OPTICS

Study of light is called optics.

- Light is the form of energy.
- Light has dual nature (wave nature and particle nature).
- Light is an electromagnetic wave.
- Light is a non-mechanical transverse wave.
- Speed of light in vacuum is 3×10^8 m/s.
- Light travels in straight line.

REFLECTION OF LIGHT

The process of sending back the light lays which falls on the surface of an object called reflection of light.

- Silver meal is the best reflector of light.

Laws of Reflection

i) First law: - The incident ray, the reflected ray, and the normal, all lies in the same plane.

ii) Second law: - The angle of incident is always equal to the angle of reflation.

$$\boxed{\angle i = \angle r}$$

IMAGE

It is a point where the light rays coming from an object meet or appears to meet after reflection or refraction.

The image is of two type.

i) Real image: - The image which can be obtained on a screen is called real image.
   - Real image is always inverted.
     e.g. Image formed on a cinema screen.

ii) Virtual image: - The image which can not be obtained on screen is called virtual image.
   - Virtual image is always erect.
     e.g. Image formed by a plane mirror.

REFLECTION OF LIGHT BY PLANE MIRROR

Image formed by a plane mirror is: -

i) Virtual
ii) Erect
iii) Same size
iv) Same distance behind the mirror as the object is in front of it.
v) Lateral inverted.

- In order to see full length image, a person requires a plane mirror which is half of his own height.
- If a plane mirror is routed through an angle θ then reflected ray turns through an angle 2θ.
- A person moves with a velocity v towards a plane mirror his image moves towards him with a velocity 2v

MULTIPLE IMAGE

When two mirrors are kept inclined at an angle, then multiple image of an object is formed.

$$\boxed{\text{No. of images formed} = \frac{360^0}{\theta} - 1}$$

Where θ = Angle between two mirrors.

Periscope: - It is a device through which a person can see objects that are out of the direct line of sight.

- In a periscope two plane mirror arranged parallel to each other.

Uses of Periscope

- It is used to see over the hade of a crowd.
- It is used by the soldiers sitting in bunkers.
- It is used in submarine to see the surface of water.

Kaleidoscope: - It is the instrument containing inclined plane mirrors which produce multiple reflection of colored glass pieces and create beautiful pattern.

- In kaleidoscope three mirrors are inclined at an angle of 60 degree.
- It is used by designers or arista to gate idea for new pattern.

REFLECTION THROUGH SPECIAL MIRROR

Spherical mirror is of two types: -

i) Concave or converging mirror.

ii) Convex or diverging mirror.

Terms: -

1. **Center of curvature** => It is the center of a hollow spare of glass of which the mirror is a part.
   a. Center of curvature of a concave mirror is in front of it.
   b. Center of curvature of convex mirror is behind it.
2. **Radios of curvature** => The distance between pole and center of curvature is called radios of curvature.
3. **Pole** => Center part of mirror is called pole.
4. **Principle axis** => The straight line passing through the center of curvature and the pole of a spherical mirror is called principle axis.
5. **Aperture of the mirror** => The portion of mirror from which the reflection of light take place.
6. **Principal focus** => It is a point on the principal axis at which rays of light meet or appears to meet after reflection by a spherical mirror.
7. **Focal length** => Distance between pole and principal focus is called focal length.
   a. Focal length of a concave mirror is negative.
   b. Focal length of a convex mirror is positive.

RELATION BRTWEEN RADIOUS OF CURVATURE AND FOCAL LENGTH

$$\boxed{F = \frac{R}{2}}$$

Where,

f = focal length and

R = radius of curvature

IMAGE FORMED BY A CONCAVE MIRROR

- Image formed by a concave mirror depends on the portion of object on the principle axis.
- Image formed by a concave mirror is –
  - Real or virtual.
  - Same size as object, larger then object or smaller then object.

SUMMARY OF THE IMAGE FORMED BY A CONCAVE MIRROR

No.	Position of object	Position of image	Size of image	Nature of image
1	Within focus (between pole P and focus F)	Behind the mirror	Enlarged	Virtual and erect
2	At focus(F)	At infinity	Highly enlarged	Real and inverted
3	Between F and C	Beyond C	Enlarged	Real and inverted
4	At C	At C	Equal to object	Real and inverted
5	Beyond C	Between F and C	Diminished	Real and inverted
6	At infinity	At focus (F)	Highly Diminished	Real and inverted

USES OF CONCAVE MIRROR

- Used in torches, head light, search light etc.
- Used as shaving mirror.
- Used by dentist.
- Used by ENT doctors.
- Used in solar furnaces.

IMAGE FORMED BY A CONVEX MIRROR.

Image formed by convex mirror is always virtual erect and smaller then object (Diminished).

SUMMARY OF THE IMAGE FORMED BY A CONVEX MIRROR

No.	Position of object	Position of image	Size of image	Nature of image
1	Anywhere between pole P and infinity	Behind the mirror between P and F	Diminished	Virtual and erect
2	At infinity	Behind the mirror at focus (F)	Highly Diminished	Virtual and erect

USES OF CONVEX MIRROR

- It is used as rear-view mirrors in vehicles because it gives a wide field of view

MIRROR FORMULA

$$\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$$

Where,
v = Image distance.
u = Object distance.
f = focal length.

MAGNIFICATION

$$\boxed{m = -\frac{v}{u}}$$

or

$$\boxed{m = -\frac{hI}{hO}}$$

where,

v = Image distance.

u = Object distance.

hI = Hight of image.

hO = Hight of object.

***

The Human Eye, Defects of Vision and Dispersion of light

1. The Human Eye It is a natural optical instrument which is used to see the objects by human beings. It is like a camera which has lens and screen system.

(i) **Retina:** It is a light sensitive screen inside the eye on which image is formed. It contains rods and cones.

(ii) **Cornea:** It is a thin membrane which covers the eye ball. It acts like a lens which refracts the light entering the eye.

(iii) **Aqueous humour:** It is fluid which fills the space between cornea and eye lens.

(iv) **Eye lens:** It is a Convex lens made of transparent and flexible jelly like material. Its curvature can be adjusted with the help of ciliary muscles.

(v) **Pupil:** It is a hole in the middle of iris through which light enters the eye. It appears black because light falling on it goes into the eye and does not come back.

(vi) **Ciliary muscles:** These are the muscles which are attached to eye lens and can modify the shape of eye lens which leads to the variation in focal lengths.

(vii) **Iris:** It controls the amount of light entering the eye by changing the size of pupil.

(viii) **Optical nerve:** These are the nerves which take the image to the brain in the form of electrical signals.

2. Accomodation power: The ability of eye to change the focal length of eye lens with the help of ciliary muscles to get the clear view of nearby objects (about 25 cm) and far distant objects (at infinity).

3. Colour blindness: Some people do not possess some cone cells that respond to certain specific colours due to genetic disorder.

