\ 1.4\ 8 \times 10^9 m)^3$

$254.4025/1.8158 \times 10^{27} = T2/3.2417 \times 10^{27}$

$824.696 \times 10^{27}\ = 1.8158\ \times 10^{27} T^2$

$T = \sqrt{454.177}$

T = 21.3 day

12. The planet Mercury travels around the Sun with a mean orbital radius of $5.8x10^{10}$ m. The mass of the Sun is $1.99x10^{30}$ kg. How long does it take Mercury to orbit the Sun. Give your answer in Earth days.

$T^2/r^3 = 4\pi^2/Gm$

$T2/(5.8x10^{10})^3 = 39.4384/6.67x10^{-11}x1.99x10^{30}$

$13.27x10^{19}T^2 = 7694.905x10^{30}$

$T^2 = 579.65x10^{11}$

$T = 7.613x10^6 sec$

$T = 7.6135x10^6 se/3.15x10^7$

$T = 0.241 year$

We can convert in to day

1year =365.5day

0.241year =x

T = 88.1 day

13. Two identical isolated particles, each of mass 2.00 kg, are separated by a distance of 30.0 cm. What is the magnitude of the gravitational force exerted by one particle on the other?

$Fg = \frac{GmM}{r^2}$

$Fg = 6.67\ x10^{-11}\ x2kg\ x2kg/0.09$

$Fg = 2.964\ x10^{-9}\ N$

Unit 3

Fluid Mechanics

- *Fluid mechanics is the branch of physics concerned with the mechanics of fluids in motion or at rest.*
- *In physics, a fluid is a substance that continually flows under an applied shear stress, or external force.*
- *Fluids are a phase of matter and include liquids and gases.*
- *solid may be thought of as having a definite shape and volume,*
- *it's possible to change its shape and volume by applying external forces.*
- *A sufficiently large force will permanently deform or break an object*
- *the external forces are removed, the object tends to return to its original shape and size. This is called elastic behavior.*

3.1 Fluid statics

Fluid mechanics is the branch of physics concerned with the mechanics of fluids in motion (fluid dynamics) or at rest (fluid statics) and the forces on them.

. ***The applications of fluid mechanics are enormous*:**

- *breathing,*
- *blood flow,*
- *swimming,*
- *pumps,*
- *fans,*
- *turbines,*
- *airplanes,*
- *ships, rivers,*
- *windmills,*
- *pipes,*

- *missiles,*
- *icebergs,*
- *Engines*
- *filters,*
- *jets, and*
- *sprinklers*

In physics, a fluid is a substance that continually deforms (flows) under an applied shear stress, or external force

. Fluids are a phase of matter and include liquids and gases.

Properties of solids, liquids and gases

solids

- *Atoms in solids are very close to each other and has fixed position*
- *The forces between them acts as a spring that allow the atoms to vibrate without changing positions relative to their neighboring atoms*
- *solid resist all types of stress because the atoms are not able to move about freely.*
- *Solids also resist compression, because their atoms are relatively fixed distance apart. Under compression, the atoms would be forced into one another*
- *solid phase except the molecules are no longer at fixed positions relative to each other and they can rotate and translate freely.*
- *Solids maintain not only their volume but also their shape*
- *Solids can be classified as either crystalline or amorphous*
- *Very Strong force between atoms*
- *Not compressed thus have constant volume and shape*
- *Do not flow, they are not fluids*

liquid,

- ✓ *the intermolecular forces are weaker relative to solids, but still strong compared with gases.*
- ✓ *Liquids deform easily when stressed and do not spring back to their original shape once the force is removed because the atoms are free to slide about and change neighbors.*
- ✓ *liquid has a definite volume but no definite shape*

- ✓ *Atoms close each other but has no fixed position*
- ✓ *Strong forces between atoms*
- ✓ *Not much compressed have constant volume but not constant shape*

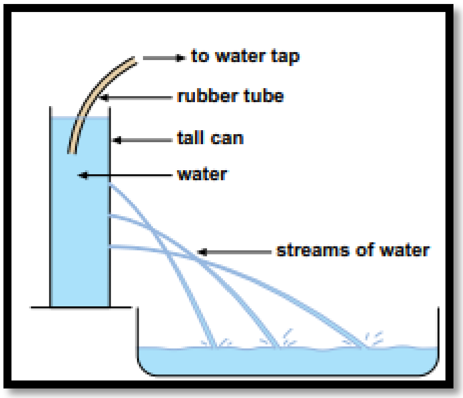
Gases

- ❖ *Atoms in gases are separated by distances that are large compared with the size of the atoms*
- ❖ *The forces between gas atoms are therefore very weak, except when the atoms collide with one another.*
- ❖ *Gases thus not only flow but they are relatively easy to compress because there is much space and little force between atoms.*
- ❖ *A gas also expands until it encounters the walls of the container and fills the entire available space*
- ❖ *. A gas differs from solids and liquids in that it has neither definite volume nor definite shape. Because gas can flow*
- ❖ *gases can be easily compressed*
- ❖ *Atoms far apart has no fixed position*
- ❖ *Very week forces between atoms*
- ❖ *Easily compressed have no constant volume and constant shape*
- ❖ *Flow, they are fluids*

Pressure in Fluid

- *Pressure is defined as a normal force exerted by a fluid (or a solid) per unit area.*
- *If F is the magnitude of the force exerted on the fluid (or solid) at a particular point and A is the surface area*
- *defined as the ratio of the force to the contact area A over which that force is exerted:*
- $P = \frac{F}{A}$
- *Pressure is a scalar quantity*
- *If a large force acts on a small area, the pressure is large*
- *the SI unit of pressure is the pascal (Pa): 1Pa = 1N/m2*

- *Pressure is directly proportional to the applied force and inversely proportional to the area at which the force exerted.*
- *other units of pressure such as millimeter mercury (mmHg), torr, atmosphere (atm) and pounds per square meter (psi)*
- *their relation shown as follow: 1 atm = 760 mmH g = 760 tor r = 101.3 K Pa = 14.7 p si*



- $p = \rho hg$

  p = pressure in Pa

  h = depth of fluid in m

  ρ = density of fluid in kg/m3

  g = gravitational field strength (9.81 N/kg)

- *In any fluid the pressure increases with depth*
- *At any given depth the pressure is equal in all directions.*
- *The pressure of fluid depends on the depth of the fluid; it is independent of the shape and size of the container*

Pressure in Gases

- *Most pressure-measuring devices, are calibrated to read zero in the atmosphere they indicate*
- *The difference between the absolute pressure and the local atmospheric pressure*
  - *This difference is called the gauge pressure (P_{gage}).*
  - *Absolute and gauge pressures are related to each other by $P_{gage} = P_{abs} - P_{atm}$*

- *the gauge used to measure the air pressure in an automobile tire reads the gauge pressure.*
- *the common reading of 32.0 psi indicates a pressure of 32.0 psi above the atmospheric pressure*

. **Density**

- The density of an object having uniform composition is defined as its mass M divided by its volume V
- SI unit: kilogram per meter cubed (kg/m^3)
- The densities of most liquids and solids vary slightly with changes in temperature and pressure;
- Under normal conditions, the densities of solids and liquids are about 1 000 times greater than the densities of gases.
- Density is an important characteristic of substances.
- It is determining whether an object sinks or floats in a fluid.
- It directly affects pressure of fluids (gases and liquids).. .
- *It is calculated by dividing the mass of an object by its volume.* $\rho = m/V$
- *Density measures the mass of one cubic meter of a substance*
- *The density of most gases is proportional to pressure and inversely proportional to temperature.*
- *density of an object may help identify its composition.*
- *Density also indicates about the phase of the matter and its particles arrangement.*
- *The densities of liquids and solids are roughly comparable,*

Relative density

- *defined as the ratio of the density of a substance to the density of some standard substance at a specified temperature*
- *Sometimes the density of a substance is given relative to the density of an another substance.*
- *it is called specific gravity,*
- *specific gravity* $= SG = \rho/\rho H2O$
- *Note that the specific gravity of a substance does have any unit.*

- *In SI units, the numerical value of the specific gravity of a substance is exactly equal to its density in g/cm^3.*

example the density of mercury at 20◦C is 13.6 x10^3 kg/m^3).calculate specific gravity.

Its relative density =13.6 x10^3 kg/m^3 /1 x10^3 kg/m^3 = 13.6.

- *Note that substances with specific gravities less than 1 are lighter than water, and thus they would float on water.*

Example A solid sphere made of wood has a radius of 0.1 m. The mass of the sphere is 1.0 kg. Determine density & specific gravity of the wood.

Solution: - $\rho = \frac{m}{V}$ but $V = \frac{4\pi r3}{3} = 4.1866*10^{-3}\ m^3$

$$P = \frac{1kgm}{4.1866*10-3\ m} = \underline{238.85kg/m^3}$$

$$SG = \rho/\ \rho H2O$$

$$SG = 238.85kg/m^3 / 1000\ kg/m^3$$

$$\underline{SG = 0.23885}$$

Ideal gas equation

- ✓ *In the gas phase that relate density and pressure of gases is the ideal-gas equation*
- ✓ *we can expressed as $PV = nRT = \frac{m}{M}RT$ where P is the absolute pressure, V is the gas volume, n is number of mole, T is the thermodynamic (absolute) temperature,*
- ✓ *c = R/M is the specific gas constant.*
- ✓ *The specific gas constant is different for different gases and R is the universal gas constant whose value is R = 8.314 J/mol. K and M is the molar mass of the gases.*

3.2 Pressure in fluids at rest :

As gas particles collide with the walls of the container in which they reside, they exert pressure. In fact, if you place any object inside a gas, the gas particles exert the same pressure on the object as the gas exerts on the walls of the container

The particles in a liquid are in continual random motion, somewhat similar to particles in gases.

Pascal's principle

Pascal's law: a change in the pressure applied to a fluid is transmitted undiminished to every point of the fluid and to the walls of the container

The pressure applied at one point is sooner transmitted to the whole part of the fluid by a continuous collisions of neighboring molecules of the fluid

application of Pascal's principles

- *Hydraulic lift (press)*
- *Hydraulic brake*
- *Hydraulic pumps*

Hydraulic press One of the technical applications of Pascal's Principle is a hydraulic press which is a form of simple machine that converts small forces into larger forces, or vice versa.

Automobile mechanics use hydraulic presses to lift cars, and dentists and barbers use them to raise and lower their clients' chairs.

The hydraulic brakes of an automobile are also a form of hydraulic press. Most of these devices work on the simple principle illustrated in Figure although the actual devices are usually more complicated in construction.

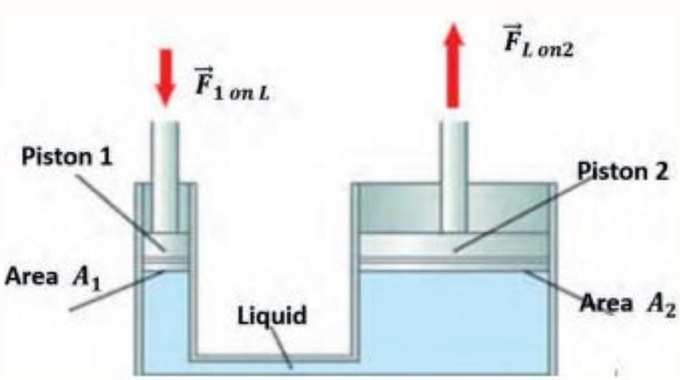


Figure 3.13 Schematic of a hydraulic press.

$$P_1 = \frac{F_{1\ on\ L}}{A_1}$$

Atmospheric pressure

- Atmospheric Pressure: is the pressure due to the weight of the atmosphere exerted on the surface of the Earth.
- Atmospheric pressure decreases with increase in altitude as a result of decrease in the density of the air.
- Atmospheric pressure is created by column of air above a particular point..
- The maximum atmospheric pressure on the surface of the earth is measured at sea level.
- Cooking, working of car engine and breathing is difficult at high altitude due to the lack of sufficient air. Nose bleeding is common in high altitude than low altitude.

.*There are two reasons air pressure decreases as altitude increases*:

- **density and depth of the atmosphere.**

Most gas molecules in the atmosphere are pulled close to Earth's surface by gravity, so gas particles are denser near the surface.

The depth (distance from top to bottom) of the atmosphere is greatest at sea level and decreases at higher altitudes.

With greater depth of the atmosphere, more air is pressing down from above. Therefore, air pressure is greatest at sea level and falls with increasing altitude.

On top of Mount Everest, which is the tallest mountain on Earth, air pressure is only about one-third of the pressure at sea level.

- Atmospheric pressure is measured by a device called a barometer; thus, the atmospheric pressure is often referred to as the barometric pressure.
- $P_{atm} = \rho g h$

where ρ is the density of mercury, g is the local gravitational acceleration, and h is the height of the mercury column above the free surface.

Gauge pressure:

It is the difference in pressure between a system and the surrounding atmosphere

Because gauge pressure is the pressure relative to atmospheric pressure, therefore, it is positive for pressures above atmospheric pressure, and negative for pressures below it.

Absolute Pressure: In fact, atmospheric pressure does add to the pressure in any fluid not enclosed in a rigid container.

The total pressure, or absolute pressure, is thus the sum of gauge pressure and atmospheric pressure

In most cases the absolute pressure in fluids cannot be negative. Fluids push rather than pull, so the smallest absolute pressure is zero.

3.3 Archimedes' principle

- Any object which is partially or totally submerged in a liquid has buoyant force acting on it which pushes the object up.
- The famous Greek mathematician, Archimedes‘ developed a principle which describes this around 250 B.C.
- Archimedes‘ principle can be stated as anybody completely or partially submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body.

$$F_{buoyant} = W_{fluid} = \rho_{fluid} V_{\substack{displaced \\ fluid}} g$$

Example: A sample of an unknown material weighs 300 N in air and 200 N when submerged in an alcohol solution with a density of alcohol $= 0.7*10^3$ m^3 What is the density of the material?

Given:
$W_{air} = 300\ N$
$W_{alcohol} = 200\ N$
$\rho_{alcohol} = 0.70 \times 10^3\ kg/m^3$

Unknown:
$\rho_{material}$ or ρ_O =?

Given:
$W_{air} = 300\ N$
$W_{alcohol} = 200\ N$
$\rho_{alcohol} = 0.70 \times 10^3\ kg/m^3$

Unknown:
$\rho_{material}$ or ρ_O =?

