PHYSICS – I

(Full Book Short Questions)

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Chapter # 1 (Measurements)
Important Short Questions

1. What are the main frontiers of the fundamental sciences?

Ans: There are three main frontiers of fundamental science.

- The world of extremely large. i.e. universe, stars etc
- The world of the extremely small (i.e. particles such as electrons, protons and neutrons)
- The world of middle sized things (from molecule to Earth). It is the world of complex matter.

2. What are the steps involving in measuring of base quantities?

Ans: The measurement of base quantities involves two steps: -

- The choice of standard.
- The procedure for comparing the quantity to be measured with the standard.

Properties of an Ideal Standard:

An ideal standard has two principle characteristics:

- It is easily accessible
- It is invariable

3. Differentiate between radian and steradian.

Ans:

Radian	Steradian
• It is plane angle (two dimensional angle) • It is the plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius of the circle. • **Diagram from book**	• It is solid angle (three dimensional angle) • It is the solid angle subtended at the center of sphere by an area of surface equal to square the radius of the sphere. • **Diagram from book**

4. Define scientific notation. Give one example.

Ans: Scientific Notation:

"Numbers are expressed in standard form is called scientific Notation, which employ power of ten. In scientific notation a number is expressed as some power of ten multiplied by a number of between 1 and 10."

Example:

A number 62750 can be expressed as $\mathbf{6.275 \times 10^4}$ and a number **0.000572** can be written as $\mathbf{5.72 \times 10^{-4}}$.

5. Differentiate between random and systematic error.

Ans: Random error:

"Random error is said to be occur when repeated measurements of the quantity, gives **different values** under the same condition."

Cause:

It is due to **unknown** reason.

Reduction of random error:

The random error can be reduced by taking several readings of same quantity and then take their mean or average.

Systematic error:

Systematic error is said to be occur when all the measurements of a particular quantity are affected equally, these gives **consistent difference** in readings.

Cause:

The systematic error occurs due to following reasons: -

- Zero error in measuring instruments.
- Poor calibration of instrument.
- Incorrect calibration on the measuring instrument.

Reduction of systematic error:

- Systematic error can be reduced by **replacing the instrument**.
- Systematic error can be reduced by applying the **correction factor**.

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6. Define significant figures. Write two rules with examples.

Ans: Significant Figures: -

"In any measurement, the accurately known digits and first doubtful digit are called significant figures."
We can increase the number of significant figures in a measurement by improving the **quality** of our instrument.

Rules for finding the significant figures: -

(i) All non-zero digits are significant.

- In 12.70 cm, there are four significant figures.
- In 8.70×10^4 kg has three significant figures.

(ii) Zeros between two significant digits are also significant.

- In 202 cm, there are three significant figures.
- In 2005 years, there are four significant figures.

(iii) Zeros on left side are not significant, they are just place holders.

- In 0.003 cm, there are one significant figures.
- In 0.00056 g, there are two significant figures.

(iv) Zero on right sides after decimal are also significant.

- In 2.00 cm, there are three significant figures.
- In 5.0 kg, there are two significant figures.

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7. How can you assess the total uncertainty in the final result in case of addition or subtraction?

Ans: In Case of Addition or Subtraction:

"Absolute uncertainties are added"

For Example:

The distance 'X' found by the difference between two separate position measurements.

$X_1 = 10.5 \pm 0.1$ cm

$X_2 = 26.8 \pm 0.1$ cm

$\mathbf{X = X_2 - X_1}$

$X = (26.8 \pm 0.1) - (10.5 \pm 0.1)$

$\mathbf{X = 16.3 \pm 0.2}$ **cm**

8. How can you assess the total uncertainty in the final result in case of multiplication or division?

Ans: In Case of Multiplication or Division:

"Percentage uncertainties are added"

For Example:

$V = 5.2 \pm 0.1\ V$
$I = 0.8 \pm 0.05\ A$
$R = ?$

$$\%\text{ age Uncertainity for } V = \frac{0.1}{5.2} \times 100 = 1.9\ \% = \text{About } 2\%$$

$$\%\text{ age Uncertainity for } I = \frac{0.05}{0.84} \times 100 = 0.59\ \% = \text{About } 6\%$$

Total % age uncertainty in R = 2 + 6 % = 8 %

$$R = \frac{V}{I} = \frac{5.2}{0.84} = 6.19 \text{ ohms with } 8\ \% \text{ uncertainty}$$

$\mathbf{R = 6.2 \pm 0.5\ \Omega}$

9. How can you assess the total uncertainty in the final result in case of power factor?

Ans: In Case of Power Factor:

"Multiply the percentage uncertainties with power"

For Example:

$r = 2.25 \pm 0.01\ cm$
Volume of sphere = V = ?

$$\%\text{ age Uncertainity for } r = \frac{0.01}{2.25} \times 100 = 0.4\ \%$$

Total % age uncertainty in V = 3 × 0.4 % = 1.2 %

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(2.25)^2 = 47.689\ cm^3 \text{ with } 1.2\ \% \text{ uncertainty}$$

$\mathbf{V = 47.7 \pm 0.6\ cm^3}$

10. How can you assess the total uncertainty in the final result in case of average of many measurement?

Ans: In Case of Average of many measurement:

- Find the average value of measured values.
- Find deviation of each measured value from the average value.
- The mean deviation is the uncertainty in the average value.

For Example:

The six reading of micrometre screw gauge to measure the diameter of wire in mm are; 1.20, 1.22, 1.23, 1.19, 1.22, 1.21

$$\text{Average} = \frac{1.20 + 1.22 + 1.23 + 1.19 + 1.22 + 1.21}{6} = 1.21\ mm$$

The deviation of readings, which are the differences between each reading and average values are; 0.01, 0.01, 0.02, 0.02, 0.01, 0

$$\text{Mean of deviation} = \frac{0.01 + 0.01 + 0.02 + 0.02 + 0.01 + 0}{6} = 0.01\ mm$$

Average value = 1.21 ± 0.01 mm

11. How can you assess the total uncertainty in the final result in case of timing experiment?

Ans: In Case of timing experiment:

"The uncertainty in the time period is found by dividing the least count with the number of observations**"**

For Example:

Time for 30 vibrations = 54.6 sec

Least Count of the stop watch = 0.01 s

Time Period = ?

$$T = \frac{54.6}{30} = 1.82 \text{ sec}$$

$$\text{Uncertainty} = \frac{0.01}{30} = 0.003 \text{ sec}$$

T = 1.82 ± 0.003 sec

12. What is the difference between precision and accuracy?

Ans:

Precision	Accuracy
• The precision means how measure values are close to each other. • Precision is defined in terms of random error. • The precision of a measurement depends upon absolute uncertainty.	• Accuracy means how close a measure value (result) is to the actual value. • Accuracy is defined in terms of systematic error. • Accuracy depends upon the fractional or percentage uncertainty in that measurement.

13. Define dimensional analysis. Write its uses.

Ans: Dimensional Analysis:

"Each basic physical quantity represented by a specific symbol with in the square brackets."

- The dimensions of physical quantities represent nature of that physical quantities.
- The dimension of length, mass and time is [L], [M] and [T].

Uses of Dimensional Analysis:

There are following two uses of dimensional analysis:

- Checking the homogeneity of the physical equation.
- Deriving the possible formula.

14. What are the dimension of force and work?

Ans: Dimension of Force:

Force = mass × acceleration

$[F] = [m][a]$

$[F] = [M][LT^{-2}]$

$\mathbf{[F] = [MLT^{-2}]}$

Dimension of Work:

Work = force × displacement

$[w] = [F][d]$
$[w] = [MLT^{-2}][L]$
$\mathbf{[w] = [ML^2T^{-2}]}$

15. Describe the principle of homogeneity of dimensional analysis.

Ans: Principle of homogeneity:

In order to check the correctness of an equation, we are to show that dimension of the quantities on both sides if the equation is the same, irrespective of the form of the formulas. This is called the principle of homogeneity of dimensions.

16. Check the correctness of the relation $v = \sqrt{\frac{F \times l}{m}}$, where v is the speed of transverse wave on stretched string of tension F, length l and mass in m

Ans:

Equation $v = \sqrt{\frac{F \times l}{m}}$

Dimension of L.H.S = $[v] = [LT^{-1}]$ ------------------ (i)

Dimension of L.H.S = $[v] = \sqrt{\frac{F \times l}{m}}$

Dimension of R.H.S = $\sqrt{\frac{[MLT^{-2}][L]}{[M]}} = \left(\frac{[MLT^{-2}][L]}{[M]}\right)^{\frac{1}{2}} = [L^2T^{-2}]^{\frac{1}{2}}$

Dimension of R.H.S = $[LT^{-1}]$ ------------------ (ii)

From equation (i) and (ii),

L.H.S = R.H.S

17. Find the dimension and hence, the SI units of coefficient of viscosity η in the relation of Stoke's law for the drag force F for the spherical object of radius r moving with velocity v given as F = 6 πηrv.

Given:

F = 6πηrv
Where F = drag force
r = radius
η = co-efficient of viscosity

To find:

(i) Dimension of co-efficient of viscosity = η = ?
(ii) SI unit of co-efficient of viscosity = η = ?

Calculations:

(i) F = 6πηrv

6π is a number having no dimension, so it is not taken in dimensional analysis.

$$[F] = [\eta rv]$$

$$[\eta] = \frac{[F]}{[r][v]} = \frac{[MLT^{-2}]}{[L][LT^{-1}]}$$

$$[\eta] = [ML^{-1}T^{-1}]$$

(ii) This SI unit of co-efficient of viscosity is $kgm^{-1}s^{-1}$ or Nsm^{-2}

Exercise Short Questions

1. Name several repetitive phenomena occurring in nature which could serve as responsible time standards.

Ans: The phenomenon that repeats itself after certain intervals of time is called **repetitive phenomenon.** Which can be serve as time standard.

Examples:

- Lattice vibrations in a crystal.
- The rotation of moon around earth.
- The rotation of earth around sun.
- The rotation of earth its own axis.
- Changes of weathers.

2. Give the draw backs to use the period of pendulum as a time standard?

Ans: As the time period of the simple pendulum can be expressed as:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

But this time period cannot serve as time standard due to several reasons.

Reason:

Time period of pendulum varies with length and length varies with temperature due to **thermal expansion.**

Time period of the simple pendulum varies with g and g varies with altitude.

Frictional Force of air may affect the time period of the pendulum.

3. Why do we find it useful to have two units for amount of substance, the kilogram and mole?

Ans: Mole:

When we concerned **number of particles** then we use mole as the unit of amount of substance because one mole of the substance contains equal number of particles i.e. $(N_A = 6.022 \times 10^{23})$.

Kilogram:

But when we are not concerned with particles (Atoms or molecules) then the amount of substance is measured in kilogram.

4. Three students measured the length of a needle with a scale on which minimum division is 1 mm and recorded as (a) 0.2145m (b) 0.21m (c) 0.214 m. Which record is correct?

Ans: 0.214 is correct record.

Reason:

It is because **the least count of the scale is 1mm or 0.001m.** So, length can be measure accurately up to three decimals. Hence 0.214 is correct record.

5. An old saying is "A chain is only as strong as its weakest link. "What analogous statement that can you make regarding experimental data used in computation?

Ans: Its analogous statement is

"A result of experimental data is only as much as accurate as its least count reading in the experiment.**"**

6. The period of a simple pendulum is measured by a stop watch. What types of error are possible?

Ans: Possible Errors:

There are types of the error are possible errors:

(i) Systematic Error:

Stop watch may be faulty:

- Zero error may occur.
- Poor calibration on the stop watch. Or incorrect calibration.

(ii) Random Error:

Random error occurs due to:

- Negligence and inexperience of the person at the time to start or stop the stopwatch.

7. Does dimensional analysis give any information about a constant of proportionality that may appear in an algebraic expression?

Ans: Dimensional analysis does not give any information about the value of constant proportionality; it can be determined by experiment.

Example:

For Time period of the simple pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Where dimensional analysis does not give may information about the constant 2π .

But dimension analysis provides the information about the dimensions of constants like "g" (Gravitational acceleration). G (Universal gravitational constant), K (spring constant). Because they have units.