4. Myopia (Short sightedness): It is a kind of defect in human eye due to which a person can see near objects clearly but he can not see the distant objects clearly. Myopia is due to

(i) excessive curvature of cornea.

(ii) elongation of eye ball.

5. Hypermetropia (Long sightedness): It is a kind of defect in human eye due to which a person can see distant objects properly but cannot see the nearby objects clearly. It happens due to

(i) decrease in power of eye lens i.e., increase in focal length of eye lens.

(ii) shortening of eye ball.

6. Presbyopia: It is a kind of defect in human eye which occurs due to ageing. It happens due to

(i) decrease in flexibility of eye lens.

(ii) gradual weakening of ciliary muscles.

7. Astigmatism: It is a kind of defect in human eye due to which a person cannot see (focus) simultaneously horizontal and vertical lines both.

8. Cataract: Due to the membrane growth over eye lens, the eye lens becomes hazy or even opaque. This leads to decrease or loss of vision.

The problem is called cataract. It can be corrected only by surgery.

9. Dispersion of white light by a glass prism: The phenomenon of splitting of white light into its seven constituent colours when it passes through a glass prism is called dispersion of white light. The various colours seen are Violet, Indigo, Blue, Green, Yellow, Orange and Red. The sequence of colours remember as•VIBGYOR. The band of seven colours is called spectrum.

10. Composition of white light: White light consists of seven colours i.e., violet, indigo, blue, green, yellow, orange and red.

11. Monochromatic light: Light consisting of single colour or wavelength is called monochromatic light, e.g., sodium light

12. Polychromatic light: Light consisting of more than two colours or wavelengths is called polychromatic light, e.g. white light.

13. Recombination of white light: Newton found that when an inverted prism be placed in the path of dispersed light then after passing through prism, they recombine to form white light.

14. Formation of rainbow: The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's eye.

15. Atmospheric Refraction: The refraction of light caused by the earth's atmosphere (having air layers of varying optical densities) is called atmospheric refraction.

16. Why, the duration of day becomes approximately 4 minutes shorter if there is no atmosphere on earth: Actual sun rise happens when it is below the horizon in the morning. The rays of light from the sun below the horizon reach our eyes because of refraction of light. Similarly, the sun can be seen about few minutes after the actual sun set. Thus the duration of, day time will increase by 4 minutes.

17. Scattering of light: According to Rayleigh's law of scattering the amount of scattered light α /(wavelength)^4

So that the wavelength of violet, blue and indigo is small as compared to the rest of the colours. So sky appears blue in colour.

18. Colour of the Sun at sunrise and sunset: At noon, the light of sun travels relatively shorter distance through earth's atmosphere thus appears white as only a little of blue and violet colours are scattered. Near the horizon, most of the blue light and shorter wavelengths are scattered and sun appears red.

Dispersion of Light

The splitting of light into seven colours on passing through a glass prism is called dispersion of light

Cause

Angle of refraction of lights of different colours is different

When passing through a glass prism

Spectrum

The band of seven colours obtained on a screen is called spectrum

In dispersion of light deviation of red colour is minimum

While deviation of red colour is minimum

***

Diffraction of Light

The bending of light ray around the smaller obstacle is called diffraction of light.

It was observed by Grimaldie.

Polarization of light

Resolving a light ray into the electric and magnetic components is called polarization of light.

It was observed by H. Bortholinus.

Theories of light

1.Newtons Corpuscular theory

According to this theory, light propagates in the form of minute particles called Corpuscular

These particles move with high speed through denser medium as well as rarer medium

2. Huygens wave theory

According to this theory, light propagates in the medium in the form of mechanical wave through the universal medium called **ETHER**

The speed of light is more in rarer medium and less in denser medium

3.Quantum theory of radiation

Given by Max Plank in 1900

According to this theory, light propagates in small energy packets called Quanta or Photons

Raman's effect is based on the quantum theory of radiation.

Interference of light was observed by Thomas Young.
When two or more light rays superimpose on each other then the intensity of resultant light may changes. This phenomenon is called interference of light

NATURE OF LIGHT
Light is a non-mechanical transverse wave
Light is an electromagnetic wave

ELECTROMAGNETIC SPECTRUM
|Gamma rays | X-rays | Ultraviolet rays | **VISIBLE** | Infrared rays | Microwave | Radio wave|

USES

1. RADIO WAVE
It is used in
Radio sets
TV broadcasting
Mobile telephones
Ionosphere reflects radio waves

2. MICROWAVE

It is used in

Microwave cooking

Satellite communication

Used in radar to locate the flying objects in the sky

3. INFRARED RAYS (Thermal Radiation)

It is used in

Remote controls

Night vision instruments

Thermographic scanners

Breath analyzer

Responsible for Green house effect

ULTRAVIOLET RAYS

It is absorbed by ozone layer

Causes Skin cancer and Snow blindness

X-RAYS

It is produced by Coolidge X-ray tube

It was discovered by Roentgen

It is used in

X-ray imaging

X-ray can cause cancer

GAMMA RAYS

It can cause gene mutation

Can cause cancer

COSMIC RAYS

High energy radiation which strike the earth from space

It is mainly composed of protons and alpha particles

***

Electricity

Charge – It is of two types
Positive chare and Negative charge.
It is a scaler quantity.
S.I. unit of charge is coulomb (C)

Electric Field
The space around a charge up to which it's effect can be experience is called it's electric field.

Electric Field Intensity (I)
Electric field intensity at a point in electric field is equal to the work done in bringing unit positive charge from infinity to that point

$I = F/q$ where, I= Electric field intensity
F = Force
q = Charge

It is a vector physical quantity.
S I.unit = N/C

Electric potential-
Electric potential at a point in electric field is equal to the work done in bringing unit positive charge from infinity to that point.

$V = W/q$

Where, V = Electric potential
W = Work done
q = Charge

It is a scaler physical quantity.
S.I. unit= volt (V)

1 Volt –
Potential of Point is said to be 1 volt when 1J of work is done in bringing unit positive charge from infinity to that point.

Potential Difference –
, Potential difference is measured by Voltmeter.
Voltmeter is always connected in parallel
Resistance of a voltmeter should be very high.

- **Electric Current**

Rate of flow of charge is called electric current.
$I = q/t$
It is a scalar physical quantity.
S.I. unit = ampere (A)
Electric current is measured by an instrument called ammeter
The ammeter is always connected in series.
An ammeter should have very low resistance.

- **Ohm's Law**

This law states that the current passing through a conductor is directly proportional to the potential difference cross its ends, provided the physical conditions like temperature, density etc. remains unchanged. $V \propto I$

Or $V = RI$ where R is a constant called resistance of the conductor.

Resistance- The opposition offered by the conductor to the flow of electric current is called resistance.
$V = RI$
Or $R = V/I$

S.I. unit of resistance is ohm.
Representation –

1 ohm

1 ohm is the resistance of a conductor such that when a potential difference of 1 volt is applied to its ends, a current of 1 ampere flows through it.

