CONTENTS

Chapter No 01

Physical Quantities And Measurement

PHYSICS:

Physics is the branch of science which observes the nature represents it mathematically and conclude with the experiment. **OR**

Physics is the branch of science which deals with studies of matter its composition, properties and interaction with energy.

BRANCHES OF PHYSICS

The main branches of Physics are as follows.

1. **Mechanics:**
   This branch of physics is mainly concerned with the laws of motion and gravitation.
2. **Thermodynamics:**
   Thermodynamics deals with heat and temperature and their relation to energy and work.
3. **Electricity:**
   Electricity is the study of properties of charges in rest and motion.
4. **Magnetism:**
   Magnetism is the study of magnetic properties of materials.
5. **Atomic Physics:**
   Atomic physics deals with the composition structure and properties of the atom.
6. **Optics:**
   Optics studies physical aspects of light and its properties with the help of optical instruments.
7. **Sound:**
   Sound is the study of production, properties and applications of sound waves.
8. **Nuclear Physics:**
   Nuclear physics deals with the constituents, structure, behavior and interactions of atomic nuclei.
9. **Particle Physics:**
   Particle Physics studies the elementary constituents of matter and radiation, and the interactions between them.
10. **Astro Physics:**
    The study of celestial objects with the help of laws of physics is known as Astrophysics.
11. **Plasma Physics:**
    The study of ionized state of mater and its properties is known as Plasma Physics.
12. **Geo Physics:**
    The study of internal structure of earth is known as Geo physics.

Importance of Physics In Our Daily Life:

- Technology is based on the principle of thermodynamics.
- Nuclear energy is used on a large scale to produce electric power.
- Radar technology is based on the rules of physics.
- Lasers are widely used in medical science.

Physical Quantities:

A physical quantity is a physical property of a phenomenon, body, or substance that can be quantified by measurement.

Types:

Physical quantities are classified into two categories:

1. **Fundamental quantities:**
   Physical quantities which cannot be explained by other physical quantities are called fundamental physical quantities.
   Examples: Length, time, mass
2. **Derived Physical quantities:**
   Physical quantities which are explained on the basis of fundamental physical quantities are called derived physical quantities.
   Examples: Force, Velocity, acceleration

S.I Unit Of Fundamental Quantities

Physical Quantities	S.I Unit	Symbol
Time	Second	S
Length	Meter	m
Mass	Kilogram	Kg
Amount Of Substance	Mole	mol
Thermodynamic Temperature	Kelvin	K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd

S.I Unit Of Some Derived Quantities

Derived Quantities	S.I Unit	Symbols
Volume	Cubic meter	m^3
Velocity	meter per second	m / s
Force	Newton	N
Density	Kilogram per cubic meter	kg/m^3
Acceleration	meter per second square	m / s^2

The Meter (m):

The length of the path traveled by light in vacuum during the time interval of 1/299 792 458 of a second.

Meter Rule:

A meter rule is a device which is used to measure length of different objects.

1m = 100 centimeters (cm).

1m = 1000 millimeters (mm).

Vernier Caliper:

The Vernier Caliper is a precision instrument that can be used to measure internal and external distance extremely accurate.

Micrometer Screw Gauge:

Micrometer screw gauge is an instrument that can be used for measuring extremely small dimensions.

Mass:

The kilogram is a cylinder of special metal about 39 millimeters wide by 39 millimeter tall that serves as the world's mass standard.

The Physical Balance:

The physical balance is an instrument used for measurement of mass.

The Standard Time:

The second is defined as 9192631770 times the period of vibration of radiation from the cesium atom.

Stop Watch:

A stop watch is used to measure the time interval between two events.
There are two types of stop watch.

i. **Mechanical / Analogue Stop Watch:**
   A mechanical stop watch can measure a time interval up to 0.1 second.

ii. **Digital Stop Watch:**
   A digital stop watch can measure a time interval up to 0.01 second.

PREFIXES:

A unit prefix is a specifier. It indicates multiples or Fractions of the units.
They are useful for expressing unit of physical quantities that are either very big or very small.

Prefix	Symbol	Multiplier
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
	Less than 1	
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
fimto	f	10^{-15}
atto	a	10^{-18}

SCIENTIFIC NOTATION:

Scientific notation is a Simple method of writing very large numbers or very Small numbers.
Scientific Notations are made up of three Parts:

1. The coefficient
2. The base
3. The exponent.

Density:

The mass of a substance per unit volume is called density.

Formula: $\rho = \frac{mass}{Volume}$

Unit: $\rho = Kg/m^3$

SIGNIFICANT FIGURE:

The number of reliable known digits in a value is known as significant figure.

Rules:

Rule	Examples
All non zeroes are significant	2.25 (3 significant figure)
Leading zeroes are not significant	0.00000034 (2 significant figure)
Trailing zeroes are significant only if an explicit decimal point is present.	200 (1 significant figure) 200. (3 significant figure) 2.00 (3 significant figure)
Trapped zeroes are significant	0.00509 (3 significant figure) 2045 (4 significant figure)

PROBLEMS

Examples:

1. Convert mass of Sun 2 000 000 000 000 000 000 000 000 000 000 Kg into Scientific Notation.
2. Convert mass of an electron $9.11x10^{-31}$ kg into standard form.
3. What is the mass of a solid iron wrecking ball of radius 18 cm. if the density of iron is 7.8 gm/cm^3.
4. How many significant figures are there in the area of a cylinder whose diameter is 5 cm?

Convert the following values.

i. 230 cm = ________ m
ii. 250 g = ________ Kg
iii. 0.5 Sec = ________ms
iv. 0.8 m = _________mm
v. 350 ms = ________sec
vi. 1.2 Kg = ________ g

Write the correct prefixes of notation.

i. 750mmm = 750_________
ii. $2/1000$ Sec = 1________
iii. $1/1000000$ g = 1_______
iv. 1000000000 m = ________

Multiple Choice Questions

1. The Figure 1.26 shows part of a Vernier scale, what is the reading on the Vernier scale:
   (a) 6.50cm (b) 6.55cm
   (c) 7.00cm (d) 7.45cm
2. Ten identical steel balls each of mass 27g are immersed in a measuring cylinder having 20 cm^3 of water. The reading of water level rises to 50 cm^3. What is the density of the steel?
   (a) 0.90 gm/cm^3 (b) 8.1 gm/cm^3
   (c) 9.0 gm/cm^3 (d) 13.5 gm/cm^3
3. An object of mass 100g is immersed in water as shown in the figure 1.27, what is the density of the material from which object is made?
   (a) 0.4 gcm^3 (b) 0.9 gcm^3
   (c) 1.1 gcm^3 (d) 2.5 gcm^3
4. What is the reading of this micrometer in figure 1.28:
   (a) 5.43mm (b) 6.63mm
   (c) 7.30mm (d) 8.13mm
5. A chips wrapper is 4.5 cm long and 5.9 cm wide. Its area up to significant figures will be:
   (a) 30 cm^2 (b) 28 cm^2
   (c) 26.55 cm^2 (d) 32 cm^2
6. A worldwide system of measurements in which the units of base quantities were introduced is called:
   (a) Prefixes (b) international system of units
   (c) Hexadecimal system (d) none of above
7. All accurately known digits and first doubtful digit in an expression are known as:
   (a) Non-significant figures (b) significant figures
   (c) Estimated figures (d) crossed figures
8. If zero line of Vernier scale coincides with zero of main scale, then zero error is:
   (a) Positive (b) zero
   (c) Negative (d) one
9. Zero error of the instrument is:
   (a) Systematic error (b) human error
   (c) Random error (d) classified error
10. Length, mass, electric, current, time, intensity of light and amount of substance are examples of:
    (a) Base quantities (b) derived quantities
    (c) Prefixes (d) quartile quantities

Chapter No 02

KINEMATICS

MECHANICS:

The branch of physics, which is related with the study of motion of objects, is called mechanics.

Types:

It is divided in two parts.

i. **Kinematics:**
Kinematics is the branch of Mechanics which deals with motion of objects without reference of force which causes motion.

ii. **Dynamics:**
Dynamics is the branch of Mechanics which deals with motion of objects with reference of force which causes motion.

REST:

A body is said to be in rest, if it does not changes its position with respect to its surroundings.
Examples: A book placed on table.

MOTION:

A body is said to be in motion, if it changes its position with respect to its surroundings.
Examples: A car moving on road.

TYPES OF MOTION:

There are three types of motion.

1. **Translatory Motion:**
When all points of a moving body move uniformly along the same straight line, such motion is called translatory motion.
Examples.
   - Motion of boat
   - Motion of car.

2. **Rotatory/ Spin Motion:**
The motion of the body around fixed axes which passes through body itself is called spin or rotatory motion.
Examples:
   - Motion of the earth.
   - Motion of the fan.

3. **Vibratory OR Oscillatory Motion:**
Back and forth motion of a body about its mean position is called vibratory or oscillatory motion.

Examples:
- Motion of swing.
- Motion of pendulum.

Sub-Types Of Translatory Motion:

i. **Linear motion:**
Motion of a body along a straight line is called linear motion.
Example: Motion of car on road.

ii. **Circular Motion:**
Motion of a body along a circular path is called circular motion.
Example: Motion of Earth.

iii. **Random Motion:**
Irregular motion of an object is called random motion.
Example: Motion of molecules in gases.

Describing Motion:
The motion of an object can be described by specifying its position, change in position, speed, velocity and acceleration.

Distance:
The total length covered by moving body without mentioning direction of motion is called "Distance".
Unit: The S.I unit is m.

Displacement:
The distance measured in straight line in a particular direction is called "Displacement"
Unit: The S.I unit is m.

Speed:
The distance covered by an object in a unit time is called speed.

Formula: $\vec{V} = \frac{\vec{d}}{t}$

Unit: The S.I unit of speed is m/s.

Types Of Speed:

i. **Uniform Speed:**
When a body covers equal distance in equal interval of time its speed is known as uniform speed.

ii. **Variable Speed:**
When a body does not cover equal distance in equal interval of time, then its speed is called variable speed.

iii. **Average Speed:**
When total distance covered by a body is divided by total time, then it is called average speed.

$$V_{avg} = \frac{V_i + V_f}{2}$$

Velocity:

The rate of change of displacement with respect to time is called velocity.

Formula: $\vec{V} = \frac{\vec{s}}{t}$

Unit: The S.I unit of velocity is m/s.

Types of Velocity:

i. **Uniform Velocity:**
When speed and direction of motion of a body do not change, the velocity is said to be uniform.

ii. **Variable Velocity:**
When speed or direction of motion of a body change, the velocity is said to be uniform.

iii. **Average Velocity:**
When total displacement covered by a body is divided by total time, then it is called average velocity.

$$V_{avg} = \frac{V_i + V_f}{2}$$

Acceleration:

The rate of change of velocity of an object with respect to time is called acceleration.

Formula: $\vec{a} = \frac{\Delta\vec{V}}{t}$

Unit: The S.I unit of acceleration is m/s^2.

Types of Acceleration:

1. **Positive Acceleration:**
If the velocity of a body increases continuously then the acceleration is called positive acceleration.