8. Write the dimension of (a) Pressure (b) density

Ans: Dimension of pressure:

$$\text{Pressure}=p=\frac{F}{A}=\frac{ma}{A}=\frac{[M][LT^{-2}]}{[L^2]}=[ML^{-1}T^{-2}]$$

Dimension of Density:

$$\text{Density} = \rho = \frac{m}{V} = \frac{[M]}{[L^3]} = [ML^{-3}]$$

9- The wavelength depends upon speed "v" of wave and its frequency "f", knowing that $[\lambda]=[L]$ and $[v]=[LT^{-1}]$ and $[f]=[T^{-1}]$. Decide which one id correct.

(a) $f=v\lambda$ **(b) $f=\frac{v}{\lambda}$**

(a) For $f=v\lambda$

$[T^{-1}] = [LT^{-1}][T^{-1}]$

$[T^{-1}] = [LT^{-2}]$

Which is not correct.

(b) For $f=\frac{v}{\lambda}$

$[T^{-1}] = \frac{[LT^{-1}]}{[L]}$

$[T^{-1}] = [T^{-1}]$

Which is correct

Numerical Problems

1. A light year is the distance light travels in one year. How many meters are there?

Given:

Time = t = 1 year

t = 365 days

t = 365 × 24 hours

t = 365 × 24 × 60 min

t = 365 × 24 × 60 × 60 sec

t = 31536000 sec

t = 3.1536×10^7 sec

Speed of light = v = c = $3.0 \times 10^8\ ms^{-1}$

To find:

Distance = S = ?

Calculations:

S = vt = ct

$S = 3.0 \times 10^8 \times 3.1536 \times 10^7$

$S = 9.5 \times 10^{15}$ m

2. (a) How many seconds are there in 1 year?
(b) How many nano seconds in 1 year?
(c) How many year in 1 second?

Given:

1 year = 365 days

To find:

(a) Seconds in 1 year = ?

(b) Nano seconds in 1 year = ?

(c) Years in 1 seconds = ?

Calculation:

(a) As 1 year = 365 days

1 year = 365 × 24 hours

1 year = 365 × 24 × 60 min

1 year = 365 × 24 × 60 × 60 sec

1 year = 31536000 sec

1 year = 3.1536 × 10^7 sec

(b) As 1 year = 3.1536 × 10^7 sec

1 year = 3.1536 × 10^7 × 10^9 × 10^{-9} sec

1 year = 3.1536 × 10^{16} ns

(c) 1 year = 3.1536 × 10^7 sec

$$1 \text{ sec} = \frac{1}{3.1536 \times 10^7}$$

1 sec = 3.17 × 10^{-8} years

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4. What are the dimensions and units of gravitational constant G in the formula $F = G\frac{m_1m_2}{r^2}$

Given:

$$\text{Gravitational force} = F = G\frac{m_1m_2}{r^2}$$

To find:

(i) Dimension of G = ?

(ii) SI unit of G = ?

Calculations:

(i) $$F = G\frac{m_1m_2}{r^2}$$

$$G = \frac{Fr^2}{m_1m_2}$$

$$[G] = \frac{[MLT^{-2}][L^2]}{[M][M]} = \frac{[ML^2T^{-2}]}{[M^2]}$$

$[G] = [M^{-1}L^2T^{-2}]$

(ii) This SI unit of Gravitational Constant G is Nm^2kg^{-2}

5. Show that the expression $V_f = V_i + at$ is dimensionally correct, where V_i is the velocity at t = 0, a is the acceleration and V_f is the velocity at time t.

Ans:

Equation $V_f = V_i + at$

Dimension of L.H.S = $[V_f] = [LT^{-1}]$ -------- (i)

Dimension of R.H.S = $[V_i] + [at]$

$= [LT^{-1}] + [LT^{-2}][L]$

$= [LT^{-1}] + [LT^{-1}]$

$= 2[LT^{-1}]$

As 2 has no dimension because it is a constant.

Dimension of R.H.S = $[LT^{-1}]$ ---------------- (ii)

From equation (i) and (ii),

L.H.S = R.H.S

6. Show that the famous formula "Einstein equation" $E = mc^2$ is dimensionally correct.

Ans:

Einstein Equation $E = mc^2$

Dimension of L.H.S = $[E] = [W] = [F.d] = [MLT^{-2}][L]$

Dimension of L.H.S = $[ML^2T^{-2}]$ ------------------ (i)

Dimension of R.H.S = $[mc^2] = [M][LT^{-1}]^2$

Dimension of R.H.S = $[ML^2T^{-2}]$ ----------------- (ii)

From equation (i) and (ii),

L.H.S = R.H.S

Important Dimensions

Physical Quantities	Symbol or Formula	Unit	Dimension
Mass	m	kilogram	$[ML^oT^o] = [M]$
Length	l	meter	$[M^oLT^o] = [L]$
Time	t	second	$[M^oL^oT] = [T]$
Velocity or Speed	v	ms^{-1}	$[M^oLT^{-1}] = [LT^{-1}]$
Acceleration	a	ms^{-2}	$[M^oLT^{-2}] = [LT^{-2}]$
Area	A	m^2	$[M^oL^2T^o] = [L^2]$
Volume	V	m^3	$[M^oL^3T^o] = [L^3]$
Density	$\rho = m/v$	Kg/m^3	$[ML^3T^o] = [ML^3]$
Force	$F = ma$	$N = kgms^{-2}$	$[MLT^{-2}]$
Pressure	$P = F/A$	$Pa = Nm^{-2}$	$[ML^{-1}T^{-2}]$
Momentum or Impulse	$P = mv$, $I = \Delta P$	$Ns = kgms^{-1}$	$[MLT^{-1}]$
Torque, Work and Energy	$\tau = l \times F$ $W = Fd$	$J = Nm =$ Kgm^2s^{-2}	$[ML^2T^{-2}]$
Power	$P = w/t$	$W = J/s$	$[ML^2T^{-3}]$
Angular displacement	θ	Radian	None
Angular Velocity	$\omega = \Delta\theta/\Delta t$	Rad/s	$[T^{-1}]$
Angular Acceleration	$\alpha = \Delta\omega/\Delta t$	Rad/s^2	$[T^{-2}]$
Angular Momentum	$L = mvr$	$Js = Kgm^2s^{-2}$	$[ML^2T^{-1}]$
Moment of Inertia	$I = mr^2$	Kgm^2	$[ML^2]$
Gravitational Constant	$G = \frac{Fr^2}{m_1m_2}$	Nm^2/kg^2	$[M^{-2}L^3T^{-2}]$
Acceleration due to gravity	$g = w/m$	ms^{-2}	$[LT^{-2}]$
Time period	T	sec	[T]
Frequency or angular frequency	$f = 1/f$ $\omega = 2\pi f$	Hz = cycle/sec	$[T^{-1}]$
Coefficient of viscosity	$\eta = \frac{F}{6\pi rv}$	$Ns/m^2 =$ $kgm^{-1}s^{-1}$	$[ML^{-1}T^{-1}]$
Wavelength	$\lambda = \frac{v}{f}$	m	[L]
Stress	$\sigma = \frac{F}{A}$	$Pa = Nm^{-2}$	$[ML^{-1}T^{-2}]$
Strain	$\varepsilon = \frac{\Delta V}{V} = \frac{\Delta l}{l}$	none	none
Elastic Modulus	$E = \frac{\sigma}{\varepsilon}$	$Pa = Nm^{-2}$	$[ML^{-1}T^{-2}]$
Focal Length	F	m	[L]

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Chapter # 02 (Vectors and Equilibrium)
Important Short Questions

1. Differentiate between scalars and vectors.

Ans:

Scalars	Vectors
• The quantities which are describe completely by its magnitudes only are called scalar quantities. • For example, length, mass, time. Temperature etc	• The quantities which are describe completely by its magnitude as well as direction are called vector quantities. • For example, force, displacement. Torque etc.

2. How a vector is represented?

Ans: Vectors can be represented by two methods: -

- Numerical method
- Graphical method

1) Numerical method: -

We can represent vector quantities by using bold letters such ad **F, a, d** or a bar or arrow over their symbols such as $\overline{F}, \overline{a}, \overline{d}$ or $\vec{F}, \vec{a}$ and $\vec{d}$.

2) Graphical method: -

A vector can be represented graphically by line segment with an arrow head. The line AB with arrow head represents a vector **V**. The length of line AB gives the magnitude of the

3. What is rectangular coordinate system? Discuss its two types.

Ans: <u>Rectangular Coordinate system (Cartesian coordinate system):-</u>

"The set of two or three mutually perpendicular lines intersecting at a point is called rectangular coordinate system."

The lines are called coordinate axes. One of these is called x-axis (Horizontal axis), the other is called y-axis (Vertical axis). The axis that is perpendicular to x-axis and y-axis is called z-axis.

<u>(i) Two dimensional coordinate system (Plane):-</u>

"The system in which two mutually perpendicular lines intersect at a point is called two-dimensional coordinate system"

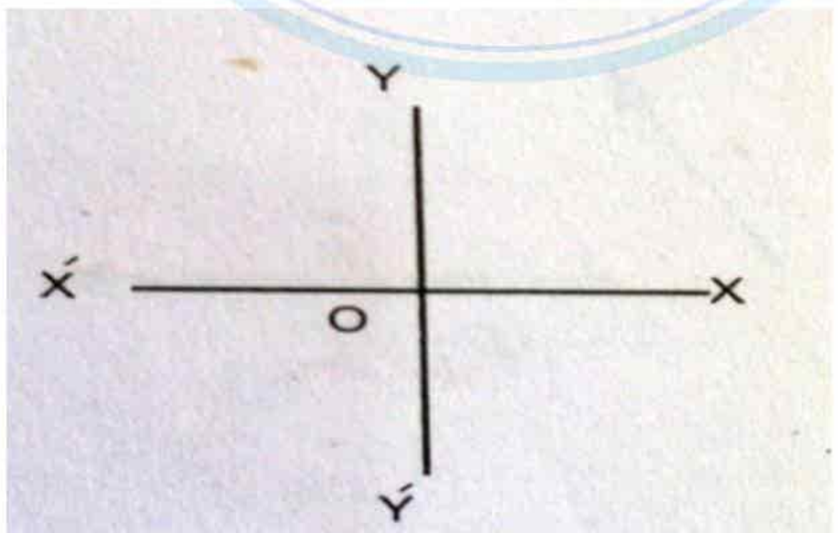


Fig. 2.1(a)

Direction of vector in xy- plane:

It is represented by the angle which the vector makes with positive x-axis in anti-clockwise direction.

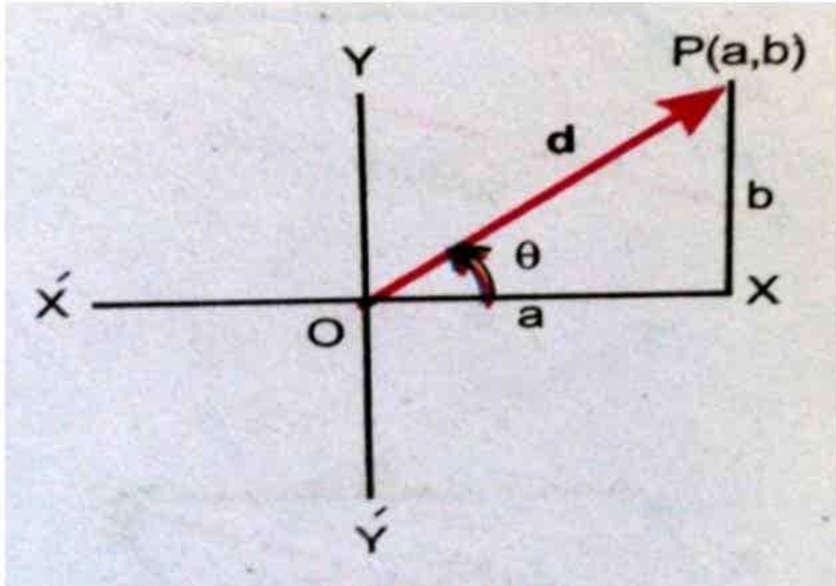


Fig. 2.1(b)

(i) Three dimensional coordinate system (Space):-

"The system in which three mutually perpendicular lines are intersecting at a point is called three-dimensional coordinate system"

Direction of vector in space:

It is represented by three angles which the vector makes with x, y and z-axis.