Factors affecting the resistance of a conductor.

Factors on which resistance of a conductor depends: The resistance R of a conductor depends

Directly on its length L i.e. R α L.

Inversely on its area of cross-section A i.e. R α 1/A.

on the nature of material of the conductor on. On combining the above factors, we get

R α L/A

R = ρ ×L/A

Where ρ is a constant called resistivity of conductor.

Its S.I. unit is ohm-meter (Ωm)

Resistivity.

ρ = RA/L

Combination of resistances-

Series Combination-

R_s =R1 +R2 +R3 + ...

Parallel

***

REFRACTION OF LIGHT

The refraction of light when it goes from one medium to another, is called refraction of light.

Cause of refraction

- Speed of light changes when it goes from one medium to another medium.
  - The frequency (colours) and phases remains unchanged during refraction.
  - The wavelength and velocity of light change during refraction.

Laws of refraction

1. The normal, the incident ray, and the refracted ray all lies in same plane.
2. The ratio of sine of angle of incidence to the sine of angle of refraction is a constant quantity which is called refractive index of second medium with respect to the first medium.

Snell's law

$$\boxed{\frac{\sin i}{\sin r} = constant.}$$

- Refractive index of a medium indicates light bending ability of that medium.
- A substance having higher refractive index is denser then another substance having lower refractive index.
- Refractive index depends on the nature of material of the medium and on the wave length of light used.

Note-1:- When light goes from rarer medium to denser medium, it bends towards the normal.
Note-2:- When light goes from denser medium to rarer medium, it bends away from the normal.
Note-3:- When the light incident normally, it goes straight.

- Incident ray and emergent ray are parallel to each other.

PHENOMENON DUE TO REFRACTION

1. Partially immersed stick in water appears to be bent.
2. An object placed under water appears to be raised.
3. A pool of water appears to be less deep then the actual depth.
4. When a thick glass slab is placed over some printed matter, the letter appears raised.
5. A lemon kept in water in a glass appears to be bigger then the actual size.
6. When a coin is placed under water, coin appears to be raised.
7. A fish under water appears to be shallower then it's actual depth.

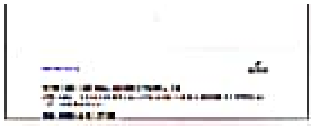
ATMOSPHERIC REFRACTION

- Different layer of atmosphere has different optical densities.
- Optical density of atmosphere decreases with height.

When the light ray pass through the atmosphere having layer of different optical density, then refraction of light take place, this refraction of light by earth's atmosphere is called atmospheric refraction.

PHENOMENON DUE TO ATMOSPHERIC REFRACTION

i) Twinkling of star.
ii) Star appear liter then their actual position.
iii) Advance sun rays and delayed sun set.
* The sun is visible to us about two minutes before the actual sun rise and about two minutes after the actual sun set.
* Due to atmospheric refraction duration of day in increased by four minutes.



CRITICLE ANGLE AND TOTAL INTERNAL REFLECTION (TIR)

Criticle Angle:- The angle of incident in denser medium, for which angle of refraction in rarer medium is 90^0 , is called criticle angle.

TOTAL INTERNAL REFLECTION

When light ray incident at reflecting surface from denser medium at an angle of incidence greater than criticle angle then ray returns back in the same medium this phenomenon is called total internal reflection.

CONDITION REQUIRED FOR TIR

i) Light must pass from denser medium to the rarer medium.
ii) The angle of incidence must be grater than the criticle angle.

Examples of TIR.

- Optical fiver
    - Optical fiver is used in endoscope.
    - Optical fiver is used in telecommunication.
- Shining of air bubbles.
- Sparkling of diamonds
- Mirage :-it is caused due to TIR in desert region.
- Looming :-It is caused due to TIR in polar region.

REFRACTION OF LIGHT BY LENSES

Lenses are of two type:-

- Convex lens or converging lens.
- Concave lens or diverging lens.

TERMS RELATED TO LENSES

- **Optical center:** - It is central point of the lens.
- **Principal axis:** - The line passing through the optical center is called principal axis.
- **Principal focus:** - A point of the principal axis at which the rays of light meet or appears to meet after refraction through a lens, is called principal focus.
- **Focal length:** - Distance between optical center and principal focus is called focal length.
    - Focal length of convex lens is positive.
    - Focal length of concave lens is negative.

IMAGE FORMED BY A CONVEX LENS

Image formed by a convex lens is

- Real or virtual.
- Same size as object.
- Larger then object (Magnified).
- Smaller than object (Diminished)

SUMMERY OF THE IMAGE FORMED BY THE CONVEX LENS

No.	Position of object	Position of image	Size of image	Nature of image
1	Between f and lens.	On the same side as object	Enlarged	Virtual and erect
2	At focus(f)	At infinity	Highly enlarged	Real and inverted
3	Between f and 2f	Beyond 2f	Enlarged	Real and inverted
4	At 2f	At 2f	Same size as object	Real and inverted
5	Beyond f	Between f and 2f	Diminished	Real and inverted
6	At infinity	At f (at Focus)	Highly Diminished	Real and inverted

USE OF CONVEX LENS

- Used in microscope and magnifying glass.
- Used in camera.
- Used in the correction of hypermetropia.

IMAGE FORMED BY A CONCAVE LENS

Image formed by a concave lens is always virtual, erect, and smaller then object.

SUMMERY OF THE IMAGE FORMED BY THE CONCAVE LENS

No.	Position of object	Position of image	Size of image	Nature of image
1	Anywhere between optical center C and infinity	Between optical center (C) and focus(f)	Diminished	Virtual and erect
2	At infinity	At focus (F)	Highly Diminished	Virtual and erect

USING CONCAVE LENS

- Camera
- Telescope
- Lasers
- Binoculars
- Used in correction of myopia.

POWER OF LENS

It is equal to the reciprocal of focal length of the lens.

$$\boxed{P = \frac{1}{f_{(m)}}}$$

Where,

P = Power.

f = focal length.

- S.I unit of power of a lens is diotre (D).
- Power of convex lens is positive.
- Power of concave lens is negative.
- Power of sun glass is zero.

POWER OF A COMBINATION OF LENSES

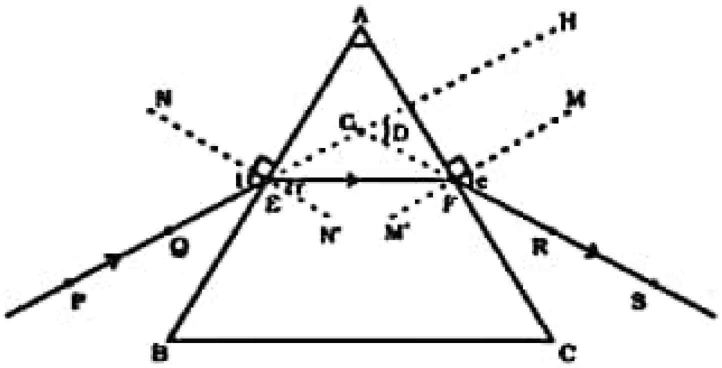
$P = P_1 + P_2 + P_3 + \ldots\ldots\ldots\ldots$

Where,

P = Power of combination.