2. **Negative Acceleration:**
If the velocity of a body decreases continuously then the acceleration is called negative acceleration or deceleration or retardation.

3. **Uniform Acceleration:**
A constant rate of change of velocity is called uniform acceleration.

SCALARS:

The physical quantities that have magnitude and a suitable unit are called scalar quantities.

Examples:
Time, Speed, Temperature etc

VECTORS:

The physical quantities which are completely specified by magnitude with suitable unit and particular direction are called "Vectors" quantities.

Examples:
Displacement, Velocity, Force etc

EQUATIONS OF MOTION:

There are three basic equations of motion.

First equation of Motion: ($V_f = V_i + at$)

Suppose a body is moving with initial velocity "V_i" and undergoes uniform acceleration "a" for a time "t", such that its final velocity becomes "V_f".

Change of velocity is = $V_f - V_i$

The rate of change of change in velocity = $\frac{V_f - V_i}{t}$

∴ As the rate of change of change in velocity is called acceleration

Therefore, $a = \frac{V_f - V_i}{t}$

$$V_f - V_i = at$$

$$V_f = V_i + at$$

Second Equation of Motion: ($S = V_i t + \frac{1}{2}at^2$)

Suppose a body starts with an initial velocity "V_i" and travels with uniform acceleration "$\vec{a}$" for a period of time "t". The distance covered by the body in this time is "$\vec{s}$" and its final velocity becomes "V_f".

Since the acceleration is uniform,

$$S = \bar{V} \times t$$

But $\bar{V} = \frac{V_i + V_f}{2}$

Put in above eq

$$S = \left(\frac{V_i + V_f}{2}\right) \times t$$

From 1st equation on motion we have,

$$\therefore V_f = V_i + at$$

$$S = \left(\frac{V_i + V_i + at}{2}\right) \times t$$

$$S = \left(\frac{2V_i + at}{2}\right) \times t$$

$$S = \left(\frac{2V_i t + at^2}{2}\right)$$

$$S = \frac{2V_i t}{2} + \frac{at^2}{2}$$

$$S = V_i t + \frac{1}{2}at^2$$

Third Equation of Motion: ($2aS = V_f^2 - V_i^2$)

Suppose a body starts with an initial velocity "V_i" and travels with uniform acceleration "$\vec{a}$" for a period of time "t". The distance covered by the body in this time is "$\vec{s}$" and its final velocity becomes "V_f".

According to First equation of motion;

$$V_f = V_i + at$$

Squaring both sides

$$(V_f)^2 = (V_i + at)^2$$

$$\therefore (a + b) = a^2 + 2ab + b^2$$

$$V_f^{\,2} = V_i^{\,2} + 2V_i at + a^2t^2$$

Divide and multiply a^2t^2 by "2"

$$V_f^{\,2} = V_i^{\,2} + 2V_i at + \frac{2}{2}a^2t^2$$

$$V_f^{\,2} = V_i^{\,2} + 2a(V_i t + \frac{1}{2}\mathrm{a}t^2)$$

$$V_f^{\,2} = V_i^{\,2} + 2aS$$

OR $2aS = V_f^{\,2} - V_i^{\,2}$

Motion Due To Gravity:

The change in velocity due to attraction of earth is called "Acceleration Due To Gravity". Its value is "9.8 m/s ^{2}. It is denoted by "g".

Equations Of Motion Under Gravity:

For free falling bodies

$$V_f = V_i + gt$$

$$h = V_i t + \frac{1}{2}gt^2$$

$$2gh = V_f^{\,2} - V_i^{\,2}$$

Translatory Motion	Rotatory Motion	Vibratory Motion
A body moves along a straight line.	The spinning of a body about its axes.	The body moves back and forth about mean position.
Movement of an object from one place to another.	The motion of an object about fixed point.	The body moves up and down.
All particles of the rigid body move with the same velocity.	The motion of a rigid body about fixed axes.	An object repeats its motion itself.

Scalar	Vector
The physical quantities that have magnitude and a suitable unit are called scalar quantities.	The quantities, which are described completely by their magnitudes, specific units and direction, are called "Vectors".
Examples: Time, Speed, Temperature etc	Examples: Displacement, Velocity, Force etc

Speed	Velocity
The distance covered by an object in a unit time is called speed.	The rate of change of displacement with respect to time is called velocity.
Formula: $\vec{V} = \frac{\vec{d}}{t}$	Formula: $\vec{V} = \frac{\vec{S}}{t}$
It is a scalar quantity.	It is a vector quantity.

Distance	Displacement
The total length covered by moving body without mentioning direction of motion is called "Distance".	The distance measured in straight line in a particular direction is called "Displacement"
It is a scalar quantity.	It is a vector quantity.
It is denoted by "d"	It is denoted by "S"

PROBLEMS

EXAMPLES:

1. A car travels 700m in 35 seconds. What is the speed of car?
2. The speed of a train is 108 km/h. How much distance will be cover in 2 hours?
3. A bus starts from rest and travels along a straight path its velocity become 15 m/s in 5 seconds. Calculate acceleration of the bus?
4. A motorcyclist moving along a straight path applies breaks to slow down from 10m/s to 3m/s in 5seconds. Calculate its acceleration?
5. A car moving on a road with velocity of 30 m/s, when breaks are applied its velocity decreases at a rate of 6 meter per second. Find the distance it will cover before coming to rest.
6. A motorcycle moving with velocity of 40 m/s. It gets acceleration at a rate of 8 m/s^2. How much distance will cover in the next 10 second?
7. A ball is thrown vertically upward with velocity of 12m/s. The ball will be slowing down due to pull of Earth's gravity on it, and will be returned back to Earth. Find out the time the ball will take to reach the maximum height.

EXERCISE:

1. Calculate the acceleration of a bus that speeds up from 20m/s to 40m/s in 8 seconds.
2. A bus is moving on a road with 15m/s and it accelerates at 5 m/s^2. Find the final velocity of bus after 6 seconds.
3. A car starts moving from rest with an acceleration of 5 m/s^2. Find out the time to travel 50m distance.
4. A ball is dropped from a height of 50m. What will be its velocity before touching ground?
5. If a body is thrown upward with vertical velocity 50m/s. Calculate maximum height which body can reach.
6. A ball falls down from top of height of 70m. How much time the ball will take to reach the ground.

Multiple Choice Questions

1. Scalar Quantities have____________and suitable unit:
   (a) Magnitude (b) direction (c) both a and b
2. Vector quantities have ___________along with magnitude and unit:
   (a) Magnitude (b) direction (c) both a and b
3. Which one is a vector quantity __________:
   (a) Mass (b) Weight (c) time
4. Which one is a scalar Quantity__________;
   (a) Time (b) Force (c) Velocity
5. Distance is a ___________ quantity.
   (a) Vector (b) Scalar (c) both a and b
6. What is SI unit of acceleration:
   (a) ms^{-1} (b) ma^{-2} (c) nm
7. What is a SI Unit of Velocity__________:
   (a) Nm (b) ms^{-1} (c) ms^{-2}
8. Shortest distance between two points is called:
   (a) Distance (b) speed (c) displacement

Chapter No 03

DYNAMICS

Force:

Force is the agent that changes the state of rest or motion of a body.

Formula: $F = ma$

Unit: The S.I unit is N

One Newton Force:

The amount of force that can produce 1 m/s^2 accelerates in one Kg mass

Momentum:

The quantity of motion contained in a body is called "Momentum".

OR

The product of mass and velocity of the body is called "Momentum".

Formula: $P = mV$

Unit: The S.I unit is kg m/s & Ns.

Momentum In Terms of Force:

Consider a body of mass "m" moving with initial velocity V_i. A Force F acts on the body to produce acceleration a, therefore the final velocity after time t will become V_f. If P = mV and m is constant, then the change in velocity changes the momentum of the body.

Initial momentum $P_i = mV_i$

Initial momentum $P_f = mV_f$

Change in momentum $P_f - P_i = mV_f - mV_i$

Divide both sides by t

$$\frac{P_f - P_i}{t} = \frac{mV_f - mV_i}{t}$$

$$\frac{P_f - P_i}{t} = m\frac{V_f - V_i}{t}$$

Since rate of change of velocity is acceleration

$$a = \frac{V_f - V_i}{t}$$

$$\frac{P_f - P_i}{t} = ma$$

But $F = ma$

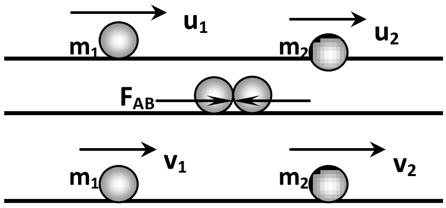
$$\frac{\Delta P}{t} = F$$

$$\Delta P = Ft$$

Law Of Conservation Of Momentum:

This law states that the total momentum of an isolated system always remains constant.

Mathematical Representation:



Consider two bodies "A" and "B" having masses m_1 and m_2
With U_1 and U_2 velocities respectively before collision,
Total momentum before collision = $m_1U_1 + m_2U_2$
Their velocities become V_1 and V_2 respectively after collision.
Total Momentum After collision = $m_1V_1 + m_2V_2$
Mathematical representation for the law of conservation of momentum is given below:

Total momentum before collision = Total Momentum After collision

$$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$$

Application Of Law Of Conservation Of Momentum:

The recoil of a gun when a bullet is fired from it.

Newton's Law Of Motion:

Newton's Fist Law Of Motion:

A body continues its state of rest or of uniform motion in a straight line unless an external force acts on it.

Example:

(a) A book will always place on a table.
(b) A running ball will continue its states of motion.

Newton's Second Law Of Motion:

This law states that,

"When a net force acts on a body it produces acceleration in the direction of force. The magnitude of acceleration is directly proportional to the applied force and inversely proportional to the mass of body."

Mathematical Representation:

If "F" force is applied on a body having mass "m" and it accelerates the body in its own direction then according to Newton's Second Law.

$$a \propto F \longrightarrow \text{(i)}$$

$$a \propto \frac{1}{m} \longrightarrow \text{(ii)}$$

Combining equation (i) and (ii)

$$a \propto \frac{F}{m}$$

$$a = \text{constant } \frac{F}{m}$$

$$a = k\,\frac{F}{m}$$ where K = proportional constant

$$ma = k\,.F$$ In S.I system k =1

$$ma = 1.F$$

$$F = ma$$

This is mathematical representation of "Newton's Second Law of Motion".

Newton's Third Law Of Motion:

This law states that

"To every action, there is an equal and opposite reaction."

$$F_{AB} = -F_{BA}$$

Example:

i. The weight of a book placed on a table acts downward and same reaction of the surface acts upward.
ii. Our walking on the ground is the result of our feet's' action and same reaction of the earth's surface.

Law of Inertia:

Inertia is the property of an object due to which it tends to continue its state of rest or motion.

Mass:

The quantity of matter present in the body is called mass.

Formula: $m = \frac{W}{g}$

Unit: The S.I unit is K. g

Weight:

The earth attraction on a body towards its center is called "Weight".

Formula: $W = mg$

Unit: The S.I unit is N

Comparison between Weight and Mass:

S. No.	Mass	Weight
1	It is quantity of matter of substance.	It is earth's attraction towards its center.
2	Its unit is Kilogram.	Its unit is Newton.
3	It is scalar.	It is vector.
4	It is constant for all universes.	It varies from distance to distance with respect to earth's center.