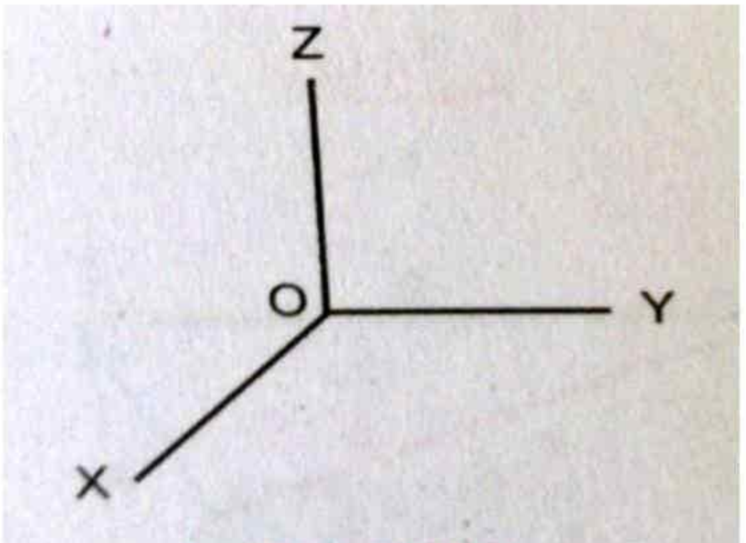


Fig. 2.2(a)

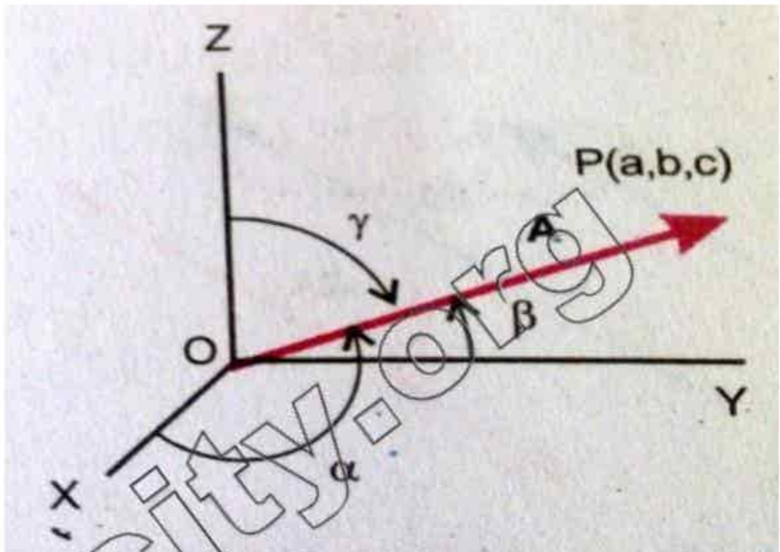


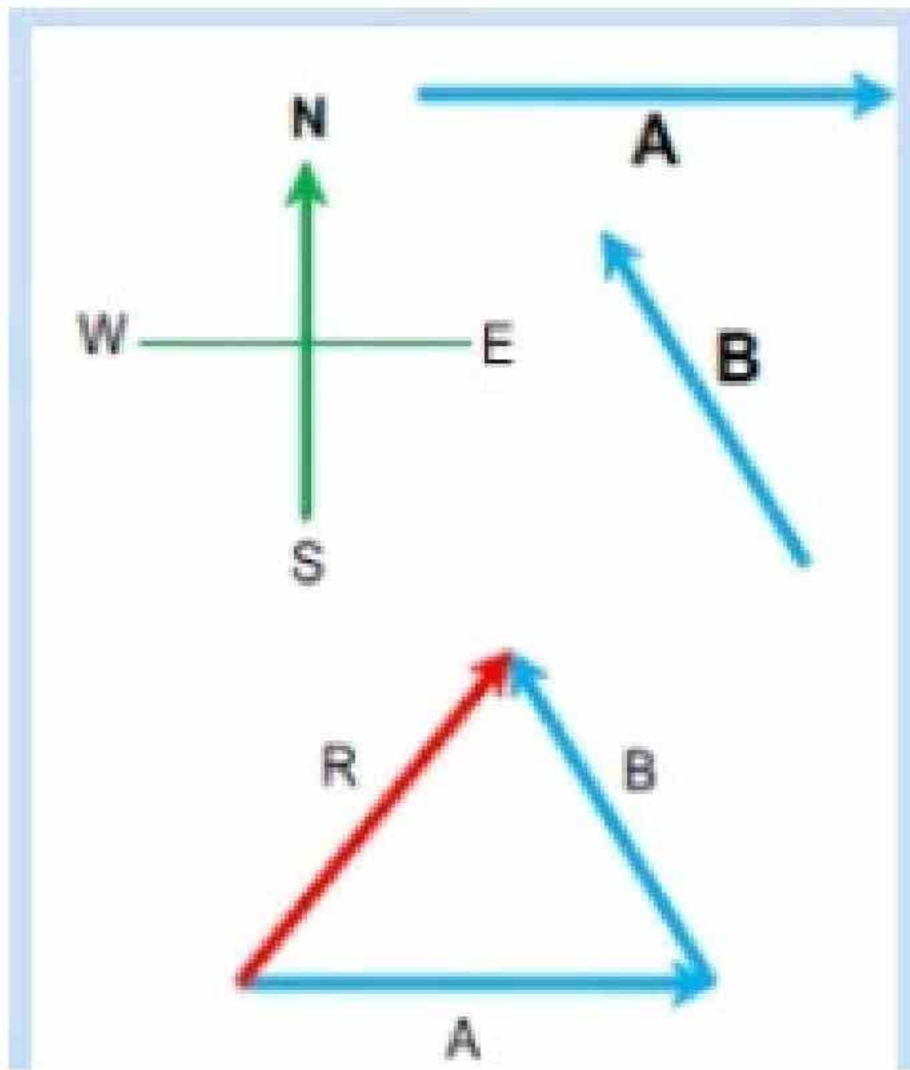
Fig. 2.2(b)

4. What is head to tail rule?

Ans: Ans: It is a graphical method used for the addition of the forces.

Explanation: -

- First draw all forces according to suitable scale such as **A** and **B**.
- Take one of the forces as a first vector. For example, vector **A**.
- Then draw the next vector **B** such as its tail coincides with the head of the first vector.
- Similarly draw the all-next forces (if any) with its tail coinciding with the head of the previous force and so on.
- Now draw a vector **R** such that its tail is at the tail of vector **A**, the first vector, while its head is at the head of vector **B**, the last vector.



5. How a vector is subtracted?

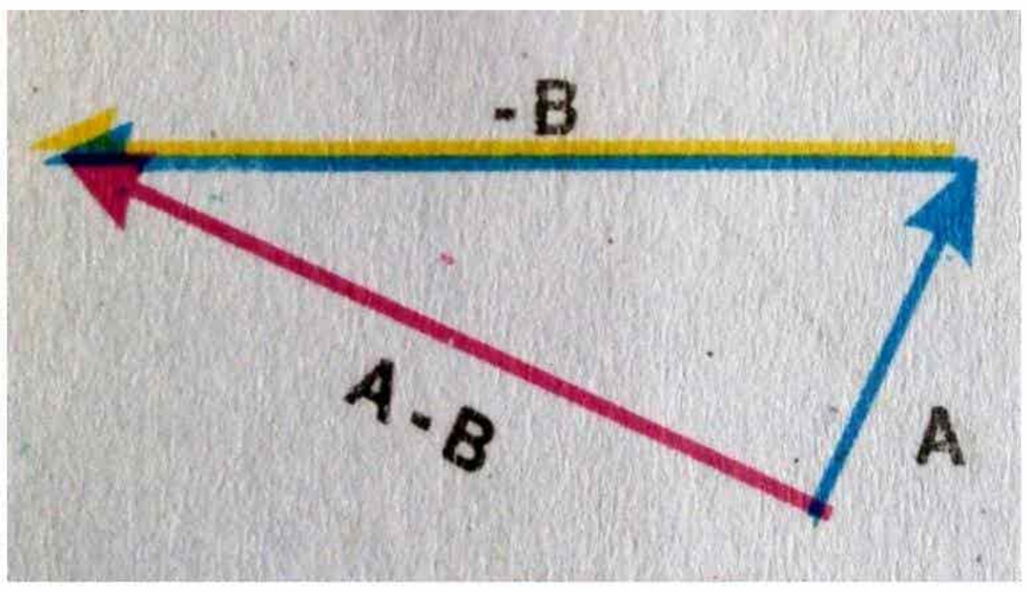
Ans: Vector Subtraction:

The subtraction of vector is equivalent to the addition of same vector with the direction reversed.

Explanation:

Consider two vectors $\vec{A}$ and $\vec{B}$. To subtract $\vec{B}$ from vector $\vec{A}$. First take the negative of vector $\vec{B}$. Add $(-\vec{B})$ into vector $\vec{A}$ graphically as shown in fig.

$$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$$



6. Discuss multiplication of a vector.

Ans: <u>Multiplication of a vector by a scalar:</u>

A vector can be multiplied by:

- A positive number.
- A negative number.
- A scalar with dimension.

(i) Multiplication with a positive number:

When a vector $\vec{A}$ is multiplied by a positive number n (n > 0) then the product vector will have magnitude equal to nA and same direction as that of $\vec{A}$.

(ii) Multiplication with a negative number:

When a vector $\vec{A}$ is multiplied by a negative number n (n < 0) then the product vector will have magnitude equal to nA and opposite direction as that of $\vec{A}$.

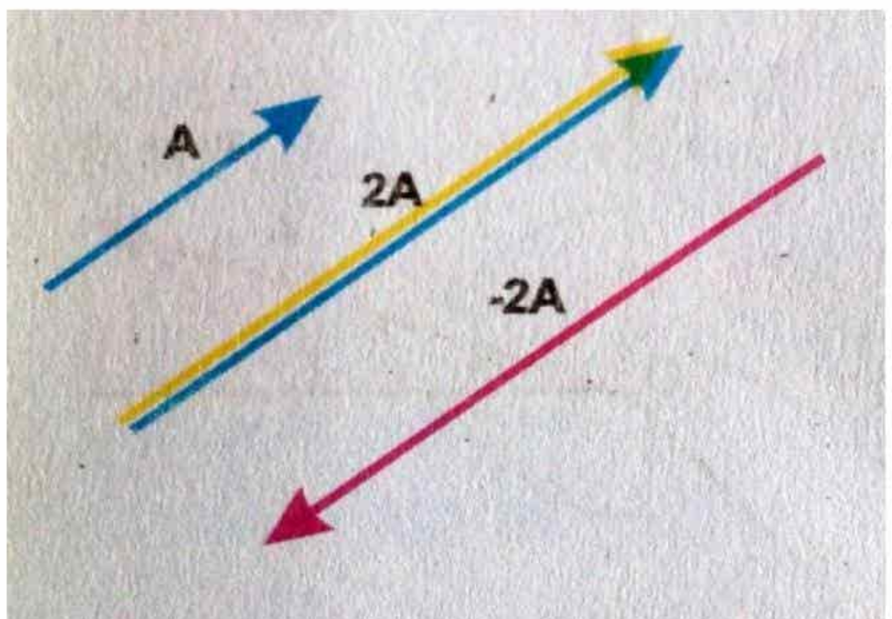


Fig. 2.4

(iii) Multiplication with a scalar quantity:

When a vector $\vec{A}$ is multiplied by a scalar quantity n. then the product vector will be a new physical quantity whose dimension equal to product of the dimension of n and $\vec{A}$.

Examples:

- Product of mass and velocity is momentum ($\vec{P} = m\vec{v}$)
- Product of mass and acceleration is force ($\vec{F} = m\vec{a}$)
- Product of force and time is impulse ($\vec{I} = \vec{F} \times t$)

7. Define resultant vector, unit vector, null vector and equal vector.

Ans: (i) <u>Resultant vector:</u>

"A vector which has the same effect as the combined effect of all the vectors to be added is called resultant vector."

<u>(ii) Unit vector:</u>

"A vector whose magnitude is equal to one with no unit in a given direction is called unit vector." It is represented by a letter with a cap or hat on it.