REFRACTION OF LIGHT THROUGH A GLASS PRISM

Diagram: -



PE – Incident ray
EF – Refracted ray
FS – Emergent ray
∠A – Angle of the prism
∠i – Angle of incidence
∠r – Angle of refraction
∠e – Angle of emergence
∠D – Angle of deviation

When a light ray passes through a prism, it bends towards the base of the prism.

•••

Laws of Motion

IMPORTANT TERMS

1. Mass: It is the matter contained in a body. The units of mass are kilogram, tonne etc.

2. Weight: It is the force, by which the body is attracted towards the centre of the earth. The units of weight are the same as those of force i.e. N, kN etc.

3. Momentum: It is the quantity of motion possessed by a body. It is expressed mathematically as

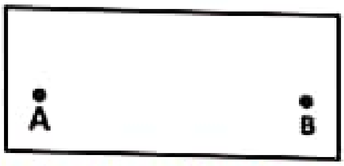
$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

The units of momentum depend upon the units of mass and velocity. In S.I. units, the mass is measured in kg, and velocity in m/s, therefore the unit of momentum will be kg-m/s.

4. Force: It is a very important factor in the field of dynamics also, and may be defined as any cause which produces or tends to produce, stops or tends to stop motion. The units of force, like those of weight, are N, kN etc.

5. Inertia: It is the property of a body, which offers resistance to the change of its state of rest or uniform motion.

RIGID BODY



If distance between any two points (say A and B) does not change with the application of force then, such a body is called rigid body.

NEWTON'S LAWS OF MOTION

1. Newton's First Law of Motion states, "Everybody continues in its state of rest or of uniform motion, in a straight line, unless it is acted upon by some external force."

2. Newton's Second Law of Motion states, "The rate of change of momentum is directly proportional to the impressed force, and takes place in the same direction, in which the force acts."

3. Newton's Third Law of Motion states, "To every action, there is always an equal and opposite reaction."

NEWTON'S FIRST LAW OF MOTION

It is also called the law of inertia, and consists of the following two parts:

1. A body at rest continues in the same state, unless acted upon by some external force. It appears to be self-evident, as a train at rest on a level track will not move unless pulled by an engine. Similarly, a book lying on a table remains at rest, unless it is lifted or pushed.

2. A body moving with a uniform velocity continues its state of uniform motion in a straight line, unless it is compelled by some external force to change its state. It cannot be exemplified because it is, practically, impossible to get rid of the forces acting on a body.

The effect of inertia is of the following two types:

1. A body at rest has a tendency to remain at rest. It is called inertia of rest.

2. A body in uniform motion in a straight line has a tendency to preserve its motion. It is called inertia of motion.

NEWTON'S SECOND LAW OF MOTION

This law enables us to measure a force and establishes the fundamental equation of dynamics.
Let m = mass of body
u = initial velocity of the body
v = final velocity of the body
a = constant acceleration
t = Time in seconds required to change velocity from is to v
F = Force required to change velocity from u to v in t seconds.
Initial momentum = mu
Final momentum = mv

Therefore, Rate of change of momentum $= \frac{mv - mu}{t}$

$$= \frac{m(v-u)}{t} = ma$$

According to Newton's second law of motion,

$$F \propto ma$$
$$F = kma$$

Where k is constant of proportionality
The unit of force is adopted in such a way that it produces unit accelerartion to a unit mass.

$$F = ma = \text{Mass} \times \text{Acceleration}$$

Unit of force in Newton (N)
1 Newton may be defined as the force required to produce acceleration of 1 m/s^2 on a body of mass 1 kg
It is also called the Law of dynamics and consists of the following two parts:

1. A body can posses acceleration only when some force is applied on it.

2. The force applied on a body is proportional to the product of the mass of the body and the acceleration produced in it.

ABSOLUTE AND GRAVITATIONAL UNITS OF FORCE

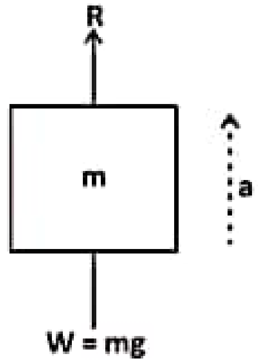
The units of force *i.e.* kg-wt (written as kgf) is called gravitational units of force ; whereas N or kN are absolute or scientific units of force. It is thus obvious, that the gravitational unit are '*g*' times greater than the units of force in the absolute units.

$$1 \text{ kg} - \text{wt} = 9.8 \text{ N}$$

MOTION OF A LIFT

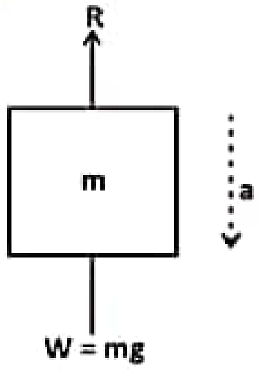
Consider a lift carrying some mass and moving with a uniform acceleration
Let m = mass carried by the lift
a = uniform acceleration
R = Reaction of life or tension in the cable, supporting the lift

Case-I : Lift is moving upwards



$\Sigma F = R - mg$
According to Newton's IInd law of motion
$\Sigma F = ma$
Therefore, $R - mg = ma$
$R = mg + ma$
$= m (g + a)$

Case-II : Lift is moving downwards



$\Sigma F = mg - R$
According to Newton's IInd law of motion
$\Sigma F = ma$
Therefore, $mg - R = ma$
$R = mg - ma$
$= m(g - a)$
In above cases, we considered only mass carried by the lift
Suppose, we include mass of lift (M) as well.

Then,
In case of lift moving upwards
$R = (m + M)(g + a)$
In case of lift moving downwards
$R = (m + M)(g - a)$

Special case

If $a = g$ [Free Fall]
Then, when moving downwards
$R = (m + M)(g - g) = 0$
This condition is known as **weightlessness.**

D'ALEMBERT'S PRINCIPLE

According to Newton's II[nd] Law of Motion
$F = ma$
Or $F - ma = 0$
or $\underbrace{F}_{\text{Externally applied load}} + \underbrace{(-ma)}_{\text{Inertia load}} = 0$

According to D'Alembert's Principle

Algebraic sum of externally applied load and inertia force is equal to zero.