Solution:
$F_{buo} = W_{air} - W_{alcohol} = 300N - 200N = 100\ N$

$$\frac{W_{air}}{F_{buoy}} = \frac{\rho_O}{\rho_{alcohol}} \Rightarrow \rho_O = \rho_{alcohol}\left(\frac{W_{air}}{F_{buoy}}\right)$$
$$= (0.70 \times 10^3\ kg/m^3)\left(\frac{300N}{100N}\right)$$
$$= 2.1 \times 10^3\ kg/m^3$$

Buoyant force

- It is extremely difficult to push a ball down under water because of the large upward force exerted by the water on the ball.
- The upward force exerted by a fluid on any immersed object is called a buoyant force.
- the upward force on the bottom of an object in a fluid is greater than the downward force on the top of the object.
- Buoyant force is also called up thrust force.
- Archimedes' principle is Stated as follows: The buoyant force on an object equals the weight of the fluid it displaces. In equation form, Archimedes' principle is given as:

$$F_{buoyant} = W_{fluid} = \rho_{fluid} V_{\underset{fluid}{displaced}}\, g$$

The ratio of the volume of displaced fluid to the volume of a floating object is equal to the ratio of the density of the object to the density of the fluid

- If the density of the object is greater than the density of the fluid, the upward buoyant force is less than the downward gravitational force and the unsupported object sinks.

- ☞ If the density of the object is less than the density of the fluid, the downward gravitational force is less than the weight of the liquid displaced by the whole volume of the object (buoyant force) and the unsupported object floats
- ☞ If the density of the submerged object equals the density of the fluid, the net force on the object is zero and the object remains in equilibrium. It can be anywhere inside the fluid.

3.4 Fluid flow

- ✓ to flow from the higher pressure region toward the lower pressure region.
- ✓ The flow is said to be steady, or laminar, if each particle of the fluid follows a smooth path without crossing.

Fluid motion can be characterized in to two

- ❖ *Streamline (laminar flow) and*
- ❖ *turbulent flow*

Streamline (laminar flow) is a fluid where the fluid particles move smoothly in regular layers

Factors affecting laminar flow

- ✓ *density,*
- ✓ *temperature and*
- ✓ *compressibility,*
- ✓ *viscosity of the fluid*

.The laminar flow always occurs when the fluid flow with low velocity and in small diameter pipes. The turbulent flow occurs when the velocity of the fluid is high and it flows through larger diameter pipes .

In laminar flow, fluid particles cannot flow into or out of the sides of this tube; if they could, the streamlines would cross one another and results in turbulent flow

. turbulent flow is the fluid flow in which fluid particles move in zigzag

Flow rate Flow rate

- Q is defined to be the volume of fluid passing by some location through an area during a period of time,
- In symbols, this can be written as Q = $\frac{V}{t}$ where V is the volume and t is the elapsed time.
- The SI unit for flow rate is m^3 /s

Equation of continuity

States that the volume flow rate of an ideal fluid through closed pipe is the same every point

$$A_1v_1 = A_2v_2$$

Bernoulli's equation

States that in an ideal in compressible fluid when the flow is steady and continues the sum of pressure energy kinetic energy potential energy is constant along a stream line .

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$P_1 + \frac{1}{2}\rho 1 v_1^2 + \frac{1}{2}\rho 1 v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho_2 v^2 + \rho g h_2$$

3.5 Safety and High Pressure

high pressure is important in different technologies like:

- ✓ *Pressure cooker*
- ✓ *liquid petroleum gas cylinder.*
- ✓ *studying physical properties of various bodies (mainly solids) and to transform their*
- ✓ *nature filling vehicles tires*
- ✓ *to control the microorganism activity called pascalization. Pascalization can be used to increase the shelf lives of perishable foodstuffs: juice, fish, meat, dairy products, etc.*

High pressure important in many scientific and technological fields, like

- ❖ biology,
- ❖ chemistry,
- ❖ environmental engineering,
- ❖ food technology,
- ❖ material science,
- ❖ pharmacy, and physics

List the high-pressure equipment components

- : high-pressure compressors,
- high pressure piping,
- high pressure vessels,
- Safety Accessories and high-pressure instrumentation.

High pressure device work at a pressure far greater than 1 atmosphere.

High pressure system has diverse applications like

- *High pressure cookers,*
- *Petroleum*
- *gas cylinders,*
- *laboratory gas cylinders,*
- *high pressure washers*

High pressure system and equipment risks like:

- *Damaged equipment or system design*
- *Poor or no maintenance*
- *An unsafe system of work*
- *Operator error due to lack of training/supervision*
- *Incorrect installation*
- *Inadequate repairs or modification*

Exercise 3.1

Repeat example 3.1, if the woman stands on her two shoes. Compare the result with example 3.1. What can you say about the difference between the results? Assume the shoes have equal area and her weight is balanced on her two shoes.

$A = w \times l$

$A = 10\ cm \times 30\ cm$

$A = 300\ cm^2 = 0.03\ m$ *one of her shoes.*

But two shoes $=2A$

$A= 0.03m^2 x2$

$A= 0.06m^2$

$P = f/A$

$F = mg$

$F = 55x9.8$

$F= 539\ N$

P =539/0.06

P =8983

Exercise 3.2

Determine the absolute pressure where gauge pressure is 61.152 KPa and atmospheric pressure is 14.0 psi. Determine the absolute pressure where gauge pressure 61.152 KPa and atmospheric pressure is 14.0 Psi.

Solution

p_{gag} =61.152kpa

p_{atm} =14psi we can convert in to kpa

101.3 kpa = 14.7psi

Xkpa = 14psi

14 x101.3=14.7xpsi

1418.2/14.7

Patm =96.476kpa

Pab = p gag +patm

61.152kpa + 96.476 kpa

Pab =157.628kpa

Exercise 3.4

Dear students, in example 3.8, if you needed to lift the car about 0.10 m above the ground, what distance would you have to push down on the small piston?

Ans The volume of liquid pushed down by the height, , is equal to the volume of liquid pushed 0.10 m at the larger piston Therefore, to raise the car to 0.1 m, the small piston should push down 10 m.

Exercise 3.5

(i) The reading of a barometer in your room is 700 mm Hg. What does this mean?

(ii) What is the pressure in pascals?

(iii) If oil of density 950 kg /m^3 is used in the barometer instead of mercury, what would be the height of the oil in the tube at 1 atm?

Ans (i). The meaning of the 700-mmHg barometric reading is that the atmospheric pressure at this region can push up mercury in the barometric column 700 mm above the level of mercury in the container. To solve the pressure in pascal, we use density of mercury, . The pressure due to this column of mercury is obtained from the relation:

ii). Patm= ρgh

Patm =13595x9.81x 0.7m

Patm =93.3kpa or

101.3kpa =760mmHg

X = 700mmHg

101.3x700 =760x

70910/760

93.3kpa

If oil of density 950 kg /m^3 *is used in the barometer instead of mercury,*

Patm= ρgh

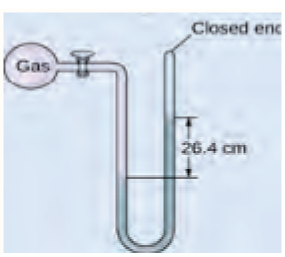
Patm =950kg/m3x9.81m/s2 xh

101.3kpa =9.3195k h

h =10.869mm

Exercise 3.6

The pressure of a sample of gas is measured with a closed-end manometer, as shown in Figure 3.19. The liquid in the manometer is mercury. Determine the pressure of the gas.



Since the manometer is isolated from the atmosphere, the column of liquid at t the right arm 26.4 cm above liquid level at the left is equivalent to the pressure of the gas, hence given by: Using the density of mercury, we obtain:

Solution

$p = \rho gh$

$p = 13600kg/m^3 x 9.8 x 0.264m$

$p = 35185.92pa$

Exercise 3.7:

Suppose your mass is 70.0 kg and your density is 970 kg /m^3 . If you could stand on a scale in a vacuum chamber on Earth's surface, the reading of the scale would be mg = (70.0 kg)(9.80 N/kg) = 686 N. What will the scale read when you are completely submerged in air of density 1.29 kg /m^3 ?

. $\rho_{man} = 970kg/m^3$

. $\rho = 1.29kg/m^3$

First we can find the volume of the man

$V_m = \frac{wman}{\rho\ man} = \frac{686N}{970x\ 9.81} = \frac{686N}{9515.7} = 0.072m^3$

$F_b = .\ \rho_{air} V_{man} g$

$F_b = 1.29x0.072x9.81$

$F_b = 0.0911528N$

. $\rho_{man} = 970kg/m^3$

. $\rho = 1.29kg/m^{3/}$

. $\rho_{air}/\ \rho = 1.29/97$

0.133%

0.001329x100%

Exercise 3.8:

A crown weighs 25.0 N when it is measured in air and 22.6 N when it is submerged in water. Check whether the crown is made from pure gold or some less valuable metal assuming the density of gold is 19,300kg /m^3 .

W_{air} =25 N W_{water} =22.6 N

$F_b = W_{air} - W_{water}$

$F_b = 25N - 22.6$

$F_b = 2.4N$

$W_{air} / F_b = \rho c / \rho_{water}$

$25N/2.4N = \rho c / 1000kg/m^3$

$Pc = 25000kg/m^3 / 2.4$

$Pc = 10416.66\ kg/m^3$

It is not made from pure gold b/c *Pc less than* 19,300kg /m^3

Exercise 3.9:

A rectangular wooden block floats with 75 % of its volume inside a water. What is the density of this block?

$75\% = \rho o / \rho water$

$0.75 = \rho o / 1000kg/m^3$

$Po = 750kg/m^3$

End of unit questions

1.*The distance between air particles is very small about 3×10^{-7} cm. How can we say that there is considerable empty space in air?*

***Ans**: The reason is that the size of atoms is in the order of nanometer.*

2. How would you determine the density of an irregularly shaped object?

Answer

- The density of an irregular shaped object can be determined as follow: measure the mass of the object in air
- Fill water in a graduated container
- Put the object in to water filled container and collect the overflowed water
- Measure the volume of the overflowed water.

- ☞ The volume of the overflowed water is the same as the volume of irregular object.
- ☞ Then divide the mass of the irregular object measured in air to the volume of the irregular object to get the density of the object.

3. Pascal's Principle says that an increase in pressure in one part of an enclosed liquid results in an increase in pressure throughout all parts of that liquid. Why then does the pressure differs at different heights?

Answer *The pressure difference with height is due to the weight of liquid above that point. However, if a pressure is increased at a point this pressure is equally distributed undiminished to all part of the fluid, i.e., it is independent of depth*

4. What does the atmospheric pressure is 760 mm of mercury mean?

Answer

- ☞ *In preparing a barometer, a glass tube at least 760 mm long and closed at one end is filled with mercury and then carefully inverted into a pool of mercury.*
- ☞ *The level of the mercury in the column will fall slightly and then become steady. The height of the column of mercury measures the pressure of the atmosphere.*
- ☞ *The reason is that the surface of the mercury pool at the base of the column is pressed by column of atmospheric air. On the surface under the mercury column, the mercury is pressing down. The two pressures must be equal.*
- ☞ *If they were not, mercury would be flowing into or out of the column, and the height of the column would not be steady.*
- ☞ *The atmosphere must be exerting a pressure equal to that exerted by the mercury column.*
- ☞ *In other words, the atmospheric pressure can carry a volume of mercury in a barometer tube 760 mm above the level of mercury in the mercury pool.*

5 Why does a fluid exert an upward force on an object submerged in it? .

Answer

- ☞ *The pressure at the bottom of the object is greater than the pressure at the top of the object. This pressure difference creates upthrust force on the object called buoyant* *force. This means the upward force from water has to be greater than the downward force from water*.

6 What would happen to the level of water in the oceans if all icebergs presently floating in the oceans melted?

Answer *The Archimedes principle says that a floating body will displace an amount of fluid that is equal to its weight. Since the iceberg floats, it weighs the same as the water it displaces. If icebergs had the same salt concentration as the ocean, it would occupy exactly the same volume as it displaced and the sea level wouldn't change*

7. Describe a method to measure the density of a liquid.

Answer

- *Option one: To measure the density of a liquid you do the same thing you would for a solid. Mass the fluid, find its volume, and divide mass by volume.*
- *To measure mass of the fluid, weigh it in a container, pour it out, weigh the empty container, and subtract the mass of the empty container from the full container.*
- *Option two: Measure the mass of an object with known density in air and in the liquid whose density is unknown.*
- *Find the buoyant force. The buoyant force is equal to the weight of displaced liquid which is the product of the volume and density of displaced liquid with gravity*.

8. Two objects have the same volume, but one is heavier than the other. When they are completely submerged in oil, on which one does the oil exert a greater buoyant force?

Answer

- *Since the volume of the displaced oil is the same in both cases the buoyant force is the same on both objects.*

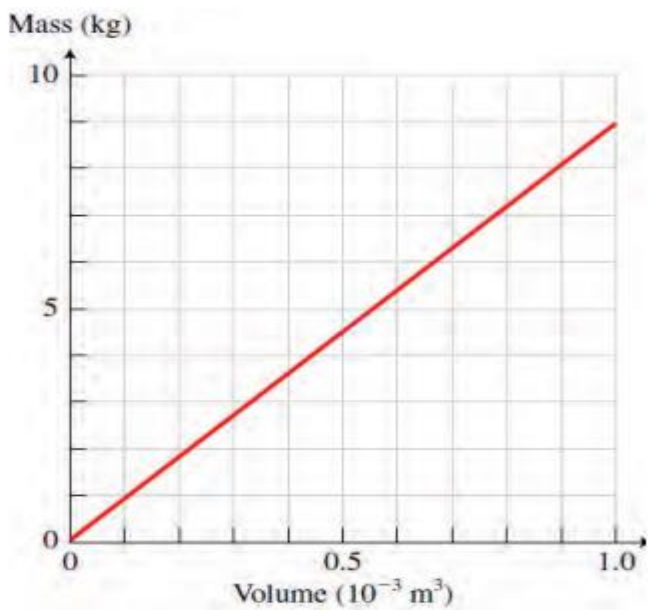
9. An iron ball with radius 5.0 cm has a mass of 2.0 kg. Determine the ball's density.

Solotion - $\rho = \frac{m}{V}$ but $V = r^3 = (0.5)^3 = 0.125m^3$

- $\rho = \frac{2kg}{0.125m3}$ $=16kg/m^3$

10. Determine the density of the material whose mass-versus volume graph line is shown in Figure 3.31. If you double the mass of this substance, what will happen to its density? What substance might this be?