Centripetal Force:

The force required to move a body along a circular path is called centripetal force.

Formula: $F_c = \frac{mv^2}{r}$

Unit: The S.I unit is Newton.

Centrifugal Force:

A force that acts outward on a body which moves along a curved path is called Centrifugal force.

Formula: $F_c = -\frac{mv^2}{r}$

Unit: The S.I unit is Newton.

Application of Centrifuge:

- ✓ Road banking
- ✓ Cream separator
- ✓ Dryer

Friction:

The force that resists relative motion between two surfaces is called friction.

Mathematically

Many experiments prove that limiting friction is directly proportional to the reaction of surface.

$$Fs \propto R$$

$$Fs = \mu R \qquad \therefore R = W = mg$$

So, $$Fs = \mu mg$$

Co-efficient Of Friction:

It is ratio between limiting friction and reaction of the surface.

$$\mu = \frac{Fs}{R}$$

Types of Friction:

1. **Static Friction:**
   It is force acting on an object at rest that resists its ability to start moving.

2. **Limiting Friction:**
   The maximum value of the static friction is called limiting friction.

3. **Kinetic Friction:**
   It is the force that resists the motion of a moving object.

4. **Sliding Friction:**
   When one body slides over the other body, the friction between two surfaces is said to be sliding friction.

5. **Rolling Friction:**
   When a body moves on wheels the friction is said to be rolling friction.

Advantages of Friction:

- ➢ Fiction enables us to walk on the ground.
- ➢ Friction protects from sliding during rain.
- ➢ A nail stays in the wood because of friction.
- ➢ Nut and bolt can hold a body due to friction.

Disadvantages of Friction:

- ➢ A large amount of energy in machines is wasted due to friction.
- ➢ Friction leads to wear and tear of parts.
- ➢ Due to friction machine catch fire.
- ➢ Due to friction the efficiency of machine is less than 100%.

Method of Reducing Friction:

- ➢ Due to friction the efficiency of machine is less than 100%.
- ➢ Wheels, Pullies, ball bearing, lubricants and graphite are used to overcome the friction.
- ➢ The various parts of machine which are moving over one another are properly lubricated.
- ➢ The shape of vehicle is also designed to reduce air resistance.

PROBLEMS

EXAMPLES:

1. A car of mass 800 kg is moving with velocity of 2 m/s. What is its momentum?
2. A 60kg object is moving at a velocity 5 meters per second. What is its momentum?
3. Find the force that can stop a body to reset in 4 seconds from its initial velocity of 16m/s. The mass of body is 3kg.
4. A gun of mass 8kg fires a bullet of mass 40 gram with a velocity of 100m/s. Calculate the recoil velocity of gun.
5. Find the force that can accelerate a body of 50 kg mass up to 5 m/s^2.
6. Find the force that stops a car of 1000 kg mass from its velocity of 72 km/h over a distance of 40 meters.
7. A cyclist is making a turn along a circle of radius 20 m, at a speed of 5m/s. If the combined mass of the cyclist plus the cycle is 60 kg, calculate the static friction that road exerts on the tyres?

EXERCISE:

1. Find the moment of body of mass 6 kg moving with a velocity of 25 m/s.
2. What will be the velocity if the momentum becomes 200 N-s.
3. A body of mass 10 kg is moving with velocity of 10 m/s. A force acts for 5 seconds to reduce its velocity to 2 m/s. Find the momentum of body before and after application of the force on it.
4. A force of 3400N is applied on a body of mass is 850 kg. find the acceleration produced by the force.
5. How much force should be applied on a body of mass 425 kg to produced acceleration same as calculated in part b.
6. Find the mass of a body which is accelerated by applying a force of 200 N , that speeds up it to 36m/s.
7. What should be the acceleration of the same body if the applied force change to 280N.
8. An empty car has 1200 kg mass. Its engine can produce acceleration of 4m/s2. If 300 kg load is added to mass by passengers and luggage. What acceleration the same engine will produce.
9. The mass of an object is 60 kg, find its weight on Earth, Moon and Mars assume the acceleration due to gravity on Earth = 9.8m/s^2 on Moon =1.6m/s^2 and on Mars =3.7m/s^2.
10. A car is running on circular part of highway having about 1000m radius. The mass of car is 600kg and its velocity is 72 kmh. Find
    i. Centripetal force exerted by the car.
    ii. Centripetal acceleration of car.
11. A block is placed on a wet slippery floor. When it is pulled through a string and spring balance, it shows force equal to 3N. Find the coefficient of friction. (Fs= μ mg)

Multiple Choice Questions

1. Newton`s First law of motion is also known as law of :
   (a) Speed (b) rest
   (c) Inertia (d) force

2. Quantity of matter contained in body is called___________:
   (a) Mass (b) Volume
   (c) Area (d) Weight

3. Quantity of motion contained in body is called:
   (a) Force (b) inertia
   (c) Momentum (d) gravity

4. Law of conservation of momentum defines that the total momentum of a system of two bodies before and after collision __________:
   (a) Remains constant (b) Retains more momentum
   (c) Losses some momentum (d) None

5. Weight of a body can be measured using a spring balance; it differs from place to place because of variation in_______________:
   (a) acceleration (b) gravitational Pull
   (c) Velocity (d) Size of spring balance

6. It is easier to push an empty shopping cart than a full one, because the filled cart has more mass than the empty one. This can be expressed by:
   (a) $F > m$ (b) $F < m$
   (c) $F \propto \frac{1}{m}$ (d) $F \propto m$

7. Centrifugal force is always directed:
   (a) Towards centre (b) Away from centre
   (c) Along the circular path (d) All sides

8. Friction opposes motion between two bodies in contact because of:
   (a) Charges on Bodies (b) Weight of Bodies
   (c) Roughness of Surfaces (d) None

9. Which statement is true for limiting frictional force:
   (a) It is greater than rolling friction
   (b) It is greater than sliding friction
   (c) It is greater than kinetic friction
   (d) All are true

10. A man pulls a crate of mass 25 kg across leveled ground with a horizontal force of 60 N. A constant force of friction of 20 N acts on the sledge. What is the acceleration of the sledge?
   (a) $0.63\ m/s^2$ (b) $1.6\ m/s^2$
   (c) $2.4\ m/s^2$ (d) $3.2\ m/s^2$

Chapter No 04

TURNING EFFECT OF FORCES

PARALLEL FORCES:

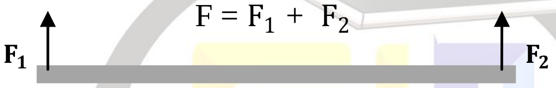
When a number of forces act on a body and if their direction is parallel, they are called parallel forces.

Types of parallel forces:

1. **Like parallel forces:**

   The forces that act along the same direction are called like parallel forces.

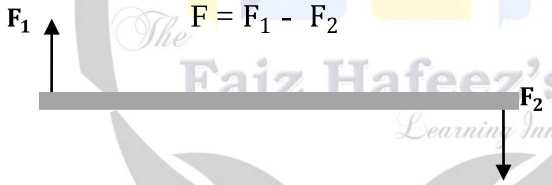
$$F = F_1 + F_2$$



2. **Unlike Parallel Forces.**

   The forces that act along opposite directions are called unlike parallel forces.

$$F = F_1 - F_2$$



Addition Of Forces:

The sum of the two or more forces is called the resultant of forces.

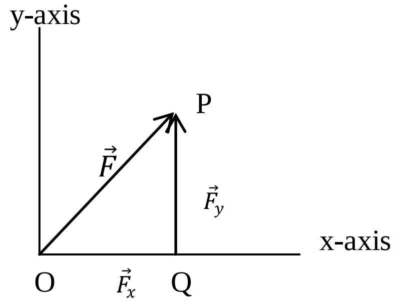
Vector Addition By Head to Tail Rule:

Following steps are involved in this method:

i. Choose a suitable scale.
ii. Draw all the forces vectors according to scale.
iii. Now take any vector as first vector and draw next vector in such a way that its tail coincides with head of previous.
iv. Use a straight line with arrow pointed towards last vector to join the tail o first vector with the head of last vector. This is the resultant vector.

Resolution Of Forces:

The process of splitting of a vector into mutually perpendicular components is called Resolution of vectors.



Method:

Consider a vector $\vec{F}$ represented by a line segment OA which makes an angle θ with x – axis. Draw a perpendicular AB on x-axis from A. the components $\overline{OB} = F_x$ and $\overline{BA} = F_y$ are perpendicular to each other. They are called the perpendicular components.

Magnitude Of F_x:

For horizontal components:

$$\cos\theta = \frac{\text{base}}{\text{hyp}}$$

$$\cos\theta = \frac{OB}{OA}$$

$$\cos\theta = \frac{F_x}{F}$$

$$F_x = F\cos\theta$$

Magnitude Of F_y:

For vertical components:

$$\sin\theta = \frac{\text{perp}}{\text{hyp}}$$

$$\sin\theta = \frac{BA}{OA}$$

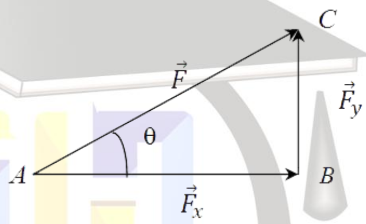
$$\sin\theta = \frac{F_y}{F}$$

$$F_y = F\sin\theta$$

Determination Of Forces from its Perpendicular Components:

The process of determining the force itself from the perpendicular components is called composition.

Suppose F_x and F_y are the perpendicular components of the force $\vec{F}$ and are represented by line segments op and PR with arrowhead respectively as sown in fig.



According to Pythagoras theorem:

$$H^2 = B^2 + P^2$$

$$(\overline{OR})^2 = (\overline{OP})^2 + (\overline{PR})^2$$

$$\vec{F}^2 = (F_x)^2 + (F_y)^2$$

Taking sq Root b/s

$$\vec{F} = \sqrt{(F_x)^2 + (F_y)^2}$$

DIRECTION:

The direction of vector $\vec{F}$ with x-axis is given by

$$\tan\theta = \frac{Perp}{Base}$$

$$\tan\theta = \frac{F_y}{F_x}$$

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$

This is mathematical representation for the direction of resultant vector.

TORQUE OR MOMENT OF A FORCE:

The turning effect of force is called torque or moment of a force.

Formula:

Torque = force x moment arm

$$\vec{\tau} = \vec{F} \times \vec{d}$$

$$\vec{\tau} = Fd\sin\theta$$

Unit: The S.I unit is N-m

Factors Affecting On Torque:

There are three factors affecting on torque.

1. Magnitude of Force.
2. Magnitude of Moment Arm.

Principle of Moment:

The principle of moment states that a body is in equilibrium, if sum of the clockwise moments acting on a body is equal to the sum of the anticlockwise moments acting on the body.

Centre Of Mass OR Centre Of Gravity:

The center of mass or center of gravity is a point where whole weight of the body acts vertically downward.

Couple:

Two equal and opposite forces acting along different lines of action form a couple.