Mathematically Form:

If $\vec{A}$ is a vector with magnitude A, then $\vec{A} = A\hat{A}$

$$\hat{A} = \frac{\vec{A}}{A}$$

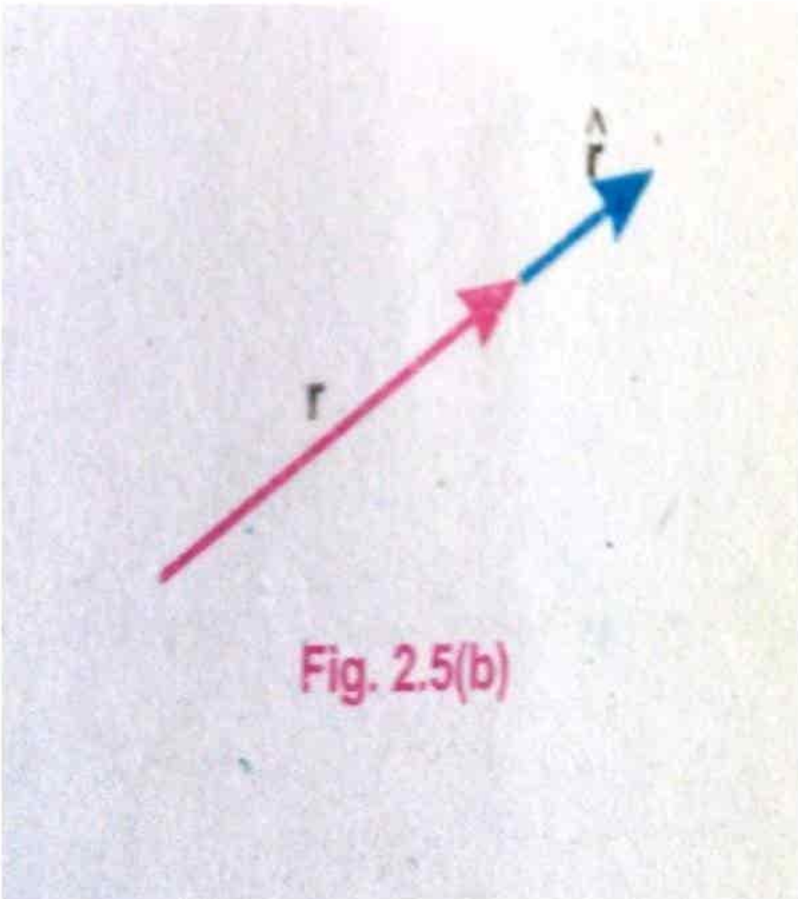


Fig. 2.5(b)

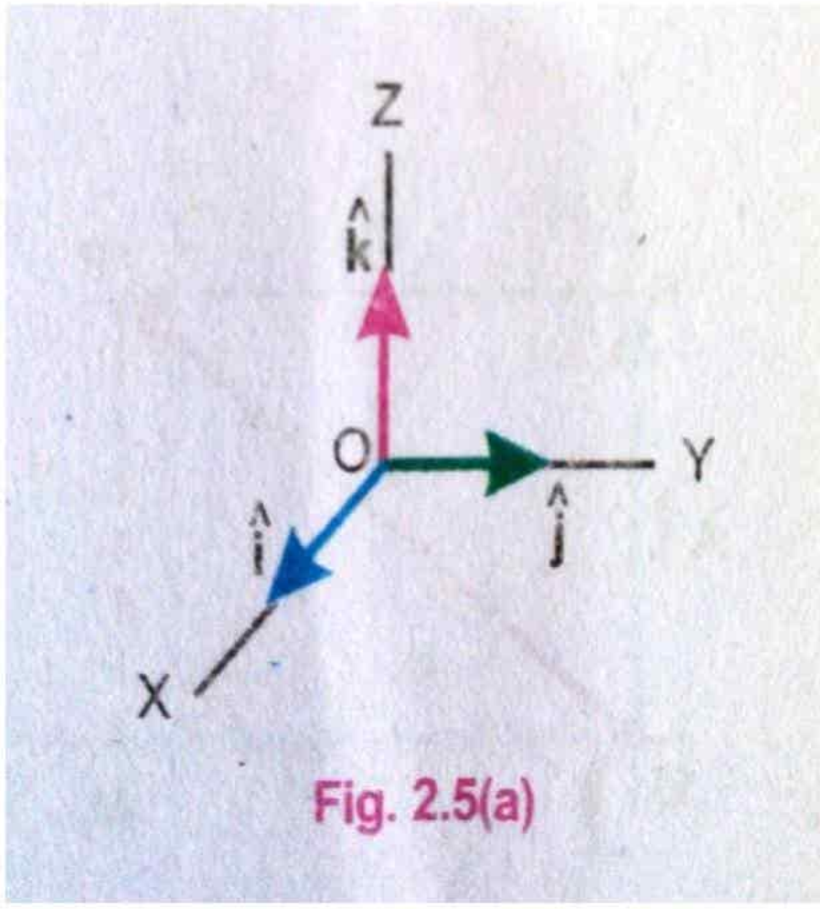


Fig. 2.5(a)

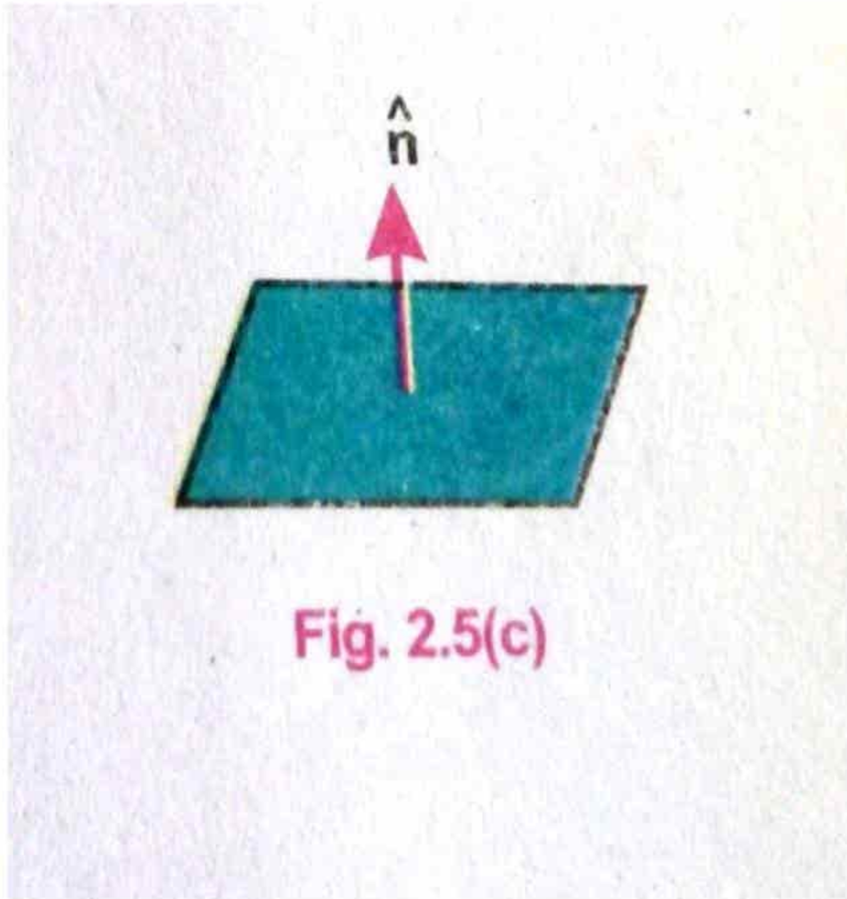


Fig. 2.5(c)

Examples:

- Direction along x, y and z-axis are represented by $\hat{i}$, $\hat{j}$ and $\hat{k}$ respectively.
- Unit vector $\hat{r}$ represent the direction of $\vec{r}$.
- Unit vector $\hat{n}$ represent the direction of normal drawn on a certain surface.

(iii) Null or zero vector:

"A vector whose magnitude is zero and direction arbitrary is called a null vector."

It is represented by $\vec{O}$.

Examples:

- The sum of $\vec{A}$ and its negative vector $(-\vec{A})$ is a null vector.

$$\vec{A} + (-\vec{A}) = \vec{O}$$

- Sum of vectors by head to tail along the sides of closed triangle is null vector.

(iv) Equal Vectors:

"The vectors are said to be equal to be equal vectors if they have same magnitude and same direction regardless of the position of their initial points."

8. Define rectangular components. Drive its formula.

Ans: Rectangular Component of a vector:

"The components that are perpendicular to each other are called rectangular components."

X-component of $\vec{A}$:-

In right angle triangle OPM,

$$\frac{OM}{OP} = \cos\theta$$

$$\frac{A_x}{A} = \cos\theta$$

$$\mathbf{A_x = A\cos\theta} \qquad ----(ii)$$

Y-component of $\vec{A}$:-

In right angle triangle OPM,

$$\frac{PM}{OP} = \sin\theta$$

$$\frac{A_y}{A} = \sin\theta$$

$$\mathbf{A_y = A\sin\theta} \qquad ----(iii)$$

9. Define position vector.

Ans: <u>Position Vector:</u>

"The vector which represent the position of a point or a particle with respect to fixed origin is called position vector."

It is represented by $\vec{r}$.

Explanation:

In two dimensional coordinated system (plane), the position of a point P(a,b) is represented by

$$\vec{r} = a\hat{i} + b\hat{j}$$

The magnitude of this position vector is

$$r = \sqrt{a^2+b^2}$$

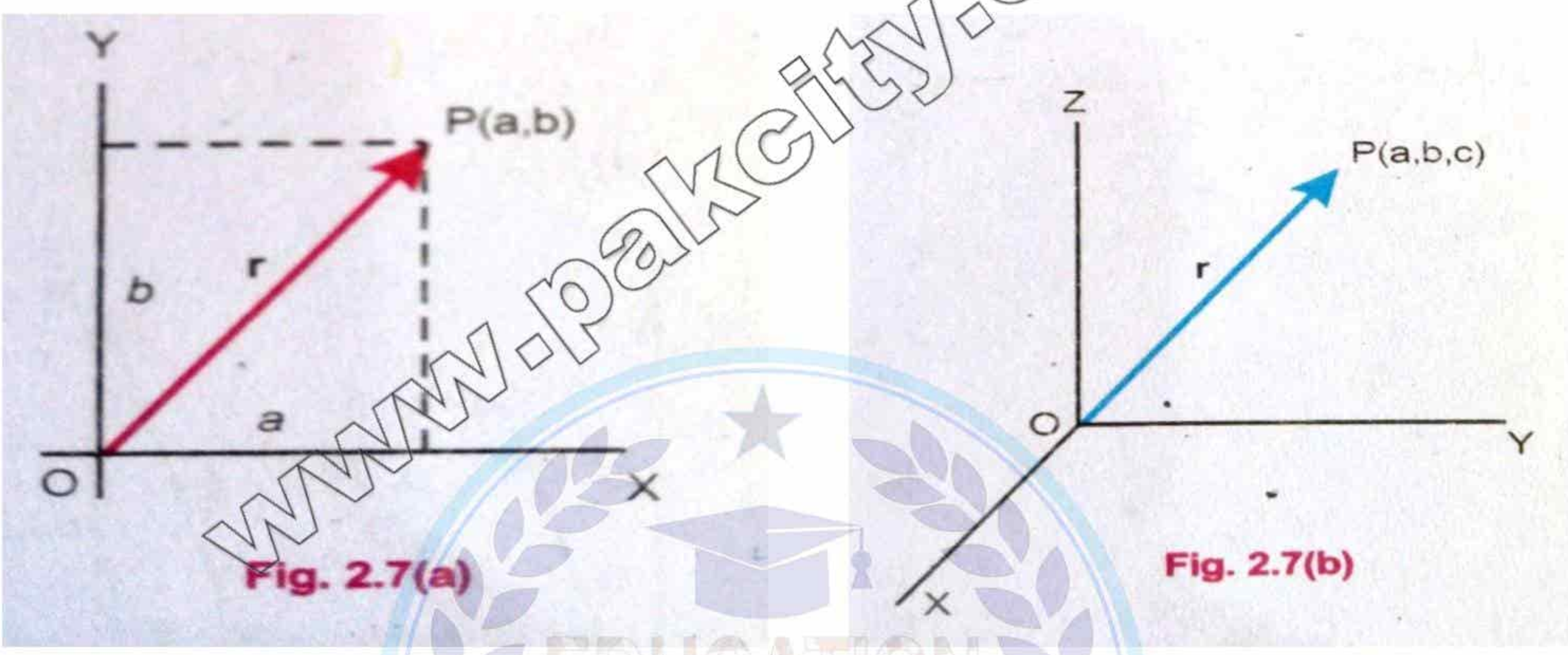


Fig. 2.7(a) Fig. 2.7(b)

In three dimension coordinated system (space) , the position of P(a,b,c) is represented by

$$\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$$

And its magnitude is

$$r = \sqrt{a^2+b^2+c^2}$$

10. Define dot product. Give its two examples.

Ans: <u>Scalar product or Dot product:</u>

"If the product of two vectors is a scalar quantity, then the product is called scalar product."