Doubling of the mass of the material also doubles the volume of the materials. Therefore, no change is observed on the density of the material.



11 The pressure in a water line is 1500 kPa. What is the line pressure in

(a) torr units

Solution: 101.3kpa =760 torr

1500kpa = x

101.3kpa x=1140000kpa torr

X =11253.7 torr

psi units? 101.3kpa =14.7 psi

1500kpa= x

X =217.67 psi

(c) atm units 101.3 kpa =1atm

1500kpa = x

X =14.8 atm

12. How tall must a water-filled closed end manometer be to measure blood pressures as high as 300 mm Hg?

Patm =- ρgh

101.3kpa =1000kg/m3x 9.81 h

.h = 101300/ 9810

.h= 1.032m

13. What fraction of ice is submerged when it floats in freshwater, given the density of water and ice at 0◦C respectively are very close to 1000 and 917 kg /m^3 ?

$$\frac{V_{dis}}{V_{obj}} = \frac{\rho_{obj}}{\rho_{fluid}}$$

$$\frac{917\ kg/m3}{1000} = \underline{0.917 = \quad 91.7\%}$$

14. A rock with a mass of 540 g in air is found to have an apparent mass of 342 g when submerged in water.

(a) What mass of water is displaced?

Solution mass of water is displaced =mass in air – mass submerged in water.

mass of water is displaced = 540g – 342g

mass of water is displaced = 198g

What is the volume of the rock?

Solution $\rho = \frac{m}{V}$ *we can use density of water*

$$V = \frac{m}{\rho}$$

$$V = \frac{0.198kg}{1000kg/m3}$$

$\underline{V = 1.98*10^{-4}m^3}$

What is its average density? $\rho\ 1 = \frac{m}{V}$ *mass of water is displaced*

$\rho_1 = \frac{0.198kg}{1.98*10-4m3}$

$\rho_1 = 0.0969*10^4\ kg/m^3$

$\rho_2 = \frac{m}{V}$ *mass submerged in water*

$\rho 2 = \frac{0.342kg}{1.98*10-4m3}$

$\rho_2 = 0.172*10^4\ kg/m^3$

$\underline{\rho ave = \frac{1}{2}(\rho\ 1 + \rho 2) = 1.34*10^3}$ kg/m^3

15. A manometer is used to measure the air pressure in a tank. The fluid used has a specific gravity of 1.40, and the differential height between the two arms of the manometer is 50 cm. If the local atmospheric pressure is 0.8 atm, determine the absolute pressure in the tank for the cases of the manometer arm with the higher and lower fluid level being attached to the tank.

Solution h=50cm = 5m at the higher level

& h =0 at the lower

$SG = 1.4$ $p_{atm}=0.8atm$ $p_{abs} = ?$

$SG = \frac{\rho}{\rho H2o}$

$1.4 = \frac{\rho}{1000} = \underline{1400kg/m^3}$

$p = \rho g h$

$p = 1400kg/m^3 x10m/s2 x5m$

$p = 70000pa = \underline{70kpa}$

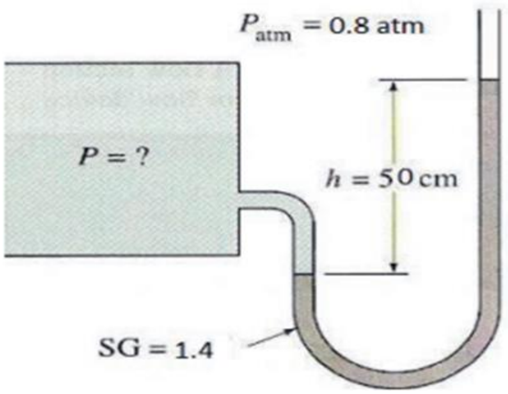
$101.3kpa = 1atm$

$70kpa = x$

$X = \underline{0.691atm}$

$P_{abs} = P_{amt} + P_{gaug} = 0.8atm + 0.691atm$

$P_{abs} = \underline{1.49atm}$



16. The gage pressure in a liquid at a depth of 2.5 m is read to be 28 kPa. Determine the gage pressure in the same liquid at a depth of 9 m.

2.5m=28kp

9m= x

X=100.8kpa

17. *Consider a 55-kg woman who has a total foot imprint area of 400 cm² . She wishes to walk on the snow, but the snow cannot withstand pressures greater than 0.5 kPa. Determine the minimum size of the snowshoes needed (imprint area per shoe) to enable her to walk on the snow without sinking.*

Solution A=400cm²but in one foot A= 200cm² = 2m² m=55kg

$$P = \frac{F}{A} \text{ but } f=mg= 55 \times 9.8 = 539N$$

$$P = \frac{539N}{2m2} = 269.5pa = \underline{0.2695kpa}$$

18. (a) A 75.0-kg man floats in freshwater with 3.00% of his volume above water when his lungs are empty, and 5.00% of his volume above water when his lungs are full. Calculate the volume of air he inhales called his lung capacity in liters. (b) Does this lung volume seem reasonable?

From Archimedes Principle, fractional volume inside water when the lung is empty

$\frac{Vdis}{Vobj}$ =0.03 vdis =0.03vobj m=75kg&ρH_2o = 1000kg/m^3

But $\rho = \frac{m}{V}$ $m=\rho V$

75 kg=1000kg/m^3 0.03V

V=75/30 =2.5 m^3

fractional volume inside water when the lung is I full:

$\frac{Vdis}{Vobj}$ =0.05

$\rho = \frac{m}{V}$ $m=\rho V$

75 kg=1000kg/m^3 0.05V

V=75/50 =1.5l

19. A hydraulic lift has a small piston with surface area 0.0020 m^2 and a larger piston with surface area 0.20 m^2 . Assume your mass is 60 kg. If you stand at the smaller piston, how much mass can you lift at the larger piston?

Solution A_1 = 0.002m^2 A_2 = 0.2 m^2 m_1 = 60kg m_2 = ? but f=mg

F1/A1 = F2/A2

- $m_1g/A_1 = m_2g/A_2$
- $m_1gA_2 = m_2gA_1$
- $m_1A_2 = m_2A_1$
- 60kg x 0.002m^2 = 0.2m_2
- 0.12 =0.2m_2
- M_2 =0.6kg

20. A fluid that occupies a volume of 24 L weighs 225 N at a location where the gravitational acceleration is 9.80 m/s2 . Determine the mass of this fluid and its density.

Solution V =24L w=225N g= 9.8m/s^2

Determine the mass of this fluid *w =mg*

225N = 9.8m/s^2m

M=22.95kg

$\rho = \frac{m}{V} = \frac{22.95kgm}{24} = 0.95625kg/L$

21 Blood flows at an average speed of 0.40 m/s in a horizontal artery of radius 1.0 cm. The average pressure is 1.4×10^4 N/m^2 above atmospheric pressure (the gauge pressure).

(a) What is the average speed of the blood past a constriction where the radius of the opening is 0.30 cm? (b) What is the gauge pressure of the blood as it moves past the constriction?

We can find v_2 using equation of continuity

V1 =0.4m/s r =1 cm r2 = 0.3cm

$P_1 = 1.4x1\ 0^4$=14kpa

A1 = πr^2 A2 =πr_2^2

$A_1v_1 = A_2V_2$

$\pi r^2 V = \pi r_2^2 V_2$

$1x10^{-6}$ x0.4 =0.09V2

V_2 =4.4m/s

By using Bernoulli's equation,

$$P_1 + \frac{1}{2}\rho 1 v_1^2 + \frac{1}{2}\rho 1 v_1^2 = p_2 + \frac{1}{2}\rho_2 v^2$$

$$P2 = 14kpa + \frac{1}{2}1000kg/m3\ (0.40\ m/s)^2 - \frac{1}{2}1000kg/m^3\ (4.4m/s)^2$$

$$P2 = 14000pa + 80pa - 9680pa = 4.4x10^3 pa$$

22. Suppose your mass is 70.0 kg and your density is 970 kg/m3 . If you could stand on a scale in a vacuum chamber on Earth's surface, the reading of the scale would be mg = (70.0 kg) (9.80 N/kg2) = 686 N.

What will the scale read when you are completely submerged in air of density 1.29 kg/m3 ?

. $\rho_{man} = 970kg/m^3$

. $\rho = 1.29kg/m^3$

First we can find the volume of the man

$V_m = \frac{wman}{\rho\ man} = \frac{686N}{970x\ 9.81} = \frac{686N}{9515.7} = 0.072m^3$

$F_b = .\ \rho_{air} V_{man} g$

$F_b = 1.29x0.072x9.81$

F_b $=0.0911528N$

. ρ_{man} $=970kg/m^3$

. ρ $=1.29kg/m^{3/}$

fraction submerged = . $\rho_{air}/\ \rho=1.29/97$

$=0.00133$

(b) What will the scale read if you weigh yourself in a swimming pool with your body completely submerged?

Solution The scale reading in the air is the difference of the actual weight and the buoyant force due to air

F_b $=.\ P_{water}V_{man}g$

F_b = 1000x0.072m^3 9.81

Fb =706.32N

. $\rho_{man}/\ \rho wat=970/1000$

The fraction scale $=0.97$

23. The aorta is the principal blood vessel through which blood leaves the heart in order to circulate around the body.

(a) Calculate the average speed of the blood in the aorta if the flow rate is 5.0 L/min. The aorta has a radius of 10 mm

From equation of continuity $Q=5.0$ *L/min* $A=\ \pi r^{2}$ $r=10mm = 0.1m$

$Q = Av$

$5.0\ L/min = \pi r^{2}\ V$

$\frac{5}{3.14x1o-3}$ $=V=1.59x10^3m/s$

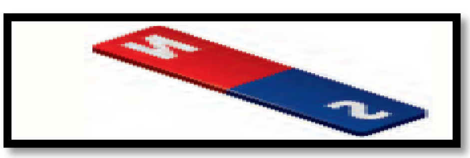
Unit 4

Electromagnetism

- ✓ Electromagnetism is one of the fundamental force in nature consisting of the elements electricity and magnetism.
- ✓ It involves the study of electromagnetic force.
- ✓ The electromagnetic force is carried by electromagnetic fields composed of electric fields and magnetic fields.
- ✓ all magnetic phenomena result from forces
- ✓ electromagnetism, devices such radios, televisions, computers, tape recorders, CD players, electric motors, and generators,

4.1 Magnets and Magnetic field

- ☞ Magnetic Field is the region around a magnet or a moving electric charge within which the force of magnetism acts
- ☞ A magnet generates a magnetic field which represents the magnetic force existing in the region around the magnet.
- ☞ A magnetic pole is the part of a magnet that exerts the strongest force on other magnets or magnetic material, such as iron, nickel and cobalt.
- ☞ Every magnet has two poles: a north pole (N) and a south pole (S) Like poles (N-N or S-S) repel each other, and opposite poles (N-S) attract each other.



- ☞ Although the force between two magnetic poles is similar to the force between two electric charges, electric charges can be isolated (as a positive and negative charge), whereas it is not possible to separate the north and south poles of a magnet.
- ☞ magnetic poles are always found in pairs. No matter how many times a permanent magnet is cut in to two, each piece always has a north and a south pole
- ☞ Permanent magnets are materials where the magnetic field is generated by the internal structure of the material itself.
- ☞ the permanent magnets are magnetized then they hold their magnetic property for a very long time.
- ☞ *The electromagnet generates a magnetic field when an electric current is provided to it and it loses its magnetism when the current is off.*

is defined by the force that a charged particle experiences moving in this field, after we account for the gravitational and any additional electric forces possible on the charge magnetic field

The magnitude of this force is proportional to the amount of charge q, the speed of the charged particle v, and the magnitude of the applied magnetic field.

The direction of this force is perpendicular to both the direction of the moving charged particle and the direction of the applied magnetic field.

$$\vec{F} = q\vec{V} \times \vec{B}$$

In fact, this is how we define the magnetic field B, in terms of the force on a charged particle moving in a magnetic field. The magnitude of the force is determined from the definition of the cross product as it relates to the magnitudes of each of the vectors. In other words, the magnitude of the force satisfies F= qvBsin θ

Differences Between Electric Field and Magnetic Field

- ❖ The SI unit of an electric field is Newton/coulomb, whereas the SI unit of magnetic field is Tesla.

- ❖ The region around the electric charge where the electric force exists is called an electric field. The region around the magnet where the pole of the magnet exhibits a force of attraction or repulsion is called a magnetic field.
- ❖ The electric field produces by a unit pole charge, i.e., either by a positive or through a negative charge, whereas the magnetic field caused by a dipole of the magnet (i.e., the north and south pole).
- ❖ The electric field lines start on a positive charge and end on a negative charge, whereas the magnetic field line do not have starting and ending point
- ❖ The electric field lines do not form a loop whereas the magnetic field lines form a closed loop.

ELECTRIC FIELD LINES

- ➢ Electric field the force per unit positive charge acting on a positive test charge placed in the field.
- ➢ The electric field vector E S is tangent to the electric field line at each point
- ➢ electric field lines for two point charges of equal magnitude but opposite sign.

☞ Note that the number of lines that begin at the positive charge must equal the number that terminate at the negative charge.

- ➢ At points very near either charge, the lines are nearly radial.

The high density of lines between the charges indicates a strong electric field in this region.

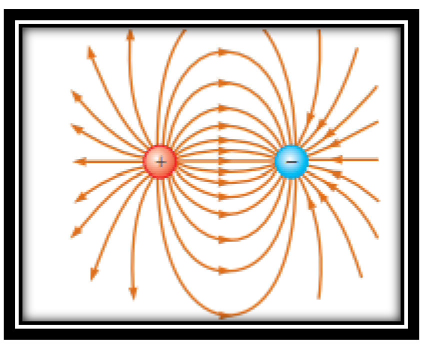
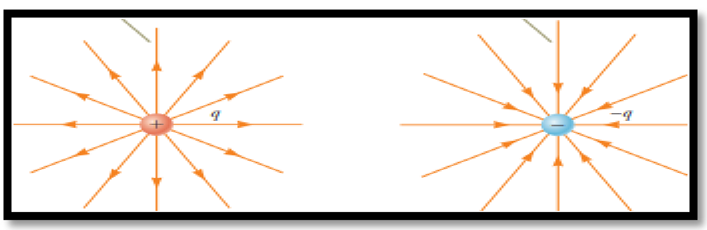


Figure (a) The electric field lines for two equal and opposite point charges (an electric dipole). Note that the number of lines leaving the positive charge equals the number terminating at the negative charge

Electric field strength is a vector quantity and its SI unit is N/C

Properties of electric e field line .

