UNITS OF MEASUREMENT

In order to measure something, you need to define a unit of measurement. "Unit" refers to 1. In this way, all measurements are multiples of that unit. For example, the unit of mass is the kilogram. Thus, the measurement of mass is in multiples-or fractions-of 1 kilogram. Originally, the English unit foot was the length of the King's foot. Thus, a distance of 25 feet was 25 time the foot unit of measurement. Unfortunately, each King had a different sized foot, so that brought about some confusion. Finally, they agreed on a standard length for a foot that would not vary. The units of measurement are defined as standard and do not vary.

THE INTERNATIONAL SYSTEM OF UNITS (SI)

All systems of weights and measures, metric and non-metric, are linked through a network of international agreements supporting the International System of Units. The International System is called the **SI**, using the first two initials of its French name **Système International d'Unités**. The key agreement is the Treaty of the Meter ,signed in **Paris on May 20, 1875**. *The United States is a charter*. At the heart of the SI is a short list of base units defined in an absolute way without referring to any other units. In all there are seven SI base units:

1. **Metre** (m): The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.
2. **kilogram** (kg): The kilogram is the mass of the platinum-iridium prototype which was approved by the Conference Generale des Poids et Mesures, held in Paris in 1889, and kept by the Bureau International des Poids et Mesures.
3. **Second** (s): The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.
4. **Ampere** (A): The ampere is the intensity of a constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2 x 10-7 newton per metre of length.
5. **Kelvin (K):** The kelvin is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water.
6. **Candela** (cd): The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradia
7. **Mole** (mol): The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0,012 kilogram of carbon 12.

Other SI units, called SI **derived units**, are defined algebraically in terms of these fundamental units. For example, the SI unit of force, the **newton**, is defined to be the force that accelerates a mass of one kilogram at the rate of one meter per second per second. Currently there are 22 SI derived units that have special names and symbols. The **radian and steradian** for plane and solid angles, respectively; the **newton** for force and the **pascal for pressure**; the **joule** for energy and the **watt** for power; the degree **Celsius** for everyday measurement of temperature; units for measurement of electricity: the **coulomb** (charge), **volt** (potential), **farad** (capacitance), **ohm** (resistance), and **siemen**s (conductance); units for measurement of magnetism: the **weber** (flux), **tesla** (flux density), and **henry** (inductance);the **lumen** for flux of light and the **lux** for illuminance; the **hertz** for frequency of regular events and the **becquerel** for rates of radioactivity and other random events; the **gray and sievert** for radiation dose; and the **katal**, a unit of catalytic activity used in biochemistry.

Bureau of Indian Standards (BIS)

The National Standards Body has been successfully promoting and nurturing standards movement within the country since 1947. **BIS came into existence on 01 April 1987 through an Act of Parliament dated 26 November 1986**. It took over the staff, assets, liabilities and functions of the erstwhile Indian Standards Institution (ISI) with an enlarged scope and enhanced powers for harmonious development of activities of standardization, marking and quality certification of goods and for matters connected therewith or incidental thereto. Keeping in view, the interest of consumers as well as the industry, BIS is involved in various activities as given below:

a. Standards Formulation
b. Certification : Product, Hallmarking and Systems
c. Foreign Manufacturers Scheme
d. Registration Scheme
e. Testing & Calibration Services
f. Sale of Indian Standards and other publications
g. International Activities
h. I-Care Activities (for consumer and industry)
i. Promotional Activities
j. Training Services
k. Information services
l. Financial: Resources - Mobilization and utilization
m. Trade Facilitation Cell
n. Library Services

AGMARK

Agricultural Marketing Quality Certification Standard is a quality standard for export and domestic trade of agricultural products in India. The certification is a symbol of quality grading all agricultural products for exports and domestic trade and it is effective from the year 1986. The certification is based on the Agricultural Produce (Grading and Marking) Act, 1937 as amended in 1986. Grading for agricultural products are done at the farm level. AGMARK for agri-products acts as a third party guarantee for quality certified. AGMARK certification is specific for different products for example for cereals, pulses, livestock, spices etc.

Gold hallmarks

Hallmarks originated to show the purity of gold in a piece of gold jewellery and included the mark of the assaying office that certified the purity as well as the fineness or caratage of the gold.

Codex Alimentarius

The Codex Alimentarius (Latin for “Book of Food”) is a collection of internationally recognized standards, codes of practice, guidelines and other recommendations relating to foods, food production and food safety.

Its name is derived from the Codex Alimentarius Austriacus. Its texts are developed and maintained by the Codex Alimentarius Commission, a body that was established in early November 1961 by the Food and Agriculture Organization of the United Nations (FAO), was joined by the World Health Organization (WHO) in June 1962. The Commission’s main goals are to protect the health of consumers and ensure fair practices in the international food trade. The Codex Alimentarius is recognized by the World Trade.

■■■

MECHANICS

The motion of objects can be described by words. Even a person without a background in physics has a collection of words that can be used to describe moving objects. Words and phrases such as going fast, stopped, slowing down, speeding up, and turning provide a sufficient vocabulary for describing the motion of objects. In physics, we use these words and many more. We will be expanding upon this vocabulary list with words such as **distance, displacement, speed, velocity, and acceleration**.

Mechanics - Branch of physics that deals with the study of the motion of objects is called as mechanics

Kinematics - is the science of describing the motion of objects using words, diagrams, numbers, graphs, and equations.

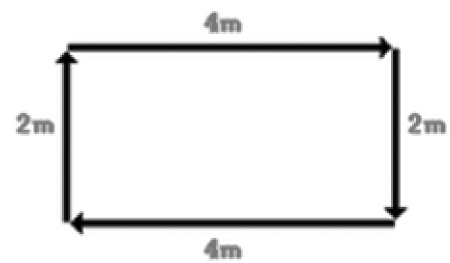
SCALARS AND VECTORS

Scalars are quantities that are fully described by a magnitude (or numerical value) alone. For example distance, speed etc.

Vectors are quantities that are fully described by both a magnitude and a direction. e.g; displacement, velocity, etc.

Distance and Displacement

Distance and displacement are two quantities that may seem to mean the same thing yet have distinctly different definitions and meanings. **Distance** is a scalar quantity that refers to “how much ground an object has covered” during its motion. **Displacement** is a vector quantity that refers to “how far out of place an object is”; it is the object’s overall change in position. Consider the motion depicted in the diagram below. A person walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.



Even though the person has walked a total distance of 12 meters, his displacement is 0 meters. During the course of her motion, he has “covered 12 meters of ground” (distance = 12 m). Yet when he is finished walking, he is not “out of place” - i.e., there is no displacement for his motion (displacement = 0 m). Displacement, being a vector quantity, must give attention to direction. The 4 meters east cancels the 4 meters west; and the 2 meters south cancels the 2 meters north. **Vector quantities such as displacement are direction aware**. *Scalar quantities such as distance are ignorant of direction.* In determining the overall distance traveled by the person, the various directions of motion can be ignored.

Speed and Velocity

Just as distance and displacement have distinctly different meanings (despite their similarities), so do speed and velocity. Speed is a scalar quantity that refers to “how fast an object is moving.” Speed can be thought of as the rate at which an object covers distance. A fast-moving object has a high speed and covers a relatively large distance in a short amount of time. Contrast this to a slow-moving object that has a low speed; it covers a relatively small amount of distance in the same amount of time. An object with no movement at all has a zero speed.

$$\text{Average Speed} = \frac{\text{Distance Traveld}}{\text{Time of Travel}}$$

$$\text{Average Velocity} = \frac{\Delta\,\text{position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

Acceleration

Acceleration is a vector quantity that is defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity. Acceleration has to do with changing how fast an object is moving. If an object is not changing its velocity, then the object is not accelerating. The data at the right are representative of a northward-moving accelerating object. The velocity is changing over the course of time. In fact, the velocity is changing by a constant amount - 10 m/s - in each second of time. Anytime an object's velocity is changing, the object is said to be accelerating; it has an acceleration.

$$\text{Ave. acceleration} = \frac{\Delta\,\text{velocity}}{\text{time}} = \frac{v_f v_i}{t}$$

Force

A force is a push or pull upon an object resulting from the object's interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force. A force is a vector quantity.

All forces (interactions) between objects can be placed into two broad categories:

1. Contact forces, and
2. Forces resulting from action-at-a-distance.

Contact forces are those types of forces that result when the two interacting objects are perceived to be physically contacting each other. Examples of contact forces include frictional forces, tensional forces, normal forces, air resistance forces, and applied forces.

Action-at-a-distance forces are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include gravitational forces. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation.

The Acceleration of Gravity

A free-falling object has an acceleration of 9.8 m/s/s, downward (on Earth). This numerical value for the acceleration of a free-falling object is such an important value that it is given a special name. It is known as the acceleration of gravity - the acceleration for any object moving under the sole influence of gravity. A matter of fact, this quantity known as the acceleration of gravity is such an important quantity that physicists have a special symbol to denote it - the symbol g. **This value (known as the acceleration of gravity) is the same for all free-falling objects regardless of how long they have been falling**, or whether they were initially dropped from rest or thrown up into the air. It must be noted that all objects irrespective of their mass fall due same acceleration due to gravity. **Falling of a piece of stone faster than a piece of paper is due to greater air resistance in case of paper and less for that of stone**. In vacuum all objects fall in the same time irrespective of mass.

Gravity Force

The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object. All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object.

Friction Force

The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - sliding and static friction. Though it is not always the case, the friction force often opposes the motion of an object. For example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together.

Mass and Weight

The force of gravity acting upon an object is referred to as the weight of the object. The mass of an object refers to the amount of matter that is contained by the object; the weight of an object is the force of gravity acting upon that object. Mass is related to how much stuff is there and weight is related to the pull of the Earth (or any other planet) upon that stuff. The mass of an object (measured in kg) will be the same no matter where in the universe that object is located. Mass is never altered by location, the pull of gravity, speed or even the existence of other forces. For example, a 2-kg object will have a mass of 2 kg whether it is located on Earth, the moon, or Jupiter; its mass will be 2 kg whether it is moving or not (at least for purposes of our study); and its mass will be 2 kg whether it is being pushed upon or not. On the other hand, the weight of an object (measured in Newton) will vary according to where in the universe the object is. Weight depends upon which planet is exerting the force and the distance the object is from the planet.

Newton's Law of Universal Gravitation

Newton's law of universal gravitation is about the universality of gravity. Newton's place in the Gravity Hall of Fame is not due to his discovery of gravity, but rather due to his discovery that gravitation is universal. ALL objects attract each other with a force of gravitational attraction. **Gravity is universal**. This force of gravitational attraction is directly dependent upon the masses of both objects and inversely proportional to the square of the distance that separates their centers.

$$F_{grav} \frac{m_1 * m_2}{d^2}$$

where Fgrav represents the force of gravity between two objects

α means "proportional to"

m_1 represents the mass of object 1

m_2 represents the mass of object 2

d represents the distance separating the objects' centers

Centripetal Force

Any motion in a curved path represents accelerated motion, and requires a force directed toward the center of curvature of the path. This force is called the centripetal force which means "center seeking" force. Swinging a mass on a string requires string tension, and the mass will travel off in a tangential straight line if the string breaks. The centripetal acceleration can be derived for the case of circular motion since the curved path at any point can be extended to a circle. Uniform circular motion can be described as the motion of an object in a circle at a constant speed. As an object moves in a circle, it is constantly changing its direction. Because of this direction change, you can be certain that an object undergoing circular motion is accelerating (even if it is moving at constant speed). And in accord with Newton's laws of motion, an accelerating object must be acted upon by an unbalanced force. This unbalanced force is in the same direction as the direction of the acceleration. For objects in uniform circular motion, the net force and subsequent acceleration is directed inwards. Circular motion requires a net inward or "centripetal" force. Without a net centripetal force, an object cannot travel in circular motion. In fact, if the forces are balanced, then an object in motion continues in motion in a straight line at constant speed.

Centrifugal force

When the subject of circular motion is discussed, it is not uncommon to hear mention of the word centrifugal. Centrifugal, not to be confused with centripetal, means away from the center or outward. The use of or at least the familiarity with this word centrifugal, combined with the common sensation of an outward lean when experiencing circular motion, often creates or reinforces a common student misconception. The common misconception, believed by many physics students, is the notion that objects in circular motion are experiencing an outward force. "After all," a well-meaning student may think, "I can recall vividly the sensation of being thrown outward away from the center of the circle on that roller coaster ride. Therefore, circular motion must be characterized by an outward force." This misconception is often fervently adhered to despite the clear presentation by a textbook or teacher of an inward force requirement. The motion of an object in a circle requires that there be an inward net force - the centripetal force requirement. There is an inward-directed acceleration that demands an inward force. Without this inward force, an object would maintain a straight-line motion tangent to the perimeter of the circle. Without this inward or centripetal force, circular motion would be impossible.

Newton's First Law

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

There are many applications of Newton's first law of motion. Consider some of your experiences in an automobile. Have you ever observed the behavior of coffee in a coffee cup filled to the rim while starting a car from rest or while bringing a car to rest from a state of motion? Coffee "keeps on doing what it is doing." When you accelerate a car from rest, the road provides an unbalanced force on the spinning wheels to push the car forward; yet the coffee (that was at rest) wants to stay at rest. While the car accelerates forward, the coffee remains in the same position; subsequently, the car accelerates out from under the coffee and the coffee spills in your lap. On the other hand, when braking from a state of motion the coffee continues forward with the same speed and in the same direction, ultimately hitting the windshield or the dash. Coffee in motion stays in motion. Newton's first law of motion predicts the behavior of objects for which all existing forces are balanced. The first law - sometimes referred to as the law of inertia - states that if the forces acting upon an object are balanced, then the acceleration of that object will be 0 m/s/s. Objects at equilibrium (the condition in which all forces balance) will not accelerate. According to Newton, an object will only accelerate if there is a net or unbalanced force acting upon it

Newton's second law of motion

The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

Newton's second law of motion pertains to the behavior of objects for which all existing forces are not balanced. The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased.

Newton's Third Law

According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body. There are two forces resulting from this interaction - a force on the chair and a force on your body. These two forces are called action and reaction forces and are the subject of Newton's third law of motion. Formally stated, Newton's third law is:

For every action, there is an equal and opposite reaction

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs. Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. Since forces result from mutual interactions, the air must also be pushing the bird upwards. The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly.

Momentum and Impulse Connection

When a sports announcer says that a team has the momentum they mean that the team is really on the move and is going to be hard to stop. The term momentum is a physics concept. Any object with momentum is going to be hard to stop. To stop such an object, it is necessary to apply a force against its motion for a given period of time. The more momentum that an object has, the harder that it is to stop. Thus, it would require a greater amount of force or a longer amount of time or both to bring such an object to a halt. As the force acts upon the object for a given amount of time, the object's velocity is changed; and hence, the object's momentum is changed. You have observed this a number of times if you have watched the sport of football. In football, the defensive players apply a force for a given amount of time to stop the momentum of the offensive player who has the ball.

Momentum: It is a quantity that describes an object's resistance to stopping (a kind of "moving inertia"), represented by the symbol p (boldface),is the product of an object's mass and velocity. It is a vector quantity (since velocity is a vector and mass is a scalar). Momentum uses the SI unit kilogram meter per second [kg m/s].

$$p=m\ v$$

Impulse:- It is a quantity that describes the effect of a net force acting on an object (a kind of "moving force"). Impulse is represented by the symbol J (boldface).It is the product of the average net force acting on an object and its duration.

$$J=F\ \Delta t$$

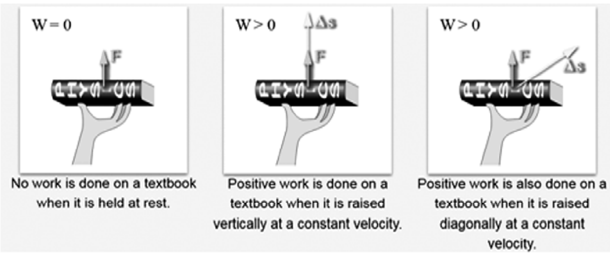
Impulse is the force–time integral. The units of impulse and momentum are equivalent [N s = kg m/s].The impulse–momentum theorem is logically equivalent to Newton's second law of motion (the force law).

Work

When a force acts upon an object to cause a displacement of the object, it is said that work was done upon the object. There are three key ingredients to work - **force, displacement, and cause**. In order for a force to qualify as having done work on an object, there must be a displacement and the force must cause the displacement. There are several good examples of work that can be observed in everyday life - a horse pulling a plow through the field, a father pushing a grocery cart down the aisle of a grocery store, a freshman lifting a backpack full of books upon her shoulder, a weightlifter lifting a barbell above his head, an Olympian launching the shot-put, etc. In each case described here there is a force exerted upon an object to cause that object to be displaced.The Joule is the unit of work.

$$W = F \bullet d \bullet \cos\theta$$

where F is the force, d is the displacement, and the angle (theta) is defined as the angle between the force and the displacement vector.



Potential Energy

An object can store energy as the result of its position. For example, the heavy ball of a demolition machine is storing energy when it is held at an elevated position. This stored energy of position is referred to as potential energy. Similarly, a drawn bow is able to store energy as the result of its position. When assuming its usual position (i.e., when not drawn), there is no energy stored in the bow. Yet when its position is altered from its usual equilibrium position, the bow is able to store energy by virtue of its position. This stored energy of position is referred to as potential energy. Potential energy is the stored energy of position possessed by an object.

The massive ball of a demolition machine and the stretched bow possesses stored energy of position - potential energy.

Kinetic energy

Kinetic energy is the energy of motion. An object that has motion - whether it is vertical or horizontal motion - has kinetic energy. There are many forms of kinetic energy - vibrational (the energy due to vibrational motion), rotational (the energy due to rotational motion), and translational (the energy due to motion from one location to another). To keep matters simple, we will focus upon translational kinetic energy. The amount of translational kinetic energy (from here on, the phrase kinetic energy will refer to translational kinetic energy) that an object has depends upon two variables: the mass (m) of the object and the speed (v) of the object. **Kinetic energy is a scalar quantity;** it does not have a direction. Unlike velocity, acceleration, force, and momentum, the kinetic energy of an object is completely described by magnitude alone. Like work and potential energy, the standard metric unit of measurement for kinetic energy is the Joule.

Power

The quantity work has to do with a force causing a displacement. Work has nothing to do with the amount of time that this force acts to cause the displacement. Sometimes, the work is done very quickly and other times the work is done rather slowly. For example, a rock climber takes an abnormally long time to elevate her body up a few meters along the side of a cliff. On the other hand, a trail hiker (who selects the easier path up the mountain) might elevate her body a few meters in a short amount of time. The two people might do the same amount of work, yet the hiker does the work in considerably less time than the rock climber. The quantity that has to do with the rate at which a certain amount of work is done is known as the power. The hiker has a greater power rating than the rock climber. Power is the rate at which work is done. It is the work/ time ratio. Mathematically, it is computed using the following equation.

$$\text{Power} = \text{Work} / \text{time}$$

Moment of a force

The Moment of a force is a measure of its tendency to cause a body to rotate about a specific point or axis. This is different from the tendency for a body to move, or translate, in the direction of the force. In order for a moment to develop, the force must act upon the body in such a manner that the body would begin to twist. This occurs every time a force is applied so that it does not pass through the centroid of the body. A moment is due to a force not having an equal and opposite force directly along it's line of action. Imagine two people pushing on a door at the doorknob from opposite sides. If both of them are pushing with an equal force then there is a state of equilibrium. If one of them would suddenly jump back from the door, the push of the other person would no longer have any opposition and the door would swing away. The person who was still pushing on the door created a moment. Elements of a Momenta column with an offset load which creates a moment. The magnitude of the moment of a force acting about a point or axis is directly proportional to the distance of the force from the point or axis. It is defined as the product of the force (F) and the moment arm (d). The moment arm or lever arm is the perpendicular distance between the line of action of the force and the center of moments.

Moment = Force x Distance or M = (F)(d)

The Center of Moments may be the actual point about which the force causes rotation. It may also be a reference point or axis about which the force may be considered as causing rotation. It does not matter as long as a specific point is always taken as the reference point. The latter case is much more common situation in structural design problems.