Scalar product of two vectors $\vec{A}$ and $\vec{B}$ is defined as

$$\vec{A}.\vec{B} = AB\cos\theta$$

Where A and B are the magnitudes of vectors $\vec{A}$ and $\vec{B}$ and θ is the angle between them.

<u>Examples:</u>

(i) **Work** is a scalar product of force and displacement.

$$w = \vec{F}.\vec{d}$$

(ii) **Power** is the scalar product of force and velocity.

$$P = \vec{F}.\vec{V}$$

11. Explain four characteristics of dot product.

Ans: Characteristics of dot product:

(i) Commutative property:

Scalar product of two vectors is commutative.

If $\vec{A}$ and $\vec{B}$ are two vectors and θ is the angle between them. Then,

$$\vec{A}.\vec{B} = AB\cos\theta \quad \text{------ (i)}$$

$$\vec{B}.\vec{A} = BA\cos\theta \quad \text{------ (ii)}$$

$$\vec{A}.\vec{B} = \vec{B}.\vec{A}$$

(ii) Perpendicular vectors:

If two vectors are mutually perpendicular to each other ($\theta = 90^o$). Their scalar product will be zero.

$$\vec{A}.\vec{B} = AB\cos 90^o$$

$$\vec{A}.\vec{B} = AB(0)$$

$$\vec{A}.\vec{B} = 0$$

In case of unit vectors,

$$\hat{i}.\hat{j} = (1)(1)\cos 90^o = (1)(1)(0) = 0$$

$$\hat{j}.\hat{k} = 0 \text{ and } \hat{k}.\hat{i} = 0$$

$$\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$$

(iii) Parallel and anti-parallel vectors:

- If two vectors are parallel ($\theta = 0^o$) to each other then, their scalar is equal to the product of their magnitudes.

$$\vec{A}.\vec{B} = AB\cos 0^o$$

$$\vec{A}.\vec{B} = AB(1)$$

$$\vec{A}.\vec{B} = AB$$

This is the positive maximum value of scalar product.

- If two vectors are anti-parallel ($\theta = 180^o$) to each other then, their scalar is equal to the negative of product of their magnitudes.

$$\vec{A}.\vec{B} = AB\cos 180^o$$

$$\vec{A}.\vec{B} = AB(-1)$$

$$\vec{A}.\vec{B} = -AB$$

(iv) Self-scalar product:

The self product of a vector is equal to the square of its magnitude.

$$\vec{A}.\vec{A} = AA\cos 0^o$$
$$\vec{A}.\vec{A} = A^2(1)$$
$$\vec{A}.\vec{A} = A^2$$

In case of unit vectors,

$$\hat{i}.\hat{i} = (1)(1)\cos 0^o = (1)(1)(1) = 1$$
$$\hat{j}.\hat{j} = 1 \text{ and } \hat{k}.\hat{k} = 1$$
$$\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$$

12. Define cross product. Give its two examples.

Ans: <u>Vector product or Dot product:</u>

"If the product of two vectors is a vector quantity, then the product is called vector product."

vector product of two vectors $\vec{A}$ and $\vec{B}$ is defined as

$$\vec{A}\times\vec{B}=AB\sin\theta\hat{n}$$

Where A and B are the magnitudes of vectors $\vec{A}$ and $\vec{B}$ and θ is the angle between them. And $\hat{n}$ is the unit vector perpendicular to plane containing $\vec{A}$ and $\vec{B}$.

Examples:

- Torque is the vector product of vector $\vec{r}$ and force $\vec{F}$ ($\boldsymbol{\tau} = \vec{\mathbf{r}}\times\vec{\mathbf{F}}$)

13. Explain right hand rule to find the direction of cross product.

Ans: Direction of cross product:

The direction of vector product can be found by right hand rule.

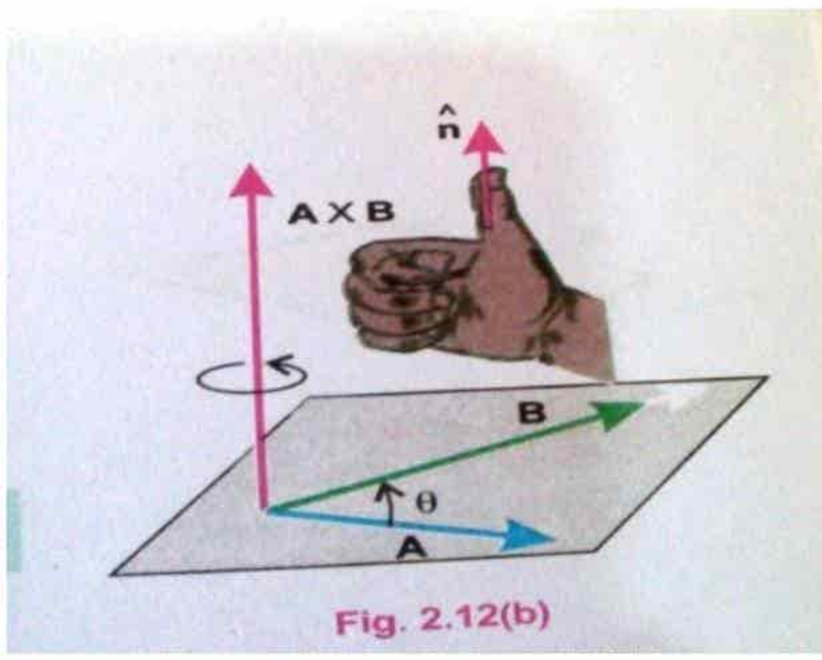


Fig. 2.12(b)

Right hand rule:

- Join the tails of two vectors to define a plane.
- Rotate $\vec{A}$ into $\vec{B}$ through smaller possible angles.
- Curl the fingers of the right hand in the direction of rotation.
- The erected thumb will represent the direction of vector product.

14. Explain four characteristics of cross product.

Ans: Characteristics of cross product:

(i) <u>Commutative property:</u>

The cross product of two vectors is not commutative.

If $\vec{A}$ and $\vec{B}$ are two vectors and θ is the angle between them. Then,

$$\vec{A}\times\vec{B} = AB\sin\theta\hat{n} \qquad \text{------ (i)}$$
$$\vec{B}.\times\vec{A} = BA\sin\theta(\hat{n}) \qquad \text{------ (ii)}$$
$$\vec{A}.\vec{B} \neq \vec{B}.\vec{A}$$
$$\vec{A}.\vec{B} = -\vec{B}.\vec{A}$$

<u>(ii) Perpendicular vectors:</u>

If two vectors are mutually perpendicular to each other ($\theta = 90^o$). Their cross product will be maximum.

$$\vec{A}.\vec{B} = AB\cos 90^{\circ}\hat{n}$$

$$\vec{A}.\vec{B} = AB(1)\hat{n}$$

$$\vec{A}.\vec{B} = AB\hat{n}$$

In case of unit vectors,

$$\hat{i}\times\hat{j} = (1)(1)\sin 90^{\circ}\hat{k} = (1)(1)(1)\hat{k} = \hat{k}$$

$$\hat{j}\times\hat{k} = \hat{i} \text{ and } \hat{k}\times\hat{i} = \hat{j}$$

$$\hat{j}.\hat{i} = -\hat{k}$$

$$\hat{k}.\hat{j} = -\hat{i}$$

$$\hat{i}.\hat{k} = -\hat{j}$$

(iii) Parallel and anti-parallel vectors:

- If two vectors are parallel ($\theta = 0^{\circ}$) to each other then, vector product is equal to zero.

$$\vec{A}\times\vec{B} = AB\sin 0^{\circ}\hat{n}$$

$$\vec{A}\times\vec{B} = AB(0)\hat{n}$$

$$\vec{A}\times\vec{B} = \vec{O}$$

This is the minimum value of vector product.

- If two vectors are anti-parallel ($\theta = 180^{\circ}$) to each other then, vector product is equal to zero.

$$\vec{A}\times\vec{B} = AB\sin 180^{\circ}\hat{n}$$

$$\vec{A}\times\vec{B} = AB(0)\hat{n}$$

$$\vec{A}\times\vec{B} = \vec{O}$$

(iv) Self scalar product:

The self-product of a vector is equal to null vector.

$$\vec{A}\times\vec{A} = AA\sin 0^{\circ}\hat{n}$$

$$\vec{A}\times\vec{A} = A^{2}(0)\hat{n}$$

$$\vec{A}\times\vec{A} = \vec{O}$$

In case of unit vectors,

$$\hat{i}\times\hat{i} = (1)(1)\sin 0^{\circ}\hat{n} = (1)(1)(0)\hat{n} = \vec{O}$$

$$\hat{j}\times\hat{j} = \vec{O} \text{ and } \hat{k}\times\hat{k} = \vec{O}$$

$$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = \vec{O}$$

15. Prove that area of parallelogram is equal to magnitude of cross product.

Ans: Area of parallelogram:

The magnitude of the cross product of two vectors represents the area of the parallelogram.

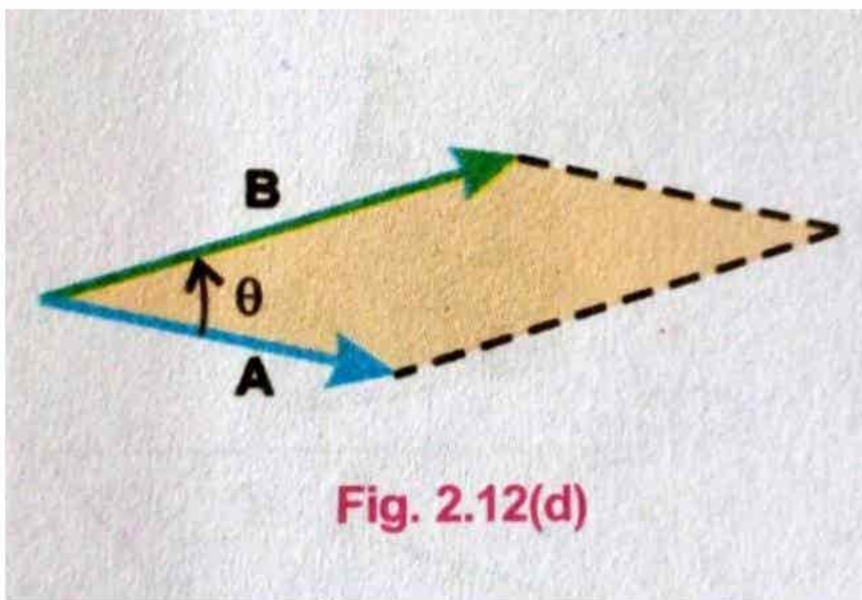


Fig. 2.12(d)

$$\text{Area of parallelogram} = (\text{Length})(\text{Height})$$

$$= A(B\sin\theta)$$

$$= \text{Magnitude of } \left(\vec{A}\times\vec{B}\right)$$

Area of parallelogram = $|\vec{A} \times \vec{B}|$

16. Define torque. Write its formula and unit.

Ans: <u>Torque:</u>

"The turning effect of force produced in a body about an axis is called torque."

OR

"The product of magnitude of force and the perpendicular distance from axis of rotation to line of action of the force is called torque."

OR

"The Cross or Vector product of force and moment arm is called torque."

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

$$\tau = rF\sin\theta$$

Where r = perpendicular distance.
F = Magnitude of Force.
θ = The angle between Force and moment arm.

Dependence of torque:

Torque depends upon the following factors:

- Magnitude of force
- Moment arm (perpendicular distance from axis of rotation to line of action of the force)
- Angle between force and the moment arm.

Unit:

Its S.I unit is Nm (Kgm^2s^{-2}) and its dimension is $[ML^2T^{-2}]$.

Example:

- Tightening of a nut with a spanner (wrench)
- A seesaw rotates on and off the ground due to torque imbalance.

17. Define equilibrium. Discuss its types.

Ans: <u>Equilibrium:</u>

"A body is said to be in equilibrium if it is at rest or moving with uniform velocity under the action of a force or a number of forces."

OR

A body is said to be in equilibrium if no net force acts on it.