- ✓ Crossing: Electric field lines never cross each other
- ✓ Direction: Electric filed lines start from the positive charge and goes to a negative charge
- ✓ spacing :Electric filed lines are closer together where the electric force is strong
- ✓ The electric field is zero everywhere inside the conducting material.
- ✓ Any excess charge on an isolated conductor resides entirely on its surface.
- ✓ The electric field just outside a charged conductor is perpendicular to the conductor's surface.
- ✓ The lines must begin on a positive charge and terminate on a negative charge.
- ✓ The lines become closer together as they approach the charge, indicating that the strength of the field increases as we move toward the source charge
- ✓ the lines are directed radially away from the source positive charge,.
- ✓ The electric field lines representing the field due to a single negative point charge are directed toward the charge (Fig.



Exercise 4.1:

1. Which one of the following is false about magnets ?

A. magnet generates a magnetic field.

B. Every magnet has two poles.

C. Like poles attract each other.

D. The magnetic field is stronger at the poles.

Ans C

2. An electromagnet loses its magnetism when the electric current is off.

A. True *B. False*

Ans: *A(*Electromagnet generate magnetic field due to electric current)

2. *Define magnetic field.*

   Ans The region around a magnet where magnetic force is detected

4. Mention some difference between electric field and magnetic field.

- The SI unit of an electric field is Newton/coulomb, whereas the SI unit of magnetic field is Tesla.
- The region around the electric charge where the electric force exists is called an electric field. The region around the magnet where the pole of the magnet exhibits a force of attraction or repulsion is called a magnetic field.
- The electric field produces by a unit pole charge, i.e., either by a positive or through a negative charge, whereas the magnetic field caused by a dipole of the magnet (i.e., the north and south pole).
- The electric field lines start on a positive charge and end on a negative charge, whereas the magnetic field line do not have starting and ending point
- The electric field lines do not form a loop whereas the magnetic field lines form a closed loop.

5. Explain the difference between permanent magnet and electromagnet.

Ans :

- Permanent magnets are materials where the magnetic field is generated by the internal structure of the material itself. The electromagnet generates a magnetic field when an electric current is provided to it and it loses its magnetism when the current is off

4.2 Magnetic field lines

Magnetic field lines are imaginary lines or a visual tool used to represent magnetic fields.

The density of the lines indicates the magnitude of the field. As with electric fields, the pictorial representation of magnetic field lines is very useful for visualizing the strength and direction of the magnetic field

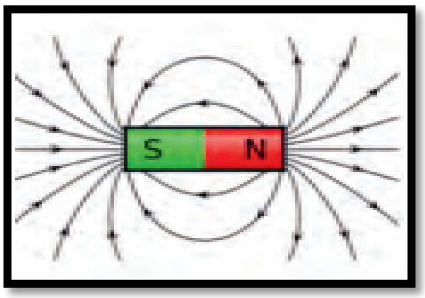
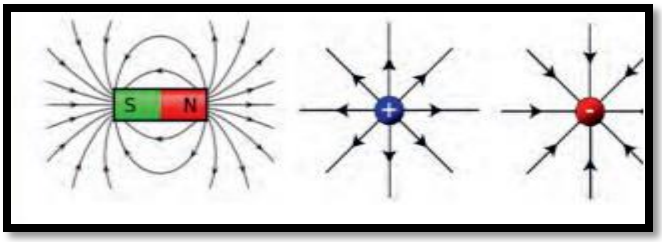


Figure shows Magnetic field pattern between opposite poles (N–S) of two bar magnets and

Properties of Magnetic Field Lines

- Field lines have both direction and magnitude at any point on the field.
- The direction of the magnetic field is tangent to the field line at any point in space.
- A small compass placed in a magnetic field will point in the direction of the field line.
- The strength of the field is proportional to the closeness of the lines.
- Magnetic field lines can never cross each other, meaning that the field is unique at any point in space.
- magnetic field lines are continuous, forming closed loops without beginning or end..
- The field lines emerge from north pole and merge at the south pole (note the arrows marked on the field lines
- Inside the magnet, the direction of field lines is from its south pole to its north pole. Thus the magnetic field lines are closed curves



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Exercise 4.2: 1.

1 Define magnetic field lines.

Ans Magnetic field lines are imaginary lines used to represent magnetic fields. They describe the direction of the magnetic

2. The magnetic field lines are denser where the magnetic field is stronger.

A. True B. False **Ans True**

3. Mention som properties of magnetic field lines.

- Field lines have both direction and magnitude at any point on the field.
- The direction of the magnetic field is tangent to the field line at any point in space.
- A small compass placed in a magnetic field will point in the direction of the field line.
- The strength of the field is proportional to the closeness of the lines.
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- magnetic field lines are continuous, forming closed loops without beginning or end..
- The field lines emerge from north pole and merge at the south pole (note the arrows marked on the field lines
- Inside the magnet, the direction of field lines is from its south pole to its north pole. Thus the magnetic field lines are closed curves

4. Which of the following is true about magnetic field lines ?

A. They form closed loops. B. They never intersect each other. C. The magnetic field lines are crowded near the pole. D. All are true

4.3 Current and Magnetism

- The connection between electricity and magnetism has many important applications in today's world. Whenever a current passes through a conductor, a magnetic field is produced.
- A compass placed near a current-carrying conductor will always point in the direction of the magnetic field lines produced.
- As soon as the current is off there is no magnetic field because the magnetic field is generated by the electric current (moving charges).

Ampere's law

Ampere's Law can be stated as: "The magnetic field created by an electric current is proportional to the size of that electric current with a constant of proportionality equal to the permeability of free space."

Magnetic Field Created by a Long Straight Current-Carrying Wire

the current through the conductor increases, the magnetic field increases proportionally. When we move further away from the wire, the magnetic field decreases with the distance.

The magnitude of the magnetic field at a point a distance r from a long straight current carrying wire is given by:

$$\vec{B} = \frac{\mu_0 I}{2\pi r} \quad \text{(for long straight wire)}$$

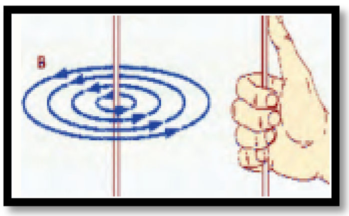
- The magnetic fild strangth depends on The current in the wire & the distance from the wire

Where $\mu_0$is permeability of free space, $\mu_0 = 4\pi\times107$T.m/A and r is the distance from the wire where the magnetic field is calculated. I is the current through the wire. The magnetic field has both magnitude and direction.

The SI unit of magnetic field is Tesla(T). The other common unit of magnetic field is gauss (G). Gauss is related to the Tesla through the conversion 1T = 10^4 G. magnetic field.

The magnetic field produced by a current flowing in a straight wire have the following properties.

- *The magnetic field lines form a circular pattern.*
- *The magnetic field strength increases when current increases.*
- *The magnetic field strength is stronger near the wire and weaker further away.*
- *When the direction of the current is reversed, the direction of the magnetic field is reversed too.*



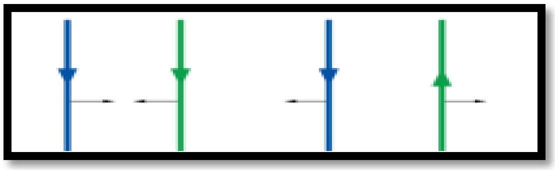
The direction of a magnetic field around a wire carrying a current is given by Fleming's Right Hand Rule.

This rule states that, if you grip a straight wire with your right hand in such a way that your extended thumb points in the direction of the current, then your fingers wrapped around the wire will point in the direction of the magnetic field lines as shown in Figure above

$$B = \frac{\mu I}{2\pi r} \quad \text{where} \quad \mu_0 = 4\pi\times 10-7 \text{ T.m/A}$$

Magnetic force between two parallel current-carrying conductors

- Two parallel wires each carrying a current will interact with eachother
- If the currents are both flowing the same way, they attraction another;
- If the currents are both flowing in opposite currents going opposite ways they repel each.
- The current in one wire creates a magnetic field that extends out to where the second wire
- The current in this second wire then experiences a force due to the motor eff ect.



The magnitude of the force which two wires that is a distance (r) r apart, each of length (l) and carrying-currents of I1 and I2 is given by:

$$F = \frac{\mu_o I_1 I_2}{2\pi r} \quad where\ B = \frac{\mu_o I}{2\pi r}$$

Example 4.1

Find the current in a long straight wire that would produce a magnetic field ***twice*** the strength of the Earth's magnetic field (The Earth's magnetic field is about 5.0×10^{-5}T) at a distance of 5.0 cm from the wire *Solution:* Magnetic field due the earth (BE) is $5x10^{-5}$ T.

Magnetic field due the current carryng wire B is B=2BE =2x5x10−5 T=1x10−4 T.

The equation $B = \mu 0I /2\pi r$

$I = 2\pi rB /\mu_0$

$I = 2\pi(5.0x10^{-2}m)(1.0x10{-}4T)\ 4\pi\times 10{-}7\ T.m/A$

$I = 25A$

Exercise 4.3:

1A long straight wire carrying a current produces a magnetic field of 0.8 T at a distance 0.5 cm from the wire. Find the magnetic field at a distance of 1 cm

Solution $\mu_0 I /2\pi r = \mu_0 I /4\pi r$

$\mu_0 I /2\pi r = 0.8T$

$\mu_0 I /4\pi r = B_2$

$\mu_0 I /2\pi r(B_2) = \mu_0 I /4\pi r(0.8)$

$x=0.8/2$

$B_2 = 0.4T$

2 Which one of the following does not affect the magnetic field produced by a long straight wire?

A. The current in the wire B. the distance from the wire C. the type of the wire D. None

Ans C

3 The magnetic field B at a distance r from a long straight wire carrying current I is directly proportional to r. A. True B. False

Ans B

4.4 Electromagnetic Induction

Electricity and magnetism were considered as separate and unrelated phenomena for a long time. The moving electric charges produce magnetic fields.

For example, an electric current deflects a magnetic compass needle placed in its vicinity.

Michael Faraday discovered that magnets could be used to generate electricity. He showed that a changing or variable magnetic field can produce an electromotive force (emf).

e.m.f produces an induced current in a closed circuit. We call this effect electromagnetic induction.

This discovery led Faraday to invent the dynamo (generator) through the use of electromagnetic induction.

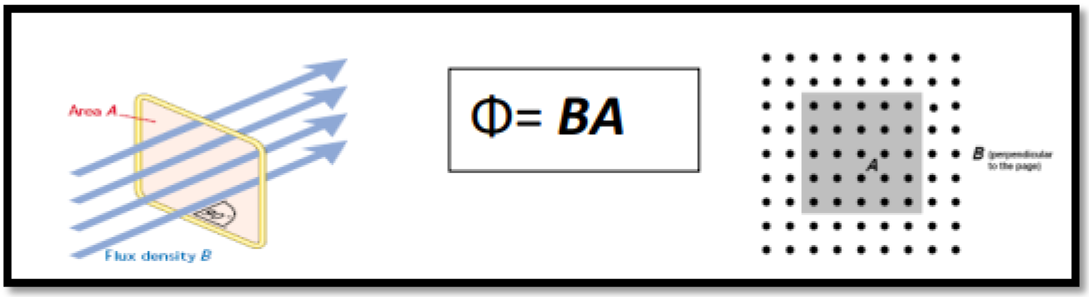
Magnetic Flux

- magnetic flux (Φ) is defined as the product of B and A.
- The unit of magnetic flux is the Weber (Wb)
- To calculate the size of the induced emf we need one more concept; magnetic flux. The symbol for magnetic flux is Φ .
- Magnetic flux –is a measure of the strength of a magnetic field over a given area.

- The lines of force start on the north pole of the magnetand end on the south, just as¬ they did with the horseshoe magnet. Where the field is strongest (close to the poles), there the lines offorce are closest together

To introduce the idea of magnetic flux consider an area, A in a uniform magnetic field.

When the magnetic force lines are perpendicular to this area (see Figure) the total magnetic flux (Φ) through the area is defined as the product of B and A.



The magnetic flux, , can be visualised as the number of magnetic field lines passing through a given area. The number of magnetic field lines per unit area, i.e. B, is then referred to as the density of the magnetic flux or, more properly, the magnetic flux density

Example 4.2

A square loop of side 3 cm is positioned in a uniform magnetic field of magnitude 0.5 T so that the plane of the loop makes an angle of 60^{0} Find the flux passing through the square loop?

Solution: Putting the known values into the magnetic flux equation

$$\Phi = BA\cos\theta$$

$$\Phi = (0.5)(0.03 \text{ x } 0.03)(\cos 300\ )$$

$$\Phi = 0.39 \text{ mWb}$$

Exercise 4.4:

1. Define magnetic flux.

Ans The total number of magnetic lines of force crossing the surface placed in a magnetic field normally

2. A circular loop of area 200 cm2 sits in the xz plane. If a uniform magnetic field of ~B= 0.5 T is applied on it. Determine the magnetic flux through the square loop?

Solution $A=200cm^2\ B= 0.5T\ ,\theta = 0^0$

$\Phi= BA\cos\theta$

$\Phi=200x10^{-4}\ x\ 0.5T\cos 0^0$

$\Phi = 0.01Wb$

3. The magnetic flux is maximum when the angle between magnetic field lines and the line perpendicular to the plane of the area is: A. 0^o B.90^0 C.45^0 D.30^0

Ans A

Solution $\Phi= BA\cos\theta$ the maximum value of $\cos\theta$ is one we can get at an Angele of 0^0

4. A magnetic field of 2.5T passes perpendicular through a disc of radius 2cm. Find the magnetic flux associated with the disc.