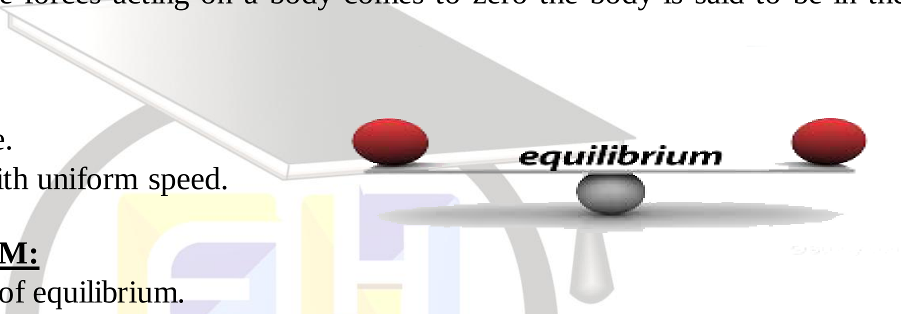
EQUILIBRIUM:

When a body does not possess any acceleration neither linear nor angular it is said to be in equilibrium. **OR**

When the resultant of all the forces acting on a body comes to zero the body is said to be in the state of equilibrium.

Example:

i. A book placed on a table.
ii. The motion of a body with uniform speed.



TYPES OF EQUILIBRIUM:

There are two types of equilibrium.

1. **Static Equilibrium:**
   A body at rest is said to be in static equilibrium.
   Example: A book lying on a table.

2. **Dynamic Equilibrium:**
   A moving object that does not possess any acceleration neither linear nor angular is said to be in dynamic equilibrium.
   Example: Motion of Paratrooper.

Conditions Of Equilibrium:

(1) First Condition Of Equilibrium:

The sum of all forces acting on a body must be equal to zero is called first condition of equilibrium.

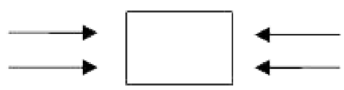
Mathematically,

$\Sigma F = F_1 + F_2 + F_3 + F_4 + \dots\dots\dots + F_N$

$\Sigma F = 0$

Along X - Axis:

The sum of all forces acting on a body along X – axis, then

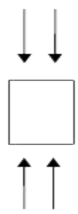


$\Sigma F_x = F_{1x} + F_{2x} + F_{3x} + F_{4x} + F_{5x} + \dots\dots\dots\dots\dots + F_{Nx}$

$\Sigma F_x = 0$

Along Y- Axis:

The sum of all forces acting on a body along Y – axis, then



$\Sigma F_y = F_{1y} + F_{2y} + F_{3y} + F_{4y} + F_{5y} + \dots\dots\dots\dots\dots + F_{Ny}$

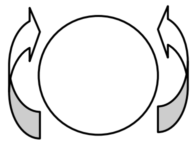
$\Sigma F_y = 0$

(2) Second Condition Of Equilibrium:

The sum of all clockwise and anticlockwise torques acting on a body must be equal to zero is called second condition of equilibrium.

Mathematically,

$$\sum \tau = \tau_1 + \tau_2 + \tau_3 + ...+ \tau_N$$
$$\sum \tau = 0$$



States Of Equilibrium:

There are three states of equilibrium.

1. **Stable Equilibrium:**

   An object is in stable equilibrium, if it returns to its original position after it is slightly disturbed.

   Example:

   A book placed flat on a table.

2. **Unstable Equilibrium:**

   An object is in unstable equilibrium, if it does not return to its original position after it is slightly disturbed.

   Example:

   A vertical pencil placed on table.

3. **Neutral Equilibrium:**

   An object is in neutral equilibrium, if its center of gravity is not raised or lowered from its original position after it is slightly disturbed.

   Example:

   A rolling ball on ground

Stability:

A body whose center of gravity is above its base of support will be stable if a vertical line projected downward from the centre of gravity falls within base of support.

PROBLEMS

EXAMPLES:

1. Find the resultant of three forces 15N along x-axis, 10N making an angle of 30° with x-axis and 10N along y-axis.
2. A man is pushing a wheelbarrow on a horizontal ground with a force of 300N making an angle of 60° with ground. Find the horizontal and vertical components of the force.
3. A car driver tightens the nut of wheel using 20cm long spanner by exerting a force of 300N. Find the torque.
4. Consider a meter rod supported at mid-point O. The block of 20N is suspended at point A 30cm from O. Find the weight of the block that balances it at point B, 20cm from O.
5. A uniform rod of length 2.0m is placed on a wedge at 0.5 from its one end. A force of 150N is applied at one of its ends near the wedge to keep it horizontal. Find the weight of the rod and the reaction of the wedge.

EXERCISE:

1. A pair of like parallel forces 15N each is acting on a body. Find their resultant.
2. Two unlike parallel forces 10 N each acting along same line. Find their resultant.
3. Three forces 12 N along x-axis, 8 N making an angle of 45° with x-axis and 8 N along y-axis.
   i. Find their resultant
   ii. Find the direction of resultant
4. A gardener is driving a lawnmower with a force of 80 N that makes an angle of 40° with the ground.
   i. Find its horizontal component
   ii. Find its vertical component
5. Horizontal and vertical components of a force are 4N and 3N respectively.
   i. Find resultant force
   ii. Find direction of resultant.
6. A spanner of 0.3m length can produce a torque of 300Nm.
   i. Determine the Force applied on it
   ii. What should be the length of the spanner if torque is to be increased to 500Nm with same applied force?
7. A uniform meter rule is supported at its center is balanced by two forces 12 N and 20N.
   i. If 20N force is placed at a distance of 3m from pivot find the position of 12N force on the other side of pivot.
   ii. If the 20N force is moved to 4cm from pivot then find force to replace 12N force.
8. A mechanic uses a double arm spanner to turn a nut. He applies a force of 15 N at each end of the spanner and produces a torque of 60 Nm. What is the length of the moment arm of the couple?
9. If he wants to produce a torque of 80Nm with same spanner then how much force he should apply?
10. A uniform meter rule is balanced at the 30 cm mark when a load of 0.80N is hung at the zero mark.
    i. At what point on the rule is the Center of gravity of the rule?
    ii. Calculate the weight of the rule.

Multiple Choice Questions

1. A pair of unlike parallel forces having different lines force produce________:
   - (a) Equilibrium (b) Torque
   - (c) a couple (d) Unstable Equilibrium
2. Head to tail rule can be used to add _______ forces:
   - (a) Two (b) Three
   - (c) Five (d) Any Number of
3. A force of 15N makes an angle of 60^0 with horizontal. Its vertical component will be:
   - (a) 15N (b) 10N
   - (c) 13N (d) 7N
4. A body is in equilibrium when it has:
   - (a) Uniform speed (b) Uniform acceleration
   - (c) Both (a) and (b) (d) Zero acceleration
5. A body is in stable equilibrium after slight tilt if its centre of gravity:
   - (a) Remains above the point of contact
   - (b) Remains on one side of point of contact
   - (c) Passes over the point of contact
   - (d) Is at lowest position
6. A body is in unstable equilibrium after slight tilt if its centre of gravity:
   - (a) Remains above the point of contact
   - (b) Remains on one side of point of contact
   - (c) Passes over the point of contact
   - (d) Is positioned at its bottom
7. A body is in neutral equilibrium after slight tilt if its centre of gravity:
   - (a) Is at the lowest position
   - (b) Remains at same height
   - (c) Is at highest position
   - (d) Is at its base
8. Bunsen burner is made stable by:
   - (a) Increasing its length (b) Increasing its mass
   - (c) Decreasing its base area (d) Increasing its base area
9. A tight rope walker carries a long pole to:
   - (a) Increase his weight
   - (b) Raise his Centre of gravity
   - (c) Lower his Centre of gravity
   - (d) Keep his centre of gravity in fixed position
10. Stability of a racing car is increased by:
    - (a) Increasing its height
    - (b) Raising its Centre of gravity
    - (c) Decreasing its width
    - (d) Lowering its Centre of gravity

Chapter No 05

FORCES AND MATTER

Force:
A push or pull that changes or tends to change the state of rest or uniform motion of an object or changes the direction or shape of an object.

Effect of forces:
- ✓ Force is needed to move a car.
- ✓ Force causes the spring to stretch.
- ✓ We need force to move some luggage.
- ✓ Force can change the shape of plastics.

Elasticity:
Elasticity is the property of a body to regain its original shape and size when deforming forces are removed.

Elastic Behavior:
When the external force is removed, the object tends to return to its original shape and size. This behavior is known as Elastic behavior.

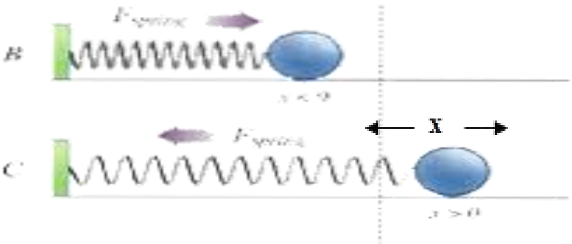
Elastic Change:
An elastic changes occurs when an object returns to its original shape and size after the load is removed.

Extension of spring:
The increase in length of spring is known as extension.

Length of stretched spring = Original Length + Extension

Hook's Law:
Within elastic limit, the displacement produced in the spring is directly proportional to the force applied.

$$F \propto x$$
$$F = k.x$$



Properties of Spring:
- ✓ Springs are useful in making balances.
- ✓ A spiral spring could be used to control a clock or wrist watch.

Pressure:
The force acting normally per unit area on the surface of a body is called pressure.

Formula:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Unit:

The S.I unit is N/m^2 OR Pascal
$\therefore 1$ atm = $1.013x10^5 Pascal$

Pressure In Fluids:

The pressure exerted by fluids is known as fluid pressure.

Derivation:

Consider a liquid in a container of height "h" and area of cross section "A". The density of liquid is given

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

m = ρ V $\qquad \therefore$V = Ah

m = ρAh

Pressure exerted by liquid

P = $\frac{F}{A}$

Force applied by liquid is equal its weight

P = $\frac{W}{A}$

P = $\frac{mg}{A}$

P = $\frac{\rho A h g}{A}$

P = ρ g h

The pressure of liquid is directly proportional to the density "p" of liquid and depth "h" measured from the free surface of the liquid.

Factors affecting Pressure:

1. Pressure depends upon the depth.
2. Pressure depends upon the density of the material.

Hydraulic Machine:

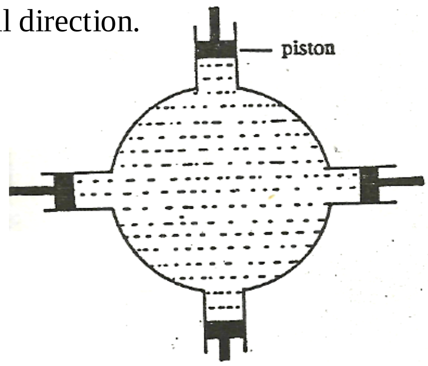
The machine in which force is transmitted by liquids under pressure is known as hydraulic machine.

Pascal's Law:

It states that the liquids transfer the applied pressure equally in all direction.