Centre of gravity

The point from which the weight of the body acts, i.e., the point at which if the entire mass of the body is assumed to be concentrated, the gravitational force acting on the body remains the same or The point at which if the entire mass of the body is assumed to be concentrated, the gravitational potential energy of the body remains the same or The point at which if the entire mass of the body is assumed to be concentrated, the gravitational torque acting on the body about the origin remains the same.

The position of the centre of gravity of an object affects its stability. The lower the centre of gravity (G) is, the more stable the object. The higher it is the more likely the object is to topple over if it is pushed. Racing cars have really low centres of gravity so that they can corner rapidly without turning over. The center of gravity is a geometric property of any object. The center of gravity is the average location of the weight of an object. We can completely describe the motion of any object through space in terms of the translation of the center of gravity of the object from one place to another, and the rotation of the object about its center of gravity if it is free to rotate. If the object is confined to rotate about some other point, like a hinge, we can still describe its motion. In flight, both airplanes and rockets rotate about their centers of gravity. A kite, on the other hand, rotates about the bridle point. But the trim of a kite still depends on the location of the center of gravity relative to the bridle point, because for every object the weight always acts through the center of gravity.

Density

Density is the mass per unit volume. This means that the density of any solid, liquid or gas can be found by dividing its mass in kilograms by its volume in cubic metres. Density can be found using the equation:

Density = {mass \over volume}   P = {m \over v}

The unit for density is kg m-3.The density of water is approximately 1000 kg m-3 and air is approximately 1.3 kg m-3.When most substances change from a solid state to a liquid state their volume does not change much. This is because the particles stay approximately the same distance apart. This means that the density of a substance, say iron, does not change by much when it melts.

Specific gravity

The term specific gravity, symbolized sp gr, refers to the ratio of the density of a solid or liquid to the density of water at 4 degrees Celsius. The term can also refer to the ratio of the density of a gas to the density of dry air at standard temperature and pressure, although this specification is less often used. Specific gravity is a dimensionless quantity; that is, it is not expressed in units. To find the sp gr of a solid or liquid, you must know its density in kilograms per meter cubed (kg/m3) or in grams per centimeter cubed (g/cm3). Then, divide this density by the density of pure water in the same units. If you use kg/m3, divide by 1000. If you use g/cm3, divide by 1 (that is, leave the number alone). It is important to use the same units in the numerator and denominator. The difference between density and specific gravity is that one is a ratio of the other. Specific gravity is a measure of density relative to the density of a reference substance.The reference material could be anything, but the most common reference is pure water. One example is salt water aquarium enthusiasts measure the amount of salt in their water by specific gravity where their reference material is fresh water.

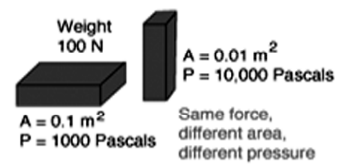
Buoyancy

When an object is placed in a fluid, the fluid exerts an upward force we call the buoyant force. The buoyant force comes from the pressure exerted on the object by the fluid. Because the pressure increases as the depth increases, the pressure on the bottom of an object is always larger than the force on the top - hence the net upward force. The symbol for the magnitude of buoyancy is B or FB.As a vector it must be stated with both magnitude and direction. Buoyancy acts upward for the kind of situations encountered in everyday experience .As with other forces, the SI unit of buoyancy is the newton [N].Buoyancy is caused by differences in pressure acting on opposite sides of an object immersed in a static fluid. The factors that affect buoyancy are , the density of the fluid, the volume of the fluid displaced, and the local acceleration due to gravity. The buoyant force is not affected by the mass of the immersed object or the density of the immersed object. Objects immersed in a fluid have an apparent weight that is reduced by the buoyant force (less than their actual weight).The buoyant force is present the object floats or sinks. It is due to this force this force that a heavy ship floats and a needle of negligible weight sinks.

Pressure

Pressure is defined as force per unit area. It is usually more convenient to use pressure rather than force to describe the influences upon fluid behavior. The standard unit for pressure is the Pascal, which is a Newton per square meter. Pressure can also be measured in atmospheres, bars, inches of mercury, millimeters of mercury, or Torr. When pressure is measured by a gauge, the quantity obtained usually excludes the ambient atmospheric pressure and is therefore called overpressure. Pressure is measured by an instrument called **manometer.**

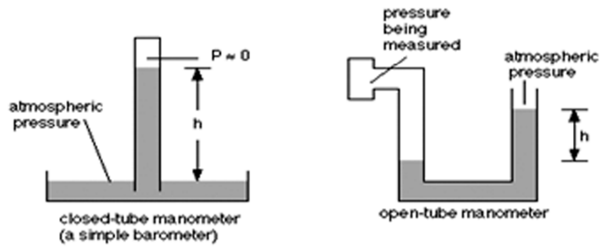
$$Pressure = \frac{Force}{Area} = \frac{F}{A}$$



Atmospheric pressure

Atmospheric pressure is the pressure exerted at the surface of a body by a column of air in an atmosphere. The pressure varies both with altitude, and weather patterns. Standard is an average atmospheric pressure at sea level, and is defined as 1 atmosphere on Earth, equal to 760 millimeters of mercury (760 Torr) and 101,325 Pascals. Atmospheric pressure is measured by Barometer.

A standard mercury barometer is a closed-tube manometer, with one end sealed. The sealed end is close to zero pressure, while the other end is open to the atmosphere, or is connected to where the pressure is being measured. Because there is a pressure difference between the two ends of the tube, a column of fluid can be maintained in the tube, with the height of the column proportional to the pressure difference. If the closed end is at zero pressure, then the height of the column is proportional to the pressure at the other end.



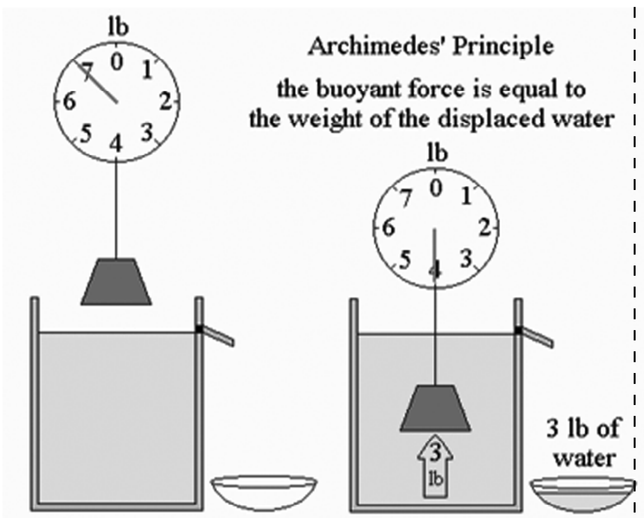
Law of Flotation/Archimedes' Principle

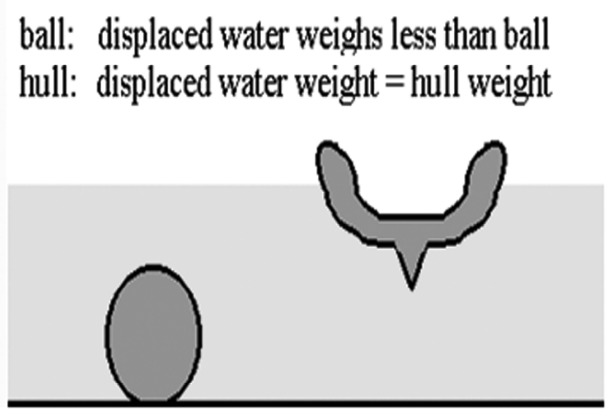
Have you ever wondered what causes things to float on water or liquid? Well, floating is caused by an up thrust force that act on the material and interestingly there's a LAW that governs whether an object floats or not it is called the LAW of Flotation. "Law of flotation is an application of Archimedes' principle".

When a piece of wood of density more than water is placed on water, it sinks and displaces some water. As it sinks, more and more water is displaced. This increases the buoyant force as the buoyant force is equal to the weight of water displaced. The wood will sink until the buoyant force equal its weight. Therefore, The law of flotation states that a floating object displaces its own weight of the fluid in which it floats .i.e. Weight of floating object= weight of fluid displaced

Mass of floating object = mass of fluid displaced

Any changes in the density of the surrounding liquid affects the level in which an object floats. Thus, you have to remember that an object will DISPLACE the amount of water or liquid that is equal to its own mass in order to float.





Matter

Matter has many definitions, but the most common is that it is any substance which has mass and occupies space. All physical objects are composed of matter, in the form of atoms, which are in turn composed of protons, neutrons, and electrons.Photons have no mass, so they are an example of something in physics is not comprised of matter. They are also not considered "objects" in the in the traditional sense, as they cannot exist in a stationary state.Matter is a substance that has inertia and occupies physical space. According to modern physics, matter consists of various types of particles, each with mass and size.The most familiar examples of material particles are the electron, the proton and the neutron. Combinations of these particles form atoms. There are more than 100 different kinds of atoms, each kind constituting a unique chemical element. A combination of atoms forms a molecule. Atoms and/or molecules can join together to form a compound.

Phases of Matter

There are four states of matter: solid, liquid, gas, and plasma.

1. Solids

A solid is in a state of matter that maintains a fixed volume and shape. A solid's particles fit closely together. The forces between the particles are so strong that the particles can not move freely; they can only vibrate. This causes a solid to be a stable, non-compressible shape with definite volume.

2. Liquids

A liquid maintains a fixed volume, but its shape will mold to the shape of the container it is being held in. In , you can see that even though the liquid's shape is determined by the container, it has a free surface that is not controlled by the container. The particles are close together but not as close as in solids; they are still able to move around, which causes the liquid to flow. Liquids usually have a higher volume than their solid counterparts, except for certain molecules, such as H_2O (water).

3. Gases

whose particles move around a lot and are much farther apart from each other, usually farther apart than the diameter of the particles themselves. The gas behaves like a liquid; the particles are moving but are still attracted to each other, so they still flow. Unlike a solid or a liquid, the gas will try to fill whatever container it is in, adapting its volume accordingly.

4. Plasma

Plasma is a gas that has been ionized. That is to say, sufficient energy has been supplied to the gas such that the electrons have enough energy to escape their atoms or molecules. Plasma contains ions and electrons that can move around freely. Matter in the plasma state has variable volume and shape. Plasma is the most common form of visible matter in the universe. Lightning, sparks, neon lights, and the sun are all examples of matter in the plasma state.

Fluid

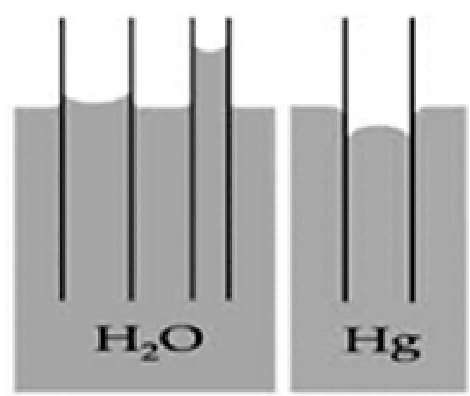
A fluid is a substance that continually deforms (flows) under an applied shear stress. Fluids are a subset of the states of matter and include three of the four states—liquids, gases, and plasma. Fluids display properties such as:

(a) not resisting deformation or resisting it only lightly (viscosity), and

(b) the ability to flow (also described as the ability to take on the shape of the container).

Capillarity

Capillarity, rise or depression of a liquid in a small passage such as a tube of small cross-sectional area, like the spaces between the fibers of a towel or the openings in a porous material. Capillarity is not limited to the vertical direction. Water is drawn into the fibres of a towel, no matter how the towel is oriented. Liquids that rise in small-bore tubes inserted into the liquid are said to wet the tube, whereas liquids that are depressed within thin tubes below the surface of the surrounding liquid do not wet the tube. Water is a liquid that wets glass capillary tubes; mercury is one that does not. When wetting does not occur, capillarity does not occur. Capillarity is the result of surface, or interfacial, forces. The rise of water in a thin tube inserted in water is caused by forces of attraction between the molecules of water and the glass walls and among the molecules of water themselves. These attractive forces just balance the force of gravity of the column of water that has risen to a characteristic height. The narrower the bore of the capillary tube, the higher the water rises. Mercury, conversely, is depressed to a greater degree, the narrower the bore.



Viscosity

Viscosity is a measurement of how resistant a fluid is to attempts to move through it. A fluid with a low viscosity is said to be "thin," while a high viscosity fluid is said to be "thick." It is easier to move through a low viscosity fluid (like water) than a high viscosity fluid (like honey). Viscosity has the SI units Pascal seconds (Pa s) which is called the Poiseuille.

Surface tension

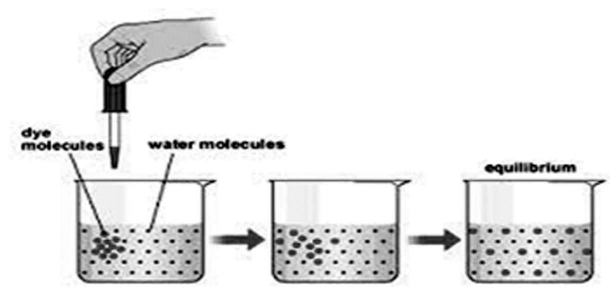
Surface tension is a phenomenon in which the surface of a liquid, where the liquid is in contact with gas, acts like a thin elastic sheet. This term is typically used only when the liquid surface is in contact with gas (such as the air). If the surface is between two liquids (such as water and oil), it is called "interface tension. "Various intermolecular forces, such as Van der Waals forces, draw the liquid particles together. Along the surface, the particles are pulled toward the rest of the liquid. Surface tension (denoted with the Greek variable gamma) is defined as the ratio of the surface force F to the length d along which the force acts: Units of Surface Tension Surface tension is measured in SI units of N/m (newton per meter), although the more common unit is the cgs unit dyn/cm (dyne per centimeter). Examples of Surface Tension.

Osmotic Pressure

The pressure that would have to be applied to a pure solvent to prevent it from passing into a given solution by osmosis, often used to express the concentration of the solution. Osmosis is a selective diffusion process driven by the internal energy of the solvent molecules. It is convenient to express the available energy per unit volume in terms of "osmotic pressure". It is customary to express this tendency toward solvent transport in pressure units relative to the pure solvent. If pure water were on both sides of the membrane, the osmotic pressure difference would be zero. But if normal human blood were on the right side of the membrane, the osmotic pressure would be about seven atmospheres! This illustrates how potent the influence of osmotic pressure is for membrane transport in living organisms.

Diffusion

Diffusion refers to the process by which molecules intermingle as a result of their kinetic energy of random motion. Consider two containers of gas A and B separated by a partition. The molecules of both gases are in constant motion and make numerous collisions with the partition. If the partition is removed as in the lower illustration, the gases will mix because of the random velocities of their molecules. In time a uniform mixture of A and B molecules will be produced in the container. The tendency toward diffusion is very strong even at room temperature because of the high molecular velocities associated with the thermal energy of the particles.



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HEAT

TEMPERATURE AND KINETIC THEORY

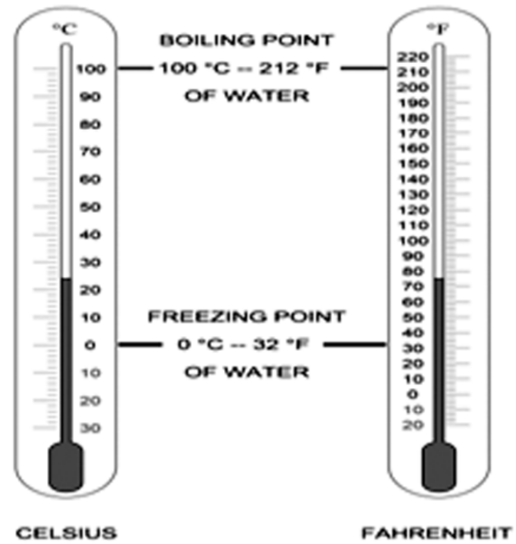
The kinetic theory of gases describes a gas as a large number of small particles (atoms or molecules), all of which are in constant, random motion. The rapidly moving particles constantly collide with each other, and with the walls of the container. Kinetic theory explains macroscopic properties of gases (such as pressure, temperature, and volume) by considering their molecular composition and motion. Essentially, the theory posits that pressure is due not to static repulsion between molecules (as was Isaac Newton's conjecture) but rather due to collisions between molecules moving at different velocities through Brownian motion. Also, the temperature of an ideal monatomic gas is a measure of the average kinetic energy of its atoms. The kinetic theory of gases uses the model of the ideal gas to relate temperature to the average translational kinetic energy of the molecules in a container of gas in thermodynamic equilibrium.

UNITS OF MEASUREMENT OF TEMPERATURE

1. Celsius, or centigrade scale

Celsius, or centigrade, is a scale and unit of measurement for temperature. It is one of the most commonly used temperature units. From 1743 until 1954, 0°C was defined as the freezing point of water, and 100°C was defined as the boiling point of water, both at a pressure of one standard atmosphere, with mercury as the working material. The Celsius scale are currently defined by two different temperatures: absolute zero and the triple point of Vienna Standard Mean Ocean Water (VSMOW; specially purified water). The temperature of the triple point of water is defined as precisely 273.16K and 0.01°C.

TCelsius = TKelvin–273.15.



2. Fahrenheit scale

The Fahrenheit scale measures temperature. It is based on a scale proposed in 1724 by physicist Daniel Gabriel Fahrenheit (1686-1736). The unit of this scale is the degree Fahrenheit (°F). On this scale, water's freezing point is defined to be 32 degrees, while water's boiling point is defined to be 212 degrees.

TCelsius=59(TFahrenheit–32)

3. Kelvin scale

The kelvin is a unit of measurement for temperature. It is one of the seven base units in the International System of Units (SI) and is assigned the unit symbol K. The Kelvin scale is named after Glasgow University engineer and physicist William Thomson, 1st Baron Kelvin (1824-1907) Unlike the degree Fahrenheit and the degree Celsius, the kelvin is not referred to or typeset as a degree. The kelvin is the primary unit of measurement in the physical sciences, but it is often used in conjunction with the degree Celsius, which has the same magnitude. The kelvin is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water (exactly 0.01°C, or 32.018°F). To convert kelvin to degrees Celsius, we use the following formula:

TCelsius = TKelvin–273.15

Absolute zero: Absolute zero is the coldest possible temperature. Formally, it is the temperature at which entropy reaches its minimum value. To be precise, a system at absolute zero still possesses quantum mechanical zero-point energy, the energy of its ground state. The zero point of a thermodynamic temperature scale, such as the Kelvin scale, is set at absolute zero. By international agreement, absolute zero is defined as 0K on the Kelvin scale and as -273.15° on the Celsius scale (equivalent to -459.67° on the Fahrenheit scale). Scientists have brought systems to temperatures very close to absolute zero, at which point matter exhibits quantum effects such as superconductivity and superfluidity. The lowest temperature that has been achieved in the laboratory is in the 100 pK range, where pK (pico-Kelvin) is equivalent to 10-12 K. The lowest natural temperature ever recorded is approximately 1K, observed in the rapid expansion of gases leaving the Boomerang Nebula.

HEAT AS ENERGY TRANSFER

Heat is the spontaneous transfer of energy due to a temperature difference. If two objects at different temperature are brought together, energy will transfer from the hotter object to the cooler one until both are at the same temperature. This transfer of energy is known as heat. Heat should not be confused with temperature. Temperature describes the internal state of an object, while heat refers to the energy transferred to or from the object. Since heat is a form of energy, its SI unit is the joule. Owing to the fact that heat is a form of energy, it has the SI unit of joule (J). The calorie (cal) is a common unit of energy, defined as the energy needed to change the temperature of 1.00 g of water by 1.00°C —specifically, between 14.5°C and 15.5°C, since there is a slight temperature dependence.

HEAT CAPACITY

Heat capacity is the measurable physical quantity that characterizes the amount of heat required to change a substance's temperature by a given amount. It is measured in joules per Kelvin .The heat capacity is an extensive property, scaling with the size of the system. The heat capacity of most systems is not constant (though it can often be treated as such). It depends on the temperature, pressure, and volume of the system under consideration. In SI units, heat capacity is expressed in units of joules per kelvin (J/K).