Types of Equilibrium:

There are two types of equilibrium:

(i) Static Equilibrium:

"If a body is at rest, then it is said to be in static equilibrium."

Example: Book lying on the table.

(ii) Dynamic Equilibrium:

"If a body is moving with uniform velocity, it is said to be in dynamic equilibrium."

Example: A car moving with uniform velocity, Motion of paratrooper etc.

<u>(iii) Translational Equilibrium:</u>

"When first condition of equilibrium is satisfied, the linear acceleration of body is zero and the body is said to be in translational equilibrium."

(iv) Rotational Equilibrium:

"When second condition of equilibrium is satisfied, angular acceleration of a body is zero and the body is said to be in rotational equilibrium."

For a body to be in complete equilibrium, both conditions must be satisfied. i.e, both linear acceleration and angular acceleration must be zero.

---

18. What are conditions for equilibrium?

Ans: First condition of Equilibrium:

"The vector sum of all the forces acting on a body must be equal to zero."

$$\Sigma\vec{F} = 0$$

In case of rectangular components, then

$$\Sigma\vec{F}_x = 0$$

$$\Sigma\vec{F}_y = 0$$

- If the rightward forces are taken as positive, then leftward forces are taken as negative.
- If the upward forces are taken as positive, then downward forces are taken as negative.
- Forces which lie in a same (common) plane are said to be coplanar.

Second condition of Equilibrium:

"The vector sum of all the torques acting on a body must be zero"

$$\Sigma\vec{\tau} = 0$$

- Clockwise torque is taken as negative.
- Anti-clockwise torque is taken as positive.

Exercise Short Questions

1. Define the terms (i) Unit vector (ii) Position Vector and (iii) Component of a Vector.

Ans: Unit Vector:

"A vector whose magnitude is **One with no units** in a given direction is called unit vector."

It is represented by **a letter** with a **cap or hat** on it. A unit vector in the direction of **A** is written as $\hat{A}$.

$$\vec{A} = A\hat{A}$$

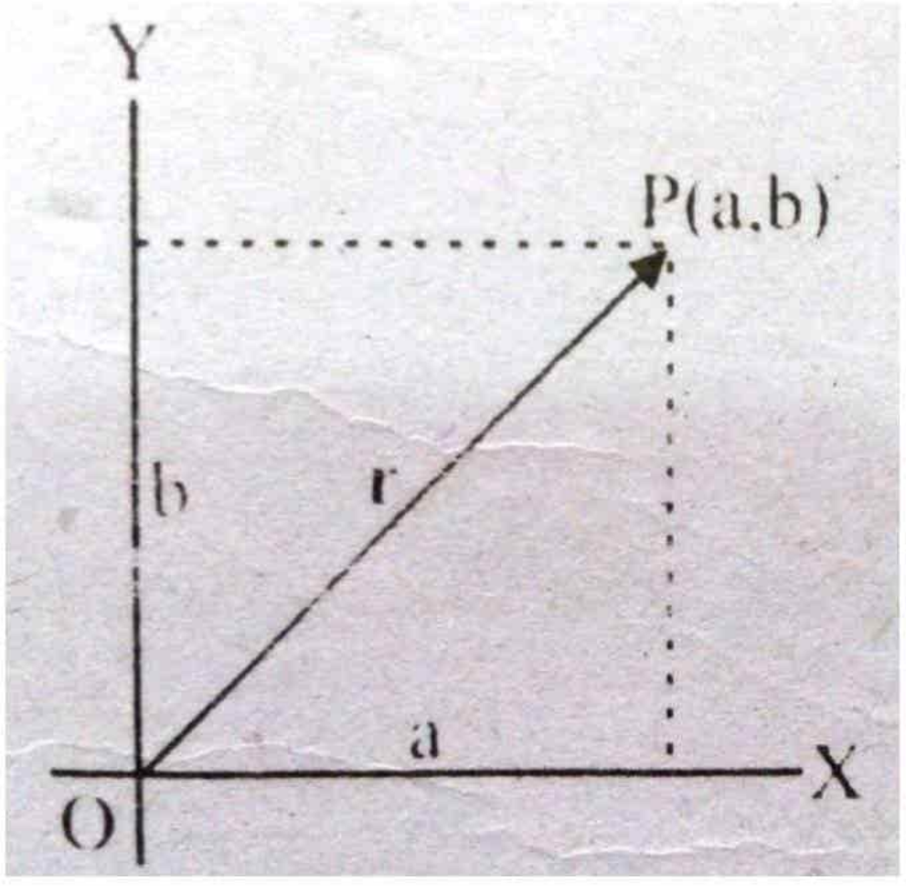
$$\hat{A} = \frac{\vec{A}}{A} \quad \text{OR} \quad \hat{A} = \frac{A_x\hat{i}+A_y\hat{j}+A_z\hat{k}}{\sqrt{A_x^2+A_y^2+A_z^2}}$$

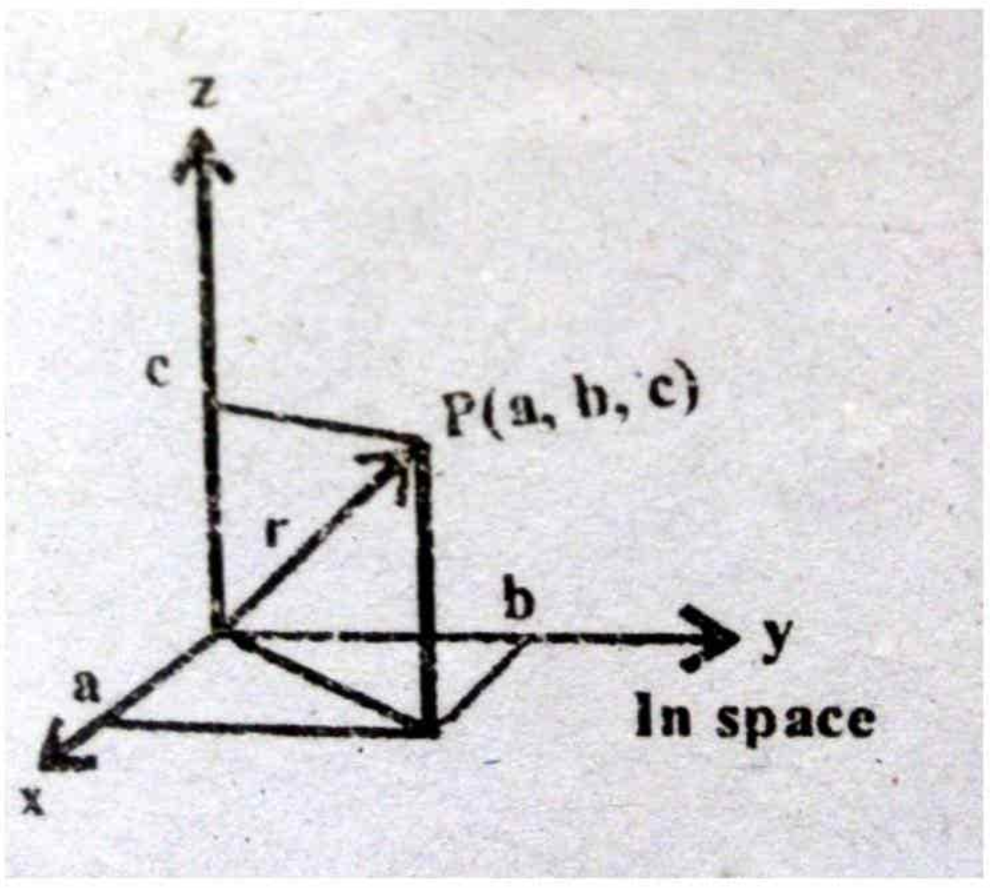
Examples of Unit vectors: -

- $\hat{i}$ is a unit vector along x- axis.
- $\hat{j}$ is a unit vector along y- axis.
- $\hat{k}$ is a unit vector along z- axis.

Position Vector: "A Vector that describe the position of a particle or a point with respect to a fixed origin is called Position vector."

- It is represented by $\vec{r}$. In two-dimensional coordinate system (plane), the position vector of a point P (a, b) is represented by $\vec{r} = a\hat{i} + b\hat{j}$ $\quad r = \sqrt{a^2 + b^2}$.
- In three-dimensional coordinate system (space), the position vector of a point P (a , b , c) is represented by $\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$ $\quad r = \sqrt{a^2 + b^2 + c^2}$.





Position Vector: "The **effective value** of a vector in a given direction is called component of a vector." A vector may split into **two or more** components.

---

2. The vector sum of three vectors gives zero resultant. What can be the possible orientation of the vectors?

Ans: If the three vectors are represented by the **sides of a triangle** joined by head to tail rule, there sum will be zero.

Explanation: Consider three vectors $\vec{F_1}$, $\vec{F_2}$ and $\vec{F_3}$ as shown in figure. It is clear that the sum of the vectors is zero because tail of first vector **coincides** with the head of the last vector.

---

3. Vector $\vec{A}$ lies in xy-plane.

(i) For what orientation both of the rectangular components be negative?

(ii) For what orientation will its components have opposite sign?

Ans: (i) If the vector lies in **3rd quadrant**, both of its rectangular components will be **negative**.

(ii) If the vector lies in **2nd and 4th quadrants**, both of its rectangular components will have **opposite sign.**

---

4. If one of the rectangular components of a vector is not zero. Can its magnitude be zero? Explain.

Ans: **No**, it's magnitude cannot be zero.

Reason: -

The magnitude of vector $\vec{A}$ is given by $A = \sqrt{A_x^2 + A_y^2 + A_z^2}$.

This equation shows that magnitude of a vector will be zero only when all components of the vector are **zero**.

Otherwise, if any of the rectangular component is zero. The magnitude of a vector can never be zero.

5. Can a vector have components greater than the vector's magnitude?

Ans: The rectangular components of a vector can **never** be greater than the vector's magnitude. It may **equal or less** than vector's magnitude.

Explanation: -

The magnitude of a vector $\vec{A}$ is given by

$$A = \sqrt{A_x^2 + A_y^2}$$

$$A^2 = A_x^2 + A_y^2$$

$$A^2 \geq A_x^2 \quad OR \quad A^2 \geq A_y^2$$

$$A \geq A_x \quad \text{OR} \quad A \geq A_y$$

The component of a vector **other than rectangular components** may be greater than the magnitude of the vector.

6. Can the magnitude of a vector have a negative value?

Ans: **No**, it can never be **negative.**

Reason: -

As

$$A = \sqrt{A_x^2 + A_y^2}$$

A_x and A_y may be negative but the squares of negative values always positive. So, the magnitude of a vector cannot be negative.

7. If $\vec{A}+\vec{B}=\vec{0}$, What can you say about the components of two vectors?

Ans: Sum of their respective components will be zero.

Explanation: -

If

$$\vec{A} = A_x\hat{i} + A_y\hat{j} \text{ and } \vec{B} = B_x\hat{i} + B_y\hat{j}$$

Then $$\vec{A}+\vec{B} = \vec{0}$$

8. Under what circumstances would a vector have components that are equal in magnitude?

Ans: It is possible only when the vectors make an angle of **45° with positive x-axis.**

Proof: -

Let A_x and A_y be the rectangular components of a vector $\vec{A}$

If $$A_x = A_y$$

OR $$A\sin\theta = A\cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = 1$$

$$\tan\theta = 1$$
$$\theta = \tan^{-1}(1)$$
$$\theta = 45^{\circ}$$

Hence, it is proved.

9. Is it possible to add a scalar quantity into a vector quantity? Explain.

Ans: **No**, it is not possible.

Reason: -

By the rule of vectors addition, only similar quantities can be added, whereas vector and scalar are both **different physical quantities**. Vectors have both magnitude and direction, but scalar only have magnitude. So, they can never be added.

10. Can you add zero to a null vector?

Ans: **No**, it is not possible.

Reason: -

Both zero and null vector are different physical quantities, one is scalar and other is vector. So, zero cannot be added to a null vector.

11. Two vectors have unequal magnitude. Can their sum be equal to zero? Explain.

Ans: **No**, their sum cannot be zero.

Reason: -

Because it is only possible if two vectors have **equal magnitude** and **same direction.**

12. Show that the sum and difference of two perpendicular vectors of equal lengths are also perpendicular and of the same length?

Ans: Consider two vectors $\vec{A}$ and $\vec{B}$ as shown in figure.