Inertia Force

It is the product of mass and acceleration. It acts in the direction opposite to that of acceleration
Inertia Force $= -m \times a$
$= -$Mass × Acceleration

NEWTON'S THIRD LAW OF MOTION

It states "*To every action, there is always an equal and opposite reaction.*"

By *action* is meant the force, which a body exerts on another, and the *reaction* means the equal and opposite force, which the second body exerts on the first. This law, therefore, states that a force always occurs in pair. Each pair consisting of two equal opposite forces.

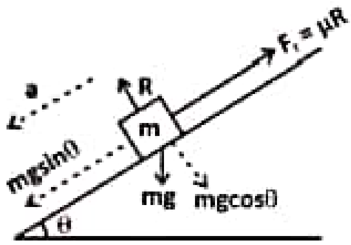
RECOIL OF GUN

According to Newton's Third Law of Motion, when a bullet is fired from a gun, the opposite reaction of the bullet is known as the recoil of gun.
Let M = Mass of the gun
V = Velocity of gun with which is recoils
m = mass of the bullet

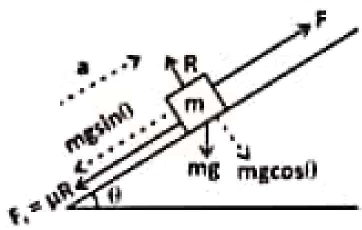
v = velocity of the bullet after explosion
Initially, both gun and bullet are at rest. So, initial momentum of the system is zero/
In this case, since no external force acts on the system, therefore rate of change of momentum (or change of momentum) is equal to zero
Mass × [Final velocity – Initial velocity] = 0
Or mass of gun × initial velocity of gun + mass of bullet × initial velocity of bullet = mass of gun × final velocity of gun + mass of bullet × final velocity of bullet
M × O + m × o = M × V + m × v
Or MV × mv = 0 [Law of conservation of momentum]

MOTION ON INCLINED PLANES

Motion in downward direction



Along inclined plane
mgsinθ – Ff = ma
mgsinθ – μR = ma
mgsinθ – μ(mg cosθ) ma
or a = g(sinθ – μcosθ)
Motion in upward direction



Along inclined plane
F – mgsinθ – μR = ma
F – mgsinθ – μ (mg cosθ) = ma

$$a = \frac{F - mg\sin\theta - \mu mg\cos\theta}{m}$$

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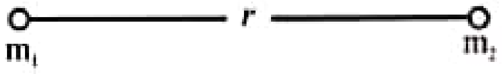
GRAVITATION

Every object in the universe attracts every other object with a force which is called the force of **gravitation.**
Although, of negligible importance in the interactions of elementary particles, gravity is of primary importance in the interactions of objects. It is gravity that holds the universe together.

Newton's Law of Gravitation

Gravitational force is a attractive force between two masses m_1 and m_2 separated by a distance r.
The gravitational force acting between two point objects is proportional to the product of their masses and inversely proportional to the square of the distance between them.
Gravitational force.

$$F = \frac{Gm_1m_2}{r^2}$$



where G is universal gravitational constant.
The value of G is 6.67×10^{-11} Nm^2 kg^{-2} and is same throughout the universe.
The value of G is independent of the nature and size of the bodies well as the nature of the medium between them.
Dimensional formula of G is $[M^{-1}L^3T^{-2}]$.

Important Points about Gravitation Force

(i) Gravitational force is a central as well as conservative force.
(ii) It is the weakest force in nature.
(iii) It is 1036 times smaller than electrostatic force and 1018times smaller than nuclear force.
(iv) The law of gravitational is applicable for all bodies, irrespective of their size, shape and position.
(v) Gravitational force acting between sun and planet provide it centripetal force for orbital motion.
(vi) Gravitational pull of the earth is called gravity.
(vii) Newton's third law of motion holds good for the force of gravitation. It means the gravitation forces between two bodies are action-reaction pairs.

Acceleration Due to Gravity

The uniform acceleration produced in a freely falling object due to the gravitational pull of the earth is known as acceleration due to gravity.
It is denoted by g and its unit is m/s^2. It is a vector quantity and its direction is towards the centre of the earth.
The value of g is independent of the mass of the object which is falling freely under gravity.
The value of g changes slightly from place to place. The value of g is taken to be 9.8 m/s^2 for all practical purposes.
The value of acceleration due to gravity on the moon is about. one sixth of that On the earth and on the sun is about 27 times of that on the earth.
Among the planets, the acceleration due to gravity is minimum on the mercury. Relation between g and a is given by $g = Gm / R^2$ where M = mass of the earth = $6.0 * 10^{24}$ kg and R = radius of the earth

Factors Affecting Acceleration Due to Gravity

(i) **Shape of Earth** Earth is elliptical in shape. Its diameter at poles is approximately 42 km less than its diameter at equator.
Therefore, g is minimum at equator and maximum at poles.
(ii) **Rotation of Earth about Its Own Axis**
If earth stops its rotation about its own axis, then g will remain unchanged at poles but increases at equator
(iii) **Effect of Altitude** The value of g at height h from earth's surface $g' = g / (1 + h / R)^2$
Therefore g decreases with altitude.
(iv) **Effect of Depth** The value of gat depth h A from earth's surface $g' = g * (1 - h / R)$
Therefore g decreases with depth from earth's surface.
The value of g becomes zero at earth's centre.

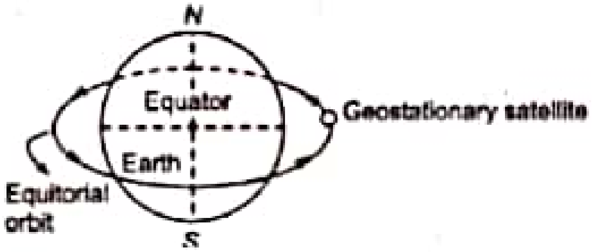
Gravitational Field
The space in the surrounding of anybody in which its gravitational pull can be experienced by other bodies is called **gravitational field.**

Intensity of Gravitational Field
The gravitational force acting per unit mass at Earth any point in gravitational field is called intensity of gravitational field at that point. It is denoted by E_g or I.
E_g or $I = F / m$
Intensity of gravitational field at a distance r from a body of mass M is given by E_g or $I = GM / r^2$
It is a vector quantity and its direction is towards the centre of gravity of the body.
Its S1 unit is N/m and its dimensional formula is $[LT^{-2}]$.

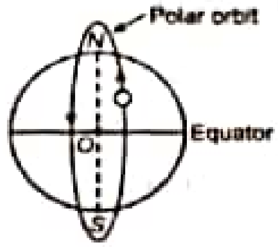
Gravitational Potential
Gravitational potential at any point in gravitational field is equal the work done per unit mass in bringing a very light body from infinity to that point.
It is denoted by V_g.

Satellite
A heavenly object which revolves around a planet is called a satellite. Natural satellites are those heavenly objects which are not man made and revolve around the earth. Artificial satellites are those heavenly objects which are man made and launched for some purposes revolve around the earth.