LATENT HEAT

The latent heat is the energy associated with a phase change of a substance. Energy is required to change the phase of a substance, such as the energy to break the bonds between molecules in a block of ice so it may melt. During a phase change energy may be added or subtracted from a system, but the temperature will not change. The temperature will change only when the phase change has completed.

SPECIFIC HEAT

The specific heat is an intensive property that describes how much heat must be added to a particular substance to raise its temperature. Unlike the total heat capacity, the specific heat capacity is independent of mass or volume. It describes how much heat must be added to a unit of mass of a given substance to raise its temperature by one degree Celsius. The units of specific heat capacity are J/(kg°C) or equivalently J/(kg K).

CALORIMETRY

Calorimetry is the measurement of the heat of chemical reactions or physical changes. A calorimeter is used to measure the heat generated (or absorbed) by a physical change or chemical reaction. The science of measuring these changes is known as calorimetry. In order to do calorimetry, it is crucial to know the specific heats of the substances being measured.

Calorimetry can be performed under constant volume or constant pressure.

TRANSFER OF HEAT

1. Conduction

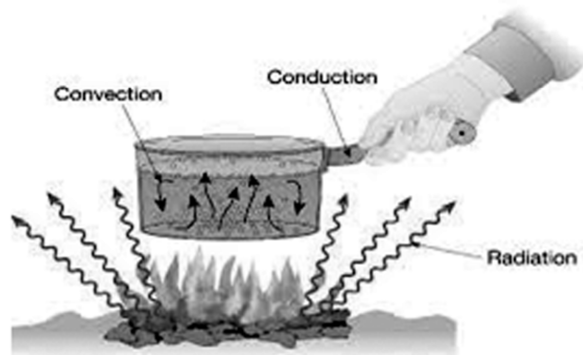
Conduction is the transfer of heat through physical contact. On a microscopic scale, conduction occurs as rapidly moving or vibrating atoms and molecules interact with neighboring particles, transferring some of their kinetic energy. Conduction is the most significant form of heat transfer within a solid object or between solids in thermal contact. The rate of heat transfer by conduction is dependent on the temperature difference, the size of the area in contact, the thickness of the material, and the thermal properties of the material(s) in contact.

2. Convection

Convection is the heat transfer by the macroscopic movement of a fluid, such as a car's engine kept cool by the water in the cooling system. Convection is driven by the large scale flow of matter in fluids. Solids cannot transport heat through convection. Natural convection is driven by buoyant forces: hot air rises because density decreases as temperature increases. This principle applies equally with any fluid. Convection can transport heat much more efficiently than conduction. Air is a poor conductor and a good insulator if the space is small enough to prevent convection.

3. Radiation

Radiation is the transfer of heat through electromagnetic energy.The energy of electromagnetic radiation depends on the wavelength (color) and varies over a wide range: a smaller wavelength (or higher frequency) corresponds to a higher energy. All objects emit and absorb electromagnetic energy. The color of an object is related emissivity, or its efficiency of radiating away energy. Black is the most effective while white is the least effective (e=1 and e=0, respectively). An ideal radiator, often called a blackbody, is the same color as an ideal absorber and captures all the radiation that falls on it.



HEAT TRANSFER

All objects absorb and emit electromagnetic radiation. The rate of heat transfer by radiation is largely determined by the color of the object. Black is the most effective, and white the least. People living in hot climates generally avoid wearing black clothing, for instance. Similarly, black asphalt in a parking lot will be hotter than the adjacent gray sidewalk on a summer day, because black absorbs better than gray. The reverse is also true—black radiates better than gray. Thus, on a clear summer night the asphalt will be colder than the gray sidewalk because black radiates energy more rapidly than gray.

EVAPORATION

Evaporation is the process of molecules on a liquid's surface achieving sufficient energy to break free of the liquid and become gas.Evaporation turns liquids into gas.Evaporation can take place at temperatures below boiling point since the molecules in the liquid have different energies. As the molecules in a liquid collide, some achieve higher energies, allowing them to escape. This process lowers the energy of the remaining molecules and is the source of cooling in evaporating liquids.Evaporation is a type of vaporization of a liquid that only occurs on the liquid's surface. Usually, the molecules in a glass of water do not have enough heat energy to escape from the liquid. With sufficient heat, however, the liquid would quickly turn into vapor. When the molecules collide, they transfer energy to each other in varying degrees. Sometimes the transfer is so one-sided for a molecule near the surface that it achieves enough energy to escape the liquid.

LAWS OF THERMODYNAMICS

The First Law: The 1st law of thermodynamics states that internal energy change of a system equals net heat transfer minus net work done by the system. The first law of thermodynamics is a version of the law of conservation of energy, specialized for thermodynamical system. In equation form, the first law of thermodynamics is

$$\Delta U = Q - W.$$

Heat engines are a good example of the application of the 1st law; heat transfer into them takes place so that they can do work.

Second law of thermodynamics: The second law of thermodynamics states that heat transfer occurs spontaneously only from higher to lower temperature bodies. Many processes occur spontaneously in one direction only, and the second law of thermodynamics deals with the direction taken by spontaneous processes.According to the second law of thermodynamics, it is impossible for any process to have heat transfer from a cooler to a hotter object as its sole result.

Third Law: According to the third law of thermodynamics, the entropy of a perfect crystal at absolute zero is exactly equal to zero. At zero kelvin the system must be in a state with the minimum possible energy, thus this statement of the third law holds true if the perfect crystal has only one minimum energy state. Entropy is related to the number of possible microstates, and with only one microstate available at zero kelvin the entropy is exactly zero.

ENTROPY

The entropy of a system is a measure of its disorder and of the unavailability of energy to do work.Entropy is a property of state. Therefore, the change in entropy ΔS of a system between two states is the same no matter how the change occurs.The total change in entropy for a system in any reversible process is zero.

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WAVE

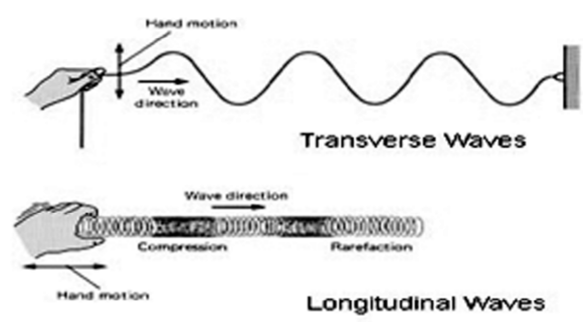
WAVE

Wave motion transfers energy from one point to another, usually without permanent displacement of the particles of the medium. A wave can be thought of as a disturbance or oscillation that travels through space-time, accompanied by a transfer of energy. The direction a wave propagates is perpendicular to the direction it oscillates for transverse waves. A wave does not move mass in the direction of propagation; it transfers energy.

A wave can be transverse or longitudinal depending on the direction of its oscillation. Transverse waves occur when a disturbance causes oscillations perpendicular (at right angles) to the propagation (the direction of energy transfer). Longitudinal waves occur when the oscillations are parallel to the direction of propagation. While mechanical waves can be both transverse and longitudinal, all electromagnetic waves are transverse. Sound, for example, is a longitudinal wave.

TRANSVERSE WAVES

A transverse wave is a moving wave that consists of oscillations occurring perpendicular (or right angled) to the direction of energy transfer. If a transverse wave is moving in the positive x-direction, its oscillations are in up and down directions that lie in the y–z plane. Light is an example of a transverse wave. For transverse waves in matter, the displacement of the medium is perpendicular to the direction of propagation of the wave. A ripple on a pond and a wave on a string are easily visualized transverse waves.



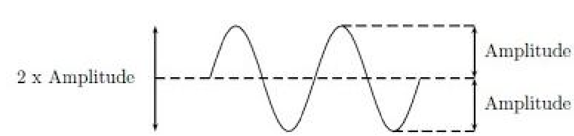
LONGITUDINAL WAVES

Longitudinal waves have the same direction of vibration as their direction of travel. This means that the movement of the medium is in the same direction as the motion of the wave. Some longitudinal waves are also called compressional waves or compression waves. An easy experiment for observing longitudinal waves involves taking a Slinky and holding both ends. After compressing and releasing one end of the Slinky (while still holding onto the end), a pulse of more concentrated coils will travel to the end of the Slinky .

Characteristics of Waves

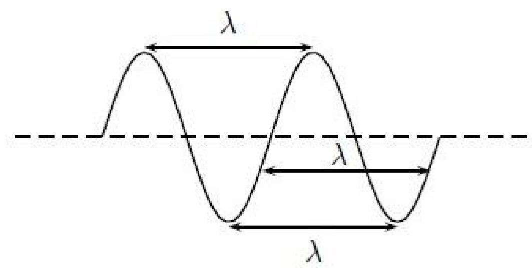
Amplitude

The characteristic height of a peak and depth of a trough is called the amplitude of the wave. The vertical distance between the bottom of the trough and the top of the peak is twice the amplitude. The units of amplitude are metres (m).



Wavelength

Look a little closer at the peaks and the troughs. The distance between two adjacent (next to each other) peaks, This distance which is a characteristic of the wave is called the wavelength.Waves have a characteristic wavelength. The units are metres (m).



The wavelength is the distance between any two adjacent points which are **in phase**. Two points in phase are separate by an integer (0,1,2,3,...) number of complete wave cycles. They don't have to be peaks or trough but they must be separated by a complete number of waves.

Period

The time between two adjacent peaks is same and also the time between two adjacent troughs always the same, no matter which two adjacent troughs you pick. The time you have been measuring is the time for one wavelength to pass by. We call this time the period and it is a characteristic of the wave.

Waves have a characteristic time interval which we call the period of the wave and denote with the symbol T. It is the time it takes for any two adjacent points which are in phase to pass a fixed point. The units are seconds (s).

Frequency

There is another way of characterising the time interval of a wave. We timed how long it takes for one wavelength to pass a fixed point to get the period. We could also turn this around and say how many waves go by in 1 second.

We can easily determine this number, which we call the frequency and denote f. To determine the frequency, how many waves go per second, we work out what fraction of a waves goes by in 1 second by dividing 1 second by the time it takes T. The unit of frequency is the Hz.

Waves have a characteristic frequency. F=1/T

Speed

Now if you are watching a wave go by you will notice that they move at a constant velocity. The speed is the distance you travel divided by the time you take to travel that distance. This is excellent because we know that the waves travel a distance equal to wavelength in a time T.

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ELECTROMAGNETIC RADIATION

WIRELESS COMMUNICATION

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor. The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g., radio transmitters and receivers, remote controls, etc.) that use some form of energy (e.g., radio waves, acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances. Wireless operations permit services, such as long-range communications, that are otherwise impossible (or impractical) to implement with the use of wires.

TYPES OF RADIO WAVES AND APPLICATIONS

Radio waves have many uses—the category is divided into many subcategories, including **microwaves** and **electromagnetic waves used for AM and FM radio, cellular telephones and TV**. The lowest commonly encountered radio frequencies are produced by **high-voltage AC power transmission** lines at frequencies of 50 or 60 Hz. These extremely long wavelength electromagnetic waves (about 6000 km) are one means of energy loss in long-distance power transmission. **Extremely low frequency (ELF) radio waves** of about 1 kHz are used to communicate with submerged submarines. The ability of radio waves to penetrate salt water is related to their wavelength (much like ultrasound penetrating tissue)—**the longer the wavelength**, the farther they penetrate. Since salt water is a good conductor, radio waves are strongly absorbed by it; very long wavelengths are needed to reach a submarine under the surface.

AM Radio Waves

AM radio waves are used to carry commercial radio signals in the frequency range from 540 to 1600 kHz . The abbreviation **AM stands for amplitude modulation**—the method for placing information on these waves. A carrier wave having the basic frequency of the radio station (for instance, 1530 kHz) is varied or modulated in amplitude by an audio signal. The resulting wave has a constant frequency, but a varying amplitude.

FM Radio Waves

FM radio waves are also used for commercial radio transmission, but in the frequency range of 88 to 108 MHz . **FM stands for frequency modulation**, another method of carrying information. In this case, a carrier wave having the basic frequency of the radio station (perhaps 105.1 MHz) is modulated in frequency by the audio signal, producing a wave of constant amplitude but varying frequency.FM radio is inherently less subject to noise from stray radio sources than AM radio because amplitudes of waves add noise. Thus, an AM receiver would interpret noise added onto the amplitude of its carrier wave as part of the information. An FM receiver can be fashioned to reject amplitudes other than that of the basic carrier wave and only look for variations in frequency. Thus, since noise produces a variation in amplitude, it is easier to reject noise from FM.

TV

Electromagnetic waves also broadcast television transmission. However, as the waves must carry a great deal of visual as well as audio information, each channel requires a larger range of frequencies than simple radio transmission. TV channels utilize frequencies in the range of 54 to 88 MHz and 174 to 222

MHz (the entire FM radio band lies between channels 88 MHz and 174 MHz). These TV channels are called VHF (very high frequency). Other channels called UHF (ultra high frequency) utilize an even higher frequency range of 470 to 1000 MHz.The TV video signal is AM, while the TV audio is FM. Note that these frequencies are those of free transmission with the user utilizing an old-fashioned roof antenna. Satellite dishes and cable transmission of TV occurs at significantly higher frequencies, and is rapidly evolving with the use of the high-definition or HD format.

Microwaves

Microwaves are radio waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently with frequencies between 300 MHz (0.3 GHz) and 300 GHz. The microwave region of the electromagnetic (EM) spectrum is generally considered to overlap with the highest frequency (shortest wavelength) radio waves. As is the case for all EM waves, microwaves travel in a vacuum at the speed of light. The prefix “micro-” in “microwave” is not meant to suggest a wavelength in the micrometer range. It indicates that microwaves are “small” because have shorter wavelengths as compared to waves used in typical radio broadcasting. The boundaries between far infrared light, terahertz radiation, microwaves, and ultra-high-frequency radio waves are fairly arbitrary. They are used variously between different fields of study.

Infrared Waves

Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 0.74 micrometers (μm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 300 GHz to 400 THz, and includes most of the thermal radiation emitted by objects near room temperature. Infrared light is emitted or absorbed by molecules when they change their rotational-vibrational movements.

Ultraviolet Light

Ultraviolet (UV) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays, that is, in the range 10 nm to 400 nm. It is so-named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet. These frequencies are invisible to humans, but visible to a number of insects and birds.

Harmful Effects: An overexposure to UVB radiation can cause sunburn and some forms of skin cancer. In humans, prolonged exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye, and immune system. Moreover, UVC can cause adverse effects that can variously be mutagenic or carcinogenic.

Beneficial Effects: UVB exposure induces the production of vitamin D in the skin. The majority of positive health effects are related to this vitamin. It has regulatory roles in calcium metabolism (which is vital for normal functioning of the nervous system, as well as for bone growth and maintenance of bone density), immunity, cell proliferation, insulin secretion, and blood pressure.

X-Rays

X-rays are electromagnetic waves with wavelengths in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×1016 Hz to 3×1019 Hz) and energies in the range 100 eV to 100 keV. They are shorter in wavelength than UV rays and longer than gamma rays. In many languages, X-radiation is called Röntgen radiation, after Wilhelm Röntgen, who is usually credited as its discoverer, and who had named it X-radiation to signify an unknown type of radiation.

Gamma Rays

Gamma radiation, also known as gamma rays or hyphenated as gamma-rays and denoted as γ, is electromagnetic radiation of high frequency and therefore high energy. Gamma rays typically have frequencies above 10 exahertz (or >1019 Hz), and therefore have energies above 100 keV and wavelengths less than 10 picometers (less than the diameter of an atom). However, this is not a hard and fast definition, but rather only a rule-of-thumb description for natural processes. Gamma rays from radioactive decay are defined as gamma rays no matter what their energy, so that there is no lower limit to gamma energy derived from radioactive decay. Gamma decay commonly produces energies of a few hundred keV, and almost always less than 10 MeV.

RADIOACTIVITY

Radioactivity refers to the particles which are emitted from nuclei as a result of nuclear instability. Radioactive decay occurs in unstable atomic nuclei – that is, ones that don't have enough binding energy to hold the nucleus together due to an excess of either protons or neutrons. The most common types of radiation are called alpha, beta, and gamma radiation, but there are several other varieties of radioactive decay.

Radioactive decay rates are normally stated in terms of their half-lives, and the half-life of a given nuclear species is related to its radiation risk. The different types of radioactivity lead to different decay paths which transmute the nuclei into other chemical elements. Examining the amounts of the decay products makes possible radioactive dating.

Though the most massive and most energetic of radioactive emissions, the alpha particle is the shortest in range because of its strong interaction with matter. The electromagnetic gamma ray is extremely penetrating, even penetrating considerable thicknesses of concrete. The electron of beta radioactivity strongly interacts with matter and has a short range.

The amount of radiation absorbed by non-biological matter is measured in **grays**, a unit equivalent to a joule of energy per kilogram of mass. For biological tissue, a dose equivalent is measured in **sieverts** (Sv) depending on the type of radiation involved and how much damage that radiation does to the particular cells affected.

HALF OF A LIFE

When a radioactive nucleus changes, the remaining nucleus (and atom) is not the same as it was. It changes its identity. The term half-life describes the time it takes for half of the atoms in a sample to change, and half to remain the same. Let's say you have 100g of uranium (don't try this at home, it's radioactive). When 50g remain (and 50g have become something different), the amount of time that has passed is the half-life. Every element has its own unique half-life. The half-life of uranium-235 is 713,000,000 years. The half-life of uranium-238 is 4,500,000,000 years. That is a long time to wait for radioactive atoms to change, and many of the things that the original atoms change into are ALSO radioactive and dangerous!

CARBON DATING

Carbon dating is a variety of radioactive dating which is applicable only to matter which was once living and presumed to be in equilibrium with the atmosphere, taking in carbon dioxide from the air for photosynthesis.Cosmic ray protons blast nuclei in the upper atmosphere, producing neutrons which in turn bombard nitrogen, the major constituent of the atmosphere. This neutron bombardment produces the radioactive isotope carbon-14. The radioactive carbon-14 combines with oxygen to form carbon dioxide and is incorporated into the cycle of living things.The carbon-14 forms at a rate which appears to be constant, so that by measuring the radioactive emissions from once-living matter and comparing its activity with the equilibrium level of living things, a measurement of the time elapsed can be made.Carbon-14 dating is a radiometric dating method that uses the radioisotope carbon-14 (14C) to estimate the age of object.

RADIATION DETECTION

A radiation detector is a device used to detect, track, or identify high-energy particles. Gaseous ionization detectors use the ionizing effect of radiation upon gas-filled sensors. A semiconductor detector uses a semiconductor (usually silicon or germanium) to detect traversing charged particles or the absorption of photons. A scintillation detector is created by coupling a scintillator to an electronic light sensor.

MEDICAL IMAGING AND DIAGNOSTICS

Radiation therapy involves the application of ionizing radiation to treat conditions such as hyperthyroidism, thyroid cancer, and blood disorders. Radiation therapy is particularly effective as a treatment of a number of types of cancer if they are localized to one area of the body. It may also be used as part of curative therapy, to prevent tumor recurrence after surgery, or to remove a primary malignant tumor. Radiation therapy is synergistic with chemotherapy and has been used before, during, and after chemotherapy in susceptible cancers.

Ionizing radiation works by damaging the DNA of exposed tissue, leading to cellular death. When external beam therapy is used, shaped radiation beams are aimed from several angles of exposure to intersect at the tumor, providing a much larger absorbed dose there than in the surrounding, healthy tissue.

Brachytherapy is another form of radiation therapy, in which a therapeutic radioisotope is injected into the body to chemically localize to the tissue that requires destruction. A key feature of brachytherapy is that the irradiation affects only a very localized area around the radiation sources. Exposure to radiation of healthy tissues further away from the sources is therefore reduced in this technique.

Radiation therapy is in itself painless. Many low-dose palliative treatments (for example, radiation therapy targeting bony metastases) cause minimal or no side effects, although short-term pain flare-ups can be experienced in the days following treatment due to edemas compressing nerves in the treated area. Higher doses can cause varying side effects during treatment (acute), in the months or years following treatment (long-term), or after re-treatment (cumulative). The nature, severity, and longevity of side effects depend on the organs that receive the radiation, the treatment itself (type of radiation, dose, fractionation, concurrent chemotherapy), and the individual patient.