Explanation:

Consider a vessel containing a liquid with four freely moveable pistons. When a pressure is applied on one of the pistons, others move in backward direction equally due to pressure transferred by liquid.



Applications of Pascal's principle:

i. Hydraulic brakes
ii. Hydraulic Car lift
iii. Hydraulic Jacks
iv. Forklifts
v. Hydraulic press

Hydraulic Press:

It is a system used to press substances such as cotton-powdered materials etc.

Construction:

It consists of two pistons connected by a liquid-filled pipe.

Working:

When the small force F, is applied on a small piston of area A_1 it produces pressure which transmitted to large piston of area A_2 throw liquid.

$P_1 = \frac{F_1}{A_1} \longrightarrow$ (i)

$P_2 = \frac{F_2}{A_2} \longrightarrow$ (ii)

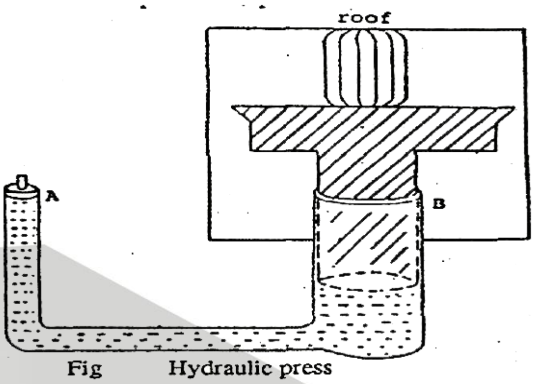


Fig Hydraulic press

According to Pascal's law pressure same.

$P_1 = P_2$

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$F_2 = \frac{F_1}{A_1} \times A_2$

Which shows: small force F_1 acting on a small area A_1 generates a large Force F_2 on large area A_2

PROBLEMS

EXAMPLES:

1. A spring has spring constant K=30 Nm^{-1}. What load is required to produce an extension of 4 m?
2. Calculate the pressure at a depth of 3m in a swimming pool? (Density of water =1000Kgm^{-3})
3. A boy is digging a hole with spade of edge 0.1cm^2. Calculate the pressure when he is exerting the force of 1000N onto the spade.
4. In a hydraulic lift system, what must be the surface area of a piston, if a pressure of 300 kpa is used to provide an upward force of 2000 N?

EXERCISE:

1. Calculate the spring constant for a spring which extends by a distance of 3.5cm when a load of 14N is hung from its end.
2. A boy is pressing a thumbtack into a piece of wood with a force of 20 N. the surface area of head of thumbtack is 1cm^2 and the cross-section area of the tip of the thumbtack is 0.01cm^2. Calculate,
   (a) The pressure exerted by boy's thumb on the head of thumbtack.
   (b) The pressure of the tip of the thumbtack on the wood.
   (c) What conclusion can be drawn from answers of part (a) and (b)?
3. A basic hydraulic system that has small and large pistons of cross section area of 0.005 m^2 and 0.1 m^2 respectively. A force of 20N is applied to small piston. Calculate
   (a) The pressure transmitted into hydraulic fluid.
   (b) The force at large piston.
   (c) Discuss the distance travelled by small and large pistons.

Multiple Choice Questions

1. The springs in brakes and clutches are used:
   (a) To restore original position (b) To measure Forces
   (c) To absorbs Shocks (d) To absorbs shocks
2. If the material recovers the original dimension, when an external force is removed, this deformation is known an _______ deformation:
   (a) Inelastic (b) Permanent
   (c) Elastic (d) Irreversible
3. Which of the following material is more elastic?
   (a) Rubber (b) Glass
   (c) Steel (d) wood
4. If a spring stretches easily then its spring constant has ____________:
   (a) Large Value (b) Small value
   (c) Constant value (d) Both (a) and (b)
5. What is the unit for the spring constant?
   (a) Nm (b) Nm^{-2}
   (c) Nm^{-1} (d) Nm^{2}
6. The spring obeys Hooke`s law for the earlier extensions and when the spring becomes damaged it does not appear to do so; Fig 5,12. Estimate, from graph, after addition of which weight the spring damaged:
   (a) 1.5 N (b) 8 N
   (c) 1.6 N (d) 2.0 N
7. Which of the following is not a unit of pressure?
   (a) Pascal (b) Bar
   (c) Atmosphere (d) Newton
8. If a metal block applies a force of 20 N on an area of 5 cm^2. Find the pressure being applied by the block on the area of ____________:
   (a) $100\ Ncm^{-2}$ (b) $0.8\ Ncm^{-2}$
   (c) $0.25\ Ncm^{-2}$ (d) $4\ Ncm^{-2}$
9. The Fig 5.13 shows a container with three spouts. The container is with water. Jets of water pour out of the spouts. Why does the jet of water from the bottom spout goes farthest out from the container?
   (a) Pressure decreases with depth
   (b) Pressure increases with depth
   (c) More water available to flow out from the bottom.
   (d) Density of water different at different places.

Chapter No 06

GRAVITATION

Gravitational field:

A gravitational field is a region in which a mass experiences a force due to gravitational attraction.

GRAVITY:

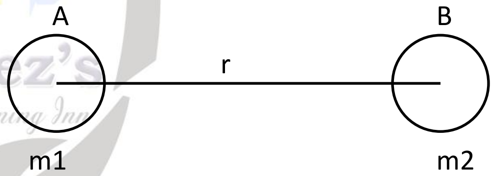
The gravitational force of earth is known as gravity.

Newton's Law OF Gravitation:

This law states that everybody in the universe attracts every other body with a force, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

Mathematical Representation:

Consider two bodies A and B having masses "m_1" and "m_2" respectively. The distance Between their centers is "r".



According to Newton's law of Gravitation

$$F \propto m_1 m_2 \longrightarrow \text{(i)}$$

$$F \propto \frac{1}{r^2} \longrightarrow \text{(ii)}$$

Combine equations (i) and (ii)

$$F \propto \frac{m_1 m_2}{r^2}$$

$$F = \text{Const}\ \frac{m_1 m_2}{r^2}$$

$$F = \frac{G\, m_1 m_2}{r^2}$$

Where G is gravitation constant having value of $6.67 \times 10^{-11}\ Nm^2 / kg^2$

Weight:

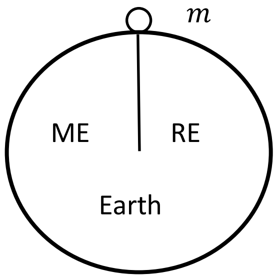
The weight of an object is the measurement of gravitational force acting on the object.

Formula: W = mg

Unit: The S.I unit is Newton.

Mass Of Earth:

Consider a body placed on the surface of the earth having mass "m". The distance between the Centers of the body to the Centre of the earth is "r" which is approximately equal to the radius of the earth " R_e" and mass of the earth is " M_e".



According to Newton's law of gravitation

$$F = \frac{GmM_e}{R_e^{\;2}}$$

But attraction of earth is called weight

F= W = mg

Therefore,

$$mg = \frac{GmM_e}{R_e^{\;2}}$$

$$g = \frac{GM_e}{R_e^{\;2}}$$

$$\frac{g\,R_e^{\;2}}{G} = M_e$$

$$or \qquad M_e = \frac{g\,R_e^{\;2}}{G}$$

Where

$g = 9.8\ \text{m/sec}^2$

$R_e = 6.4 \times 10^6$ m

$G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$

$$M_e = \frac{9.8 \times (6.4 \times 10^6)^2}{6.67 \times 10^{-11}}$$

$$M_e = 6.0 \times 10^{24}\ Kg$$

Satellite:

A satellite is an object that revolves around a planet.

Types of Satellite:

There are two types of satellite.

Natural Satellites:

Natural satellite is a planet that revolves around another planet naturally is called natural satellite.

Example: Moon

Artificial Satellite:

An artificial satellite is an object which is sent to space to revolve around a planet is called artificial satellite.

Example: sputnik-1

Uses of Satellite:

Artificial satellite are used for different purposes

i. For communication
ii. For making star maps.
iii. For making maps of planetary surfaces
iv. For collecting information about weather
v. For taking pictures of planets.

Orbits of Satellite:

There are different types of satellite orbits.

i. For communication.
ii. Low-Earth orbit.
iii. Medium-Earth orbit.
iv. Geostationary Orbit.
v. Elliptic orbit.

Newton's Law Of Gravitation In The Motion Of Satellite:

Consider the motion of a satellite which is revolving around the earth. Newton's law of Gravitation plays an important role because the gravitational pull of earth on a satellite provides the necessary centripetal force for orbital motion.

Centripetal force = Gravitational force

$$\frac{mv^2}{r} = \frac{G\,mM_e}{r^2}$$

$$V^2 = \frac{GM_e}{r}$$

$$V^2 = \frac{GM_e}{R+h} \qquad \therefore r = R + h$$

$$V = \sqrt{\frac{GM_e}{R+h}}$$

This shows that the speed of the satellite is independent of its mass.

Time Period For Satellite:

The time required for a satellite to complete one revolution around the earth in its orbit is called its time period.

$$T = \frac{2\pi r}{V} \longrightarrow \text{(i)}$$

The velocity of satellite is

$$V = \sqrt{\frac{GM_e}{R+h}}$$

Put in eq (i)

$$T = \frac{2\pi r}{\sqrt{\frac{GM_e}{R+h}}}$$

$$T = \frac{2\pi r}{\sqrt{\frac{GM_e}{r}}}$$

$$T = 2\pi r\sqrt{\frac{r}{GM_e}}$$

$$T = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

Motion Of Artificial Satellite:

Orbital Velocity:

The velocity required to keep the satellite into its orbit is called Orbital Velocity.

Critical Velocity:

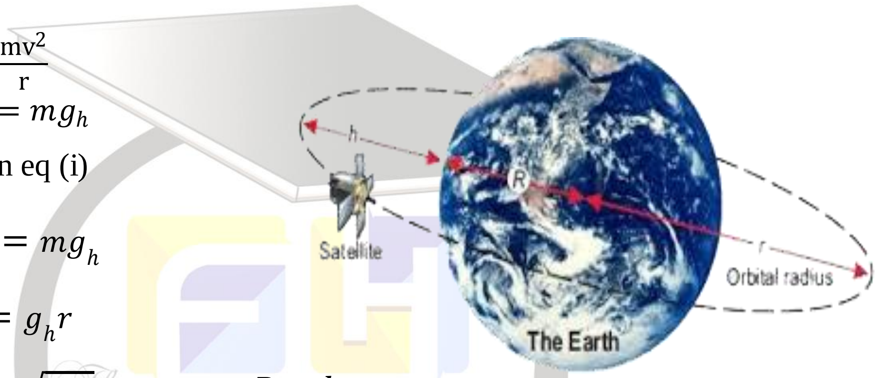
The constant horizontal velocity required to put the satellite into a stable circular orbit around the earth is called Critical Velocity.