Artificial satellites are of two types :
1. **Geostationary or Parking Satellites**
A satellite which appears to be at a fixed position at a definite height to an observer on earth is called geostationary or parking satellite.



Height from earth's surface = 36000 km
Radius of orbit = 42400 km
Time period = 24 h
Orbital velocity = 3.1 km/s
There satellites revolve around the earth in equatorial orbits.
The angular velocity of the satellite is same in magnitude and direction as that of angular velocity of the earth about its own axis.
These satellites are used in communication purpose.
INSAT 2B and INSAT 2C are geostationary satellites of India.
2. **Polar Satellites**
These are those satellites which revolve in polar orbits around earth. A polar orbit is that orbit whose angle of inclination with equatorial plane of earth is 90°.



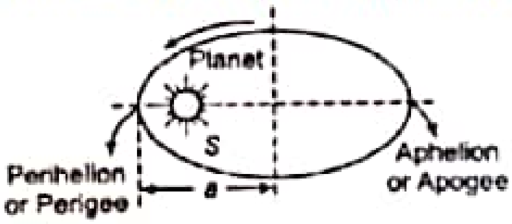
Height from earth's surface = 880 km
Time period = 84 min
Orbital velocity = 8 km / s
There satellites revolve around the earth in polar orbits.
These satellites are used in forecasting weather, studying the upper region of the atmosphere, in mapping, etc.
PSLV series satellites are polar satellites of India.

Orbital Velocity
Orbital velocity of a satellite is the minimum velocity required to the satellite into a given orbit around earth.
Orbital velocity of a satellite is given by $v_o = \sqrt{GM / r} = R \sqrt{g / R + h}$
where, M = mass of the planet, R = radius of the planet and h = height of the satellite from planet's surface.
If satellite is revolving near the earth's surface, then r = (R + h) =- R
Now orbital velocity, $v_o = \sqrt{gR} = 7.92km / h$

Escape Velocity
Escape velocity on earth is the minimum velocity with which a body has to be projected vertically upwards from the earth's surface so that it just crosses the earth's gravitational field and never returns.
Escape velocity of any object $v_e = \sqrt{2GM / R}$
$= \sqrt{2gR}$
Escape velocity does not depend upon the mass or shape or size of the body as well as the direction of projection of the body.
Escape velocity at earth is 11.2 km / s.
Relation between escape velocity and orbital velocity of the satellite $v_e = \sqrt{2}\, v_o$

Weightlessness
It is a situation in which the effective weight of the body becomes zero,
Weightlessness is achieved
(i) during freely falling under gravity
(ii) inside a space craft or satellite
(iii) at the centre of the earth
(iv) when a body is lying in a freely falling lift.

Kepler's Laws of Planetary Motion
(i) **Law of orbit** Every planet revolve around the sun in elliptical orbit and sun is at its one focus.



(ii) **Law of area** The radius vector drawn from the sun to a planet sweeps out equal areas in equal intervals of time, i.e., the areal velocity of the planet around the sun is constant. (iii) **Law of period** The square of the time period of revolution of planet around the sun is directly proportional to the cube semi-major axis of its elliptical orbit.

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HEAT

The branch dealing with measurement of temperature is called thremometry and the devices used to measure temperature are called thermometers.

Heat

Heat is a form of energy called thermal energy which flows from a higher temperature body to a lower temperature body when they are placed in contact.

Heat or thermal energy of a body is the sum of kinetic energies of all its constituent particles, on account of translational, vibrational and rotational motion.

The SI unit of heat energy is joule (J).

The practical unit of heat energy is calorie.

1 cal = 4.18 J

1 calorie is the quantity of heat required to raise the temperature of 1 g of water by 1°C.

Temperature

Temperature of a body is the degree of hotness or coldness of the body. A device which is used to measure the temperature, is called a thermometer.

Highest possible temperature achieved in laboratory is about 108 while lowest possible temperature attained is 10-8 K.

Branch of Physics dealing with production and measurement temperature close to 0 K is known as cryagenics, while that deaf with the measurement of very high temperature is called pyromet

Temperature of the core of the sun is 107 K while that of its surface 6000 K.

NTP or STP implies 273.15 K (0°C = 32°F).

Different Scale of Temperature

1. **Celsius Scale** In this scale of temperature, the melting point ice is taken as 0°C and the boiling point of water as 100°C and space between these two points is divided into 100 equal parts
2. **Fahrenheit Scale** In this scale of temperature, the melt point of ice is taken as 32°F and the boiling point of water as 211 and the space between these two points is divided into 180 equal parts.
3. **Kelvin Scale** In this scale of temperature, the melting point of ice is taken as 273 K and the boiling point of water as 373 K the space between these two points is divided into 100 equal parts

Relation between Different Scales of Temperatures

$$\frac{C}{100}=\frac{F-32}{180}=\frac{K-273}{100}=\frac{R}{80}$$

Thermal Equilibrium

When there is no transfer of heat between two bodies in contact, the bodies are called in thermal equilibrium.

Zeroth Law of Thermodynamics

If two bodies A and B are separately in thermal equilibrium with third body C, then bodies A and B will be in thermal equilibrium with each other.

Triple Point of Water

The values of pressure and temperature at which water coexists inequilibrium in all three states of matter, i.e., ice, water and vapour called triple point of water.

Triple point of water is 273 K temperature and 0.46 cm of mere pressure.

Specific Heat

The amount of heat required to raise the temperature of unit mass the substance through 1°C is called its specific heat.

It is denoted by c or s.

Its SI unit is joule/kilogram-°C'(J/kg-°C). Its dimensions is $[L^2T^{-2}\theta^{-1}]$.

The specific heat of water is 4200 J kg^{-1}°C^{-1} or 1 cal g^{-1} C^{-1}, which high compared with most other substances.

Latent Heat

The heat energy absorbed or released at constant temperature per unit mass for change of state is called latent heat.

Heat energy absorbed or released during change of state is given by $Q = mL$

where m = mass of the substance and L = latent heat.

Its unit is cal/g or J/kg and its dimension is $[L^2T^{-2}]$.

For water at its normal boiling point or condensation temperature (100°C), the latent heat of vaporisation is

L = 540 cal/g

= 40.8 kJ/ mol

= 2260 kJ/kg

For water at its normal freezing temperature or melting point (0°C), the latent heat of fusion is

L = 80 cal/ g = 60 kJ/mol

= 336 kJ/kg

It is more painful to get burnt by steam rather than by boiling was 100°C gets converted to water at 100°C, then it gives out 536 heat. So, it is clear that steam at 100°C has more heat than wat 100°C (i.e., boiling of water).

After snow falls, the temperature of the atmosphere becomes very This is because the snow absorbs the heat from the atmosphere to down. So, in the mountains, when snow falls, one does not feel too but when ice melts, he feels too cold.