DOSIMETRY

Radiation dosimetry is the measurement and calculation of the absorbed dose resulting from the exposure to ionizing radiation. There are several ways of measuring doses of ionizing radiation: personal dosimeters, ionization chambers, and internal dosimetry. The distinction between absorbed dose (Gy/rad) and dose equivalent (Sv/rem) is based upon the biological effects. Dose is a measure of deposited dose and therefore can never decrease: removal of a radioactive source can reduce only the rate of increase of absorbed dose — never the total absorbed dose.

PET (POSITRON EMISSION TOMOGRAPHY)

Positron emission tomography (PET) is a nuclear medical imaging technique that produces a three-dimensional image or picture of functional processes in the body. The system detects pairs of gamma rays emitted indirectly by a positron-emitting radionuclide (tracer), which is introduced into the body on a biologically active molecule. Three-dimensional images of tracer concentration within the body are then constructed by computer analysis.

COMPUTED TOMOGRAPHY

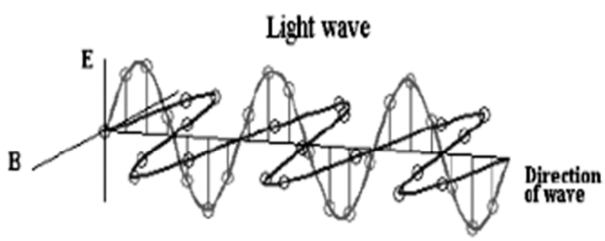
Computed tomography (CT) scanning, also known as computerized axial tomography (CAT) scanning, is a diagnostic imaging procedure that uses X-rays in order to present cross-sectional images (“slices”) of the body. Cross sections are reconstructed from the measurements of attenuation coefficients of X-ray beams in the volume of the object studied. CT is based on the fundamental principle that the density of the tissue passed by the X-ray beam can be measured from the calculation of the attenuation coefficient. So, CT allows the reconstruction of the density of the body, by two dimensional section perpendicular to the axis of the acquisition system. There are basically two processes of the absorption: the **photoelectric effect and the Compton effect**. This phenomenon is represented by a single coefficient.

■■■

LIGHT

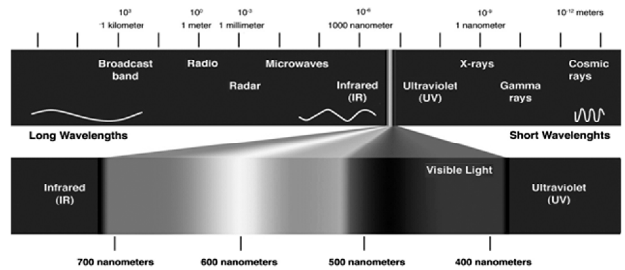
LIGHT

Light may be defined as complete mixture of wavelengths of visible spectrum, that enables us to see various objects by our eye. Light is **a transverse electromagnetic wave**. **Electromagnetic waves** are waves that are capable of traveling through a vacuum, unlike **mechanical waves** that require a medium in order to transport their energy. They consist of both an electric and a magnetic component. An electric field and a magnetic field change orthogonally to the direction of the light wave as shown below:



The light that we see every day is only a fraction of the total energy emitted by the sun incident on the earth. Sunlight is a form of "electromagnetic radiation" and the visible light that we see is a small subset of the **electromagnetic spectrum**.

Electromagnetic spectrum: The electromagnetic spectrum consists of all the different wavelengths of electromagnetic radiation, including light, radio waves, and X-rays. We name regions of the spectrum rather arbitrarily, but the names give us a general sense of the energy of the radiation; for example, ultraviolet light has shorter wavelengths than radio light. The only region in the entire electromagnetic spectrum that our eyes are sensitive to is the visible region.



Gamma rays have the shortest wavelengths, < 0.01 nanometers (about the size of an atomic nucleus). This is the highest frequency and most energetic region of the electromagnetic spectrum. Gamma rays can result from nuclear reactions and from processes taking place in objects such as pulsars, quasars, and black holes.

X-rays range in wavelength from 0.01 – 10 nm (about the size of an atom). They are generated, for example, by super-heated gas from exploding stars and quasars, where temperatures are near a million to ten million degrees.

Ultraviolet radiation has wavelengths of 10 – 310 nm (about the size of a virus). Young, hot stars produce a lot of ultraviolet light and bathe interstellar space with this energetic light.

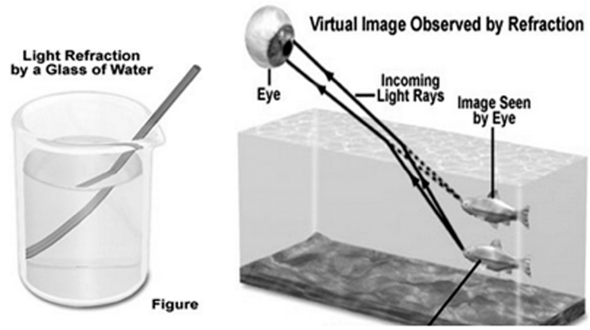
Visible light covers the range of wavelengths from 400 – 700 nm (from the size of a molecule to a protozoan). Our sun emits the most of its radiation in the visible range, which our eyes perceive as the colors of the rainbow. Our eyes are sensitive only to this small portion of the electromagnetic spectrum. Expressed in more familiar units, the range of wavelengths extends from 7×10^{-7} meter to 4×10^{-7} meter. This narrow band of visible light is affectionately known as **ROYGBIV**.

Infrared wavelengths span from 710 nm – 1 millimeter (from the width of a pinpoint to the size of small plant seeds). At a temperature of 37 degrees C, our bodies give off infrared wavelengths with a peak intensity near 900 nm.

Radio waves are longer than 1 mm. Since these are the longest waves, they have the lowest energy and are associated with the lowest temperatures. Radio wavelengths are found everywhere: in the background radiation of the universe, in interstellar clouds, and in the cool remnants of supernova explosions, to name a few. Radio stations use radio wavelengths of electromagnetic radiation to send signals that our radios then translate into sound. Radio stations transmit electromagnetic radiation, not sound. The radio station encodes a pattern on the electromagnetic radiation it transmits, and then our radios receive the electromagnetic radiation, decode the pattern and translate the pattern into sound.

Refraction of Light

When electromagnetic radiation, in the form of visible light, travels from one substance or medium into another, the light waves may undergo a phenomenon known as **refraction**, which is manifested by a bending or change in direction of the light. Refraction occurs as light passes from one medium to another only when there is a difference in the **index of refraction** between the two materials. The effects of refraction are responsible for a variety of familiar phenomena, such as the apparent bending of an object that is partially submerged in water and the mirages observed on a hot, sandy desert. The refraction of visible light is also an important characteristic of lenses that enables them to focus a beam of light onto a single point. The refraction of light, when it passes from a fast medium to a slow medium bends the light ray toward the normal to the boundary between the two media. Refraction is merely one of several possible boundary behaviors by which a light wave could behave when it encounters a new medium or an obstacle in its path. The transmission of light across a boundary between two media is accompanied by a change in both the speed and wavelength of the wave. The light wave not only changes directions at the boundary, it also speeds up or slows down and transforms into a wave with a larger or a shorter wavelength. The only time that a wave can be transmitted across a boundary, change its speed, and still not refract is when the light wave approaches the boundary in a direction that is perpendicular to it. As long as the light wave changes speed and approaches the boundary at an angle, refraction is observed.



Figure

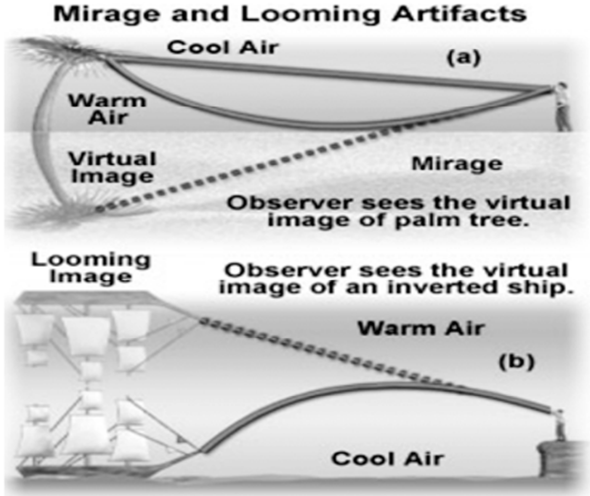
Mirage

Under a baking sun, a weary traveller trudges across a seemingly never-ending expanse of desert. Looking up, he suddenly spots something in the distance: a sparkling lake. He rubs his eyes. It's still there. Picking up the pace in glee he strides ahead… only for the water to melt into thin air.

You might think our traveller was hallucinating, but mirages are a naturally-occurring optical illusion.The illusion results from the way in which light is refracted (bent) through air at different temperatures. Cold air is denser than warm air, and therefore has a greater refractive index. This means that as light passes down from cool to hot air, it gets bent upwards towards the denser air and away from the ground .To your eyes, these distorted rays seem to be coming from the ground, so you perceive a refracted image of the sky on the ground. This looks just like a reflection on the surface of a pool of water, which can easily cause confusion. The actual mirage effect that is visualized depends upon whether cooler air overlies warmer air, or vice versa One type of mirage appears as an upside-down virtual image directly beneath the real object, and occurs when a layer of warm air near the ground or water surface is trapped by denser, cooler air lying above. Light from the object traveling downward into the warmer air adjacent to the ground (or water) is refracted upward toward the horizon. At some point the light reaches a critical angle for the warm air, and is bent upward by **total internal reflection**, resulting in the virtual image appearing below the object.

Another form of mirage, termed **looming**, occurs when warm air lies over a layer of cooler air, and is common over large bodies of water that may remain relatively cool when the air above the water is heated during the day .Light rays from an object, such as a ship on the water, traveling upward through the cool air into the warmer air are refracted downward toward an observer's line of sight. The rays then appear to originate from above the object and it appears to "loom" above its actual position. It is common for ships at sea near the horizon to appear to float above the water.

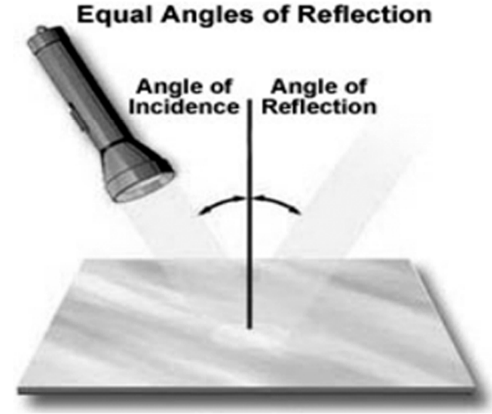
Mirage and Looming Artifacts



Reflection of Light

Reflection of light and other forms of electromagnetic radiation occurs when waves encounter a boundary that does not absorb the radiation's energy, but instead bounces the waves off its surface. In such cases, the incoming light wave is referred to as an **incident** wave and the wave that is bounced from the surface is called the **reflected** wave. This simple concept can be easily illustrated by a flashlight and a glass mirror.

Equal Angles of Reflection



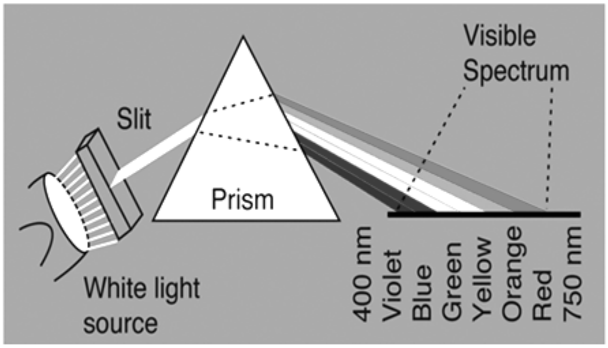
In Figure , the visible white light emitted by the flashlight bulb is directed onto the surface of a mirror at an angle, described as the **angle of incidence**. This light is then reflected back into space at another angle, known as the **angle of reflection**. As shown above, the angle of incidence for visible light is equal to the angle of reflection. This concept, which holds true for all types of electromagnetic radiation, is often termed the **law of reflection**. It is important to note that the light in Figure is not separated into its component colors because all wavelengths are being reflected equally, rather than being "bent" or **refracted**.

The Law of Reflection

When a ray of light strikes a plane mirror, the light ray reflects off the mirror. Reflection involves a change in direction of the light ray. The convention used to express the direction of a light ray is to indicate the angle which the light ray makes with a normal line drawn to the surface of the mirror. The angle of incidence is the angle between this normal line and the incident ray; the angle of reflection is the angle between this normal line and the reflected ray. According to the law of reflection, the angle of incidence equals the angle of reflection.

Dispersion

The process of splitting of white light into seven colours is called dispersion of light. It was mentioned in the Light and Color unit that each color is characteristic of a distinct wave frequency; and different frequencies of light waves will bend varying amounts upon passage through a prism.

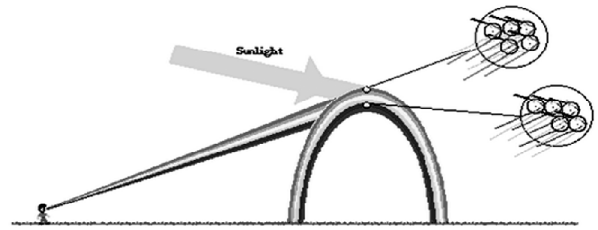


Rainbow: A rainbow is an excellent demonstration of the dispersion of light and one more piece of evidence that visible light is composed of a spectrum of wavelengths, each associated with a distinct color. To view a rainbow, your back must be to the sun as you look at an approximately 40 degree angle above the ground into a region of the atmosphere with suspended droplets of water or even a light mist. Each individual droplet of water acts as a tiny prism that both disperses the light and reflects it back to your eye. As you sight into the sky, wavelengths of light associated with a specific color arrive at your eye from the collection of droplets. The net effect of the vast array of droplets is that a circular arc of ROYGBIV is seen across the sky. A rainbow is most often viewed as a circular arc in the sky. An observer on the ground observes a half-circle of color with red being the color perceived on the outside or top of the bow. **Those who are fortunate enough to have seen a rainbow from an airplane in the sky may know that a rainbow can actually be a complete circle**. Observers on the ground only view the top half of the circle since the bottom half of the circular arc is prevented by the presence of the ground (and the rather obvious fact that suspended water droplets aren't present below ground). Yet observers in an airborne plane can often look both upward and downward to view the complete circular bow.

Formation of Rainbow

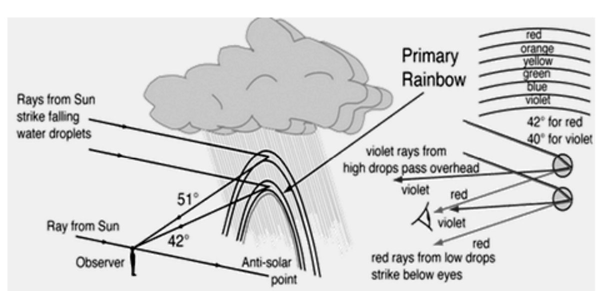
Step 1: Sunlight passes through the raindrops.

Step 2: Some of the sunlight is reflected and some other part is refracted (passes into the water droplets). A collection of suspended water droplets in the atmosphere serves as a refractor of light. The water represents a medium with a different optical density than the surrounding air. Light waves refract when they cross over the boundary from one medium to another. The decrease in speed upon entry of light into a water droplet causes a bending of the path of light towards the normal. And upon exiting the droplet, light speeds up and bends away from the normal. The droplet causes a deviation in the path of light as it enters and exits the drop. There are countless paths by which light rays from the sun can pass through a drop. Each path is characterized by this bending towards and away from the normal. One path of great significance in the discussion of rainbows is the path in which light refracts into the droplet, internally reflects, and then refracts out of the droplet.



Primary Rainbow

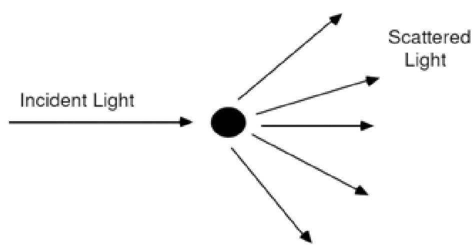
The primary rainbow forms between about 40° and 42° from the antisolar point(The **antisolar point** is the imaginary **point** on the celestial sphere exactly opposite the Sun from the viewpoint of an observer). The light path involves refraction and a single reflection inside the water droplet. If the drops are large, 1 millimeter or more in diameter, red, green, and violet are bright but there is little blue. Such large droplets are suggested by the rainbow at right.



Secondary Rainbow

The secondary rainbow is about 10° further out from the antisolar point than the *primary bow*, is about twice as wide, and has its colors reversed.

Scattering



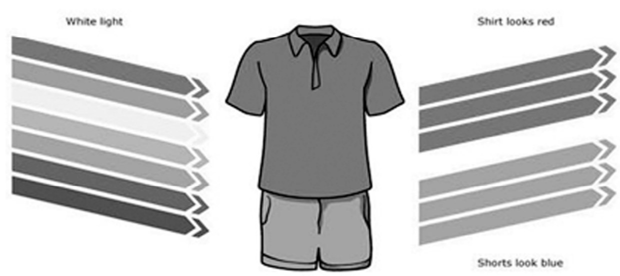
In scattering, light is intercepted by an object and sent off in many directions; this movement may appear to be random and not following the law of reflection. Rayleigh scattering refers to the scattering of light by molecules in air, and is what causes the sky to have **a blue color**. Because this type of scattering is proportional to the 4th power of the frequency, blue light (which has the highest frequency of visible light) scatters the most. **Rayleigh scattering** can be considered an elastic collision of a photon with an atom or molecule. Another type, **Raman scattering**, is due to an inelastic collision with a molecule, and is used by chemists and physicists to measure the vibrational quantum state of molecules. The **red colour** in the sky at sunset (and sunrise) is due to an effect called Rayleigh scattering. There is a similar form of scattering called Mie scattering which is responsible for the **white colour of clouds.**

Particles in our atmosphere that are approximately the same size as the wavelength of visible light cause the white light from the sun to scatter and split into individual components. Oxygen and Nitrogen (the main components of our atmosphere) scatter violet and blue light due to their small size. This is why the sky appears to be blue in the day time, especially at midday when the Sun is closest to us.

During sunrise and sunset the distance that the light has to travel from the Sun to an observer is at its greatest. This means the a large amount of blue and violet light has been scattered so the light that is recieved by an observer is mostly of a longer wavelength and therefore appears to be read.

Colour of objects

Objects appear different colours because they absorb some colours (wavelengths) and reflected or transmit other colours. The colours we see are the wavelengths that are reflected or transmitted.For example, a red shirt looks red because the dye molecules in the fabric have absorbed the wavelengths of light from the violet/blue end of the spectrum. Red light is the only light that is reflected from the shirt. If only blue light is shone onto a red shirt, the shirt would appear black, because the blue would be absorbed and there would be no red light to be reflected.White objects appear white because they reflect all colours. Black objects absorb all colours so no light is reflected.



Colour detection

The retina of our eyes contains two types of photoreceptors – rods and cones. The cones detect colour. The rods only let us see things in black, white and grey. Our cones only work when the light is bright enough, but not when light is very dim. This is why things look grey and we cannot see colours at night when the light is dim.

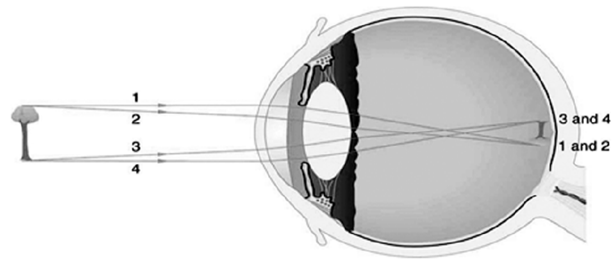
There are three types of cones in the human eye that are sensitive to **short (S), medium (M) and long (L) wavelengths** of light in the visible spectrum. (These cones have traditionally been known as blue-sensitive, green-sensitive and red-sensitive, but as each cone is actually responsive to a range of wavelengths, the S, M and L labels are more accepted now.)These three types of colour receptor allow the brain to perceive signals from the retina as different colours. Some estimate that humans are able to distinguish about 10 million colours.