Derivation:

Consider a satellite of mass "m moving in an orbit of radius "r" with velocity "v" around the earth. The gravitational pull of earth on a satellite provides the necessary centripetal force for orbital motion. Since this force is equal to the weight of satellite.

$$F_c = W_s \longrightarrow \text{(i)}$$

Where,



$$F_c = \frac{mv^2}{r}$$

$$W_s = mg_h$$

Put in eq (i)

$$\frac{mv^2}{r} = mg_h$$

$$v^2 = g_h r$$

$$V = \sqrt{g_h r} \quad \therefore r = R + h$$

$$V = \sqrt{g_h (R + h)}$$

If satellite is orbiting very close to the surface of earth then in this case,

$$R + h = R$$

$$g_h = g$$

$$V = V_c$$

Equation becomes

$$V_c = \sqrt{gR}$$

If

$$g = 10\text{m}/s^2$$

$$R = 6.38\, x10^6 \text{ m}$$

Then

$$V_c = \sqrt{(10)(6.38\, x10^6)}$$

$$V_c = 7.99\, x\, 10^3 \text{ m/s}$$

$$V_c = 8\, K\text{m/s}$$

PROBLEMS

EXAMPLES:

1. Determine the gravitational force of attraction between two spherical bodies of masses 500 kg and 800 kg. Distance between their centers is 2 meters.
2. Calculate the weight of Rumaisa, who has a mass of 65 Kg standing at the ground. The strength of gravitational field on Rumaisa is 10 Newton per Kilogram?
3. Calculate the acceleration due to gravity on a planet that has mass two times to the mass of earth and radius 1.5 times to the radius of earth. If the acceleration due to gravity on the surface of earth is 10 m/s^2. Calculate acceleration due to gravity on the planet?
4. Calculate the speed of a satellite which orbits the Earth at an altitude of 1000 kilometers above Earth's surface?

EXERCISE:

1. Determine the gravitational force of attraction between Urwa and Ayesha standing at a distance of 50m apart. The mass of Urwa is 60kg and that of Ayesha is 70kg?
2. What weight of Naveera is 700N on the Earth's surface. What will be naveera's weight at the surface of moon?
3. A Planet has mass four times of earth and radius two times that of earth .if the value of "g" on the surface of is 10 m/s^2. Calculate acceleration due to gravity on the planet.
4. Evaluate the acceleration due to gravity in terms of mass of Earth"M_e", radius of Earth "R_e"and universal gravitational constant "G".
   i. At a distance, twice the earth's radius
   ii. At a distance, One half the earth's radius.
5. Calculate the speed of a satellite which orbits the earth at an altitude of 400 kilometers above earth's surface?

Multiple Choice Questions

1. The motion of a falling ball towards Earth is due to the:
   (a) Weightlessness (b) Gravitational Forces
   (c) Acceleration due to gravity (d) both "a" and "b"

2. Newton's law of gravitation holds between every two objects on the;
   (a) Earth (b) Jupiter
   (c) Moon (d) Universe

3. Numerical value of G is:
   (a) $G = 6.673 \times 10^{-11}\ Nm^2/kg^2$ (b) $G = 6.67 \times 10^{11}\ Nm^2/kg^2$
   (c) $G = 6.763 \times 10^{-11}\ Nm^2/kg^2$ (d) $G = 6.763 \times 10^{11}\ Nm^2/kg^2$

4. Gravitational field of Earth is directed:
   (a) Towards the Earth (b) Towards the sun
   (c) Towards the Moon (d) away from earth

5. ________________ was the first scientist who gave the concept of gravitation:
   (a) Einstein (b) Newton
   (c) Faraday (d) Maxwell

6. According to Newton`s law of universal gravitation force ∝:
   (a) $m_1 m_2$ (b) $\frac{1}{r^2}$
   (c) r^2 (d) Both (a) and (b)

7. Gravitational force is always ___________:
   (a) Repulsive (b) Attractive
   (c) Both (d) None of these

8. Numerical value of ________remains constant everywhere:
   (a) g (b) G
   (c) F (d) W

9. Gravitation force is _______________ of the medium between the objects:
   (a) Dependent (b) Independent
   (c) Both (a) and (b) (d) None of these

10. Near Earth's surface g = ____________:
   (a) 10 m/s^2 (b) 1.6 m/s
   (c) Both (a) and (b) (d) None of these

11. Newton's law of gravitation is consistent with Newton's _______________ law of motion:
   (a) 1st (b) 2nd
   (c) 3rd (d) All of them

12. Spring balance is used to measure ___________:
   (a) Mass (b) weight
   (c) Elasticity (d) Density

13. Your weight as measured on Earth wills be______________ on Moon:
   (a) Increased (b) Decreased
   (c) Remains same (d) None of these

14. Mass of Earth is _____________:
   (a) $6.0 \times 10^{23}\ Kg$ (b) $6.0 \times 10^{24}\ Kg$
   (c) $6.0 \times 10^{25}\ Kg$ (d) $6.0 \times 10^{26}\ Kg$

15. _______________ is a natural satellite:
   (a) Earth (b) Jupiter
   (c) Moon (d) Mars

16. A communication satellite completes its one revolution around the Earth in _________ hours:
   (a) 6 (b) 12
   (c) 18 (d) 24

17. The velocity of a satellite is ______________ of its mass:
   (a) Independent (b) Dependent
   (c) Equal (d) Double

18. _________ are used to put satellites into orbits:
   (a) Helicopter (b) Aeroplane
   (c) Rocket (d) None of these

19. The critical velocity V_c = __________:
   (a) gR (b) $\frac{g}{R}$
   (c) $\sqrt{gR}$ (d) $\sqrt{\frac{g}{R}}$

Chapter No 07

PROPERTIES OF MATTER

Matter:

Anything which occupies space and has mass is called Matter.

Example:

Air, Soil, Water etc.

States Of Matter:

There are three states of Matter.

Properties of Solid:

1. Solids bodies have fixed volume and fixed shape.
2. In solids, the molecules are closely packed.
3. In solids, intermolecular force is very strong.
4. In solids, the molecules have only vibratory motion
5. In solids, molecules don’t leave their mean position.

Properties of liquid:

1. Liquid have fixed volume but no fixed shape.
2. They assume shape of the container.
3. In liquid, intermolecular force are small as compared to solids.
4. The liquid molecules move freely.
5. Liquids are incompressible and maintain their level.

Properties of Gases:

1. Gases have neither fixed volume nor fixed shape.
2. They can occupy any space available to them.
3. Intermolecular force of gases is negligibly small.
4. Gas molecules move freely in all direction.
5. Gases are compressible.

Changes in the States of matter:

Addition or removal of a certain amount of energy can change the state of matter. The term for these changes in the state is:

1. Melting: conversion from solid to liquid.
2. Boiling: conversion from liquid to gas.
3. Condensing: conversion from gas to liquid.
4. Freezing: conversion from liquid to solid.
5. Evaporation: conversion from liquid to gas.

Kinetic Molecular Model of matter:

The kinetic molecular theory suggests that the molecules in a substance are always in continuous random motion.

Brownian Motion:

The irregular motion of pollen grains caused by water molecules is called Brownian motion.

PROPERTIES:

The kinetic molecular theory explains the physical properties of solids, liquids and gases by considering the position and motion of molecules.

Physical properties of solid (by position):

i. The molecules are closely packed together and occupy minimum space.
ii. The molecules usually arranged in a regular pattern called lattice.
iii. There are a large number of particles per unit volume. That is why solids have the highest densities.

Physical properties of solid (by motion):

i. The forces of attraction between particles are very strong.
ii. The particles are not able to change positions.
iii. The particles vibrate about fixed positions.
iv. Solids have fixed shapes and volumes.

Physical properties of Liquids (by position):

i. The molecules are slightly further apart compared to that of solids.
ii. The molecules occur in clusters.
iii. There is slightly less number of particles per unit volume compared to solids.
iv. Liquids have relatively high densities.

Physical properties of liquids (by motion):

i. The forces of attraction between particles are strong.
ii. The particles are free to move about within the liquid.
iii. These features explain why liquids have fixed volumes, but take the shape of the container.

Physical properties of gases (by position):

i. The molecules are very far apart.
ii. The molecules are arranged randomly and are free to move with very high speeds.
iii. There is small number of particles per unit volume.

Physical properties of Gases (by motion):

i. The forces of attraction between particles are negligible.
ii. The particles are able to move freely in random directions at very high speeds.
iii. The particles occupy any available space.

Gases and The Kinetic Theory:

Kinetic molecular theory clearly describes the properties and behavior of gases. The behavior of gases can be described completely by its pressure, volume and temperature.

1. **Pressure:**
   Pressure is the total force exerted per unit area by the gas molecules during collision only when they collide with the walls. The number of collision is proportional to the number of molecules.

2. **Volume:**
   The gas has no definite volume because the molecules of the gas are far away from each other and can move freely at high speeds. Therefore gas always takes up the shape and volume of its container.

3. **Temperature:**
   Temperature of a gas is the average translational kinetic energy of its molecules. If the gas is heated, the average translational kinetic energy of its molecules increases and temperature of the gas rises.

Pressure-Volume Relationship in Gases:

BOYLE's LAW:

The volume of a fixed mass of a gas is inversely proportional to its pressure, provided its temperature remains constant.

Mathematically,

$$V \propto \frac{1}{P}$$

$$V = \frac{constant}{P}$$

$$PV = \text{constant}$$

For Initial Stage: $P_1V_1 = \text{constant} \longrightarrow$ (i)

For Final Stage: $P_2V_2 = \text{constant} \longrightarrow$ (ii)

Combining eq (i) and (ii)

$$P_1V_1 = P_2V_2$$

Application of Boyle's Law (P-V relation):

A bicycle pump is good example of Boyle's law. As the volume of the air trapped the pump is reduced, its pressure goes up and air is forced into the tyre.

PROBLEMS

EXAMPLES:

1. A cylinder contains $60\ cm^3$ of air at a pressure of 140 KPa. What will its volume be if the pressure on it is increased to 420 KPa?
2. Air at a pressure of $1.0x10^5\ Pa$ is contained in a cylinder fitted with a piston. The air is now compressed by pushing the piston, so that the same mass of air now occupies one-fifth the original volume without any change in temperature. Calculate the pressure of the air.

EXERCISE:

1. The pressure on $9\ cm^3$ of oxygen gas is double at a fixed temperature. What will be its volume become?
2. A container holds $30\ m^3$of air at a pressure of 150000Pa. if the volume changed to $10\ m^3$ by decreasing load on the piston. What will the pressure of the gas become? Assume that its temperature remains constant.
3. Air at atmospheric pressure of 760 mm of Hg is trapped inside a container available with a movable piston. When the piston is pulled out slowly so that the volume is increased from $100\ dm^3$ to $1500\ dm^3$, the temperature remaining constant. What will be the pressure of the air becomes?