There is more shivering effect of ice cream on teeth as compare that of water (obtained from ice). This is because when ice cream down, it absorbs large amount of heat from teeth.

Melting

Conversion of solid into liquid state at constant temperature is melting.

Evaporation

Conversion of liquid into vapour at all temperatures (even below boiling point) is called evaporation.

Boiling

When a liquid is heated gradually, at a particular temperature saturated vapour pressure of the liquid becomes equal to atmospheric pressure, now bubbles of vapour rise to the surface d liquid. This process is called boiling of the liquid.

The temperature at which a liquid boils, is called boiling point The boiling point of water increases with increase in pre sure decreases with decrease in pressure. **Sublimation**

The conversion of a solid into vapour state is called sublimation.

Calorimetry

This is the branch of heat transfer that deals with the measorette heat. The heat is usually measured in calories or kilo calories.

Principle of Calorimetry

When a hot body is mixed with a cold body, then heat lost by ha is equal to the heat gained by cold body.

Heat lost = Heat gain

Thermal Expansion

Increase in size on heating is called thermal expansion. There are three types of thermal expansion.

1. Expansion of solids
2. Expansion of liquids
3. Expansion of gases

Expansion of Solids

Three types of expansion -takes place in solid.

Linear Expansion Expansion in length on heating is called linear expa

Superficial Expansion Expansion in area on heating is called superficial expansion. .

Cubical Expansion Expansion in volume on heating is called cubical expansion.

Anamalous Expansion of Water

When temperature of water is increased from 0°C, then its vol decreases upto 4°C, becomes minimum at 4°C and then increases. behaviour of water around 4°C is called, anamalous expansion water.

Practical Applications of Expansion

1. When rails are laid down on the ground, space is left between the end of two rails.
2. The transmission cables are not tightly fixed to the poles.
3. The iron rim to be put on a cart wheel is always of slightly smaller diameter than that of wheel.
4. A glass stopper jammed in the neck of a glass bottle can be taken out by warming the neck of the bottles.

Important Points

- Due to increment in its time period a pendulum clock becomes slow in summer and will lose time.
- At some higher temperature a scale will expand and scale reading will be lesser than true values
- However, at lower temperature scale reading will be more or true value will be less.

SOUND

1. Production of Sound

Sound is produced due to the vibration of objects. Vibration is the rapid to and fro motion of an object.

Vibrating objects are the source of all sounds Irregular, chaotic vibrations produce noise Regular, controlled vibration can produce music All sound is a combination of pure frequencies A stretched rubber band when plucked vibrates and produces sound.

2. Propagation of Sound

When an object vibrates, the particles around the medium vibrate. The particle in contact with the vibrating object is first displaced from its equilibrium position

The disturbance produced by the vibrating body travels through the medium but the particles do not move forward themselves.

A wave is a disturbance which moves through a medium by the vibration of the particles of the medium. So sound is considered as a wave. Sound waves Require medium for transmission. **Sound waves are called mechanical waves.** When a vibrating object moves forward, it pushes and compresses the air in front of it forming a region of high pressure called compression (C). When the vibrating object moves backward, it forms a region of low pressure called rarefaction (R).

A vibrating object producing a series of compressions (C) and rarefaction (R)

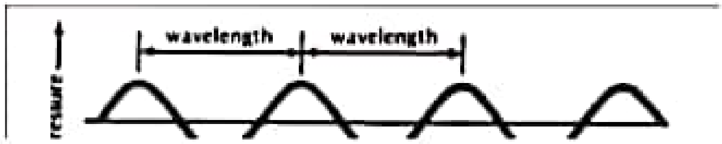
In these waves the particles move back and forth parallel to the direction of propagation of the disturbance. **Such waves are called longitudinal waves.**

3. There is another kind of waves called transverse waves. In these waves the particles oscillate up and down perpendicular to the propagation of the direction of disturbance.

Sound propagates in a medium as a series of compressions (C) and rarefactions (R). Compressions are the regions of high pressure and density where the particles are crowded and are represented by the upper portion of the curve called crest.

Rarefactions are the regions of low pressure and density where the particles are spread out and are represented by the lower portion of the curve called trough

Characteristics of a sound wave



4. Frequency of sound wave

The number of oscillations per unit time is called the frequency of the sound wave.

It is represented by the symbol ᵛ (Greek letter nu). Its SI unit is hertz (Hz)

Time period of sound wave

Frequency and time are represented as follows:- 0

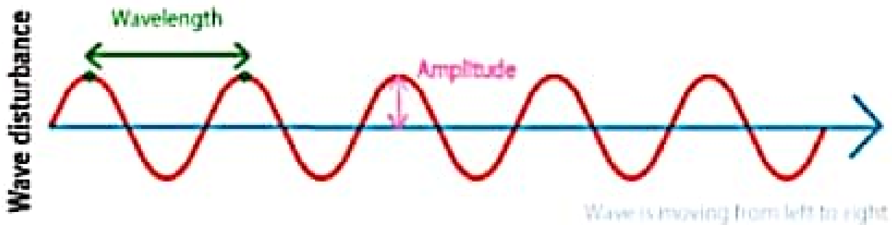
ᵛ for one oscillation

$$T = \frac{1}{V} \quad \text{or} \quad V = \frac{1}{T}$$

Amplitude of sound wave

The amplitude of sound wave is the height of the crest or tough.

It is represented by the letter A. The SI unit is the same as that of density or pressure.



Wavelength and Amplitude

Wave length -The wavelength is the distance between the "crests" of two waves that are next to each other. The amplitude is how high the crests are

5. Pitch and loudness of sound

The pitch of sound (shrillness or flatness) depends on the frequency of vibration.

If the frequency is high, the sound has high pitch and if the frequency is low, the sound has low pitch

6. Speed of sound

The speed of sound is more in solids, less in liquids and least in gases.

The speed of sound also depends on the temperature of the medium. If the temperature of the medium is more, the speed of sound is more

7. 3. Reflection of Sound

Sound gets reflected at the surface of a solid or liquid and follows the laws of reflection. i) The angle of incidence is equal to the angle of reflection. ii) The incident ray, the reflected ray and normal at the point of incidence all lie in the same plane

8. Echo

If we shout or clap near a reflecting surface like tall building or a mountain, we hear the same sound again. This sound which we hear is called echo. It is caused due to the reflection of sound. To hear an echo clearly, the time interval between the original sound and the echo must be at least 0.1 s.

Since the speed of sound in air is 344 m/s, the distance travelled by sound in 0.1 s = 344 m/s x 0.1 s = 34.4 m

So to hear an echo clearly, the minimum distance of the reflecting surface should be half this distance that is 17.2 m.

9. Reverberation

Echoes may be heard more than once due to repeated or multiple reflections of sound from several reflecting surfaces. This causes persistence of sound called reverberation. In big halls or auditoriums to reduce reverberation, the roofs and walls are covered by sound absorbing materials like compressed fibre boards, rough plaster or draperies.