Resolution of the Human Eye

The human eye is a sense organ that allows vision and is capable to distinguish about 10 million colors. The retina of human eye has a static contrast ratio of around 100:1 and a dynamic contrast ratio of about 1,000,000:1. The eye includes a lens not dissimilar to lenses found in optical instruments, such as cameras.The approximate field of view of an individual human eye is 95° away from the nose, 75° downward, 60° toward the nose, and 60° upward, allowing humans to have an almost 180-degree forward-facing horizontal field of view.

Mechanism of vision by eye

Whenever the eye moves, even just a little, it automatically readjusts the exposure by adjusting the iris, which regulates the size of the pupil. This is what helps the eye adjust to dark places or really bright lights. The lens of the eye is similar to one in glasses or cameras. The human eye is had an aperture, just like a camera. The pupil serves this function, and the iris is the aperture stop. The different parts of the eye has different refractive indexes, and this is what bends the rays to form an image. The cornea provides two-thirds of the power to the eye. The lens provides the remaining power. The image passes through several layers of the eye, but happens in a way very similar to that of a convex lens. When the image finally reaches the retena, it is inverted, but the brain will correct this. shows what happens.



Lens

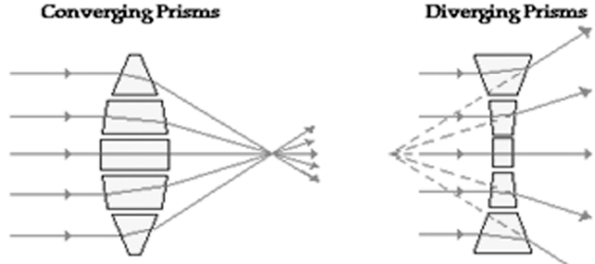
A lens is merely a carefully ground or molded piece of transparent material that refracts light rays in such as way as to form an image. Lenses can be thought of as a series of tiny refracting prisms, each of which refracts light to produce their own image. When these prisms act together, they produce a bright image focused at a point.

Types of Lenses

Lenses are classified as converging lenses and diverging lenses.

Converging lens: A converging lens is a lens that converges rays of light that are traveling parallel to its principal axis. Converging lenses can be identified by their shape; they are relatively thick across their middle and thin at their upper and lower edges.

Diverging lens: A diverging lens is a lens that diverges rays of light that are traveling parallel to its principal axis. Diverging lenses can also be identified by their shape; they are relatively thin across their middle and thick at their upper and lower edges.

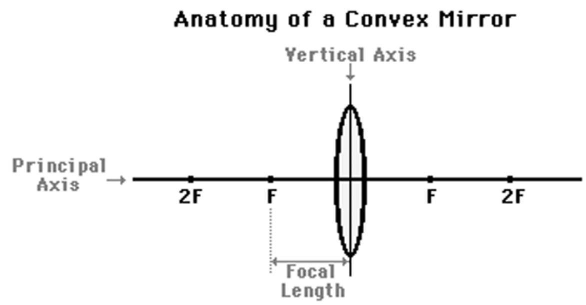


A set of prisms acting as a converging and diverging lens.

A double convex lens is symmetrical across both its horizontal and vertical axis. Each of the lens' two faces can be thought of as originally being part of a sphere. The fact that a double convex lens is thicker across its middle is an indicator that it will converge rays of light that travel parallel to its principal axis. A **double convex lens** is a converging lens. A **double concave lens** is also symmetrical across both its horizontal and vertical axis. The two faces of a double concave lens can be thought of as originally being part of a sphere. The fact that a double concave lens is thinner across its middle is an indicator that it will diverge rays of light that travel parallel to its principal axis. A double concave lens is a diverging lens.

The Language of Lenses

If a symmetrical lens were thought of as being a slice of a sphere, then there would be a line passing through the center of the sphere and attaching to the mirror in the exact center of the lens. This imaginary line is known as the **principal axis**. A lens also has an imaginary vertical axis that bisects the symmetrical lens into halves. light rays incident towards either face of the lens and traveling parallel to the principal axis will either converge or diverge. If the light rays converge (as in a converging lens), then they will converge to a point. This point is known as the focal point of the converging lens. If the light rays diverge (as in a diverging lens), then the diverging rays can be traced backwards until they intersect at a point. This intersection point is known as the **focal point of a diverging lens**. The focal point is denoted by the letter F on the diagrams below. Note that each lens has two focal points - one on each side of the lens. Unlike mirrors, lenses can allow light to pass through either face, depending on where the incident rays are coming from. Subsequently, every lens has two possible focal points. The distance from the mirror to the focal point is known as the focal length (abbreviated by f). Technically, a lens does not have a center of curvature (at least not one that has any importance to our discussion). However a lens does have an imaginary point that we refer to as the 2F point.



Whenever the eye moves, even just a little, it automatically readjusts the exposure by adjusting the iris, which regulates the size of the pupil. This is what helps the eye adjust to dark places or really bright lights. The lens of the eye is similar to one in glasses or cameras. The human eye is had an aperture, just like a camera. The pupil serves this function, and the iris is the aperture stop. The different parts of the eye has different refractive indexes, and this is what bends the rays to form an image. The cornea provides two-thirds of the power to the eye. The lens provides the remaining power. The image passes through several layers of the eye, but happens in a way very similar to that of a convex lens. When the image finally reaches the retena, it is inverted, but the brain will correct this. shows what happens.

Defects of human eye and the remedies

1. **Myopia or short sightedness**: A person suffering from myopia can see the near objects clearly while far objects are not clear.

Causes

(i) Elongation of eye ball along the axis.

(ii) Shortening of focal length of eye lens.

(iii) Over stretching of ciliary muscles beyond the elastic limit.

Remedy : *Diverging lens (concave) is used.*

2. **Hyperopia or hypermetropia or longsightedness** : A person suffering from hypermetropia can see the distant objects clearly but not the near objects.

Causes

(i) Shortening of eye ball along the axis.

(ii) Increase in the focal length of eye lens.

(iii) Stiffening of ciliary muscles.

Remedy : *A converging lens is sued.*

3. **Presbyopia :** This defect is generally found in elderly person. Due to stiffening of ciliary muscles, eye looses much of its accommodating power. As a result distant as well as nearby objects can not be seen.

Remedy : *two separate lens or a bifocal lens is used.*

4. **Astigmatism** : This defect arises due to difference in the radius of curvature of cornea in the different planes. As a result rays from an object in one plane are brought to focus by eye in another plane. For its remedy cylindrical lens is used.

ECLIPSES

When the Sun, Moon and Earth come into a straight line an **ECLIPSE** occurs. This does not happen very often because the Moon's orbit is inclined to that of the Earth. **A TOTAL** eclipse occurs when all the Moon or Sun is blotted out. **A PARTIAL** eclipse is when only part of the Sun or Moon is covered.

Lunar eclipse

When the Earth comes between the Sun and the Moon we get a 'Lunar eclipse' or eclipse of the Moon (Figure 1).

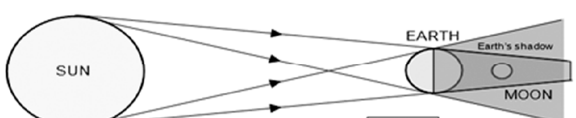


Figure 1

The Moon passes into the shadow of the Earth, it ever completely disappears because a small amount of the Sun's light is refracted by the Earth's atmosphere and falls on the Moon during the eclipse. This light gives the Moon a reddish appearance. You can see form Figure 1 that at the distance of the Moon the Earth's shadow is much bigger than the Moon and so the Moon takes some time to pass through it.

Solar eclipse

Its much more impressive when the Moon comes between the Sun and the Earth. The shadow of the Moon falls on part of the Earth and this is a Solar eclipse or eclipse of the Sun (Figure 2(a)). When seen from the Earth the Noon and Sun look almost exactly the same size and so in a total eclipse the Moon just covers the Sun.

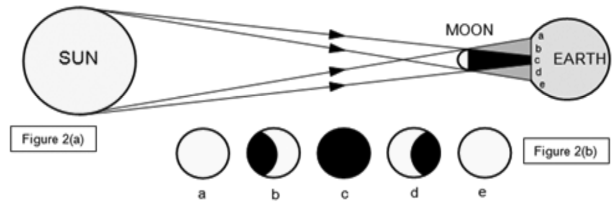


Figure 2(a) Figure 2(b)

Figure 2(b) shows the view of the Sun from the Earth during the eclipse. Diagram (c) shows the total eclipse. The shadow of the Moon falls on the Earth and because the Moon and Earth are moving compared with the Sun this shadow moves across the Earth's surface during an eclipse.

Eclipses do not occur as often as you might expect. This is due to the tilt of the Moon's orbit around then Earth compared with the plane of the Earth's orbit around the Sun. An eclipse, of the Sun or the Moon, will only occur if all three bodies – Sun, Earth and Moon are in a line. You can see this from the following diagrams.

In the first one (Figure 3(a)) there will be no eclipse but in the second one (figure 3(b)) the three bodies are all in a line and a person standing on the Earth at A will see a total eclipse of the Sun.

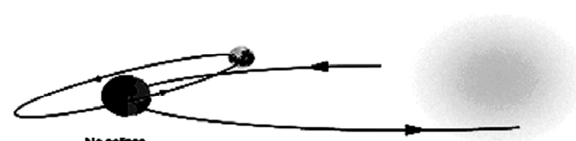
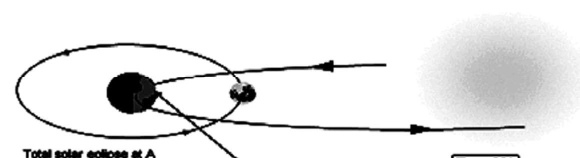

No eclipse

Figure 3(a)



Total solar eclipse at A

Figure 3(b)

Camera

A camera is a device that allows you to record images, either on film or digitally. Cameras can record images as well as movies; movies themselves got their name from moving pictures. The word camera comes from the Latin phrase camera obscura, which means "dark chamber. "Cameras are optical devices that allow a user to record an image of an object, either on photo paper or digitally. Cameras work very similarly to how the human eye works. The iris is similar to the lens; the pupil is similar to the aperture; and the eyelid is similar to the shutter. Cameras are a modern evolution of the camera obscura. The camera obscura was a device used to project images. The most important part of a camera is the lens, which allows the image to be magnified and focused. This can be done manually on some cameras and automatically on newer cameras. Movie cameras work by taking many pictures each second and then showing each image in order very quickly to give the effect that the pictures are moving. This is where the name "movie" comes from.

The Telescope

The telescope aids in observation of remote objects by collecting electromagnetic radiation, such as visible light.Until the invention of silver-backed mirrors, refractive mirrors were the standard for use in telescopes. This was because of the highly corrosive nature of the metals used in older mirrors. Since then, reflective mirrors have replaced refractive mirrors in astronomy.There are three main types of optical telescopes: refractive, reflective, and catadioptric.

Night vision technology

Night vision technology, by definition, literally allows one to see in the dark. Originally developed for military use, but now it is used also for security, surveillance as well as search and rescue. Night vision equipment has evolved from bulky optical instruments in lightweight goggles through the advancement of image intensification technology.

Types of Night Vision

Night Vision technology is a term that presently encompasses three distinct technologies. The first night vision equipment was developed during the Korean War. Now sometimes referred to as **generation-zero**, this equipment employed image converter technology to transform infrared to visible light. The subsequent principal technological development for night vision is **thermal imaging**. Thermal imagers are passive systems that respond to available infrared light at wavelengths in the 8-12 micrometer range. These wavelengths are readily emitted by all blooded animals as well as soil and plant life, warmed during the daytime hours. Infrared light is thus generated and available continuously, during both the day and night, so that these viewers have the distinction of performing equally well in both environmental lighting extremes.

The vast majority of night vision equipment and what most people think of when the are referring to "Night Vision" are devices that utilize image intensification technology. These devices are presently in their third development phase. They are passive devices that operate using naturally available light. Incoming light is converted to electrons, which are amplified and converted back into visible light.

LCDs

Liquid crystal displays use liquid crystals which do not emit light, but use the light modulating properties of the crystals. LCDs use an electric field to arrange the liquid crystals into the desired pattern, and then pass light through these layers to produce an image on the screen. LCDs can be used to display an arbitrary image made up of tiny fixed pixels, or can be used to display a fixed image, as in on a digital clock. A twisted nematic display is the most common LCD in use. This type of display is on calculators, digital watches, and clocks. When no electric field is applied, the molecules are twisted, and let some light through. When the field is applied, they untwist, blocking the light and are seen as black.

Using Interference to Read CDs and DVDs

The iridescent layer of the disc is imprinted with tiny pits and lands. Pits scatter light when illuminated, and produce a reading of 0; lands reflect light back and produce a reading of 1.The optical disc drive records the 0 and 1 readings and translates them into binary data which is used to relay whatever information is recorded on the disc. Rainbow pattern on the back of a CD is due diffraction of the reflected light by pits. Compact disks (CDs) and digital video disks (DVDs) are examples of optical discs. They are read in an optical disc drive which directs a laser beam at the disc. The reader then detects whether the beam has been reflected or scattered.

Laser

A laser is a device which is built on the principles of quantum mechanics to create a beam of light where all of the photons are in a coherent state - usually with the same frequency and phase. (Most light sources emit incoherent light, where the phase varies randomly.) Among the other effects, this means that the light from a laser is often tightly focused and does not diverge much

In simplest terms, a laser uses light to stimulate the electrons in a “gain medium” into an excited state (called optical pumping). When the electrons collapse into the lower-energy unexcited state, they emit photons. These photons pass between two mirrors, so there are more and more photons exciting the gain medium, “amplifying” the intensity of the beam. A narrow hole in one of the mirrors allows a small amount of the light to escape (i.e. the laser beam itself).This process is based on work by Albert Einstein in 1917 and many others. Physicists Charles *H. Townes, Nicolay Basov, and Aleksandr Prokhorov* received the 1964 Nobel Prize in Physics for their development of the earliest laser prototypes. Alfred Kastler received the 1966 Nobel Prize in Physics for his 1950 description of optical pumping. On May 16, 1960, Theodore Maiman demonstrated the first working laser.

Characteristics of Laser Light

1. Coherent

Different parts of the laser beam are related to each other in phase. These phase relationships are maintained over long enough time so that interference effects may be seen or recorded photographically. This coherence property is what makes holograms possible.

2. Monochromatic

Laser light consists of essentially one wavelength, having its origin in stimulated emission from one set of atomic energy levels.

3. Collimated

Because of bouncing back between mirrored ends of a laser cavity, those paths which sustain amplification must pass between the mirrors many times and be very nearly perpendicular to the mirrors. As a result, laser beams are very narrow and do not spread very much.

Use of Lasers

1. Medical Lasers

Medical lasers can be used as a scalpel. Since the laser can be controlled and can have such a small contact area it is ideal for fine cutting and depth control. Medical lasers can also be used to reattach retinas and can be used in conjunction with fiber optics to place the laser beem where it needs to be. Medical lasers can also be used to stitch up incisions after surgery, by fusing together skin. (LFI)

2. Entertainment

Laser shows are quite popular and the special effects are amazing. These use lasers that are in the visible spectrum along with vibrating mirrors to paint images in the air. Here is an example of a dance with lasers in the background:

3. Computers and Music

One popular use of lasers is the reading of CD. CD’s function by having a reflective aluminum layer that has very small pits put in the aluminum. The pits and the lack of are translated into binary by the computer and then are used for information. Another use of lasers is in the use of fiber optics. Since lasers travel very fast they make an ideal way to communicate. The laser is shot down a fiberglass tube to a receiver. These wires can be very long with no loss of signal quality. Also modern multiplexing of the line lets two lasers of different frequencies share the same line.

4. Metal working

Lasers very accurate point and solid state construction make it ideal or industrial production. Lasers allow better cuts on metals and the welding of dissimilar metals with out the use of a flux. Also lasers can be mounted on robotic arms and used in factors. This is safer then oxygen and acetylene, or arc welding. (Impulse)

5. Welding and Cutting

The highly collimated beam of a laser can be further focused to a microscopic dot of extremely high energy density for welding and cutting.The automobile industry makes extensive use of carbon dioxide lasers with powers up to several kilowatts for computer controlled welding on auto assembly lines.

6. Surveying and Ranging

Helium-neon and semiconductor lasers have become standard parts of the field surveyor's equipment. A fast laser pulse is sent to a corner reflector at the point to be measured and the time of reflection is measured to get the distance.Some such surveying is long distance! The Apollo 11 and Apollo 14 astronauts put corner reflectors on the surface of the Moon for determination of the Earth-Moon distance.

7. Lasers in the Garment Industry

Laser cutters are credited with keeping the U.S. garment industry competitive in the world market. Computer controlled laser garment cutters can be programmed to cut out 400 size 6 and then 700 size 9 garments - and that might involve just a few cuts. The programmed cutter can cut dozens to hundreds of thicknesses of cloth, and can cut out every piece of the garment in a single run.

8. Lasers in Communication

Fiber optic cables are a major mode of communication partly because multiple signals can be sent with high quality and low loss by light propagating along the fibers. The light signals can be modulated with the information to be sent by either light emitting diodes or lasers. The lasers have significant advantages because they are more nearly monochromatic and this allows the pulse shape to be maintained better over long distances. If a better pulse shape can be maintained, then the communication can be sent at higher rates without overlap of the pulses. Ohanian quotes a factor of 10 advantage for the laser modulators.

9. Heat Treatment

Heat treatments for hardening or annealing have been long practiced in metallurgy. But lasers offer some new possibilities for selective heat treatments of metal parts. For example, lasers can provide localized heat treatments such as the hardening of the surfaces of automobile camshafts. These shafts are manufactured to high precision, and if the entire camshaft is heat treated, some warping will inevitably occur. But the working surfaces of the cams can be heated quickly with a carbon dioxide laser and hardened without appreciably affecting the remainder of the shaft, preserving the precision of manufacture.

10. Barcode Scanners

Supermarket scanners typically use helium-neon lasers to scan the universal barcodes to identify products. The laser beam bounces off a rotating mirror and scans the code, sending a modulated beam to a light detector and then to a computer which has the product information stored. Semiconductor lasers can also be used for this purpose.

11. Laser Printers

The laser printer has in a few years become the dominant mode of printing in offices. It employs a semiconductor laser and the xerography principle.

12. Laser Spectroscopy

Absorption spectroscopy usually implies having a tunable frequency source and producing a plot of absorption as a function of frequency. This was not feasible with lasers until the advent of the dye lasers which can be tuned over a nearly continuous range of frequencies.

13. Laser Fusion

Laser fusion attempts to force nuclear fusion in tiny pellets or microballoons of a deuterium-tritium mixture by zapping them with such a high energy density that they will fuse before they have time to move away from each other. This is an example of inertial confinement.

Two experimental laser fusion devices have been developed at Lawrence Livermore Laboratory, called Shiva and Nova. They deliver high power bursts of laser light from multiple lasers onto a small deuterium-tritium target. These lasers are neodymium glass lasers which are capable of extremely high power pulses.

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SOUND

CHARACTERISTICS OF SOUND

Sound is a longitudinal wave of pressure that travels through compressible medias, which can be solid, liquid, gaseous, or made of plasma. Sound travels in longitudinal sinusoidal waves. Humans can characterize sound by frequency, amplitude and tone. The speed at which sound travels depends on the media through which the sound is traveling. There is no sound in a vacuum; by definition, a vacuum is a space free of any particles or matter. Thus there in a vacuum, there is no media through which sound waves can travel.

Following are some characteristics of sound:

1. Sound travels in longitudinal waves.
2. Sound waves have frequency; that is, the pitch of sounds goes up or down.
3. The amplitude of a sound determines its volume (loudness).
4. Tone is a measure of the quality of a sound wave.
5. Sound travels faster in a hot medium, or in a solid. It also travels faster at sea level (where air pressure is higher).
6. Sound intensity is the energy transmitted over a certain area. Intensity is a measure of the sound's frequency.