By using head to tail rule,

$$\vec{R} = \vec{A}+\vec{B} \quad \text{and} \quad \vec{R}` = \vec{A}-\vec{B}$$

Now A = B and angle between two vectors is 90°

Proof: -

Magnitude of $\vec{R}$:-

$$R = \sqrt{(A)^2+(B)^2} = \sqrt{A^2+B^2} \quad \rightarrow \quad (i)$$

Magnitude of $\vec{R}`$:-

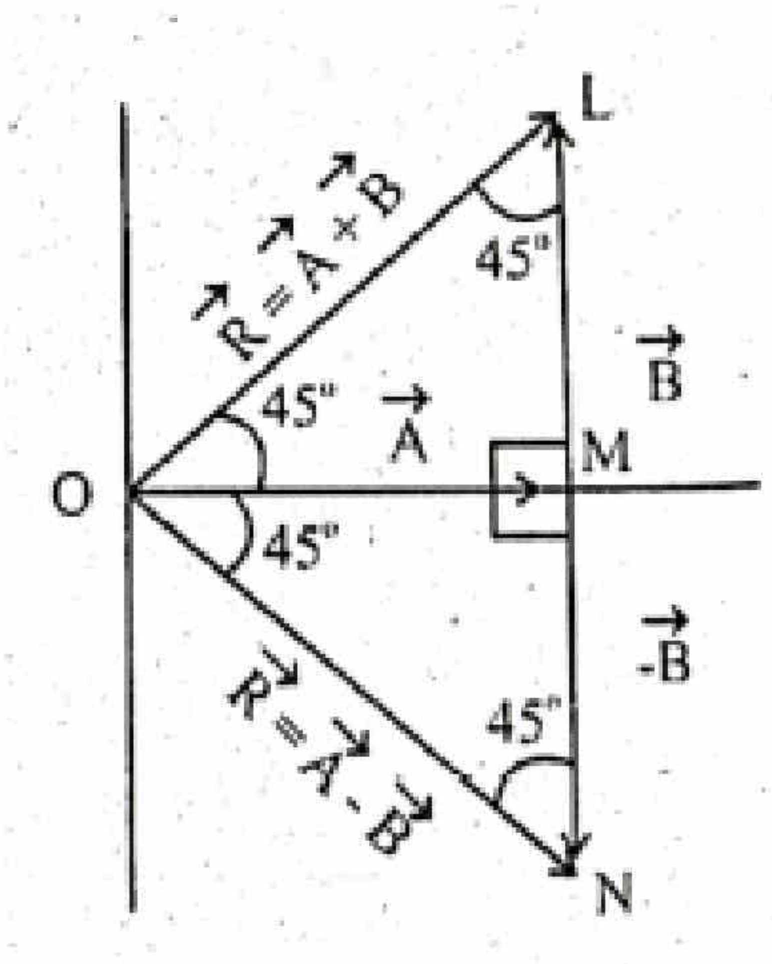
$$R` = \sqrt{(A)^2+(-B)^2} = \sqrt{A^2+B^2} \quad \rightarrow \quad (ii)$$

From equation (i) and (ii), it is clear that

$$R = R` \quad \rightarrow (iii)$$

Since A = B

$$\angle LOM = \angle NOM = 45^{\circ}$$



Therefore,

The angle between $\vec{R}$ and $\vec{R}'$ = $\angle LON = \angle LOM = \angle NOM = 45^\circ + 45^\circ$

$$\angle LON = 90^\circ$$

So $\vec{R}$ and $\vec{R}'$ are perpendicular to each other.

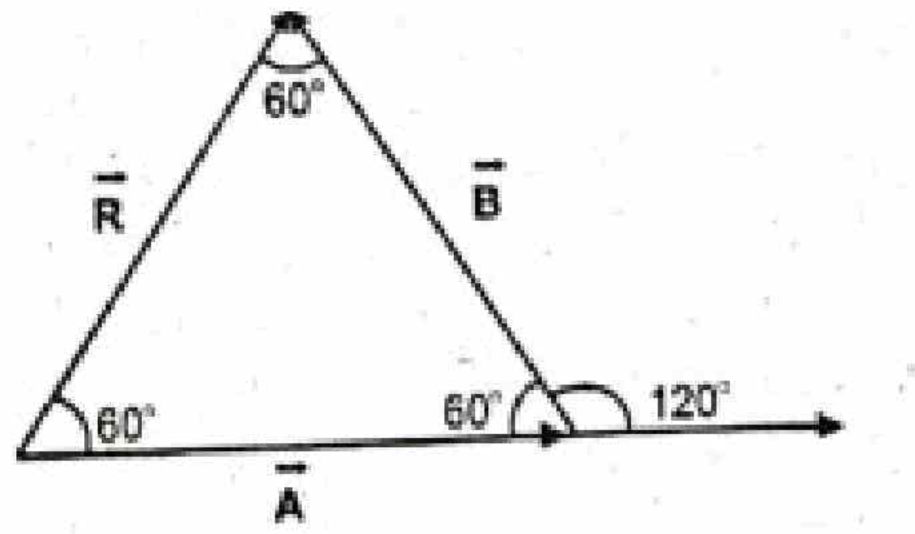
Hence proved.

13. How would be the two vectors of the same magnitude have to be oriented, if they were to be combined to give the resultant equal to a vector of the same magnitude?

Ans: It is possible only when the angle between two vectors will be **120º**.

Explanation: -

If two vectors are represented by the sides of an equilateral triangle, then the third side represents resultant such that A = B = R as shown in figure. In this case the angle between two vectors is **120º**.



14. The two vectors two be combined have magnitudes of 60N and 35N. Pick up the correct answer from those give below and tell what is the only one of the three that is correct?

(i) 100N (ii) 70N (iii) 20N

Ans: The correct answer is **70N**.

Reason: -

$$\vec{F}_1 = 60N$$

$$\vec{F}_2 = 35N$$

(a) Resultant Force will be maximum when two vectors are parallel (angle will be 0º).

$$60N + 35N = 95N$$

(b) Resultant Force will be minimum when two vectors are antiparallel (angle will be 180º)

$$60N - 35N = 25N$$

This shows that the resultant Force cannot be greater than 95N and cannot be less than 25N. So, the correct answer is 70N.

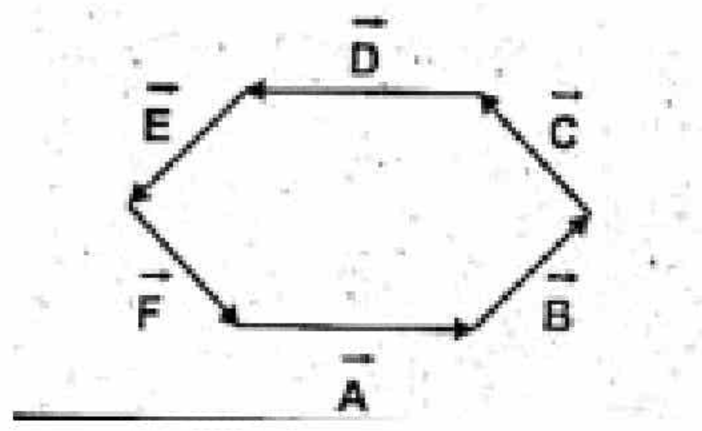
15. Suppose the sides of closed polygon represent vector arranged head to tail rule. What is the sum of these vectors?

Ans: The sum of these vectors will be zero.

Reason: -

In this case, the tail of first vector **coincides** with the head of the last vector as shown in figure.

$$\vec{A} + \vec{B} + \vec{C} + \vec{D} + \vec{E} + \vec{F} = \vec{O}$$



17. If all the components of the vectors $\vec{A}_1$ and $\vec{A}_2$ were reversed, how would this alter $\vec{A}_1 \times \vec{A}_2$

Ans: It would **not change** in this case.

Explanation: -

We know that direction of $\vec{A}_1 \times \vec{A}_2$ is perpendicular to the plane.

Containing $\vec{A}_1$ and $\vec{A}_2$ as shown in figure (a)

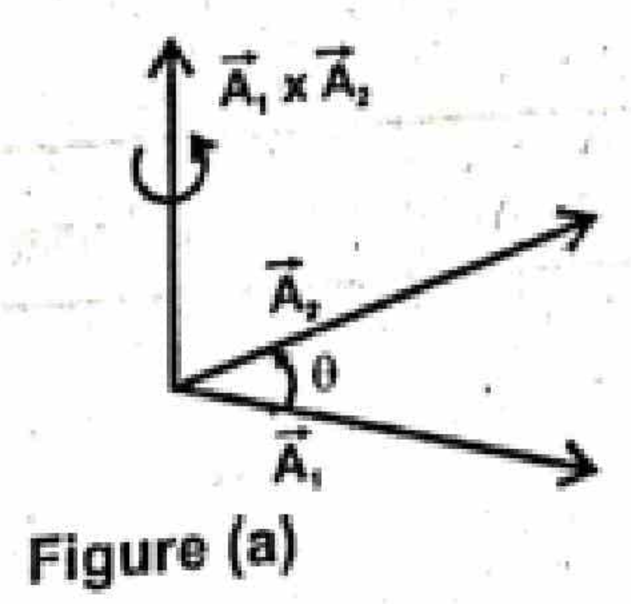


Figure (a)

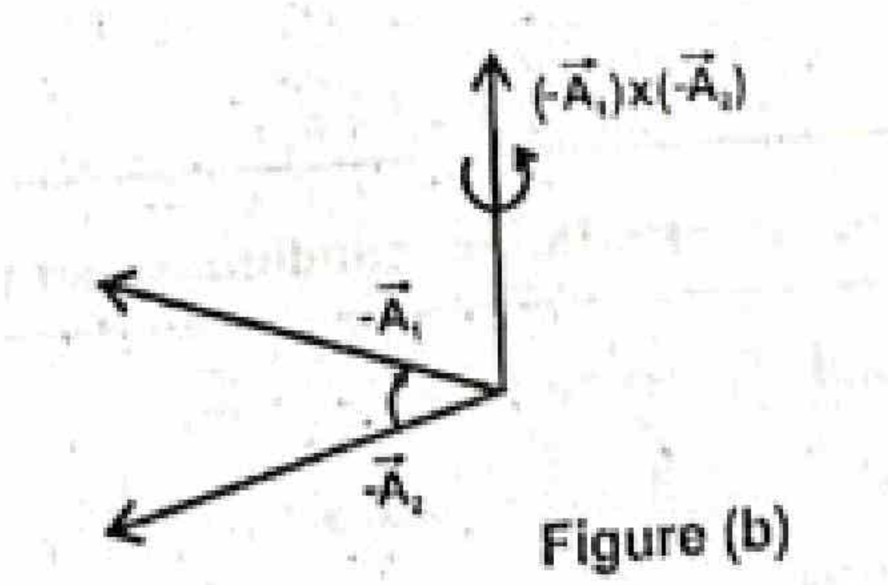


Figure (b)

Now, if all the components of vector $\vec{A}_1$ and $\vec{A}_2$ are reversed (i.e. if we take negative of $\vec{A}_1$ and $\vec{A}_2$), then again, the direction of $(-\vec{A}_1) \times (-\vec{A}_2)$ remains the same as shown in figure in (b).

i.e. $$\vec{A}_1 \times \vec{A}_2 = (-\vec{A}_1) \times (-\vec{A}_2)$$

18. Name the three different conditions that could make $\vec{A}_1 \times \vec{A}_2 = \vec{O}$

Ans: If $\vec{A}_1$ and $\vec{A}_2$ are two vectors then,

$$\vec{A}_1 \times \vec{A}_2 = A_1 A_2 \sin\theta \hat{n}$$

Conditions: -

$\vec{A}_1 \times \vec{A}_2$ is **null** vector if

- $\vec{A}_1$ or $\vec{A}_2$ is **null** vector.
- $\vec{A}_1$ and $\vec{A}_2$ parallel [i.e. $\theta = 0^\circ$]
- $\vec{A}_1$ and $\vec{A}_2$ antiparallel [i.e. $\theta = 180^\circ$]

19. Identify true or false statements and explain the reason

(a) A body in equilibrium implies that it is neither moving nor rotating.

(b) If coplanar Forces acting on a body form closed polygon, the body is said to be in equilibrium.

Ans: (a) This statement is **false**.

Reason: -

Because in **dynamic equilibrium** body **may move or rotate** with **uniform velocity.**

(b) The 2nd statement is true.