Multiple Choice Questions

1. An object with particles close together and vibrating describes a__________:
   (a) Gas (b) Liquid
   (c) Solid (d) All three
2. A burning candle is an example of____________ state of matter:
   (a) Gas (b) Liquid
   (c) Solid (d) All three
3. During which process a gas become a liquid__________:
   (a) Melting (b) Freezing
   (c) Condensing (d) Boiling
4. A solid can_________ :
   (a) Have a fixed shape (b) Be easily compressed
   (c) Take a shape of container (d) Have freely moving molecules
5. According to Kinetic molecular theory, the pressure exerted by a gas is caused by the __:
   (a) Bombardment of the gas molecules on the walls of the container
   (b) Collision between gas molecules
   (c) Large distance between gas molecules
   (d) Random motion of the gas molecules
6. If a gas is heated in a sealed cylinder, then________ increases:
   (a) Pressure inside the container
   (b) Average kinetic energy of the particles
   (c) Temperature of the gas
   (d) All of them
7. A gas in a container of fixed volume is heated, what happens to the molecules of the gas?
   (a) They collide less frequently
   (b) They expand
   (c) They move faster
   (d) They move further apart
8. In a liquid some energetic molecules break free from the surface even when the liquid is too cold for bubbles to form. What is the name of this process?
   (a) Boiling (b) Condensation
   (c) Convection (d) Evaporation
9. What happens to the molecules of a gas when the gas changes into a liquid?
   (a) They move closer and lose energy
   (b) They move closer and gain energy
   (c) They move apart and lose energy
   (d) They move apart and gain energy

Chapter No 08

Energy Sources and Transfer of Energy

Work:

When a force acts on a body and the body moves through some distance along the direction of force, then work is done. **OR**

The product of force and the distance moved in the direction of force is called work.

Formula: $W = F.S$

$W = FS \cos\theta$

Unit: The S.I unit of work is Joule.

Energy:

The ability of a body to do work is called energy.

Forms of energy:

1. Heat energy.
2. Solar energy.
3. Mechanical energy.
4. Kinetic energy.
5. Potential energy.
6. Electrical energy.
7. Chemical energy

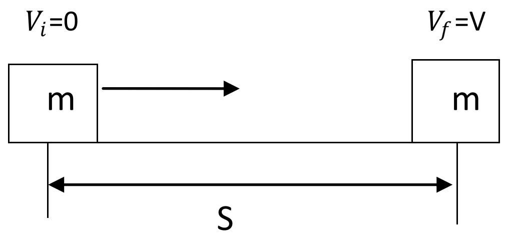
1. Kinetic Energy:

The energy possessed by an object due to its motion is called kinetic energy.

Formula: $K.E = \frac{1}{2}mv^2$

Unit: The S.I unit is Joule

Derivation:



Consider a body of mass "m" is placed on a horizontal surface initially at rest. When a force "F" is applied on a body it covers distance "S" and final velocity becomes "V".

Since the work done is

$W = F.\ S \longrightarrow$ (i)

According to Newton's law of motion

$F = ma$

Using 2^{nd} equation of motion

$2aS = Vf^2 - Vi^2$

Here $V_i = 0$, $V_f = V$

$$2a\,S = V^2 - 0$$

$$2a\,S = V^2$$

$$S = \frac{V^2}{2a}$$

Substitute the value of F and S in equation (i)

$$W = ma.\frac{V^2}{2a}$$

$$W = \frac{mV^2}{2}$$

As work is done by virtue of its motion

W = E = K.E

$$K.E = \frac{1}{2}mV^2$$

2. Potential Energy:

The energy due to position of an object is called potential energy.

KINDS OF POTENTIAL ENERGY:

i. **Gravitational Potential Energy:**

Energy of a body due to its height from the surface of the earth is called Gravitational Potential Energy.

Formula: $P.E = mgh$

ii. **Elastic Potential Energy:**

Energy of stretched or compressed spring is called Gravitational Potential Energy.

Formula: $Elastic\ Potential\ Energy = \frac{1}{2}\ kx^2$

iii. **Chemical Potential Energy:**

The energy stored in the plants that we eat is called chemical potential energy.

Derivation: ($P.E = mgh$)

Consider a body of mass “m” is lifted up through a vertical height “h”. The force required to raise the body is equal and opposite of its weight. The work done on body is given by

$$W = F.d$$

But,

$$F = W = mg$$

$$d = h$$

So,

$$W = mgh$$

$$\therefore W = P.E$$

$$P.E = mgh$$

Law Of Conservation Of Energy:

This law states that the energy neither be created nor it can be destroyed but it can be converted for one form to another form.

Heat Lost = Heat gain

1. **Fossil fuel energy:**
   Fossil fuel energy is formed from decayed plants and animals.
2. **Hydroelectric energy:**
   Hydroelectricity generated by hydro power by using gravitational force of falling or flowing water.
3. **Solar energy:**
   The energy radiated from the sun is known as solar energy.
4. **Nuclear energy:**
   The energy released during a nuclear reaction is known as nuclear energy.
5. **Geothermal energy:**
   Geothermal energy is stored in the earth as its natural heat.
6. **Wind energy:**
   The energy obtained by the wind is called wind energy.
7. **Biomass energy:**
   Biomass is the organic material that comes from plants and animals.
8. **Tidal energy:**
   It is a form of hydro power that converts the energy obtained from tides into useful form of power.

Application of Wind Energy:

1. It is used as source of energy for sailing ships in oceans.
2. It is used by wind mills to pump water.
3. It is used by wind mills to grind grain.
4. It is used to turn wind turbines to produce electricity.

Renewable Energy Sources:

Renewable resources are resources which can be used repeatedly and replaced naturally. Examples: Solar energy, Wind energy, tidal energy

Nonrenewable Energy Sources:

Nonrenewable resources are natural resources that cannot be replaced after they are used.
Examples: Petroleum, coal, and natural gas

Differences Between K.E and P.E

Kinetic Energy	Potential Energy
It is due to motion of a body.	It is due to position of a body.
It can be calculated by using following Formula: $K.E = \frac{1}{2}mV^2$	It can be calculated by using following Formula: $P.E = mgh$

Efficiency:

It is the ratio of output to the input is called efficiency.

Formula: Efficiency = $\frac{output}{input}$ x 100

Unit: It has no unit.

Power:

The rate of doing work of a body is called power. **OR**

The amount of energy transferred per unit time is called power.

Formula: $\text{Power} = \frac{\text{Work}}{\text{time}}$

Unit: The S.I unit is J/Sec called watt.

Watt:

The power of a body is said to be one watt if it does work at the rate of one Joule per second.

PROBLEMS

EXAMPLES:

1. Find the work done when a force of 50N is applied to move a trolley at a shopping mall through a distance of 200m? Assume the angle to be of 0^0 between the force and the distance the trolley moved.
2. A ball of mass 400gm, strikes the wall of velocity 4 m/s. How much is the kinetic energy of the ball at the time it strikes the wall?
3. A ball of mass 50 gm is raised to a height of 7m from the ground. Calculate its gravitational potential energy.
4. Calculate the power of a machine. If the machine performs 900 joules of work in 30 minutes.

PROBLEMS:

1. How much work is needed to move horizontally a body 20m by a force of 30N, the angle between the body and the horizontal surface is 60^0?
2. How much work is done, if a crate is moved at a distance of 50m, when a force of 30N is applied along the surface?
3. What will be the Kinetic energy of a body of mass 50Kg driving a bike with velocity of 2m/s.
4. If LED screen of mass 10Kg is lifted up and kept it on a cupboard of height 2m. Calculate the potential energy stored in the LED screen.
5. Calculate the potential energy of 3Kg water raised to the tank at the roof of a home 4m high. (Assume 10 m/s^2)
6. Calculate the efficiency of a machine which consumes 200 J of energy and performs 50J of work.
7. If the efficiency of a machine is 70% and its output is 100 J then calculate its input.
8. Which machine is more efficient, machine "A" which has an output of 200 J after consuming 400 J of energy or machine "B" which has an output of 300 J after consuming 450 J of energy?
9. The energy of 600 J dissipated by a bulb in 50 minutes. Find the power of the bulb.
10. Convert 20 watt into horse power.
11. Calculate the power of a machine, if it does 40 joules of work in 10 sec.
12. A student of weight 400n takes 5 sec to climb up an obstacle of height 2m. Calculate the power consumed.
13. If a machine consumes 250J of energy per hour then what will be its power?

Multiple Choice Questions

1. If force of 6N displaces an object 2m in the direction of force, then work done will be:
   (a) 0 (b) 12Joule
   (c) 3Joule (d) Both b and c

2. If a body of mass 1 kg is moving with velocity of 1m/sec then K.G of the body will be;
   (a) Joules (b) Joules
   (c) Joules (d) 1 Joules

3. If a machine performs 20J of work in 10sec then its power is:
   (a) 200 watt (b) 20 watt
   (c) 2watt (d) 0.2watt

4. A body of mass 1kg is lifted through a height of 1m. The energy possessed in the body will be : (Consider $g = 10ms^{-2}$)
   (a) 1 J (b) 10 Joule
   (c) 100 Joule (d) 1000 Joule

5. The energy released during fission or fusion reaction is called:
   (a) Solar energy (b) Geothermal energy
   (c) Tidal energy (d) Nuclear energy

6. Which is the renewable source of energy:
   (a) Solar and wind (b) Coal
   (c) Natural gas (d) Petroleum

7. The ratio of output to input is called:
   (a) Energy (b) Work
   (c) Power (d) Efficiency

8. Work done per unit time is called:
   (a) Efficiency (b) Energy
   (c) Power (d) Force

9. Coal, gas and oil are all examples of:
   (a) Tidal energy (b) Nuclear energy
   (c) Fossil fuel energy (d) Biomass energy

10. ________________is not a renewable source of energy:
    (a) Solar energy (b) Coal
    (c) Wind energy (d) Geothermal energy

Chapter No 09

Thermal Properties Of Matter

HEAT:

Heat is the form of energy which transfers from hot body to cold.

Units: Its units are Joule, Calorie, B.T.U.

TEMPERATURE:

The degree of hotness or coldness of a body is called Temperature.

Units: The units of temperature are K °F °C.

HEAT	TEMPERATURE
Heat is the form of energy which transfers from hot body to cold.	The degree of hotness or coldness of a body is called Temperature.
It is the total kinetic energy of the molecules of a substance.	It is the average kinetic energy of the molecules of a substance.
Its units are joule, Calorie, B.T.U.	Its units are K °F °C.

Thermometer:

It is a device used to measure Temperature.

Temperature Scale:

There are three scales used to measure temperature. They are

i. Celsius Scale
ii. Fahrenheit scale
iii. Kelvin scale

Inter Relation Between°C,°F , K:

- $T_K = T_{°C} + 273$
- $T_{°F} = 1.8\ T_{°C} + 32$

Heat capacity:

The amount of heat required to raise the temperature of a body through 1 Kelvin.

Formula: Heat capacity = $\frac{\Delta Q}{\Delta T}$

UNIT: The S.I unit is JK^{-1}

Specific Heat capacity:

The amount of heat required to raise the temperature of unit mass of the substance by 1 Kelvin.

Formula: $C = \frac{\Delta Q}{m\Delta T}$

UNIT: The S.I unit is J/kgK

Effects Due To Large Specific Heat Of Water:

Large specific heat of water plays an important role in everyday life.

i. The large amount of water in ocean and lakes help to maintain the temperature range in their surroundings.
ii. Water with coolant is used to reduce the temperature of engine through radiator of vehicle.
iii. Water helps to maintain our body temperature.

LATENT HEAT:

The amount of heat required to change the state of a unit mass without change of temperature is called latent heat.

Formula: $L = \frac{Q}{m}$

UNIT: The S.I unit is J/kg.