FREQUENCY OF SOUND WAVES

This is the number of occurrences of a repeating event per unit of time. The perception of frequency is called pitch. A period is the duration of one cycle of a repeating event, and is the reciprocal, or inverse of the frequency. The SI unit of frequency is called a Hertz, denoted Hz. A hertz is defined as the number of cycles per second. So 100 Hz would mean 100 cycles per second. Sound waves, like all other waves have a property called frequency. This is the number of occurrences of a repeating event per unit of time. Frequency is dependent on wavelength and the speed of sound. According to their frequency range, longitudinal mechanical waves are divided into the following categories:

1. **Audible or Sound Waves**: The longitudinal mechanical waves which lie in the frequency range 20 Hz to 20000 Hz are called audible or sound waves. These waves are sensitive to human ear. These are generated by the vibrating bodies such as tuning fork, vocal cords etc.
2. **Infrasonic Waves** : The longitudinal mechanical waves having frequencies less than 20 Hz are called Infrasonic. These waves are produced by sources of bigger size such as earth quakes, volcanic eruptions, ocean waves and by elephants and whales.
3. **Ultrasonic Waves** : The longitudinal mechanical waves having frequencies greater than 20000 Hz are called ultrasonic waves. Human ear cannot detect these waves. But certain creatures like dog, cat,, bat, mosquito can detect these waves. Bat not only detect but also produce ultrasonic.

Ultrasonic waves: These can be produced by Gal ton's whistle or Hartman's generator or by the high frequency vibrations of a quartz crystal under an alternating electric field (Piezo - electric effect) or by the vibrations of a ferromagnetic rod under an alternating magnetic field (Magnetostriction)

Applications of Ultrasonic Waves:

1. For sending signals.
2. For measuring the depth of sea.
3. For cleaning cloths, aeroplanes and machinery parts of clocks.
4. For removing lamp-shoot from the chimney of factories.

5. In sterilizing of a liquid.
6. In Ultrasonography.

ECHO

The sound waves received after being reflected from a high tower or mountains is called echo. To hear echo, the minimum distance between the observer and reflector should be 17 m (16.6 m).

SPEED OF SOUND

Sound can travel through any compressible material. These media can be solid, liquid, gas, or even plasma. The speed of sound is dependent on the properties of the material it travels through. It will travel faster through a solid than a liquid, and faster through a liquid than a gas.The general number given for the speed of sound is calculated at sea level, in air, at normal atmospheric pressure. That value is 344 m/s. However, this number is not constant. Sound travels faster in a solid than in a liquid, and faster in a liquid that in a gas.

INTENSITY

Sound Intensity is the power per unit area carried by a wave. Power is the rate that energy is transferred by a wave. The larger your sound wave oscillation, the more intense your sound will be. Although the units for sound intensity are technically watts per meter squared, it is much more common for it to be referred to as decibels, dB.

Resonance: If the frequency of imposed periodic force is equal to the natural frequency of a body, the body oscillates with a very large amplitude This phenomenon is called resonance.

SOUND PERCEPTION

Every sound wave has properties that define its frequency, such as wavelength, amplitude and intensity. Calculating these properties is outside the scope of this atom and will be addressed later. For now, it is important to know the basics of sound. As with light waves, sound frequencies have a range. Each living creature has a different level of sound perception. For example, consider the following examples of sound ranges (in Hz, Hertz):

Humans 20 - 20,000 Hz

Dogs 50 - 45,000 Hz

Bats 20 - 120,000 Hz

HUMAN PERCEPTION OF SOUND

The study of human perception of sound is called **psychoacoustics**. Frequency is perceived by humans as pitch. The sound intensity is what humans can hear, and is generally only a specific range of sound, usually from 20 Hz to 20,000 Hz. The factors that go into a sound are its intensity, frequency and overtones (which are like interference or background noises).

DECIBELS

The decibel is a logarithmic unit used to quantify sound levels, by comparing a physical quantity to a reference level. In acoustics, the decibel is quantified relative to a reference which has been set at a sound pressure level of 20 micropascals, and is called a 0 dB. The human ear has a standard sound threshold of 120 dB, which expressed logarithmically is around 1012. This is a standard threshold, but it also depends on frequency.

DOPPLER EFFECT

The Doppler effect is observed whenever the source of waves is moving with respect to an observer. The Doppler effect can be described as the effect produced by a moving source of waves in which there is an apparent upward shift in frequency for observers towards whom the source is approaching and an apparent downward shift in frequency for observers from whom the source is receding. It is important to note that the effect does not result because of an actual change in the frequency of the source.

Moving Observer

The Doppler effect is the apparent change in frequency of a wave when the observer and the source of the wave move relative to each other. When the object in motion moves towards the other, the frequency is increased because the time between successive sound waves is shortened. Therefore the pitch is higher. When the object in motion moves away from the other, the frequency is decreased because the time between successive sound waves is lengthened. Therefor the pitch is lowered.

Moving Source

When the object in motion moves towards the other, the frequency is increased because the time between successive sound waves is shortened (therefore the pitch is higher).When the object in motion moves away from the other, the frequency is decreased because the time between successive sound waves is lengthened (therefore the pitch is lowered).

SONIC BOOMS

A sonic boom is the sound associated with the shock waves created by an object traveling through the air faster than the speed of sound. It can be viewed as a Doppler effect on steroids; sonic booms generate an enormous amount of energy, and sound like explosions. The first man made object to ever create this phenomenon was a bullwhip. The 'crack' of the whip is a result of this sonic boom.

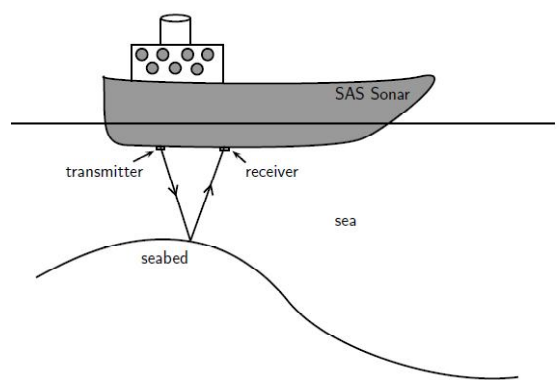
APPLICATIONS: ULTRASOUND, SONAR, AND MEDICAL IMAGING

Ultrasound

Ultrasound is sound with a frequency higher than 20 kHz. This is above the human range of hearing. The most common use of ultrasound, creating images, has industrial and medical applications. The use of ultrasound to create images is based on the reflection and transmission of a wave at a boundary. When an ultrasound wave travels inside an object that is made up of different materials (such as the human body), each time it encounters a boundary (e.g., between bone and muscle, or muscle and fat), part of the wave is reflected and part of it is transmitted. The reflected rays are detected and used to construct an image of the object.

Sonar(Sound Navigation And Ranging)

Illustrates how a ship on the ocean utilizes the reflecting properties of sound waves to determine the depth of the ocean. A sound wave is transmitted and bounces off the seabed. Because the speed of sound is known and the time lapse between sending and receiving the sound can be measured, the distance from the ship to the bottom of the ocean can be determined. This technique is called **sonar**. Just as ships on the ocean, certain animals, like dolphins and bats, make use of sounds waves (sonar) to navigate or find their way. Ultrasound waves are sent out then reflected off the objects around the animal. Bats or dolphins then use the reflected sounds to form a "picture" of their surroundings (this is known as echolocation).



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MAGNETISM

ELECTRIC CURRENT AND MAGNETIC FIELDS

Electric current produces a magnetic field. This magnetic field can be visualized as a pattern of circular field lines surrounding a wire. One way to explore the direction of a magnetic field is with a compass. Magnetism is the property displayed by magnets and produced by the movement of electric charges, which results in objects being attracted or pushed away. Magnet is a piece of iron or other materials that can attract iron containing objects and that points north and south when suspended. A magnet is characterized by following two properties:

1. **Attractive property:** A magnet attracts magnetic substances like iron, cobalt, nickel and some of their alloys like magnetite ($Fe_3 0_4$)
2. **Directive property:** When a magnet is freely suspended, it aligns itself in the geographical north south direction.

A magnet may be Natural or Artificial. Natural magnet is oxide of iron. But due to irregular shape, weak magnetism and high brittleness, natural magnets find no use in the laboratory. The magnets made by artificial methods are called artificial magnets or man made magnets. They may be of different types like bar magnet, horse shoe magnet, Robinson's ball ended magnet, magnetic needle, electromagnet etc. The two points near the two ends of a magnet where the attracting capacity is maximum are called **magnetic poles**. When a magnet is freely suspended, its one pole always directs towards the north. This pole is called **north pole**. The other pole is called **south pole**. The imaginary line joining the two poles of a magnet is called magnetic axis of the magnet. ***Similar poles repel each other and dissimilar poles attract each other.*** When a magnetic substance is placed rear a magnet, it gets magnetised due to induction.

Magnetic Field: Region in space around a magnet where the magnet has its magnetic effect is called magnetic field of the magnet. Intensity of magnetic field or magnetic flux density : Magnetic flux density of a point in a magnetic field is the force experienced by a north pole.

PERMANENT MAGNETS

A magnet is a material or object that generates a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet: a force that pulls on other ferromagnetic materials, such as iron, and attracts or repels other magnets .A permanent magnet is an object made from a material that is magnetized and creates its own persistent magnetic field . An everyday example is a refrigerator magnet used to hold notes on a refrigerator door.

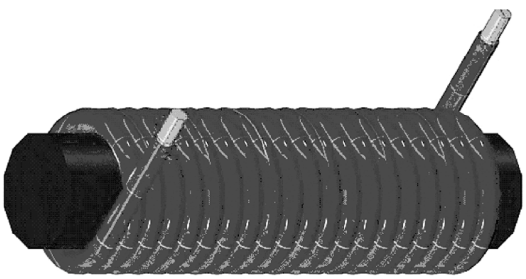
TYPES

1. Ferromagnets

Only certain materials (e.g., iron, cobalt, nickel, and gadolinium) exhibit strong magnetic effects. These materials are called ferromagnetic, after the Latin word ferrum (iron). A group of materials made from the alloys of the rare earth elements are also used as strong and permanent magnets (neodymium is a common one). Other materials exhibit weak magnetic effects detectable only with sensitive instruments. Not only do ferromagnetic materials respond strongly to magnets (the way iron is attracted to magnets), they can also be magnetized themselves—that is, they can be induced to become magnetic or made into permanent magnets.

2. Electromagnets

In an electromagnet the magnetic field is produced by the flow of electric current. If the current disappears, the magnetic field is turned off. Electromagnets are widely used as components of electrical devices, such as motors, generators, relays, loudspeakers, hard disks, MRI machines, scientific instruments and magnetic separation equipment; they are also employed as industrial lifting electromagnets for picking up and moving heavy iron objects like scrap iron.An electric current flowing in a wire creates a magnetic field around the wire. To concentrate the magnetic field, the wire is wound into a coil with many turns of wire lying side by side. The magnetic field from all the turns of wire passes through the center of the coil creating a strong magnetic field there.



POLARITY

All magnets have two poles, one called the north pole and one called the south pole . Like poles repel and unlike polls attract (in analogy to positive and negative charges in electrostatics). North and south poles always exist in pairs (there are no magnetic monopoles in nature), so if one were to split a permanent magnet in half, two smaller magnets would be created, each with a north pole and south pole.

GEOMAGNETISM

Earth is largely protected from the solar wind, a stream of energetic charged particles emanating from the sun, by its magnetic field, which deflects most of the charged particles. These particles would strip away the ozone layer, which protects Earth from harmful ultraviolet rays. The region above the ionosphere, and extending several tens of thousands of kilometers into space, is called the **magnetosphere**. This region protects Earth from cosmic rays that would strip away the upper atmosphere, including the ozone layer that protects our planet from harmful ultraviolet radiation. The magnetic field strength ranges from approximately 25 to 65 microteslas (0.25 to 0.65 G; by comparison, a strong refrigerator magnet has a field of about 100 G). The intensity of the field is greatest near the poles and weaker near the equator. An isodynamic chart of Earth's magnetic field, shows a minimum intensity over South America while there are maxima over northern Canada, Siberia, and the coast of Antarctica south of Australia. Near the surface of Earth, its magnetic field can be closely approximated by the field of a magnetic dipole positioned at the center of Earth and tilted at an angle of about 10° with respect to the rotational axis of Earth.

MRI

Magnetic resonance imaging (MRI) is a noninvasive medical test that helps physicians diagnose and treat medical conditions. MRI uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. MRI does not use ionizing radiation (x-rays). Detailed MR images allow physicians to evaluate various parts of the body and determine the presence of certain diseases. The images can then be examined on a computer monitor, transmitted electronically, printed or copied to a CD.

MAGLEV TRAINS

A few countries are using powerful electromagnets to develop high-speed trains, called maglev trains. Maglev is short for magnetic levitation, which means that these trains will float over a guide way using the basic principles of magnets to replace the old steel wheel and track trains.

Electromagnetic Suspension (EMS): If you've ever played with magnets, you know that opposite poles attract and like poles repel each other. This is the basic principle behind electromagnetic propulsion. Electromagnets are similar to other magnets in that they attract metal objects, but the magnetic pull is temporary. The magnetic field created in this wire-and-battery experiment is the simple idea behind a maglev train rail system.

There are three components to this system:

1. A large electrical power source
2. Metal coils lining a guide way or track
3. Large guidance magnets attached to the underside of the train.

The big difference between a maglev train and a conventional train is that maglev trains do not have an engine — at least not the kind of engine used to pull typical train cars along steel tracks. The engine for maglev trains is rather inconspicuous. Instead of using fossil fuels, the magnetic field created by the electrified coils in the guide way walls and the track combine to propel the train.

MAGNETIC SUBSTANCES

On the basis of magnetic behavior , substances can be divided into three categories.

(i) Diamagnetic substance: Diamagnetic substances are such substances which when placed in a magnetic field, acquire feeble magnetism opposite to the direction of magnetic field.

Examples: Bismuth, Zinc, Copper, Silver, Gold, Diamond, Water, Mercury, Water etc.

(ii) Paramagnetic Substance : Paramagnetic substances are such substances which when placed in a magnetic field acquire a feeble magnetism in the direction of the field.

Examples: Aluminum, Platinum, Manganese, Sodium, Oxygen etc.

(iii) Ferromagnetic substance : Ferromagnetic substances are those substance, which when placed in a magnetic field, are strongly magnetised in the direction of field.

Examples: Iron, Cobalt, Nickel etc.

Domain: Atoms of ferromagnetic substance have a permanent dipole moment i.e. they behave like a very small magnet. The atoms form a large no. of effective regions called domain in which 10^{18} to 10^{21} atoms have their dipole moment aligned in the same direction. The magnetism in ferromagnetic substance, when placed in a magnetic field, is developed due to these domain by:

(i) the displacements of boundaries of the domain

(ii) the rotation of the domains.

Curie Temperature: As temperature increases, the magnetic property of ferromagnetic substance decreases and above a certain temperature the substance changes into paramagnetic substance. This temperature is called Curie temperature.

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STATIC ELECTRICITY

ELECTRIC CHARGE IN THE ATOM

Atoms contain negatively charged electrons and positively charged protons; the number of each determines the atom's net charge.A proton is a positively charged particle located in the nucleus of an atom. An electron has 11836 times the mass of a proton, but an equal and opposite negative charge.Unlike protons, electrons can move from atom to atom. If an atom has an equal number of protons and electrons, its net charge is 0. If it gains an extra electron, it becomes negatively charged and is known as an anion. If it loses an electron, it becomes positively charged and is known as a cation.

Protons: Protons are found in the center of the atom; they, with neutrons, make up the nucleus. Protons have a charge of +1 and a mass of 1 atomic mass unit, which is approximately equal to 1.66×10-24 grams. The number of protons in an atom defines the identity of the element (an atom with 1 proton is hydrogen, for example, and an atom with two protons is helium).

Electrons: Electrons are found in the periphery of the atom and have a charge of -1. They are much smaller than protons; their mass is 11836 amu. Typically in modeling atoms, protons and neutrons are regarded as stationary, while electrons move about in the space outside the nucleus like a cloud.

Ions: In the ground state, an atom will have an equal number of protons and electrons, and thus will have a net charge of 0. However, because electrons can be transferred from one atom to another, it is possible for atoms to become charged. Atoms in such a state are known as **ion**. If a neutral atom gains an electron, it becomes negative. This kind of ion is called an **anion**. If a neutral atom loses an electron, it becomes positive. This kind of ion is called a **cation.**

Current: The steady flow of electrons is called current. Current is what flows through electrical wires and powers electronics items, from light bulbs to televisions.

Dielectrics: A dielectric is an insulator that can be polarized by an electric field, meaning that it is a material in which charge does not flow freely, but in the presence of an electric field it can shift its charge distribution. Positive charge in a dielectric will migrate towards the applied field, while negative charges will shift away. This creates a weak local field within the material that opposes the applied field.

Static Electricity: Static electricity is when an excess of electric charge collects on an object's surface. It can be created through contact between materials, a buildup of pressure or heat, or the presence of a charge. Static electricity can also be created through friction between a balloon (or another object) and human hair (see). It can be observed in storm clouds as a result of pressure buildup; lightning (see) is the discharge that occurs after the charge exceeds a critical concentration.

ELECTROSTATICS OR STATIC ELECTRICITY OR FRICTIONAL ELECTRICITY

All of us have the experience of seeing a spark or hearing a crackle when we take off our synthetic clothes or sweater, particularly in dry weather. The reason for these experiences is discharge of electric charges through our body. Static means anything that does not move or change with time. The branch of physics, which deals with study of charges at rest (static charge), the force between the static charges fields and potentials due to these charges is called as **Electrostatics or Static Electricity**. **Frictional Electricity** is the electricity produced by rubbing two suitable bodies and transfer of electrons from one body to other.

Historically, this phenomenon was discovered by a Greek ‘ Thales of Miletus’ around 600BC. The name electricity was taken from the Greek word ‘Elecktron’.

CONDUCTORS AND INSULATORS

All materials can be categorized as either insulators or conductors based on a physical property known as resistivity.Resistivity, a physical property that measures the ability of a material to carry current, is the main factor in determining whether a substance is a conductor or an insulator.

Conductors: All conductors contain electric charges that, when exposed to a potential difference, move towards one pole or the other. The positive charges in a conductor will migrate towards the negative end of the potential difference; the negative charges in the material will move towards the positive end of the potential difference. This flow of charge is electric current. Ionic substances and solutions can conduct electricity, but the most common and effective conductors are metals. Copper is commonly used in wires due to its high conductivity and relatively inexpensive price. However, gold-plated wires are sometimes used in instances in which especially high conductivity is necessary. Every conductor has a limit to its ampacity, or amount of current it can carry. This usually is the current at which the heat released due to resistance melts the material.

Insulators: Insulators are materials in which the internal charge cannot flow freely, and thus cannot conduct electric current to an appreciable degree when exposed to an electric field. While there is no perfect insulator with infinite resistivity, materials like glass, paper and Teflon have very high resistivity and can effectively serve as insulators in most instances. Just as conductors are used to carry electrical current through wires, insulators are commonly used as coating for the wires. Insulators, like conductors, have their physical limits. When exposed to enough voltage, an insulator will experience what is known as electrical breakdown, in which current suddenly spikes through the material as it becomes a conductor.

Semiconductor

A semiconductor is a substance, usually a solid chemical element or compound, that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current. Its conductance varies depending on the current or voltage applied to a control electrode, or on the intensity of irradiation by infrared (IR), visible light, ultraviolet (UV), or X rays. e.g; silicon, germanium etc.

Superconductor

A superconductor is a material that can conduct electricity or transport electrons from one atom to another with no resistance. This means no heat, sound or any other form of energy would be released from the material when it has reached “critical temperature” (T_c), or the temperature at which the material becomes superconductive. Unfortunately, most materials must be in an extremely low energy state (very cold) in order to become superconductive. Research is underway to develop compounds that become superconductive at higher temperatures. Currently, an excessive amount of energy must be used in the cooling process making superconductors inefficient and uneconomical.