10. Uses Of Multiple Reflection Of Sound

Megaphones, horns, musical instruments like trumpets, etc. are deigned to send sound by multiple reflection in a particular direction without spreading in all directions.

ii) Doctors listen to sounds from the human body through a stethoscope. The sound of heartbeatreaches the doctor's ears by multiple reflection.

iii) Generally the ceilings of cinema halls and auditoriums are curved so that sound after multiple reflection reaches all parts of the hall. Sometimes a curved sound board is placed behind the stage so that sound after multiple reflection spreads evenly across the hall.

11. Range of Hearing

Human beings can hear sound frequencies between 20 Hz and 2000 Hz

Sound whose frequency is less than 20 Hz is called infrasonic sound

Sound whose frequency is more than 2000 Hz is called ultrasonic sound

12. Uses of ultrasonic sound

Ultrasonic sound is used to clean objects like electronic Components, used to detect cracks in metal blocks, used in ultra sound scanners for getting images of internal organs of the human body used to break small stones formed in the kidneys into fine grains.

13. Sonar

It is a device which uses ultrasonic waves to measure distance, direction and speed of underwater objects. The distance of the object can be calculated by knowing the speed of sound in water and the time taken between the transmission and reception of ultrasound

KEY LEARNING :

Vibration -

repetitive back and forth motion Periodic motion -

a motion that repeats itself Mechanical waves require medium for propagation Waves move through medium but medium remains in place Longitudinal waves-Vibration direction parallel to wave propagation direction Particles in medium move closer together/farther apart. Example:

sound waves Gases and liquids - support only longitudinal waves Transverse waves-

Vibration direction perpendicular to wave propagation direction. Example: plucked string Solids - support both longitudinal and transverse waves Sound waves Require medium for transmission

1. Sound is a wave motion, produced by a vibrating source.
2. A medium is necessary for the propagation of sound waves.
3. Sound is a longitudinal wave in which the particles of medium move along the direction of motion of wave.
4. The part or region of a longitudinal wave in which the density of the particles of the medium is higher than the normal density is known as compression.
5. The part or region of a longitudinal wave in which the density of the particles of the medium is lesser than the normal density is called a rarefaction.
6. The point of maximum positive displacement on a transverse wave is known as crest.
7. The point of maximum negative displacement on a transverse wave is known as through.
8. A wave or short duration which is confined to a small portion of a medium at any given time is known as a pulse.
9. The maximum displacement of particles of the medium from their mean positions during the propagation of a wave is known as amplitude of the wave.
10. The distance traveled by a wave in one second is called wave velocity. It depends upon the nature of the medium through which it passes.
11. The speed of sound depends primarily on the nature and the temperature of the transmitting medium.
12. Sound travels faster in solids than in air. The speed of sound in solids is much more than the speed of sound in liquids or gases.
13. The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength.

14. Frequency is defined as the number of oscillations per second.
15. The time taken by the wave for one complete oscillation of the density or pressure of the medium is called the time period, T.
16. How the brain interprets the frequency of an emitted sound is called the pitch of sound.
17. Loudness is the degree of sensation of sound produced.
18. Sound properties such as pitch, loudness and quality are determined by the corresponding wave properties.
19. Sound gets reflected and follows the same law as the reflection of light.
20. The persistence of sound due to repeated reflection and its gradual fading away is called reverberation of sound.
21. Echo is a repetition of sound due to the reflection of original sound by a large and hard obstacle.
22. The audible range of hearing for average human beings is in the frequency range of 20 Hz – 20 kHz.
23. The amount of sound energy passing each second through unit area is called the intensity of sound.
24. Sound of frequency less than 20 Hz is known as infrasound and greater than 20 kHz is known as ultrasound.
25. Ultrasound has many medical and industrial applications.
26. SONAR stands for Sound Navigation and Ranging and it works on the principle of reflection of sound waves.
27. The SONAR technique is used to determine the depth of the sea and to locate under water hills, valleys, submarines, icebergs sunken ships etc.

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WORK, ENERGY AND POWER

Work

When a force acts on an object and the object actually moves in the direction of force, then the work is said to be done by the force.

Work done by the force is equal to the product of the force and the displacement of the object in the direction of force.

If under a constant force F the object displaced through a distance s, then work done by the force $W = F * s = F s \cos \theta$ where a is the smaller angle between F and s.

Work is a scalar quantity, Its S1 unit is joule and CGS unit is erg.

$\therefore$ 1 joule = 10^7 erg

Its dimensional formula is $[ML^2T^{-2}]$.

Work done by a force is zero, if

(a) body is not displaced actually, i.e., s = 0

(b) body is displaced perpendicular to the direction of force, i.e., $\theta = 90°$

Work done by a force is **positive** if angle between F and s is acute angle.

Work done by a force is **negative** if angle between F and s is obtuse angle.

Power

The time rate of work done by a body is called its power.

Power = Rate of doing work = Work done / Time taken

If under a constant force F a body is displaced through a distance **s** in time t, the power p=W/t

power is a scalar quantity. Its S1 unit is watt and its dimensional formula is $[ML^2T^{-3}]$. Its other units are kilowatt and horse power,

1 kilowatt = 1000 watt

1 horse power = 746 watt

Energy

Energy of a body is its capacity of doing work.

It is a scalar quantity.

Its S1 unit is joule and CGS unit is erg. Its dimensional formula is $[ML^3T^{-3}]$.

There are several types of energies, such as mechanical energy (kinetic energy and potential energy), chemical energy, light energy, heat energy, sound energy, nuclear energy, electric energy etc.

Mechanical Energy

The sum of kinetic and potential energies at any point remains constant throughout the motion. It does not depend upon time. This is known as law of conservation of mechanical energy.

Mechanical energy is of two types:

1. Kinetic Energy

The energy possessed by any object by virtue of its motion is called its kinetic energy.

Kinetic energy of an object is given by $k = 1 / 2\ mv^2 = p^2 / 2m$

where m = mass of the object, U = velocity of the object and p = mv = momentum of the object.

2. Potential Energy

The energy possessed by any object by virtue of its position or configuration is called its potential energy.

(i) Gravitational Potential Energy If a body of mass m is raised through a height h against gravity, then its gravitational potential energy = mgh,

(ii) Elastic Potential Energy If a spring of spring constant k is stretched through a distance x. then elastic potential energy of the spring = $1.2\ kx^2$

Mass-Energy Equivalence

According to Einstein, the mass can be transformed into energy and vice – versa.

$E=mc^2$ Where E= energy, m=mass, c= velocity of light

Principle of Conservation of Energy

The sum of all kinds of energies in an isolated system remains constant at all times.

Principle of Conservation of Mechanical Energy

For conservative forces the sum of kinetic and potential energies of any object remains constant throughout the motion.

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