Types:

1. **Latent heat of fusion:**
   The amount of heat required to change the state of substance from solid into liquid without change of temperature is called latent heat of fusion.

2. **Latent heat of vaporization:**
   The amount of heat required to change the state of substance from liquid into vapors without change of temperature is called latent heat of vaporization.

EVAPORATION:

The process in which the water changes from liquid to gas or vapor form is known as evaporation.

Factors:

1. **Temperature:**
   With the increase in temperature, the rate of evaporation also increases.
2. **Wind speed:**
   Rate of evaporation also increases with the increase in wind speed.
3. **Surface area of liquid:**
   Rate of evaporation increases with the increase in surface area of liquid.
4. **Humidity:**
   Rate of evaporation decreases with increase in humidity.
5. **Nature of Liquid:**
   Liquid with lower boiling point evaporate more rapidly.
6. **Solute Concentration:**
   Salty water evaporates more slowly than pure water.

EVAPORATION	BOILING
It takes place without supply having external source.	It only takes place with supply of external heat source.
It occurs at any temperature below boiling point.	It occurs only at certain temperature called Boiling point.
It causes cooling.	It does not cause cooling.
It is relatively slow.	It is relatively fast.
It takes place only at the liquid surface.	It takes place through the liquid.
No formation of bubbles.	Bubbles are formed.

Thermal expansion:

The expansion of substance on heating is called Thermal expansion.

Examples:

- Expansion in railway tracks.
- Expansion in bridges.

Types:

There are two types of thermal expansions.

1. Linear thermal expansions.
2. Volumetric Or cubical thermal expansions.

1. **Linear Thermal Expansions.**

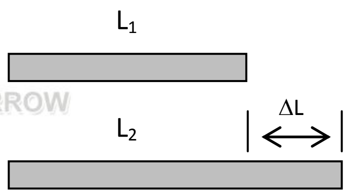
The expansion in the length of a solid object on heating is called linear Thermal expansion.

Derivation:

Consider a metallic rod having initial length "L_1" and temperature "T_1" after heating its final length becomes "L_2" and temperature "T_2".
It is practically observed that change in length is directly proportional to initial length and rise in temperature.

$\Delta L \propto L_1 \longrightarrow$ (i)

$\Delta L \propto \Delta T \longrightarrow$ (ii)



Comparing equation (i) and (ii)

$\Delta L \propto L_1 \Delta T$

$\Delta L = Constant\ L_1 \Delta T$

$\Delta L = \alpha\ L_1 \Delta T \therefore where$ as $\alpha = coefficient\ of\ linear\ expansion$

$\therefore \Delta L = L_2 - L_1$

$L_2 - L_1 = \alpha\ L_1 \Delta T$

$L_2 = L_1 + \alpha\ L_1 \Delta T$

$L_2 = L_1\ (1 + \alpha \Delta T)$

2. **Volumetric Thermal Expansions.**

The expansion in volume of a solid object on heating is called volumetric Thermal expansion.

Derivation:

Consider a metallic rod having initial length "L_1" and temperature "T_1" after heating its final length becomes "L_2" and temperature "T_2".

It is practically observed that change in length is directly proportional to initial length and rise in temperature.

$$\Delta V \propto V_1 \longrightarrow \text{(i)}$$

$$\Delta V \propto \Delta T \longrightarrow \text{(ii)}$$

Comparing equation (i) and (ii)

$$\Delta V \propto V_1 \Delta T$$

$$\Delta V = Constant\ V_1 \Delta T$$

$$\Delta V = \beta\ V_1 \Delta T \qquad \therefore where \text{ as } \beta = coefficient\ of\ volumetric\ expansion$$

$$\therefore \Delta V = V_2 - V_1$$

$$V_2 - V_1 = \beta\ V_1 \Delta T$$

$$V_2 = V_1 + \beta\ V_1 \Delta T$$

$$V_2 = V_1\ (1 + \beta \Delta T)$$

Co-efficient Of Linear Thermal Expansion:

"The change in length per unit length per Kelvin rise in temperature of a body is called Co-efficient of linear expansion."

$$\alpha = \frac{\Delta L}{L_1 \Delta T}$$

Co-Efficient Of Cubical Thermal Expansion:

"The change in volume per unit volume per Kelvin rise in temperature of a body is called Co-efficient of cubical expansion."

$$\beta = \frac{\Delta V}{V_1 \Delta T}$$

Prove that $\beta = 3\alpha$.

Consider a cubic having initial length "L_1" and breath "b_1" and height "h_1" after heating length, breath and height becomes "L_2" "b_2" and "h_2" and its volume becomes

$$V_2 = L_2 h_2 b_2 \longrightarrow \text{(i)}$$

Since,

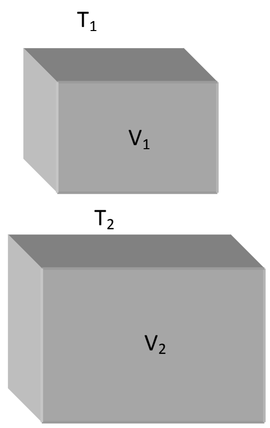
$$L_2 = L_1\ (1 + \alpha \Delta T)$$

Similarly,

$$h_2 = h_1\ (1 + \alpha \Delta T)$$

$$b_2 = b_1\ (1 + \alpha \Delta T)$$

Putting value of L_2, h_2, and b_2 in equation (i)



$$V_2 = L_1\ (1 + \alpha \Delta T) \times h_1\ (1 + \alpha \Delta T) \times b_1\ (1 + \alpha \Delta T)$$

$$V_2 = L_1\ h_1\ b_1\ (1 + \alpha \Delta T)^3$$

$$V_2 = V_1\ (1 + \alpha \Delta T)^3 \qquad \therefore V_1 = L_1\ h_1\ b_1$$

$$\therefore (a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

$$V_2 = V_1\ [(1)^3 + 3\,(1)^2\,(\alpha\Delta T) + 3\,(1)\,(\alpha\Delta T)^2 + (\alpha\Delta T)^3]$$

$$V_2 = V_1\ [1 + 3\alpha\Delta T + 3\alpha^2\Delta T^2 + \alpha^3\Delta T^3]$$

Neglecting α^2 and α^3

$$V_2 = V_1\ (1 + 3\alpha\Delta T)$$

$$V_2 = V_1 + 3\alpha V_1\Delta T$$

$$V_2 - V_1 = 3\alpha V_1\Delta T$$

$$\Delta V = 3\alpha V_1\Delta T$$

$$\frac{\Delta V}{V_1\Delta T} = 3\alpha$$

$$\beta = 3\alpha \qquad \therefore \beta = \frac{\Delta V}{V_1\Delta T}$$

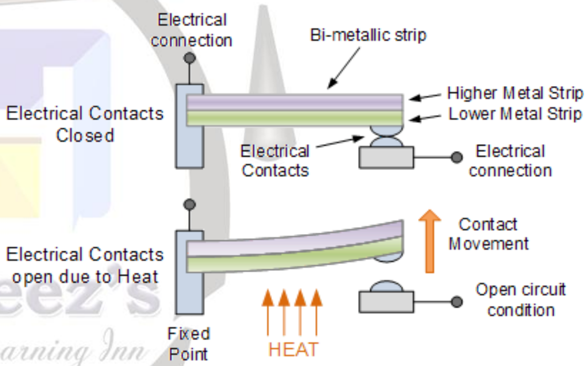
Proved

Application of Thermal Expansion:

1. **Bimetal Thermostat:**
   It is used to control temperature of ovens, refrigerator, air conditioners and so on.

   Construction.
   It consists of two metals with different coefficient of expansion in the form of a long spiral.

   Working:
   When temperature raises, metal with large value of Coefficient of linear expansion causing the strip to Bend, in this way, it cuts off the current supply. Circuit is restored again when it cools down.



2. **Rivets:**
   Rivets are used in shipbuilding and other industries to join metal plates.

3. **Car radiator Coolant:**
   Engine coolant is used in car radiator in place of pure water because water has greater volume expansion. It can expand enough to damage the engine.

Apparent Expansion of Water:

The expansion of liquid apparently observed without considering the expansion of the container is called the apparent expansion of the liquid.

Real Expansion Of Water:

Real expansion of water is the sum of apparent expansion of water and volume expansion of flask.

PROBLEMS

EXAMPLES:

1. The temperature of Hyderabad on a hot body is 45degree Celsius($45℃$). What will be its equivalent temperature on Fahrenheit Scale?
2. The thermal energy required to raise the temperature of 50 gm of water from $40℃$ to $70℃$ is 6300 Joules. Calculate the specific heat capacity of water.
3. A copper rod 15m long is heated, so that its temperature changes from $30℃$ to $85℃$. Find the change in the length of the rod. The coefficient of linear expansion of copper is $17x10^{-6}\ ℃^{-1}$.

PROBLEMS:

1. Convert $30℃$ into Kelvin and Fahrenheit Scale.
2. Convert $212°F$ into Celsius and Kelvin.
3. How much heat is required to boil 3 Kg water which is initially $10℃$?
4. 20 Kg of copper requires 2050 Joules of heat to raise its temperature through$10℃$. Calculate the heat capacity the sample.
5. An iron block of volume $3m^3$ is heated, so that its temperature changes from $25℃$ to$100℃$. If the coefficient of linear expansion of iron is $11x10^{-6}\ ℃^{-1}$. what will be the new volume of the iron block after heating?

Multiple Choice Questions

1. Heat is the form of:
   (a) Pressure (b) Weight
   (c) Energy (d) All
2. Heat capacity is the product of mass and:
   (a) Boiling point (b) freezing point
   (c) Energy (d) Specific heat of material
3. The amount of heat needed to convert a substance form liquid to gas is called:
   (a) Heat of Vaporization (b) Specific heat
   (d) latent heat of fusion (d) All
4. Thermal energy transfer required per unit mass to increase the temperature by 1Cor1 K is called:
   (a) Latent heat of Vaporization (b) Specific heat capacity
   (c) Latent heat of fusion (d) Thermal capacity
5. A fixed temperature at which at pure liquid boils is called:
   (a) Melting point (b) freezing point
   (c) boiling point (d) Both (a) and (b)
6. The melting point of ice at normal atmospheric pressure is:
   (a) 0^0C (b) 0K
   (c) 100^0C (d) Both (a) and (b)
7. Thermal energy transfer required to change a solid into liquid without changing its temperature is called:
   (a) Latent heat of Fusion (b) Latent heat of vaporization
   (c) Latent heat of boiling (d) Specific heat capacity
8. Thermal energy transfer required to change a liquid into gas without changing its temperature is called:
   (a) Latent heat of freezing (b) Latent heat of vaporization
   (c) Latent heat of boiling (d) Latent heat of melting
9. Evaporation can occur at:
   (a) Freezing point (b) Melting point
   (c) Boiling point (d) all temperatures
10. Rate of evaporation of a liquid can be increased by:
   (a) Increasing humidity (b) Decreasing temperature
   (c) Increasing its boiling point (d) Decreasing atmospheric pressure
11. Linear thermal expansion of a solid depends upon:
   (a) Increase in temperature (b) Original length
   (c) Properties of material (d) All of these