SUPERCONDUCTIVITY

Superconductivity is the ability of certain materials to conduct electric current with practically zero resistance. This produces interesting and potentially useful effects. For a material to behave as a superconductor, low temperatures are required.Superconductivity was first observed in 1911 by H. K. Onnes, a Dutch physicist. His experiment was conducted with elemental mercury at 4 degrees kelvin (approximately -452 degrees Fahrenheit), the temperature of liquid helium. Since then, some substances have been made to act as superconductors at higher temperatures, although the ideal — a material that can superconduct at room temperature — remains elusive.

Use of superconductivity

1. **Superconducting Transmission Lines:** Since 10% to 15% of generated electricity is dissipated in resistive losses in transmission lines, the prospect of zero loss superconducting transmission lines is appealing.
2. **Power Applications, High Tc:** Power applications of high temperature superconductors would have the major advantage of being able to operate at liquid nitrogen temperature. The biggest barrier to their application has been the difficulty of fabricating the materials into wires and coils.
3. **Fault-Current Limiters:** High fault-currents caused by lightning strikes are a troublesome and expensive nuisance in electric power grids. One of the near-term applications for high temperature superconductors may be the construction of fault-current limiters which operate at 77K. The need is to reduce the fault current to a fraction of its peak value in less than a cycle (1/60 sec).
4. **Superconducting Motors:** Super-conducting motors and generators could be made with a weight of about one tenth that of conventional devices for the same output. This is the appeal of making such devices for specialized applications. Motors and generators are already very efficient, so there is not the power savings associated with superconducting magnets. It may be possible to build very large capacity generators for power plants where structural strength considerations place limits on conventional generators.
5. **Superconducting Maglev Trains:** While it is not practical to lay down superconducting rails, it is possible to construct a superconducting system onboard a train to repel conventional rails below it. The train would have to be moving to create the repulsion, but once moving would be supported with very little friction. There would be resistive loss of energy in the currents in the rails. Ohanian reports an engineering assessment that such superconducting trains would be much safer than conventional rail systems at 200 km/h.A Japanese magnetically levitated train set a speed record of 321 mi/h in 1979 using superconducting magnets on board the train. The magnets induce currents in the rails below them, causing a repulsion which suspends the train above the track
6. **SQUID Magnetometer:** The superconducting quantum interference device (SQUID) consists of two superconductors separated by thin insulating layers to form two parallel Josephson junctions. The device may be configured as a magnetometer to detect incredibly small magnetic fields — small enough to measure the magnetic fields in living organisms. Squids have been used to measure the magnetic fields in mouse brains to test whether there might be enough magnetism to attribute their navigational ability to an internal compass.
7. **Superconductors in NMR Imaging:** Superconducting magnets find application in magnetic resonance imaging (MRI) of the human body. Besides requiring strong magnetic fields on the order of a Tesla, magnetic resonance imaging requires extremely uniform fields across the subject and extreme stability over time. Maintaining the magnet coils in the superconducting state helps to achieve parts-per-million spacial uniformity over a space large enough to hold a person, and ppm/hour stability with time.

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ELECTRIC CURRENT

ELECTRIC CURRENT

Electric current is nothing but the rate of flow of electric charge through a conductor with respect to time. It is caused by drift of free electrons through a conductor to a particular direction. As we all know, the measuring unit of electric change is Coulomb and the unit of time is second, the measuring unit of current is Coulombs per second and this logical unit of current has a specific name Ampere after the famous French scientist André-Marie Ampere.

TYPES OF CURRENT

There are only two types of electrical current, direct current and alternating current.

We abbreviate them as DC and AC respectively. Concept of DC was developed before AC. But AC becomes most popular means of generating, transmitting and distributing of electric power. The direction of the flow of direct current is unidirectional, means this current does not alter its direction during flowing.

ALTERNATING CURRENT

The current whose flow is not unidirectional moreover it alternates at a frequency, is called **alternating current.** In other words, the direction of the current continuously changes from forward to backward and then backward to forward in the circuit. The number of times, this direction changes from forward to backward or from backward to forward per second, is referred as frequency of the current.

DIRECT CURRENT

Direct current or DC electricity is the continuous movement of electrons from an area of negative (–) charges to an area of positive (+) charges through a conducting material such as a metal wire. Whereas static electricity sparks consist of the sudden movement of electrons from a negative to positive surface, DC electricity is the continuous movement of the electrons through a wire. A DC circuit is necessary to allow the current or steam of electrons to flow. Such a circuit consists of a source of electrical energy (such as a battery) and a conducting wire running from the positive end of the source to the negative terminal. Electrical devices may be included in the circuit. DC electricity in a circuit consists of voltage, current and resistance. The flow of DC electricity is similar to the flow of water through a hose.

Resistance

The opposite of conductance is resistance - a quantity that describes how strongly a material opposes the flow of electric current. An object or medium that has high electrical resistance is called a resistor. Resistance is the electric property that impedes a current. A current flowing through a wire (or resistor) is like water flowing through a pipe, and the voltage drop across the wire is like the pressure drop which pushes water through the pipe. Resistance is proportional to how much pressure is required to achieve a given flow, while conductance is proportional to how much flow occurs for a given pressure. Conductance and resistance are reciprocals . The resistance of an object depends on its shape and the material of which it is composed. The cylindrical resistor is easy to analyze, and by so doing we can gain insight into the resistance of more complicated shapes. The SI unit for resistance is the ohm.

The Battery

A battery is a device that converts chemical energy directly to electrical energy. It consists of a number of voltaic cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the anode, or negative electrode; the other half-cell includes electrolyte and the cathode, or positive electrode. In the redox (reduction-oxidation) reaction that powers the battery, cations are reduced (electrons are added) at the cathode, while anions are oxidized (electrons are removed) at the anode. The electrodes do not touch each other but are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half-cells allows ions to flow, but prevents mixing of the electrolytes.

Each half-cell has an electromotive force (or emf), determined by its ability to drive electric current from the interior to the exterior of the cell. The net emf of the cell is the difference between the emfs of its half-cells, or the difference between the reduction potentials of the half-reactions.

The electrical driving force across the terminals of a cell is known as the terminal voltage (difference) and is measured in volts. When a battery is connected to a circuit, the electrons from the anode travel through the circuit toward the cathode in a direct circuit. The voltage of a battery is synonymous with its electromotive force, or emf. This force is responsible for the flow of charge through the circuit, known as the electric current.

Ohm's Law

Ohm's Law states that current is proportional to voltage; circuits are ohmic if they obey the relation V=IR.

Superconductivity

Superconductivity is a phenomenon of zero electrical resistance and expulsion of magnetic fields in certain materials below a critical temp. Superconductivity is a phenomenon of exactly zero electrical resistance and expulsion of magnetic fields occurring in certain materials when cooled below a characteristic critical temperature. It was discovered by Heike Kamerlingh Onnes (shown in) on April 8, 1911 in Leiden.

Inductance

Induction is the process in which an emf is induced by changing magnetic flux. Transformers, for example, are designed to be particularly effective at inducing a desired voltage and current with very little loss of energy to other forms .

Transformers

Transformers change voltages from one value to another. For example, devices such as cell phones, laptops, video games, power tools and small appliances have a transformer (built into their plug-in unit) that changes 120 V into the proper voltage for the device.

Effects of Electric Current

There are mainly two effects of current, such as heating effect and magnetic effect. Each and every utilization of electricity, we see in our daily life, is either due to heating effect or due to magnetic effect of current. For examples, the light bulb glows in our house is due to heating effect of current and the fan rotates in our house is due to magnetic effect of current. There are thousands of other examples which can illustrate the effect of current, too.

Electric fuse

The fuse is placed in series with the device. An electric fuse consists of a piece of wire made of a metal or an alloy of appropriate melting point, for example aluminum, copper, iron, lead, etc. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire in\creases. This melts the fuse wire and breaks the circuit. The fuse wire is usually encased in a cartridge of porcelain or similar material with metal ends.

Incandescent bulbs

Incandescent lights are the most commonly used form of lighting. This includes the standard everyday light bulbs and halogen down lights. On the offset, they are inexpensive to buy but their lifetime running costs quickly add up. An incandescent light creates light by running electricity through a filament, which heats up and then literally glows white-hot. It is a very inefficient way of creating light as 90% of the electricity used is turned into heat with only 10% being turned into light. Incandescent lights are very dangerous and are a fire hazard with halogen lights being responsible for many household fires. The filaments in halogen lights rise up to 2,500°C and the bulb up to 500°C. The temperature at which paper will ignite without a spark or flame is 230°C, so if there is any insulation touching the light fitting a fire can easily start.

Compact Fluorescent Lights

Compact fluorescents have come a long way from the flickering, unflattering light they once were. They are now available in a wide range of light temperatures, are longer lasting than incandescent lights and are more energy efficient. CFL's have a lamp life of about 10,000 hours and use approximately 80% less energy than an equivalent incandescent. CLF's use gas, mercury particles and phosphor to create light. The gas becomes excited by electricity, and when combined with mercury particles, produces invisible ultraviolet light. The UV light then hits the white phosphor coating inside the bulb causing it to fluoresce and emit white light. There is circuitry inside the base of the light that stops it from flickering like in old fluoro lights.

LED Lights

LED is an acronym for Light Emitting Diode. Diodes are semiconductors, which will conduct energy in only one direction. LED lights and tubes use diodes instead of gas or heated filaments to produce light making them the most energy efficient lighting option available. Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor. The lifespan of an LED surpasses the short life of an incandescent bulb by thousands of hours. Tiny LEDs are already replacing the tubes that light up LCD HDTVs to make dramatically thinner televisions.

CFL does not require choke

Both tube lights and CFLs (compact fluorescent lamps) are low pressure mercury vapour discharge lamps. When electrical discharge could strike the column of the tube, lot of invisible UV radiation having is generated. This UV radiation when strikes the white coating inside the tube made of fluorescent material-phosphors gets converted to visible light through the process of fluorescence. Thus we see the white light. For a conventional a tube light, a choke is required, to initiate the electrical discharge process.But CFLs, being smaller in dimensions offering much lower electrical resistance do not require such bulky chokes. Instead the discharge in CFLs is initiated by much compact electronic circuits integrated into the CFL holder.

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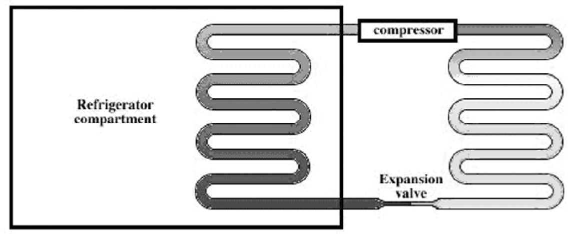
PHYSIC APPLICATION

REFRIGERATORS

Air conditioners and refrigerators are designed to cool something down in a warm environment. As with heat pumps, work input is required for heat transfer from cold to hot. The quality of refrigerators is judged by how much heat transfer occurs from a cold environment compared with how much work input is required. What is considered the benefit in a heat pump is considered waste heat in a refrigerator. The operation of a refrigerator is based on two physical principles. First, when a substance changes from liquid state to gaseous state, its temperature would remain at its boiling point until the liquid is all evaporated. The substance has to absorb certain amount of energy, called "latent heat", during the change. On the other hand, the boiling point of a substance rises under high pressure, thus the gasified substance may return to its liquid state and releases the latent heat.

The central element in the operation of a refrigerator (or a freezer) is a fluid, called a **refrigerant** or, occasionally, a working fluid. Of course, some refrigerants work better than others. The most efficient refrigerants that have been found to date belong to the Freon family which includes CCl_2F_2 (FREON-12), $CClF_3$ (FREON-13), and many others. These materials are known as **chloroflorocarbons** (CFC's). Unfortunately, it has recently become apparent that these chemicals damage the Earth's ozone layer.

In a refrigerator (or air conditioner) the refrigerant forms the "circuit" that allows heat to be "pumped" from the cooler region (inside of the 'fridge) to the warmer region (the kitchen).



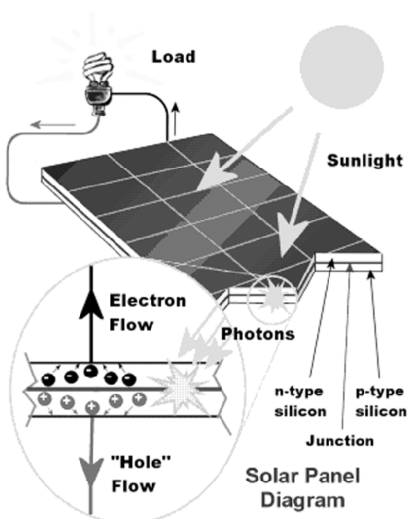
INDUCTION COOKING

Induction cooking heats a **cooking vessel by magnetic induction**, instead of by thermal conduction from a flame, or an electrical heating element. A cooking vessel must be made of or contain a ferromagnetic metal such as cast iron or stainless steel. Copper, glass and aluminum vessels can be placed on a ferromagnetic interface disk which functions as a conventional hotplate.In an induction cooker, a coil of copper wire is placed under the cooking pot and an alternating electric current is passed through it. The resulting oscillating magnetic field induces a magnetic flux which repeatedly magnetises the pot, treating it like a lossy magnetic core of a transformer. This produces large eddy currents in the ferrous pot, which because of the resistance of the pot, heats it. Induction cooking provides faster heating, improved thermal efficiency, and more consistent heating than cooking by thermal conduction, with precise control similar to gas.

A solar panel turns the sun's light into electricity! We see electricity at work every day. For instance, when you turn on a lamp, electrons move through the cord and light up the bulb. That flow of electrons is called electricity.

Solar panel

One solar panel is made up of many small solar cells. Each of these cells uses light to make electrons move. The cell is made up of two different layers that are stuck together. The first layer is loaded with electrons, so the electrons are ready to jump from this layer to the second layer. That second layer has had some electrons taken away, so it is ready to take in more electrons. When the light hits an electron in the first layer, the electron jumps to the second layer. That electron makes another electron move, which makes another electron move, and so on. It was the sunlight that started the flow of electrons, or electricity.



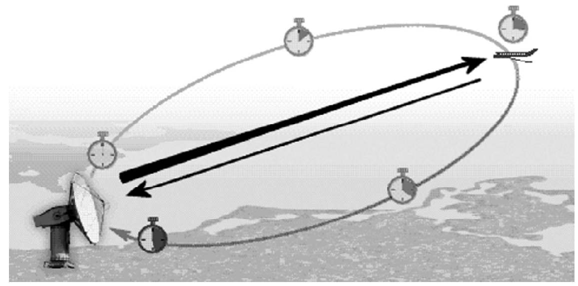
Credit card

A credit card works because it contains magnets placed in a specific pattern. The credit card machine has coil of wires that cause a change in magnetic field when the card is swiped. This process is called electromagnetic induction. The change in magnetic field induces a voltage that creates a current that is used to signal your account information to the machine.

Radar

Radar is an acronym for Radio Detection and Ranging. The term "radio" refers to the use of electromagnetic waves with wavelengths in the so-called radio wave portion of the spectrum, which covers a wide range from 104 km to 1 cm. Radar systems typically use wavelengths on the order of 10 cm, corresponding to frequencies of about 3 GHz. The detection and ranging part of the acronym is accomplished by timing the delay between transmission of a pulse of radio energy and its subsequent return. It consists of:

1. **Transmitter:** The transmitter creates the radio wave to be sent and modulates it to form the pulse train. The transmitter must also amplify the signal to a high power level to provide adequate range.
2. **Receiver:** The receiver is sensitive to the range of frequencies being transmitted and provides amplification of the returned signal. In order to provide the greatest range, the receiver must be very sensitive without introducing excessive noise. Physical fundamentals of the radar principle.



Advantages: Radar has many advantages compared to an attempt of visual observation:

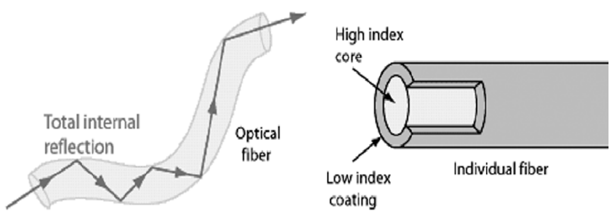
1. Radar is able to operate day or night, in lightness or darkness over a long range;
2. Radar is able to operate in all weathers, in fog and rain, it can even penetrate walls or layers of snow;
3. Radar has very broad coverage; it is possible to observe the whole hemisphere;
4. Radar detects and tracks moving objects, a high resolution imaging is possible, that results in an object recognition;
5. Radar can operate unmanned, 24 hours a day, 7 days a week.

MICROWAVE OVENS

The microwave radiation of microwave ovens and some radar applications is produced by a device called a magnetron. Modern microwave overns operate at the frequency 2,450 MHz.In a microwave oven, microwaves are produced by a device called a magnetron. The microwaves produced by the magnetron are directed towards a spinning propellor made of metal. One of the properties of microwaves is that they are reflected off of metal, and so they reflect off of the "stirrer fan" and into the oven chamber. The oven chamber is lined with metal so that the microwaves will continue to bounce around in the chamber until they are absorbed. Microwaves are absorbed by some of the chemicals in foods—most optimally water. This is because water molecules are polar, meaning that the distribution of charge within the molecule is not symmetrical; one side of the molecule is slightly positive, and the other is slightly negative. Thus, in the presence of the electric field component of a microwave, a force will be applied to both dipoles of the molecule which will cause it to rotate .As the water molecules rotate, they bump into other molecules surrounding them and transfer some of their kinetic energy. By the Kinetic Particle Theory, if the particles in the food have more kinetic energy.

Fiber Optics

The field of fiber optics depends upon the **total internal reflection** of light rays traveling through tiny optical fibers. The fibers are so small that once the light is introduced into the fiber with an angle within the confines of the numerical aperture of the fiber, it will continue to reflect almost losslessly off the walls of the fiber and thus can travel long distances in the fiber. Bundles of such fibers can accomplish imaging of otherwise inaccessible areas.



How does an Optical Fibre Work?

Light from a laser enters at one end of the fibre, striking the surface of the glass at an angle greater than the critical angle. Total internal reflection occurs at the glass surface and the light cannot escape until it reaches the other end of the fibre. Both visible light and infra-red can be used as they can travel long distances in glass with very little being absorbed. The plastic coating prevents scratches on the glass surface which can allow the light to escape from the side of the fibre.

Uses for optical fibres are:

Communication: Telephone transmission method uses fibre-optic cables. Optical fibres transmit energy in the form of light pulses. The technology is similar to that of the coaxial cable, except that the optical fibres can handle tens of thousands of conversations simultaneously.

Medical uses: Optical fibres are well suited for medical use. They can be made in extremely thin, flexible strands for insertion into the blood vessels, lungs, and other hollow parts of the body. Optical fibres are used in a number of instruments that enable doctors to view internal body parts without having to perform surgery.

Simple uses: The simplest application of optical fibres is the transmission of light to locations otherwise hard to reach. Also, bundles of several thousand very thin fibres assembled precisely side by side and optically polished at their ends, can be used to transmit images.

PHOTOCOPY MACHINES AND PRINTERS

In the first step of xerography, a high-voltage device (either a corona wire or charge roller) charges a cylindrical drum. In the second step, a lamp illuminates the original document. The white areas of the original reflect light onto the surface of the drum, which is photoconductive. The areas of the drum exposed to light then discharge to the ground. Next, the toner, a positively-charged powder used to form images on the paper, is placed on the drum. It is attracted to the negative (black) areas. This develops the image. The image with toner on the drum is then transferred to a piece of paper with more negative charge than the drum .Finally, the toner is melted and bonded to the paper by heat and pressure rollers.

MOTOR

An electrical motor is a device that converts electrical energy to mechanical energy. **It works on the principle of the interactions between the magnetic fields of a permanent magnet and the field generated around a coil conducting electricity.** The attractive and repulsive forces between the magnet and the coil create rotational motion.