$\Phi= BA\cos\theta$

$\Phi= 2.5Tx\pi x4x10^{-4}\cos 0^0$

$\Phi=10^{-3}\pi Wb$

Laws of electro magnetic induction

electro magnetic induction has two laws

Faraday's Law states that the magnitude of the induced emf is proportional to the rate of change of magnetic flux

☞ That is induced emf = change in flux /change in time

- The emf induced in a circuit is directly proportional to the time rate of change of the magnetic flux through the circuit.
- N $\frac{\Phi}{t}$

Faraday's Law depends on

The magnetic field strength (B)

The number of turns (N)

Magenetic flux(*Φ)*

Lenz's Law states that the direction of the induced emf is always such as to oppose the change producing

- Le Lenz's law states that the induced emf in a coil indirectly proportional to the time rate of change in magnetic flux in coil
- .The negative sign indicates the direction of emf or (current).
- It applies to any situation in which the dynamo effect occurs.

$$Induced emf = -N\frac{\Delta\Phi}{\Delta t}$$

Remember Faraday's Law: The size of the induced emf is proportional to the rate of change of flux.In this case the proportional constant turns out to be N (the minus sign is a reference to Lenz's Law)

factors that affect induced Emf in a coil

- Rapid motion of the coil
- strength
- Number of turn

Example 4.3

A square loop of side 10 cm and resistance 0.5 Ω is placed vertically in the east-west plane. A uniform magnetic field of 0.10 T is set up across the plane in the northeast direction. The magnetic field is decreased to zero in 0.70 s at a steady rate. Determine the magnitudes of induced emf and current during this time-interval. Solution: The angle θ made by the area vector of the coil with the magnetic field is 45◦ . From the Equation of magnetic flux:

$\Phi = BA\cos\theta$

A= 0.1x0.1 =0.01m^2 , θ = 45^0 Bi = 0.1T ,Bf= 0

$\Phi i = Bi\ A\cos\theta$

$\Phi i = 0.1x10-2\ x0.1\ \cos 45^o$

$\Phi i = 0.1x10-2\ x0.1\ x0.707$

$\Phi i = 7.07x10^{-4} wb$

$\varphi f = 0$ b/c bf is zero

$\varepsilon = \frac{-|\Delta\Phi|}{\Delta t}$

but $\Delta\Phi = \varphi f - \Phi i$

$\Delta\Phi = 7.07x10^{-4} wb$

, $\varepsilon = \frac{|7.07x10-4wb|}{0.70}$

, $\varepsilon = 1.01mv$

$I = \varepsilon / R$

$I = 1.01mv / 0.5\Omega$

$I = 2.01mA$

Exercise 4.5:

1. The emf induced in a coil can be increased by: A. increasing the number of turns in the coil (N). B. increasing magnetic field strength surrounding the coil. C. increasing the speed of the relative motion between the coil and the magnet. D. All **Ans A**

2. Faraday's Law states that the induced voltage or emf is proportional to: A. the resistance of the coil B. the cross sectional area of the coil. C. the rate of change of the magnetic flux in the coil. D. All

   Ans C
3. Lenz's law is the result of the law of conservation of: A. mass B. charge C. energy D. Momentum Ans C
4. In Lenz's law the induced emf opposes the magnetic flux. A. True B. False

   Ans B
5. a) Calculate the induced emf when a coil of 100 turns is subjected to a magnetic flux change at the rate of 0.04Wb/s. b) Calculate the induced current if the resistance of the coil is 0.08Ohm.

   ε =0.04Wb/s where N =1 ε= ?at N=100turns

   I =?

   Solution

$$Induced\,emf = -N\frac{\Delta\Phi}{\Delta t}$$

ε =100x0.04Wb/s

ε = 4 wb/s

$I = \varepsilon / R$

$\boldsymbol{I = 5A}$

4.6 Transformers

A transformer is an electrical device that transfers electrical energy from one circuit to another through the process of electromagnetic induction.

It is most commonly used to increase ('step up') or decrease ('step down') voltage levels

A Step-up Transformer converts the low primary voltage to a high secondary voltage and steps up the input voltage.(Ns.>Np)

On the other hand, a step-down transformer steps down the input voltage.(Ns<Np)

A transformer is simply a pair of coils wound on the same core.

Transformers are used in various fields like power generation grid, distribution sector, transmission and electric energy consumption.

The relationship between the voltage applied to the primary winding VP and the voltage produced on the secondary winding VS is given by

$\frac{Np}{Ns} = \frac{Vp}{Vs} = \frac{Is}{Ip}$ *the eqation is known as ideal transformer equation*

efficiency,η = $\frac{\text{output power}}{\text{Input power}}$ $x\ 100\% = \frac{IsVs}{IpVp}x100\%$

Example A transformer has a primary and a secondary coil with the number of loops of 500 and 5000 respectively. If the input voltage is 220 V. What is the output voltage?

Np/ Ns = Vp/ Vs

⇒ Vs/ Ns = Vp/ Np

⇒ Vs/ 5000 = 220/ 500

⇒ Vs = 2200V

Calculate the efficiency,η of while the current in the primary *coil is 6A*

Solution

Np=500

Ns = 5000

Ip =6A

Vp= 220v

Vs=2200v

Is= ?

$$\frac{Np}{Ns} = \frac{Vp}{Vs} = \frac{Is}{Ip}$$

$$\frac{220}{2200} = \frac{Is}{6}$$

Is = 0.6A

$$efficiency,\eta = \frac{IsVs}{IpVp}x100\%$$

efficiency,η = (0.6x2200/6x220)x100%

efficiency,η =100%

Justify the type of transformer it is Step-up Transformer b/c .(Ns.>Np)

Working principle of transformer in house appliances

An alternating current (AC) changes its direction periodically and typically supplies power to run household appliances and industrial equipment.

Transformer in Chargers: There are many appliances that use transformers in their circuit. Your phone, laptop, computer, tablet power supplies have transformers in them.

They step the voltage down to a safe voltage that will not harm you to charge your device battery.

A transformer in real life is a commonly used circuit that can either step up the voltage of incoming current or step down the voltage of incoming current.

The electronics in your mobile phone or laptop are designed to work at low voltages compared to the electric current you get in wall outlets.

A mobile phone charger also contains a rectifier. After Stepping down the voltage, AC is converted to DC using the rectifier.

Exercise 4.6:

1. A transformer has primary coil with 1200 loops and secondary coil with 1000 loops. If the current in the primary coil is 4 Ampere, then what is the current in the secondary coil.

   Solution

   Np= 1200

   Ns=1000

   Ip=4A

   Is = ?

   $\frac{Np}{Ns} = \ =\frac{Is}{Ip}$

   $\frac{1200}{1000} = \ =\frac{Is}{4}$

   Is= 4.8A

2. Calculate the turn ratio to step 110 V AC down to 20 V AC.

   Vp/Vs= 110/20 =5.5

3. Why does a transformer can not raise or lower the voltage of a DC supply? Explain your answer.

   Ans *A transformer works on principle of electromagnetic induction. According to this principle a varying current(Ac current) of primary side of transformer creates varying magnetic flux in the transformer core and this induces varying magnetic field in the secondary side of transformer and it produces electromotive force(emf) on the secondary side of transformer*.

4.7. Application and safety

- Electromagnets are used in generators, motors, transformers, electric bells, headphones, loudspeakers, relays, MRI machines and others.
- Some electromagnet uses in the home include an electric fan, electric doorbell, induction cooker, magnetic locks, etc

Electromagnets at Home or School

Electromagnets are used for various purposes on a day-to-day basis. For example, in electric bells, headphones, loudspeakers, relays, MRI machines, electric fan, electric doorbell, magnetic locks, and others. Most of the electric appliances used in the home use electromagnetism as the basic working principle.

Magnetic Relays A magnetic relay is a switch or circuit breaker that can be activated into the 'ON' and 'OFF' positions magnetically.

Electric bell Electric bell is based on the principle of electromagnetism. When the switch is pressed on, the electromagnet is activated and it attracts the soft iron towards the electromagnet.

DC Electric Motor

- A DC power source supplies electric power to the motor.
- Turns half a turn by motor effect then would stop unless battery leads could be reversed
- Split ring commutator reverses direction of current automatically

components of the DC motor

- ✓ *Split ring Commutatore*
- ✓ *permanent magnet*
- ✓ *Brush*
- ✓ *Battery*
- ✓ armatur

commutator is the rotating interface of the rotating loop (or coil) with a stationary circuit.

The permanent magnetic field helps to produce a torque on the rotating coil.

The brushes conduct current between stationary wires and moving parts.

The maximum emf induced in generator of coil $\mathcal{E}_{max} = NBA\omega$ where $\omega = 2\pi f$ which is angular speed of coil.

AC Generator

- An AC generator is a mechanical device that converts mechanical energy into electrical energy in the form of alternate electromotive force (emf).
- For example, the electricity generated at various power plants is produced by the generators installed there.
- Electromagnets are generally safe for their various uses, but you need to take precautions depending on the context in which you use them
- . very powerful electromagnets that come into contact with laptops or computers can damage their hard drives.

- An electromagnet can affect monitors for computers or television sets. For classic cathode ray tube (CRT) television sets, powerful magnets can distort the images on the screen when they come close to them. This is because the magnets deflect

The difference between DC Electric Motor & AC Generator

- D.c generator turns half turns by motor effect stop unless battry leads be reversed
- Split ring commutator reverses direction of current automatically
- Ac generator coil is turned rather than turning by motor effect
- Split ring connect to out side circuit

practice questions

1 Faraday's law says that

A an emf is induced in a loop when it moves through an electric field

B the induced emf produces a current whose magnetic field opposes the original change

C the induced emf is proportional to the rate of change of magnetic flux

D all are correct.

Ans. C

2 A generator is a device that:

A Transforms mechanical into electrical energy

B Transforms electrical into mechanical energy

C Transforms low voltage to high voltage

D all *Ans A*

A 3 .Which of the following laws is used to find the direction of the induced current in a loop of wire placed in a changing magnetic field?

A. Lenz's Law

B. Faraday's Law

C. Ampere's Law

D. Gauss's Law

4.What are some similarities between a motor and a generator?

A. They both rely on Faraday's Law.

B. Both need to be rotated by an external force.

C. Both require an input current to work.

D. Ampere's Law explains the operation of both

.Ans C

5.Lenz's law concerning the direction of an induced current in a conductor by a magnetic field could be a restatement of?

A. Ampere's Law

B. Ohm's Law

C. Tesla's Law

D. The Law of Conservation of Energy

Ans . D

6.How can the magnetic flux through a coil of wire be increased? Select two answers:

A. Increase the magnitude of the magnetic field that passes outside the loop

B. Increase the magnitude of the magnetic field that passes through the loop.

C. Increase the cross sectional area of the loop

. D. Orient the loop so its normal vector is perpendicular to the external magnetic field direction.

Ans B and C

7.A transformer has a primary to secondary turn's ratio of 15 to 1. If the primary is rated at 240 V, then the secondary voltage is:

A 120 V B 24 v C 16 v D 12 v

Ans . C

8.A transformer has a primary rated at 240 V and a secondary rated at 120 V. The primary to secondary turns ratio is:

A 4:1 B 2 :1 C 0.5 D 0.25

Ans B

9.A control transformer has a secondary rated 10.4 A at 24 V. The primary is rated480 V, and the primary to secondary turns ratio is 20 to 1. Of the following, which is the primary full-load current?

A 2.08 B 1.22 A C 0.80 A D 0.52 A

Ans D

End of unit questions and problems

1. A long straight wire carries a current of 10 A. At what distance from the wire will a magnetic field of 8 x 10−4 T be produced?

   solution

   I = 10A

   B = 8x 10^{-4}T

   $\mu_0 = 4\pi \times 10^{-7}$

   r =?

   B = $\mu_0 I / 2\pi r$

   8x 10^{-4}T = $\mu_0 I / 2\pi r$

   16 $\pi r \times 10^{-4} = 4\pi \times 10^{-7} \times 10$

   R= 400m

2. A closed coil of 40 turns and of area 200 cm^2 , is rotated in a magnetic field of flux density 2 Wb m^{-2} . It rotates from a position where its plane makes an angle of 30^0 with the field to a position perpendicular to the field in a time 0.2 sec. Find the magnitude of the emf induced in the coil due to its rotation.

   Solution

   N =40turns

   A=200cm^2 =0.02m^2

   B =2wbm^{-2}

   t=0.2sec

   $\Delta\Phi$ =?

   $\Delta\Phi = BA\cos 30^0$

   $\Delta\Phi = 2wbm^{-2}\, 0.02m^2$

   $\Delta\Phi = 0.04wb$

   $E = N\frac{\Delta\Phi}{t}$

   $E = 40 \ \frac{0.04wb}{0.2s}$

   $E = 8wb/s$

3. A portable x-ray unit has a step-up transformer, the 120 V input of which is transformed to the 100 kV output needed by the x-ray tube. The primary has 50 loops and draws a current of 10.00 A when in use. (a) What is the number of loops in the secondary? (b) Find the current output of the secondary Solution Vp= 120v

   Vs =100000v

   Np=50

   Ip =10A

   Ns= ?

   Is=?

   $\frac{Np}{Ns} = \frac{Vp}{Vs} = \frac{Is}{Ip}$

$\frac{50}{Ns} = \frac{120}{100000}$

Ns =41666.66

$= \frac{Vp}{Vs} = \frac{Is}{Ip} = \frac{120}{100000} = \frac{Is}{10}$ = Is = 0.012A

4 A 500 turns coil develops an average induced voltage of 60 V. Over what time interval must a flux change of 0.06 Wb occur to produce such a voltage?

Solution

N= 500turns

E= 60V

$\Delta\Phi$=0.06wb

.t =?

$E=N\frac{\Delta\Phi}{t}$

$t=N\frac{\Delta\Phi}{E}$

t=0.5sec

5Calculate the voltage output by the secondary winding of a transformer if the primary voltage is 35 volts, the secondary winding has 4500 turns, and the primary winding has 355 turns.

Solution

Vp =35V

Ns=4500turns

Np =355turns

Vs=?

$\frac{Np}{Ns} = \frac{Vp}{Vs}$

$\frac{355}{4500} = \frac{35}{Vs}$

Vs=443.66

6. A circular loop with a radius of 20 cm is positioned perpendicular to a uniform magnetic field, the magnetic flux that passes through the loop is 1.9x10−2W b. What is the magnetic flux density?

Solution r=20cm

$A = \pi r^2$

$A = (3.14)(0.20m)^2$

$A = 0.1256m^2$

$\Phi = 1.9x10^{-2}W\ b$

B=?

$\Phi i = Bi\ Acos\theta$

7. A uniform magnetic field has a magnitude of 0.1T. What is the flux through a rectangular piece of cardboard of sides 3cm by 2cm perpendicular to the field?

Solution:

A = 3cm x 2cm

A = 6 x 10^{-4} m^2 the flux is then,

ϕ = BA

ϕ = 0.1T x 6 x $10^{-4}m^2$

ϕ = 6 x 10-5 Wb

8. A coil of wire 1250 turns is cutting a flux of 5mWb. The flux is reversed in an interval of 0.125 sec. Calculate the average value of the induced emf in the coil.