A simple electric motor consists of the following parts:

1. A permanent magnet
2. **Armature or rotor:** This consists of a thin copper wire coiled around an iron core, hence when electric current flows it acts as an electromagnet. In the case of a simple motor this is a wire loop.
3. **Commutator:** A Commutator is a copper ring split in two halves. In a simple electric motor each half is connected to the ends of the wire loop. In practice they are connected to the axle.
4. **Brushes:** The brushes connect the wire loop or armature to the power supply
5. **Axle:** In electric motors the commutator is attached to the axle. The axle transfers the rotational motion.
6. Power supply (battery)

The design of a motor for an electrical appliance requires consideration of whether it will run at a set speed, how much power it must supply, whether it will be powered by AC or DC and what reliability is required. The essentials of an electric motor are the supply of electrical energy to a coil in a magnetic field causing it to rotate.

GENERATOR

The generation of electrical power requires relative motion between a magnetic field and a conductor. In a generator, mechanical energy is converted into electrical energy while the opposite occurs in an electric motor.

The electricity produced by most generators is in the form of alternating current. In general AC generators, motors and other electrical equipment are simpler, cheaper and more reliable than their DC counterparts. AC electricity can be easily transformed into higher or lower voltages making it more versatile than DC electricity.

The DC electric motor relies on the motor effect to create a continuous spinning motion in which current must be continuously supplied into the motor to keep the magnetic fields interacting and the external field exerting forces on the current-carrying conductors. The main features are:

1. Armature – the ferromagnetic cylinder which rotates on an axle to produce the rotational motion of the DC electric motor.
2. Coil – is wrapped/coiled around the armature on opposite sides so that the current changes direction about the armature. It is responsible for giving the current a medium to flow.
3. Split-ring commutator – is used so that the current is kept perpendicular to the magnetic field lines. The commutator's role is to change the direction of the current at the right point to ensure the armature continues rotation in the same direction.
4. Brushes – are used to keep the current flowing into the commutator without sparking.
5. Magnets – produce the external magnetic field which interacts with the field produced by the coiled wire about the armature.

Galvanometer

A galvanometer is used to **measure the magnitude and direction of direct current (DC).** It uses the motor effect to do this.

Loudspeaker

Loudspeakers are used to transform electrical energy (impulses) into sound energy. A loudspeaker consists of a circular magnet that has one pole on the outside and the other on the inside. The voice coil sits in between the poles (essentially wrapped around the centre core) which is connected to an amplifier which produces the amplified sound. This voice coil is caused to vibrate or move in and out of the magnet due to the motor effect. The force acting upon the magnetic field produced from the coil pushes the amplified waves out of the speaker cone so that it can be heard.

Electromagnetic braking

Electromagnetic braking systems utilise eddy currents to interact with electromagnets as to create a stopping force for moving vehicles. The electromagnetic brakes consist of electromagnets positioned on either side of a rotating disc. The electromagnets will be creating a magnetic field as a result of the current flowing through them will interact with this magnetic field, producing eddy currents. These **eddy currents** produced as a result of the relative motion between the disc and electromagnetic fields will produce their own magnetic field which opposes the electromagnetic field – which is the braking force. Electromagnets are chosen rather than permanent magnets, because the electromagnets can be switched off when not needing to brake (so there is no magnetic field while the disc spins). The strength of the magnetic field from the electromagnets can be increased by increasing the current in them, resulting in hard or soft braking.

Transformer

A transformer is made from two coils; one on each side of a soft iron core. It can **decrease the voltage** (called a step **down transformer**) or increase the voltage (called a **step up transformer**).

Step Up Transformer: Alternating current is passed through the primary coil (the input) which creates a changing magnetic field in the iron core. The changing magnetic field then induces alternating current of the same frequency in the secondary coil (the output). **A step up transformer has more turns of wire on the secondary coil, which makes a larger induced voltage in the secondary coil.** It is called a step up transformer because the output voltage is larger than the input voltage.

Step down transformer: When it is used to "decrease" the voltage on the secondary winding with respect to the primary it is called a **Step-down transformer**.

Fluorescence: Fluorescence occurs when an electron in an atomic orbital absorbs energy from some source (like an interaction with a photon, or a collision with another atom) is promoted to a higher energy level and then, on 'falling back', releases some of that energy in the form of visible light. The missing energy is usually converted to thermal energy (infra-red transitions), making the tube slightly hot.

Fluorescent light: A fluorescent light is a type of gas discharge tube, it is made of glass and is narrow, with two electrical connections on each of the metal caps that seal the ends of the tube. It contains an inert gas (such as argon, neon, or krypton) and mercury vapour. The gases inside the tube have a pressure of about 0.003 atmospheres. The mixture of mercury and gas is not conductive when the tube is off.

A high voltage discharge is needed to start the flow of current. The initial high voltage burst is necessary to produce electrons with enough kinetic energy to ionise the mercury atoms - the atoms in the gas need to be sparse enough (low pressure) so that KE can be built up to a level that will allow ionisation of the mercury atoms.The high speed electrons cause the mercury atoms to ionize. After this has taken place, the voltage can lowered - as the initial ionisations produce more of the same. The voltage required ranges from 100 volts for tubes under 30 watts and 100 to 175 volts for tubes of 30 watts or more.A pair of electrode filaments are located at the metal ends of the tube. They produce electrons that ionise the mercury atoms. They do this by thermionic emission. The filaments remain hot when the tube is lit producing a continuous electrical discharge. **The flow of electrons through the gases excites the electrons in the mercury atoms, which then emit ultraviolet (UV)**

radiation. There is a good reason why the lamp contains only a small amount of mercury, which must be vaporized to support the lamp current and generate light. At low temperatures the mercury is in the form of dispersed liquid droplets. As the lamp warms, more of the mercury is in vapour form - therefore more can be ionised by the electrons passing through it BUT at higher temperatures, self-absorption in the vapour reduces the yield of UV and visible light - so you cannot have too much mercury in the vapour form otherwise it will not produce light.

Advantages over the filament light bulb

1. Fluorescent bulbs are four to six times more efficient than incandescent bulbs.
2. The lamp allows brightly lit workplaces to remain at a cool temperature due to its greatly increased efficiency.

THE RICHTER SCALE

When you hear about an earthquake happening somewhere in the world its magnitude (how big and destructive it is) is usually given on the Richter scale. The magnitude value is proportional to the logarithm of the amplitude of the strongest wave during an earthquake. **A recording of 7, for example, indicates a disturbance with ground motion 10 times as large as a recording of 6, and 100 times the recording for a recording of 5.**

The energy transferred to the surroundings by an earthquake is affected by the amplitude of the wave. It increases by a factor of 30 for every unit increase in the Richter scale.

THERMOMETER

A Thermometer is an instrument that measures temperature. It can be used to measure the temperature of gases, liquids, and solids**. It works by using the fact that certain measurable physical characteristic of substances change when the temperature changes e.g. the volume of a fluid the length of a solid, the resistance - the opposition to the flow of electricity - of an electrical conductor or semiconductor**. There are many types of thermometers. They can be made as **analogue or digital thermometers** - ones that give a sliding scale reading as output or numeric output. They can be made to be used over and over again or as disposable thermometers.

The first known thermometer was invented in 1593 by the Italian astronomer Galileo. It was called a **thermoscope** and was only fairly accurate. An truly accurate thermometer using alcohol was first developed in 1641. In 1714, Gabriel D. Fahrenheit, a German physicist, built a mercury thermometer of the type used today.

Clinical (fever) thermometers: Human body temperature is measured with a clinical, or fever, thermometer. It is a specialized type of liquid-in-glass thermometer that only measures temperature within a very limited range. Many clinical thermometers today are designed to display the output in a digital format to make temperature reading easier.

Non-invasive (those that are not inserted in the body) and highly accurate infrared thermometers, called **tympanic thermometers**, have also been developed. They can take readings of body temperature by measuring heat coming from the ear. **Liquid-in-glass thermometers are the best-known type of thermometers**. They are the ones you will use in the laboratory.

Mercury is the most common liquid in these thermometers. Alcohol is used in areas where the temperature frequently drops below the freezing point of mercury -39°C or where mercury would be harmful if an accident occurred.

A large volume of the liquid fills a glass bulb, which is connected to a sealed narrow glass tube. Some of the liquid partially fills this tube - but its volume is negligible compared to that in the bulb. The bulb is immersed in whatever it to have its temperature measured and absorbs or emits heat energy until it is the same temperature as the surroundings. When the temperature goes up, the volume of the liquid expands and the liquid rises and vice versa. An increase in temperature makes some of the liquid from the bulb rise up the tube, a decrease makes the liquid in the bulb contract and the liquid in the tube contracts back down into the bulb.

A temperature scale is marked on the outside of the thermometer. The narrower the bore of the fine tube, the further apart the scale markings can be placed and the more accurately the temperature can be read.

X-RAYS

X-radiation is a form of electromagnetic radiation. **Most X-rays have a wavelength ranging from 0.01 to 10 nanometers**. X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays. **They were discovered by Rontgen**. An ideal X-ray examination would produce a film that showed sufficient contrast between the features that the doctor wants to examine while putting the patient at minimal risk from the ionizing effect of the radiation. An X-ray tube does not produce a monochromatic beam, it produces a spectrum of X-ray energies limited at the high energy end by the accelerating voltage applied.

The clinical applications of radiation fall into two primary areas:

1. obtaining information about the structure and function of the patient's internal organs, and
2. treating (i.e., killing) benign or malignant growths on the surface or within the interior of the patient's body.

LED TV

LED TV is a type of LCD television that uses light-emitting diodes (LEDs) to backlight the display instead of the cold cathode fluorescent lights (CCFLs) used in standard LCD televisions. LED TVs are more formally known as LED-backlight LCD television**. An LED is a semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength**. In comparison with fluorescent lights, LEDs have significantly lower power requirements and convert power to light more efficiently so that less is lost as heat and focus it more precisely so that there is less light leakage, which can cause fuzziness. An LED also lasts much longer than most other lighting technologies.

There are **three different LED technologies used**. The most commonly used of the three is **edge-lit LED**, in which white LEDs are situated around the edge of the screen and a diffusion panel employed to illuminate the display evenly. Edge-lit LED displays can be very thin. Another type is **dynamic RGB LED**, which are placed behind the panel. **RGB LEDs** make it possible to target areas for dimming more precisely, which in turn leads to truer reproduction of blacks and whites. In the third type of display, full-array LED, LEDs are positioned behind the panel similarly to the way they are with RGB LED displays but there is no capacity for localized dimming.

Pros:

1. Use less power
2. produce less heat than plasma or other LCD TVs. RGB LED:
3. Brighter, sharper display and better contrast ratio than other LCD TVs. Edge-lit LED.
4. Thinner format.

Cons: More expensive than plasma or other LCD TVs.

LCD TV

LCD TV is a television display technology based on a liquid crystal display. LCD TVs consume much less power than plasma displays because **they work on the principle of blocking light rather than emitting it**. An LCD display uses either a passive matrix or an active matrix display grid. The active matrix LCD is also known as a **thin film transistor** (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, which improves the refresh rate.

Pros

1. Not prone to burn-in.
2. Available in smaller sizes than plasma, so may be a better option depending on the available space.

Cons

1. Can suffer from slower response, which can create a ghosting effect.
2. Some models are also prone to the screen door effect, which means that a faint mesh pattern may be visible.

PLASMA TV

Plasma TV is a television display technology in which each pixel on the screen is illuminated by a tiny bit of plasma (charged gas). The plasma is encased between two thin sheets of glass. Plasma displays are generally considered to offer better dark-room viewing and wider viewing angles than LCD. Plasma can be vulnerable to burn-in, a phenomenon in which faint, permanent "ghosts" appear on displays that have maintained a fixed image for long periods of time. Most newer models have burn-in prevention features, but these may not always be 100% effective. However, some plasma TVs also have the ability to remove burn-in should it occur.

Pros

1. Wide viewing angles. The black-level performance (the intensity of black in the display) compensates for ambient light and sharpens the picture.
2. Excellent picture quality in higher-end models.
3. Not as bulky as rear projection TVs. Wall-mountable.
4. High refresh rate means that the picture is smoother and there is no motion blur. Burn-in is possible but not usually a problem with newer models.

Cons

1. Consume significantly more power than LCD TV of similar size.
2. Slightly heavier than LCD.
3. Glass screen can reflect light unless treated to be less reflective.

3-D TV

3-D TV is a television display technology that enables a three-dimensional effect, so that viewers perceive that an image has depth as well as height and width, similarly to objects in the real world.

The technology behind the 3-D effect is called **stereoscopy or stereoscopic imaging**. In human eyesight, the perspective difference between objects seen through the left and right eyes (binocular disparity), in conjunction with our accommodation (through focusing) to integrate those two perspectives, completes our ability to perceive three dimensions. Traditional 3-D TV (and movies as well) typically work by presenting two separate images – one for the right eye and one for the left – that are incorporated through the use of specialized glasses. Another technology, known as **autostereoscopic** imaging (auto 3-D), is screen-based and does not require viewers to wear special glasses.

OLED TVs

Promised for several years and now finally making an appearance in the large-screen TV market are OLED sets. Using **organic light-emitting diodes**, OLED TVs can light up each picture element individually, without the need for the separate light source that LCDs require. This translates into a much brighter, more colorful picture, with dark areas of the screen as deep as possible. Today's OLEDs achieve HD resolution; Ultra-HD models are anticipated to arrive late this year. OLED TVs use a thin, flexible material, and TV makers have built some screens with a slight curve. But this is more to show off the technology than to provide a better viewing experience.

Pros

1. The best TV picture, bar none, available today.
2. Colors truly pop on these sets, and blacks look deeper than on any LCD or plasma screen.

Cons

Price is a definite deterrent for OLED TVs right now. It's uncertain how the screens will fair over time, including whether they will retain "ghost" images (also known as burn-in) from displaying a static picture for too long.

ULTRA HD OR 4K TVs

Rather than using a new or different display technology**, Ultra HDTVs are LED LCD models that cram more pixels onto the screen.** This generates sharper, more-detailed images. Also known as 4K TVs, consumer Ultra HD sets have four times the resolution (3840 x 2160 pixels) of traditional HDTVs. However, don't expect to see a picture that's four times better. Given the dearth of Ultra HD content, the sets' mostly upscale current HD material to boost the image quality (a less than ideal solution).

Pros

1. Small objects on the screen have more detail, and text is easier to read.
2. Overall, images appear richer and more lifelike than on an HDTV, but the benefits can be subtle.

BLUETOOTH

Bluetooth is a computing and telecommunications industry specification that describes how mobile phones, computers, and personal digital assistants (PDAs) can easily interconnect with each other and with home and business phones and computers using a short-range wireless connection. The technology got its unusual name in honor of Harald Bluetooth, king of Denmark in the mid-tenth century.

Bluetooth requires that a low-cost transceiver chip be included in each device. The transceiver transmits and receives in a previously unused frequency band of **2.45 GHz** that is available globally (with some variation of bandwidth in different countries). Each device has a **unique 48-bit address from the IEEE 802 standard. Connections can be point-to-point or multipoint.** The maximum **range is 10 meters**. Data can be exchanged at a rate of 1 megabit per second (up to 2 Mbps in the second generation of the technology). A frequency hop scheme allows devices to communicate even in areas with a great deal of electromagnetic interference. Built-in encryption and verification is provided.

BLUE SNARFING

Blue snarfing is the theft of information from a wireless device through a Bluetooth connection. By exploiting a vulnerability in the way Bluetooth is implemented on a mobile phone, an attacker can access information — such as the user's calendar, contact list and e-mail and text messages — without leaving any evidence of the attack. Other devices that use Bluetooth, such as laptop computers, may also be vulnerable, although to a lesser extent, by virtue of their more complex systems. Operating in invisible mode protects some devices, but others are vulnerable as long as Bluetooth is enabled.

Bluejacking: Bluejacking is the practice of sending messages between mobile users using a Bluetooth wireless connection. People using Bluetooth-enabled mobile phones and PDAs can send messages, including pictures, to any other user within a 10-meter or so range. Because such communications don't involve the carrier, they are free of charge, which may contribute to their appeal.

Wibree: Wibree, also called "**Baby Bluetooth**," is a low-power wireless local area network (WLAN) technology that facilitates interoperability among mobile and portable consumer devices such as pagers, personal digital assistants (PDAs), wireless computer peripherals, entertainment devices and medical equipment. Originally conceived by Nokia and developed in conjunction with Broadcom, CSR and others, Wibree is similar to Bluetooth but consumes a small fraction of the battery power. Wibree operates at a range of 5 to 10 meters (about 16.5 to 33 feet) with a data rate of up to 1 megabit per second (Mbps) in the 2.4-GHz radio-frequency (RF) band. Wibree may be deployed on a stand-alone chip or on a dual-mode chip along with conventional Bluetooth.

BLUETOOTH BRICK

A Bluetooth brick is a battery-powered, sealed device **that has sensors for monitoring and communicating information such as temperature or vibration levels.** Bluetooth is a standard technology for short-range wireless communication. Bluetooth bricks are especially convenient in industries where cable is difficult to install or requires frequent replacement because machinery is constantly moving. The bricks, which weigh about a half pound and are about the size of a paperback book, can be hung in hard-to-reach places such as on the top of a crane, or in the middle of a moving conveyor belt. Bluetooth technology suits this kind of application because the monitoring devices are not sending out large amounts of data.

WI-FI

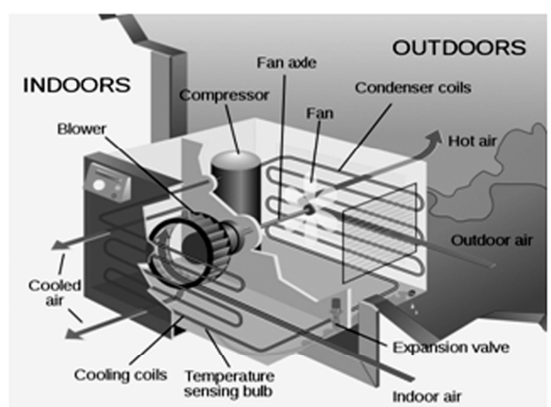
Wi-Fi (or WiFi) is a local area wireless technology that allows an electronic device to participate in computer networking using 2.4 GHz UHF and 5 GHz SHF ISM radio bands.The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network" (WLAN) product based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards". However, the term "Wi-Fi" is used in general English as a synonym for "WLAN" since most modern WLANs are based on these standards. "Wi-Fi" is a trademark of the Wi-Fi Alliance. Many devices can use Wi-Fi, e.g. personal computers, video-game consoles, smartphones, digital cameras, tablet computers and digital audio players. These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of **about 20 meters (66 feet) indoors and a greater range outdoors**. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square kilometres achieved by using multiple overlapping access points.

Depiction of a device sending information wirelessly to another device, both connected to the local network, in order to print a document. **Wi-Fi can be less secure than wired connections, such as Ethernet, because an intruder does not need a physical connection**. Web pages that use TLS are secure, but unencrypted internet access can easily be detected by intruders. Because of this, Wi-Fi has adopted various encryption technologies. The early encryption WEP proved easy to break. Higher quality protocols (WPA, WPA2) were added later. An optional feature added in 2007, called Wi-Fi Protected Setup (WPS), had a serious flaw that allowed an attacker to recover the router's password

AIR CONDITIONER

An apparatus for controlling, especially lowering, the temperature and humidity of an enclosed space. Every air conditioner (also pronounced as AC, A/C or Air Cooler in certain regions of the world) has a compressor inside it. It works to compress and pump the refrigerant gas. Compression of refrigerant produces heat. To dissipate this heat, compressed refrigerant is pumped to the condenser coils where a fan blows the heat out to outer atmosphere. During the process, refrigerant takes the liquid form. This liquid refrigerant is pumped towards expansion valve. Expansion valve has a temperature sensor connected to it which works in correlation with thermostat settings. Expansion valve releases the appropriate amount of refrigerant to evaporator (cooling coils) where liquefied refrigerant takes gaseous form. Conversion from liquid to gaseous state due to expansion produces chillness because energy is absorbed from the surrounding. Air when passes through fins (attached to coils) gets cooled and blown to the room. The refrigerant in cooling coils then enters the compressor and gets compressed once again. The cycle continues unless the compressor is shut down.

In a nutshell, air conditioner draws heat from the indoor and releases it to the outdoor. Indoor acts as a source and outdoor as a sink for heat.



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