   . Solution:

   N = 1250,

   $\phi1$ = 5mWb

   = 5 x 10-3Wb

   $\phi2$ = -5mWb=

   -5 x 10-3Wb (because the same flux is reversed)

   Δt = 0.125 sec =125 x 10-3 s applying Farady's law, we find

   $, \varepsilon = \frac{|5\text{mWb}- -5\text{mwb}|}{0.125s}$

   $, \varepsilon=10x10^{-3}/0.125$

   $, \varepsilon=8x10^{-2}v$

9. A 150 W transformer has an input voltage of 10V and an output current of 5A. a). is this step-upmor step down transformer? b). what is the ratio of Vout to Vin?

P = VI,

P_{out} = VoutIout

150W = Vout x 5A

Vout = (150W)/5A

V_{out} = 30V s, it is a step up transformer because $V_{ou}t > V_{in}$

V o/Vi = 30/10=3

Calculate the input current

$P = VI,$

$150w = 10I$

$I_p = 15A$

10. Determine the magnetic field strength at a point 5cm from a wire carrying a current of 10A.

$\mu_0 = 4\pi \times 10^{-7} \times 10$

$B = \mu_0 I / 2\pi r$

$B = 4\pi \times 10^{-7} \times 10 / 2\pi \times 5 \times 10^{-2}$

$B = 2 \times 10^{-4} T$

Unit 5

Basics of electronics

- Electronic devices influence our daily lives in such a way that it is almost impossible to spend even a few hours without them.
- Electronics: deals with the design of the system and the application of device usually electronics circuit, the operation of depend on the flow of electrons from the generation transmission, reception and storage information.

some of the electronic devices that we use every day

- ✓ Calculators,
- ✓ digital watches,
- ✓ mobile phones,
- ✓ televisions, and
- ✓ computers.

- electronics simplify our activities and lifestyle..

Electronic devices are also necessary in medicine.

For example, equipment such as magnetic resonance imaging (MRI), computed tomography (CT) and X-rays rely on electronics in order to do their work quickly and accurately.

5.1 Semiconductors conductors& insulators

- Conductors are materials which allow electricity to flow through them. Metals are good conductors of electricity.
- Conductors have free electrons that allow the easy flow of electric current.

Some materials do not allow electricity to pass through these materials are known as insulators.

Insulators do not have free electrons every electron in them is tightly bound to the parent atom. Example Plastic, wood, glass and rubber are good electrical insulators.

Semiconductors are materials which have a conductivity between conductors and insulators. Semiconductors can be pure elements, such as silicon or germanium, or compounds such as gallium arsenide or cadmium selenide.

Semiconductors act as insulators at absolute zero temperature (zero kelvin) and conductors at higher temperatures. The temperature increase in the semiconductor the conductivity of the material increase

Types of Semiconductors

- ❖ pure or
- ❖ impure.

Pure (intrinsic) : silicon and germanium are the best example for pure semi conductors.

Impure (extrinsic) : are formed by adding(doping) other elements to pure semiconductor. Doping: is deliberately introducing impurities into a pure semiconductor to change its electrical properties. It is the adding of impurity

They are 2 types of Doping

- ❖ N- type
- ❖ P- type.

N-type impurity when pure semiconductor SI or Ge doped with pentavalent atoms (five valence electrons) such as phosphorus, arsenic, antimony.

P-TYPE impurity : when pure semiconductors Si or Ge doped with trivalent (3 valance electron) such as indium, boron, and gallium.

Q1 N-type semiconductor can be produce by adding pent valiant imparity to a semiconductor crystal, True

Review question 5.1:

1. Why a semiconductor conducts better when it is hot? Explain your answer.
   Ans Conduction occurs at higher temperature because the electrons surrounding the semiconductor atoms can break away from their covalent bond and move freely about the lattice

2. Define intrinsic semiconductor and extrinsic semiconductor.

   Ans: *A semiconductor doped with Group V elements such as phosphorus (P), arsenic (As), or antimony (Sb) as an impurity is N-type semiconductor. It has surplus of electrons. A semiconductor doped with Group III elements such as boron (B) or indium (In) is called ptype semiconductor*

3. What is P-type and N-type semiconductor?

   N-type impurity when pure semiconductor SI or Ge doped with pentavalent atoms (five valence electrons) such as phosphorus, arsenic, antimony.

   P-TYPE impurity : when pure semiconductors Si or Ge doped with trivalent (3 valance electron) such as indium, boron, and gallium.

4. Which of the following impurities could be used to convert intrinsic silicon to extrinsic P-type silicon?

   (A) aluminum. (B) germanium . (C) arsenic. (D) zinc

   Ans .A

. 5. What type of impurities are chosen for doping to form N-type semiconductor?

(A) trivalent (B) tetravalent (C) pentavalent (D) both a and c

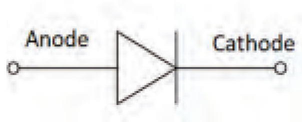
Ans C

6. Electrons are the minority carriers in

(A) extrinsic semiconductors (B) P-type semiconductors (C) intrinsic semiconductors (D) N-type semiconductors Ans B

5.2 Diodes and their Functions

A diode is a two-terminal electronic component that only conducts current in one direction and blocks current in the reverse direction.



Q Diodes can be used in both ac and dc circuits. True

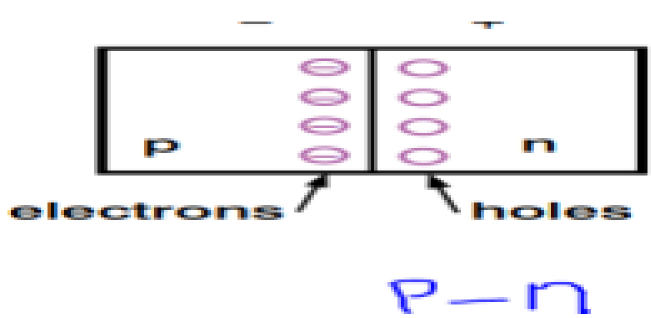
Diodes are made from a large variety of materials including silicon, germanium and gallium arsenide,etc.

P-N junction diode

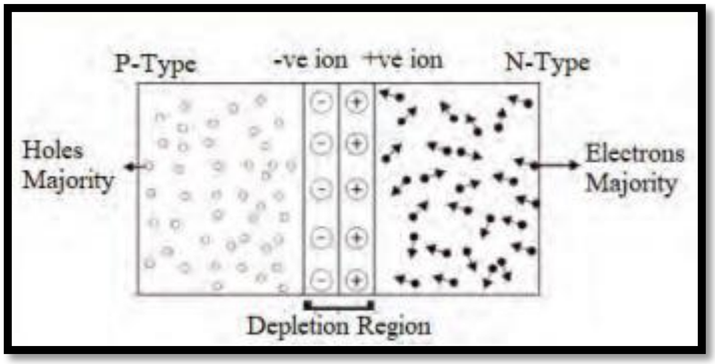
When p type is joined to n type a PN junction is formed. The surface where the two semiconductors meet is called a junction.

The p-n type semiconductor Suppose a p-type semiconductor is in contact with an n-type one.

* Both pieces of semiconductor were electrically neutral overall before they were
* contact. Some of the n-type's electrons move, or 'fall' into the p-type's holes after contact.
* This movement is known as diffusion current. It causes the p-type to become slightly
* Negative while the n-type is left equally positive, leaving a 'depletion zone'



The P-N junction diode formed between P-type and N-type semiconductors.



The combination of electrons and holes near the junction creates a narrow region in the vicinity of the junction called the depletion region

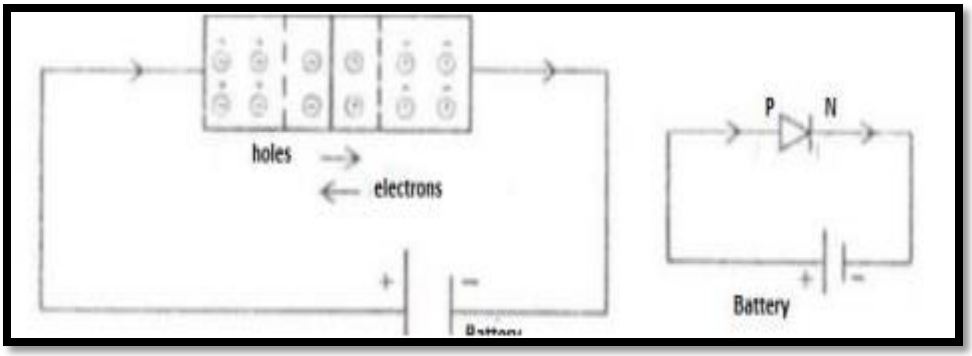
Biasing of P-N junction diode

Applying a suitable DC voltage to a diode is known as biasing.

- ✓ It can be done in two ways:
- ☞ forward and
- ☞ reverse biasing.

forward bias : the(+) terminal of the battery is connected to p type and the negative terminal to n type. . It has Narrow depletion layer and large current.

- ☞ Therefore the depletion layer is decreased and disappeared i.e., the potential barrier is disappeared

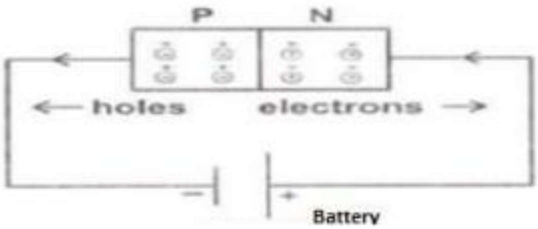


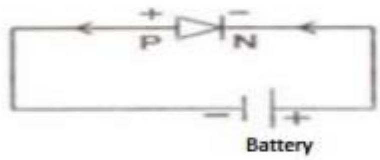
reversed bias: (+) terminal of battery is connected to the n type and the negative terminal to p type. The depletion layer is wider and very smaller current.

A P-N junction diode conducts electricity when it is forward biased and it does

not conduct electricity when it is reverse biased

- the width of the depletion layer increases and there is no current flow through the junction during reverse bias





Q Reversed biased applied to junction diode;   Ans A

a) Raised potential barrier (b) Increased the majority carrier current(c) Lowers the potential barrier (d) Increased majority carrier current **Ans A**

Review question 5.2:

1. Define diode.

   A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but blocks current from flowing in the opposite direction

2. Under forward bias, the resistance is low and the current is high. True

3. What are the current carriers in P-N junction diode?

   Ans   Holes and electrons

5. What is forward bias? What is reverse bias?

   When P side is connected + side of a battery and N side is connected to negative side of a battery, is called forward bias. When P side is connected – side and N side are connected to positive is called reverse bias.

5. The characteristic curve of the diode shows the relation between

(A) Current and voltage.   (B) voltage and resistance.

(C) voltage and power. (D) resistance and temperature

6. Depletion layer is caused by

A doping B recombination (C) barrier potential (D) ions

Ans B. (Recombination of electron-hole

5.3 Rectification

Rectification using p-n junction diode: the process changing ac voltage to dc voltage is known as rectification and the electric circuit used for the conversion is called a rectifier.

When the AC input is applied to a junction diode, it becomes forward biased during the positive half cycle and reverse biased during negative half-cycle

Rectification is the main function of diodes.

There are two basic types of rectifier circuit used with power supplies:

- *half-wave rectifiers*
- *full-wave rectifiers*

Half wave: one diode is used in circuit when current flows through the diode in forward bias only, the ac to dc only in half.

A half-wave rectifier consists of a diode and a load resistor connected in series to the cathode end of the diode

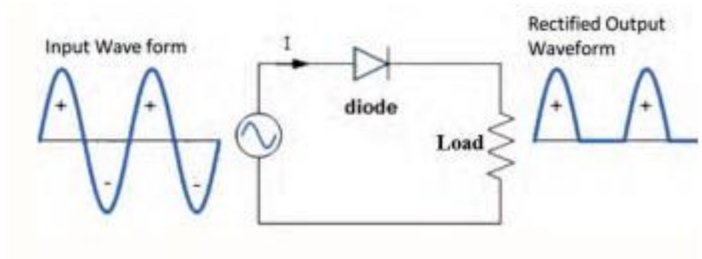
Working principle of Half Wave Rectifier

In a half-wave rectifier circuit during the positive half-cycle of the input, the diode is forward biased. Current flows through the load resistor and a voltage is developed across it. During the negative half-cycle, the diode is reverse biased and does not conduct.

- Therefore, in the negative half-cycle of the supply, no current flows in the load resistor as no voltage appears across it.

Thus the DC voltage across the load is sinusoidal for the first half-cycle only and a pure AC input signal is converted into a DC pulsating output signal

- ❖ It use only one diode



FULL wave: used 2 or 4 diodes. For further smoothing of the current flows in full wave rectification a capacitor is connected in parallel with the resistor.

Full-wave rectifier can be used a basic full-wave rectifier circuit, which uses four diodes arranged in a particular way

Working principle of full wave rectifier

The four diodes, labeled D1 to D4, are arranged in such a way that only two diodes conduct current during each half-cycle. During the positive half-cycle of the supply, diodes D1 and D2 conduct in series. diodes D3 and D4 are reverse biased and so the current flows through the load resistor,as shown in Figure During the negative half-cycle of the supply , diodes D3 and D4 conduct in series, but diodes D1 and D2 switch off as they are now reverse biased.

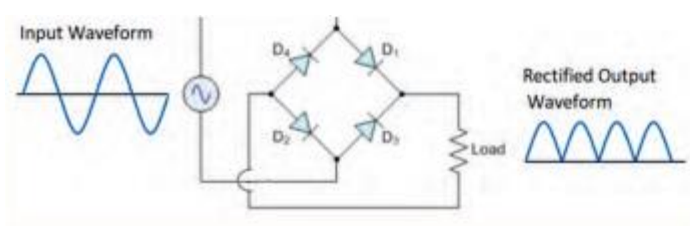


Figure 5.10 Basic full wave rectifier circuit

Diodes and capacitor

- ✓ Capacitor is used in rectifier circuits to smooth the fluctuations of the output voltage.
- ✓ A capacitor use to stores charge.

- ✓ The capacitor is connected across the terminals as During the positive quarter-cycle of the output voltage, the capacitor is charged to the peak voltage.
- ✓ Then the rectifier voltage falls, the capacitor discharges and provides the required current to the load

Practical uses of diodes

LDR: (light dependent resistor) conducts electricity, but in dark it has very high resistance.

The brighter the light, the better the conducts.

Thermostat: is a piece of semi conductor materials that has a high resistance in the cold. Its resistance drops as it becomes warmer. Variable resistor: is a very useful component in circuit, particularly in circuits containing transistor.

LED(light emitted diode) :when current is passed to forward direction, LEDs are now in range of red, green ,blue white.

White LED are increasingly being used in lighting; they produced light very efficiently (using relatively small energy).

Transistor: used to amplify or switch electronic signal.

Bipolar junction transistor made of three terminals.

- ❖ Base
- ❖ Collector
- ❖ emitter

- ☞ The base is connected to central layer, the other two (collector and emitter) are each connected to one of the outer layers.

Photodiode: is a light – sensitive diode used to detect light.

- ☞ Are reversing- biased so they do not conduct.

Photovoltaic cell : the base layer of photovoltaic solar cell is made of p –type semi conductors.

This is coved with layer n- type semi conductors. When light strikes the junction between n and p type.

- Converts solar energy to electrical energy.

Logic gates

Diodes and resistors can be combined with other components to construct AND and OR logic gates. This is referred to as diode resistor logic.

Over-voltage protection

Excess voltage can damage our electronic devices. Sensitive electronic devices need to be protected from fluctuations in voltage; the diode is perfect for this. Diodes achieve this by shutting down the switch after sensing an over-voltage condition

Review question 5.3:

1 What is rectification?

Ans Rectification is the conversion of alternating current (AC) to direct current (DC). This involves a device that only allows one-way flow of electric charge

2. Describe the function of resistor and capacitor in electronic circuit

Ans *Resistance is a measure of the opposition to current flow in an electrical circuit. Capacitor: It is a component that stores charge and then discharges it into the circuit when there is a drop in current.*

3. The dc current through each forward-biased diode in a full-wave rectifier equals:

A it makes use of transformer

B the heating loss is much less

C it utilizes both half-cycles of the input

D its output frequency is double the line frequency

Ans A

4The basic reason why a full-wave rectifier has a twice the efficiency of a half-wave rectifier is that:

A it makes use of transformer

B the heating loss is much less

C it utilizes both half-cycles of the input

D its output frequency is double the line frequency

Ans C

5.4 Transistors and their application

- ✓ A Transistor is a semiconductor device used to amplify or switch electronic signals.
- ✓ It is an essential component in an electronic circuit.

Transistors are classified into two types:

- ❖ bipolar junction transistors (BJT) and
- ❖ field effect transistors (FET).

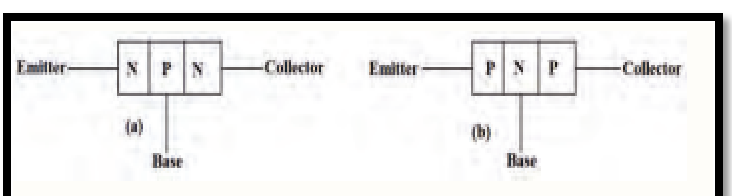
.A transistor is a three terminal, two-junction device used to control electron flow.

The three regions are arranged in one of two ways.

- ➢ NPN
- ➢ PNP

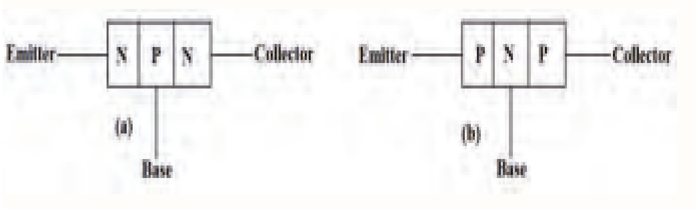
the P-type material is *sandwiched* between two N-type materials, forming an NPN transistor(Figure a)

the N-type material is *sandwiched between* two layers of P-type material, forming a PNP transistor (Figure b).



In both types of transistor, the middle region is called the base and the outer regions are called the emitter and collector.

The emitter, base, and collector are identified by the letters E, B, and C, respectively



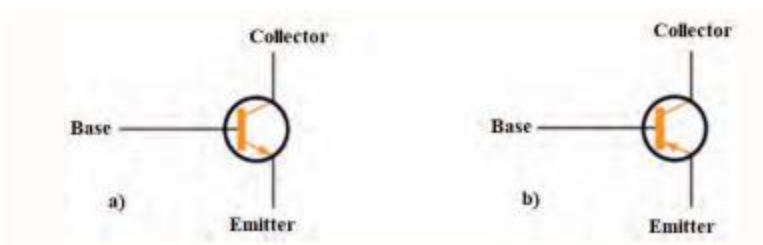
(a) NPN transistor (b) PNP transistor

- ✓ Emitter: The section on one side that supplies charge carriers (electrons or holes).
- ✓ The emitter terminal is the heavily doped region as compared to the base and collector.
- ✓ Collector: The section on the other side that collects the charges carriers.

The collector is moderately doped region and slightly larger in size as compared to the base and the emitter.

- ✓ Base: The middle section between the emitter and the collector.

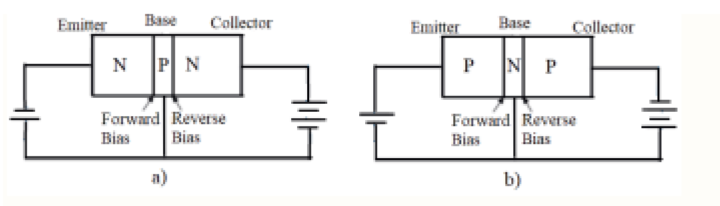
The base is lightly doped and very thin. In the symbolic representation for a transistor (Figure) the arrow mark is placed on the emitter in the direction of conventional current flow.



Transistors (pnp ,npn)

- ➢ Bipolar or junction transistor is electronic element formed by sand witching a semi conductor material of on type between 2 semi conductors that are opposite to it.
- ➢ Base: is the middle of the transistor which very thin and doped very lightly

- Emitter: is one of outer layer, which is doped heavily, it is source of charge carriers. IE = IB + IC
- Collector: is the other outer layer which is designed to have larger surface area as to store much larger carriers.
- NPN Transistor: thin layer of p type sandwiched two thicker of n type semi conductor.
- PNP Transistor: thin layer of n type sandwiched two thicker of p type semi conductors. Transistor characteristics: as current amplifier; a small change in base current can control a large current through the collector.
- Current amplification (A1) = ΔIc /ΔIb where ic is collector current and ib is base current.
- Transistor as voltage amplifier also called voltage gain of given by voltage output/ϖ voltage input. ΔVout/ΔVinput



collector. It can then be seen that the emitter current is the sum of the base current and collector current.

IE = IB + IC

Review question 5.4:

1. Describe the function of transistor in electronic circuit

   Ans) A transistor is a semiconductor device used to amplify electrical signals and acting as a switch/gate

2. Which of the transistor currents is the largest? Which is the smallest?

   Ans *Emitter current is the largest and base current is the smallest*

3. The doping concentration of base in PNP transistor is

(A) lightly doped (B) moderately doped (C) heavily doped (D) not doped Ans A

4. Which junction in the transistor is forward biassed?

- ➢ Emitter-base is forward bias

Which junction reverse biassed?

- ➢ base-collector is reverse base

6. In transistor if the current gain is 100 and the collector current is 10 mA, what is the emitter current?

   Solution By using the equation of Current amplification

ß =100mA

Ic= 10mA

Ie=?

$ß = \frac{Ic}{Ib}$

ßIb = Ic

100mAx10mA=Ic

Ic=1000mA

5.5 Integrated Circuits

- ❖ Integrated circuits are used in almost all electronic equipment
- ❖ The integrated circuit was invented by Jack Kilby and Robert Noyce.
- ❖ This invention is a boon for digital technologies like computer, mobile phones, MP3, fans, traffic lights, DVDs and many other devices.

The goal of the integrated circuit

- ✓ It is to develop a single device to perform a specific function, such as
- ☞ amplification or switching,
- ☞ microprocessor,
- ☞ timer, as computer memory,
- ☞ eliminating the separation between components and circuit

The components of an integrated circuit

- ❖ diodes,
- ❖ transistors,

- ❖ resistors, and
- ❖ capacitors.

Advantages and disadvantages of integrated components

Advantages

- ➢ a very small amount of the space is occupied by diodes and transistors.
- ➢ The rest is occupied by resistors and capacitors as their size increases with their value.
- ➢ The most obvious advantage of the integrated circuit is its small size.
- ➢ It is constructed of a chip of semiconductor material
- ➢ It is used extensively in military and aerospace programs.
- ➢ transformed the calculator from a desktop to a handheld instrument.
- ➢ Computer systems are now available in portable models.
- ➢ consumes less power and operates at higher speeds.
- ➢ internal components are connected permanently.
- ➢ reduce the number of parts needed to construct electronic equipment.

disadvantages.

- ✓ They cannot handle large amounts of current or voltage.
- ✓ High current generates excessive heat damaging the device.
- ✓ High voltage breaks down the insulation between the various internal components.
- ✓ integrated circuits cannot be repaired.

5.6 Logic gates and logic circuits

Digital and analog signals In electronics and telecommunications, "signal" refers to any time-varying voltage, current, or electromagnetic wave that carries information.

Two main types of signals

- ❖ analog and
- ❖ digital.

An analog

- signal is any continuous signal representing some time-varying quantity.
- The voltage signals which vary continuously with time are called continuous or analog voltage signals. An analogue signal carries a smooth wave.
- At any time, the voltage of the signal could take any value.

A digital signal

- is a signal that is being used to represent data as a sequence of discrete values;
- At any given time, it can only take on, at most, one of a finite number of values.
- In most digital circuits, the digital signal can have two possible valid values; this is called a binary signal or logic signal.
- They are represented by two voltage bands: one near a reference value (typically termed as ground or zero volts), and the other a value near the supply voltage.
- The low voltage level is written as 0, while the high voltage level is written as 1.

Positive and negative logic

In computing systems, the binary number symbols '0' and '1' represent two possible states of a circuit or an electronic device.

	Circuit	*Switch*	*Voltage*	*Sign*	*Statement*
1	*On*	*Closed*	*High*	*plus*	*TRUE*
0	*Off*	*Opened*	*Low*	*minus*	*FALSE*

Table of positive logic

	Circuit	*Switch*	*Voltage*	*Sign*	*Statement*
1	*Off*	*Opened*	*Low*	*minus*	*FALSE*
0	*On*	*Closed*	*High*	*plus*	*TRUE*

Table 5.2 Negative logic

If we say that value 1 stands for 5V and value 0 for 0 V, then we have positive logic system.

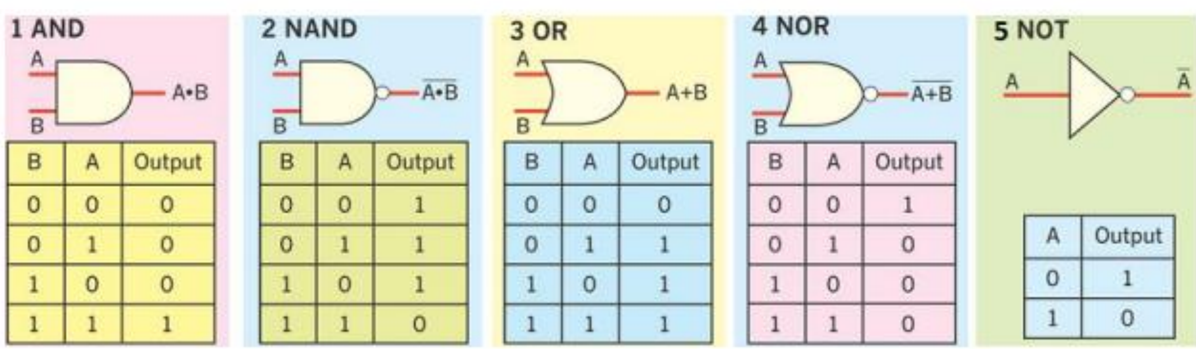
If on the other hand, we decide that 1 should represent 0 V (low voltage) and 0 should represent 5 V (high voltage), then we have negative logic system.

Logic gates

- Digital electronics is a field of electronics involving the study of digital signals and the engineering of devices that use or produce digital signals.
    - ✓ *This is in contrast to analog electronics and analog signals.*
    - ✓ *The simplest digital circuits are called logic gates.*
    - ✓ *An integrated circuit is a collection of logic gates.*
    - ✓ *The logic gates are building blocks of digital electronics.*
    - ✓ *Logic Gates Are tiny silicon chip on which are combination of transistor and resistors.*
    - ✓ *Logical gate: have 1 or more inputs and only one output.*

The most common logical gates used are

- *OR,*
- *NOT,*
- *NAND,*
- *NOR,*
- *AND gates.*



1 AND

B	A	Output
0	0	0
0	1	0
1	0	0
1	1	1

2 NAND

B	A	Output
0	0	1
0	1	1
1	0	1
1	1	0

3 OR

B	A	Output
0	0	0
0	1	1
1	0	1
1	1	1

4 NOR

B	A	Output
0	0	1
0	1	0
1	0	0
1	1	0

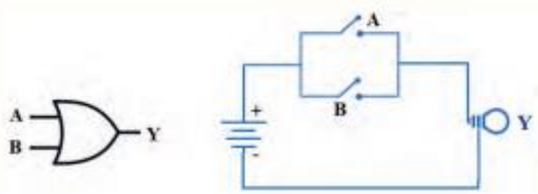
5 NOT

A	Output
0	1
1	0

OR Gates: It gives a high (1) if input A or input B or both are high (1).

If both switches A and B are open, no current will flow through the external wire. So the lamp is OFF i.e. equal to 0

- *. If switch A is closed switch B is open, the current passes through switch A and the lamp is ON, i.e. equal to 1; 1 + 0 = 1*
- *If switch A is open and switch B is closed, the current passes through B and the lamp is ON, i.e. equal to 1; 0 + 1 = 1*
- *If both switches are closed, tamp is ON, i.e. equal to 1; 1 + 1 = 1*

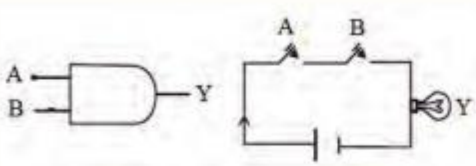


A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

NOT (NOT OR): it gives an output which is exactly the opposite of OR gate

AND gate*: it gives high (1) when both inputs are high.*

- *If both switches A and B are OPEN (i.e., A = 0, B = 0) then the lamp will not glow, i.e.y = 0. The current will not pass through the lamp.*
- *If switch A is closed and switch B is open, the current will not pass through the lamp. The lamp is OFF, so y = 0.*
- *If switch A is open and switch B is closed, the current will not pass through the lamp. The lamp is OFF, so y = 0.*
- *If both switches A and B are closed, current will pass through the circuit. Now the lamp is ON and glowing. So y = 1.*



A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

NAND (NOT AND): It gives an output which is opposite of AND gates.

A NAND logic gate is one is logic gate in which an AND gate is followed by a NOT gate.

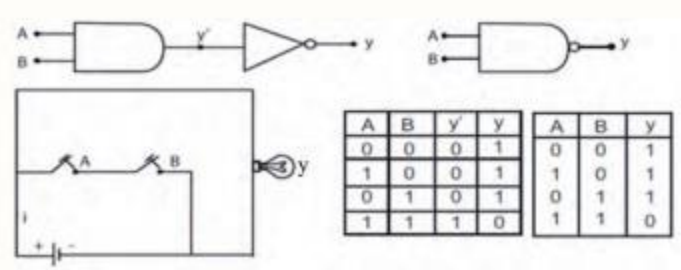
The symbol, equivalent circuit and truth table are shown in Figure

The function of this gate is to invert the output of the AND gate.

It combines the inputs A and B to give the output y, by the following Boolean expression:

Truth Table: is table showing all possible inputs and resulting output produced by particular

$y = A.B$ (5.

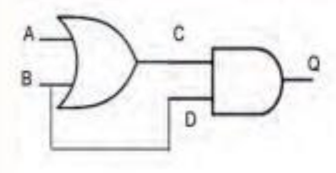


A	B	y'	y
0	0	0	1
1	0	0	1
0	1	0	1
1	1	1	0

A	B	y
0	0	1
1	0	1
0	1	1
1	1	0

Exercise 5.

1 Figure shows a logic circuit and its incomplete truth table. Complete the truth table.



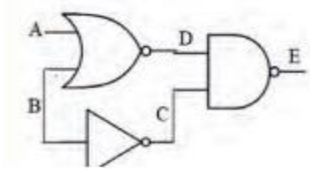
A	B	C	D	Q
0	0			
0	1			
1	0			
1	1			

Ans

A	B	C	D	E
0	0	0	0	0
0	1	1	1	1
1	0	1	0	0
1	1	1	1	1

Exercise 5

Figure shows a logic circuit and its incomplete truth table. Complete the truth table



A	B	C	D	E
0	0			
0	1			
1	0			
1	1			

A	B	C	D	Q
0	0	1	1	0
0	1	0	0	1
1	0	1	0	1
1	1	0	0	1

The truth table of a logic circuit is given in Figure 5.33 (a) and (b). Name the logic circuit..

A	B	C
0	0	1
0	1	1
1	1	1
1	1	0

a)

A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

b)

Ans A) NAND B) NOR

5.7Application of electronics

a few applications of electronics:

- Aerospace industry .
- Medicine
- Automobile
- Agriculture
- Communication .
- Residential
- Military

Aerospace industry used such as

- *Space shuttle,*

- *Satellite power supplies,*
- *aircraft power management*. used to measure different physical factors like temperature, pressure, elevation, etc.

Medical

- ✓ it possible for a doctors to examine patients.
- ✓ Many machines like Xray,
- ✓ MRI and others which are the combination of different physics theorems and electronics..

important of electronics in medical science

- *Robotic Check-Ups,*
- *Needle-Free Diabetes Care,*
- *Electronic Aspirin, etc*.

Automobile Electronics

- ✓ used in road vehicles, such as carputers, telematics, in-car entertainment systems, etc.

The first electronic pieces in cars were used to control engine functions; they were referred to as engine control units. Now, electronics are used in engine, transmission, chassis, active safety, driver assistance, passenger comfort and entertainment systems.

Electronics in Agriculture

- ❖ increase in global warming, many devices and systems are being built to monitor a crops.
- ❖ example, e-Agri Sensors Centre producing sensors to monitor the crop above and below the land.
- ❖ These sensors monitor the crop quality as well as the needs of the crop during growth.
- ❖ used to measuring the moisture level, nutrition level and also salinity of the soil.

Communication

- ☞ Electronic devices and systems are used for the acquisition or acceptance, processing, storage, display, analysis, protection, disposition, and transfer of information.

Residential

There are also various electronic equipment which make our life easy and better.such as

- air conditioner,
- cooking appliances,
- dryer
- personal computer etc.
- . Nowadays mobile phones are used by each and every person.

Military

- Electronics devices and machinery are also widely used in military.
- Unmanned aerial vehicles (UAVs) and drones are some common aerial electronics machines which are used in the military for aerial attack as well as for monitoring.
- used to guns and airplanes which help soldiers to target his enemy
- Magnetic anomaly detector
- Night vision device
- , People sniffer,
- infrared detector and
- night vision camera etc. used by military.

End unit questions

1.What determines whether a semiconductor material, when doped, is an N-type or P-type?

Ans Pure semiconductor materials doped with Group V elements are called N-type semiconductors. Pure semiconductor materials doped with Group III elements are called P-type

2. How does doping support current flow in a semiconductor material?

Ans Semiconductor materials doped with Group V elements have surpulse electrons and these electrons are majority carriers.Semiconductor materials doped with Group III elements have deficiency of electrons or excess of holes. The carriers are holes

3. What is a P-N junction?

Ans When p-type and n-type semiconductors are placed in contact with each other, a p-n junction p-n junction diode is formed.

4. Define a half-wave rectifier and full-wave rectifier

Ans In halfe-wave rectification a half-cycle of an AC voltage waveform to pass by blocking the other half-cycle. A full wave rectifier is a rectifier that converts the complete cycle of alternating current into pulsating DC.

5 How should collector-base and emitter-base junctions be biased?

.Ans The emitter-base junction is forward biased and the collector-base junction is reverse biased.

7. What are transistors used for?

   Ans. The common use of transistor is amplification or switch

8. In which direction does the arrow point on an NPN transistor?

   Ans From the base to emitter

9. To properly bias an NPN transistor, what polarity voltage is applied to the collector, and what is its relationship to the base voltage?

Ans Positive voltage is applied to the collector and the base connected to negative terminal to the base collector voltage.

10. In the NPN transistor, what section is made very thin compared with the other two sections?

   Ans The base region is made very thin

10.What is the name of the device that provides an increase in current, voltage, or power of a signal without appreciably altering the original signal?

. Amplifier

11. In the common emitter transistor amplifier, what is the phase relationship between the input and output signals? *Ans Input and output signals are* 180^0 *out of phase*.

12. What is the current gain for a common-base configuration where IE = 4.2 mA and IC = 4.0 mA?

<u>Solution</u> *Ie= Ic+ Ib*

Ib=Ie- Ic

4.2mA -4mA

Ib= 0.2mA

13. What two symbols are used in digital electronics, to represent a "high" and a "low"? What is this system known as *Ans 0 and 1 logic gate*

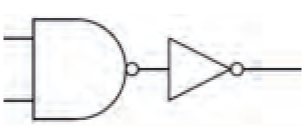
14. What is the difference between a digital signal and an analog signal?

Ans An analog signal is any continuous signal representing some time-varying quantity. A digital signal is a signal that is being used to represent data as a sequence of discrete values.

15. What is a logic gate?

Ans Logic gate is a digital circuit which works according to some logical relationship between input and output voltage. It is a building blocks of digital electronics.

16. Write out the truth table for the circuit shown in Figure . Which single gate is this circuit equivalent to?

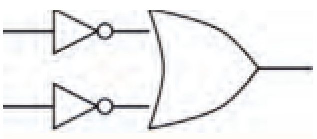


A	B	Y'	Y
0	0	0	1
1	0	0	1
0	1	0	1
1	1	0	0

OR

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

17. Write out the truth table for the circuit shown in Figure . Which single gate is this circuit equivalent to?



A	A'	B	B'	Y
0	1	0	1	1
1	0	1	0	1
0	1	0	1	1
1	0	1	0	0

18. What logical operations are performed by an AND gate and an OR gate?

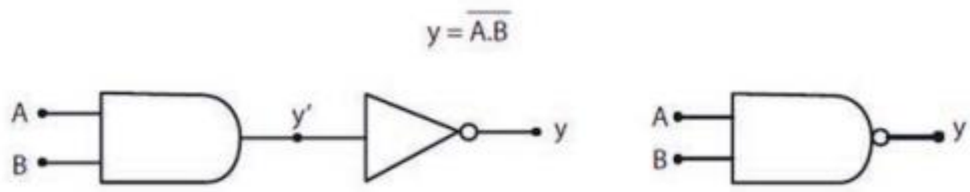
The AND operation is written as multiplication and an OR operation is written as addition.

19. What negative logic and positive logic mean?

Ans In positive logic, the 1 represents: an On circuit, a Closed switch, a High voltage, a Plus sign and a True statement. Consequently, the 0 represents: an Off circuit, a Opened switch, a Low voltage, a Minus sign and a False statement. In Negative logic, the 0 represents: an On circuit, a Closed switch, a High voltage, a Plus sign and a True statement. Consequently, the 1 represents: an Off circuit, a Opened switch, a Low voltage, a Minus sign and a False statement.

20. Draw the symbol for a NAND gate and write the Boolean expression for it.

20. The NAND gate and is Boolean Expression is show as follow.



Chapter:-5 question

1. What property of a diode makes it useful in a rectifier circuit?

2. A diode can be used as a rectifier. What is the function of a rectifier?

3. What is a depletion layer?

4. Explain how a pure semiconductor can be converted into (i) a p-type and (ii) an n-type semiconductor.

5. Distinguish between intrinsic and extrinsic conduction in a semiconductor.

6. What is a semiconductor?

7. Explain how conductivity changes with doping.

8. In n-type semiconductors, number of holes ___number of electrons.

(a) Equal (c) Less than

(b) Greater than (d) Cannot define

9. In p-type semiconductors, number of holes ___number of electrons.

(a) Equal (c) Less than

(b) Greater than (d) Twice

10. A diode will conduct when:

A. the anode is made positive with respect to the cathode

B. the cathode is made positive with respect to the anode

C. the anode and cathode are at exactly the same potential

. 11.When a diode is forward biased it will:

(a) exhibit a very low resistance

(b) exhibit a very high resistance

(c) exhibit no resistance at all.

12. A full-wave rectifier will operate:

(a) only on positive half-cycles of the supply (b) only on negative half-cycles of the supply (c) on both positive and negative half-cycles of the supply

.13.In n-p-n transistor , the base will be

a. P material

b. n material

c. either of the above

d. none

14.A p-n-p transistor has

a. Only accepted ions

b. only donor ions

c. two p-regions and one n-region

15. Which of the following is valid for both p-n-p as well as n-p-n transistor? .

A. the emitter injects holes into the base region

B. the electrons are the minority carriers in the base region.

C. the EB junction is the forward biased for active operation

. D. when a biased in the active region, current flows into their emitter terminal

16 In the symbols of p-n-p transistor and n-p-n transistor the arrow on the emitter shows the direction on the flow of

A. electrons, electrons

C. holes, electrons

B. holes, holes

D. electrons, holes

17 Which of the following is true about p-type semiconductor? It is __.

A. Acceptor

C. Trivalent atom

B. donor

. D. pentavalent atom: select two answer

18 Which of the following is true about n-type semiconductor? It is __

A. Acceptor

C. Trivalent atom

B. donor

D. pentavalent atom: select two answer.

19 Diode is an electrical device uses to rectify an electrical signal. What is the purpose of rectifier? It Converts

A. Ac to dc

C. ac to ac

B. dc to ac

D. electrical energy to mechanical energy

20 The electrical device which used as a switch and amplifier is__

A. Transistor B. resistor C. Diode D. capacitor

21 Not an example for intrinsic semiconductor.

(a) Si (b) Al (c) Ge (d) Sn

22 .Not an example for extrinsic semiconductor.

A. Aluminum C. boron

B. arsenic D. gallium

23.The arrow direction in the diode symbol indicates

a. Direction of electron flow c. Opposite to the direction of hole flow

. b. Direction of hole flow d. None

24 When the diode is forward biased, it is equivalent to

a. An off switch c. A high resistance

b. An On switch d. None of the above

25 Under normal reverse bias voltage applied to diode, the reverse current in Si diode:

a. 100 mA

b. order of μA

c. 1000 μA

d. None

26 Avalanche breakdown in a diode occurs when

a. Potential barrier is reduced to zero. b. Forward current exceeds certain value. c. Reverse bias exceeds a certain value. d. None of these

27 .Reverse saturation current in a Silicon PN junction diode nearly doubles for very

a. 2 0 rise in temp. b. 50 rise in temp. c. 60 rise in temp. d. 100 rise in temp.

28 . When a reverse bias is applied to a diode, it will a. Raise the potential barrier b. Lower the potential barrier c. Increases the majority-carrier a current greatly d. None .

. Answer

1. Allows current to flow in one direction only
2. It converts a.c. to d.c.
3. It is a region with no charge carriers / high resistance.
4. p-type: doped with an element with fewer outer electrons / boron n-type: doped with an element with more outer electrons / phosphorus
5. Intrinsic: pure semiconductor with equal number of electrons & holes. Extrinsic: doped semiconductor with unequal number of electrons & holes
6. Resistivity/conductivity between that of a conductor and an insulator
7. The carrier concentration of intrinsic semiconductors (SC), at room temperature, is very small and hence intrinsic SCs have too low conductivity for practical use.
   The conductivity of intrinsic SC can be increased by a process called Doping.
   Doping: The process of deliberate addition of controlled quantities of impurities to an intrinsic SC is called doping.
   Doping markedly increases the conductivity of a semiconductor
   A doped semiconductor is called an extrinsic semiconductor
   .♣ The concentration of added impurity is normally one part in one million, i.e., impurity atom for every 10^6 intrinsic atoms

   8. Less than

   9. Greater than

10.The anode is made positive with respect to the cathode

11. Exhibit a very low resistance

12. On both positive and negative half-cycles of the supply

. 13. n material

14. . two p-regions and one n-region

15. The EB junction is the forward biased for active operation.

16. holes, electrons

17. A and C 18. Band D 19 A 20. A 21. B 22. D 23. B 24. B 25. B 26 C 27.D 28 A