Reason: -

In this case **1st condition** of equilibrium is satisfied and the body is said to be in **translational equilibrium**.

20. A picture is suspended from a wall by two strings. Show by diagram the configuration of the strings for which the tension in the string will be minimum.

Ans: The tension will be minimum when the strings will be **vertical** ($\theta = 90^\circ$)

Proof: -

Let the picture is suspended from wall by two strings, as shown in figure. Resolve the tension into its rectangular components.

$$\sum \vec{F_y} = 0$$

$$T\sin\theta + T\sin\theta - W = 0$$

$$2T\sin\theta = 0$$

$$T = \frac{W}{2\sin\theta}$$

Tension will be minimum if $\sin\theta$ is

As $\sin\theta = 1$

$$\theta = \sin^{-1}(1)$$

$$\theta = 90^\circ$$

$$T = \frac{W}{2\sin 90^\circ}$$

$$T = \frac{W}{2} \qquad (\sin 90^\circ = 1)$$

Thus, the tension will be minimum when the strings will be **vertical**.

21. Can a body rotate about its centre of gravity under the action of its weight?

Ans: No, it is not possible.

Reason: -

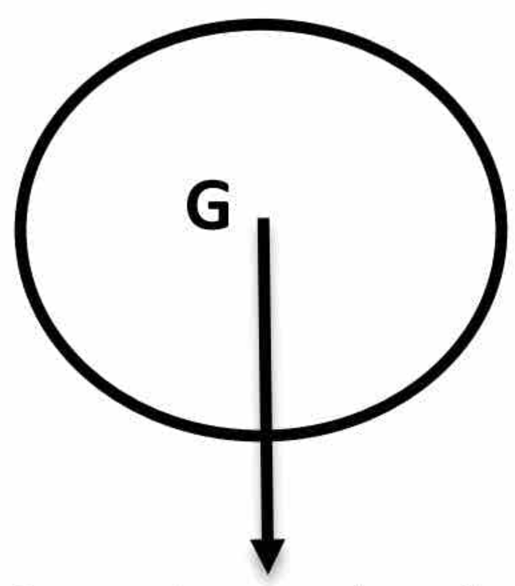
In this case the line of action of force (weight) passes through **pivot point** (centre of gravity). So, the moment arm becomes zero.

As,

$$\tau = rF$$

$$\tau = (0)F$$

$$\tau = 0$$



W

Hence, torque of the body is zero. So, the body cannot rotate about centre of gravity under the action of its weight.

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Chapter # 03 (Motion and Force)
Important Short Questions

1. Define the terms

(i) Displacement (ii) Velocity (iii) Instantaneous velocity (iv) Average velocity (v) Uniform velocity

(i) Displacement:

The change in position of a body from its initial position to final position is called displacement.

$$\vec{d} = \vec{r}_2 - \vec{r}_1$$

Its unit is meter.

(ii) Velocity

The time rate of change of displacement is called velocity.

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$$

(iii) Instantaneous velocity

The limiting value of $\frac{\Delta \vec{d}}{\Delta t}$, as time interval Δt approaches to zero is called instantaneous velocity.

$$\vec{v}_{ins} = \underset{\Delta t \to o}{Lim} \frac{\Delta \vec{d}}{\Delta t}$$

(iv) Average velocity

The ratio of the total displacement to the total time taken to cover this displacement is called as average velocity.

$$\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t}$$

(v) Uniform velocity

If a body covers equal displacement in equal interval of time is called uniform velocity.

Unit: The unit of velocity is ms^{-1}.

2. Define the terms

(i) Acceleration (ii) Instantaneous acceleration (iii) Positive acceleration (iv) Negative Acceleration

(i) Acceleration

The time rate of change of velocity is called acceleration.

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

(ii) Instantaneous acceleration

The limiting value of $\frac{\Delta \vec{v}}{\Delta t}$, as time interval Δt approaches to zero is called instantaneous acceleration.

$$\vec{a}_{ins} = \underset{\Delta t \to o}{Lim} \frac{\Delta \vec{v}}{\Delta t}$$

(iiii) Average acceleration

The ratio of the total change in velocity to the total time is called as average acceleration.

$$\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$$

(iv) Positive Acceleration

If velocity of the body increases, its acceleration is positive.

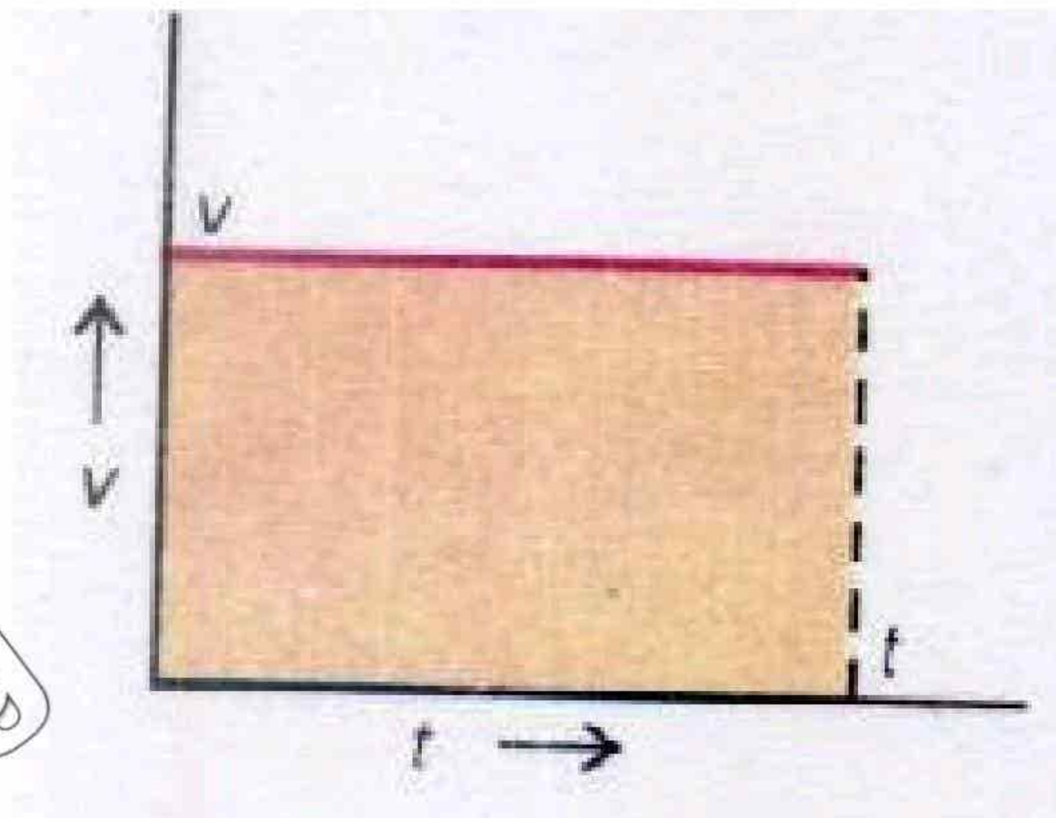
(v) Positive Acceleration

If velocity of the body decreases, its acceleration is negative. It is also called deceleration or retardation.

Unit: The unit of acceleration is ms^{-2}.

3. Show that the area between the velocity time graph is equal to the distance covered by the object.

Ans: Case I:



When the object moves with the uniform velocity, velocity-time graph is a horizontal straight line parallel to time axis.

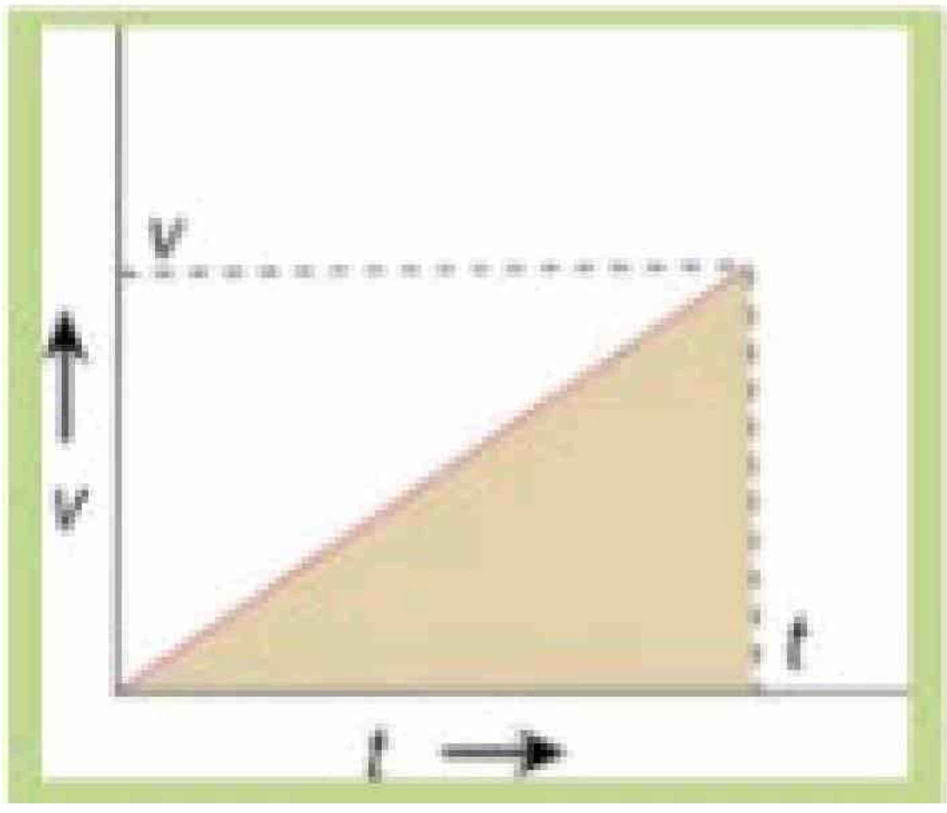
Distance covered by the body = Area of rectangle

= (Length) × (Width)

= vt

= S

Case II:



When the body moves with uniformly increasing velocity (uniform acceleration), the velocity-time graph is an inclined line with time axis.

Distance covered by the body = Area of triangle

$$= \frac{1}{2}(\text{base}) \times (\text{Height})$$

$$= \frac{1}{2}vt$$

$$= V_{av} \times t \qquad \left(V_{av} = \frac{0+v}{2} = \frac{1}{2}v\right)$$

$$= S$$

4. Define Inertial frame of reference

Ans: Inertial frame of reference

The frame of reference in which Newton's law holds is called inertial frame of reference.

Example:

The Earth is approximately an inertial frame of reference.

5. Define Newton's law.

Ans: Newton's first law of motion:

A body at rest remain at rest and a body moving with uniform velocity will continue to do so, unless unbalanced external force acts on it.

Newton's 2nd Law of motion:

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

$$a \propto F$$

$$a \propto \frac{1}{m}$$

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

$$F \propto ma$$

$$F = kma$$

$$F = ma \qquad (K = 1)$$

Newton's 3rd Law of motion

"To every action there is always an equal but opposite reaction."

- Motion of rocket
- Motion of air filled Balloon

6. Define momentum, Write its formula and unit.

Ans: Momentum:

"The product of mass and velocity is called momentum."

$$\vec{P} = m\vec{v}$$

Its unit is Ns ($Kgms^{-1}$).
It depends upon.

- Mass of the body.
- Velocity of the body

7. Define isolated with suitable example.

Ans: Isolated System:

The system on which no external force acts is called isolated system.

Example:

The molecules of gas enclosed in a glass vessel at a constant temperature.

8. State law of conservation of momentum. Write its formula.

Ans: Statement:

Total linear momentum of an isolated system remains constant.

$$\mathbf{m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'}$$

9. Drive the relation for force due to water flow.

Ans: Suppose water from a horizontal pipe strikes a wall normally. Then it exerts a force on the wall. Let initially the velocity of water flow is $\vec{v}$ and on striking the wall, it comes to at rest so final velocity becomes zero.

$$\vec{F} = \frac{m\vec{v}_f - m\vec{v}_i}{t}$$

$$\vec{F} = \frac{0 - m\vec{v}}{t}$$

$$\vec{F} = -\frac{m\vec{v}}{t}$$

According to Newton's 3rd law of motion, a force of reaction exerted by water on the wall is equal but opposite.

$$\vec{F} = -\left(\frac{-m\vec{v}}{t}\right)$$

$$\vec{F} = \frac{m\vec{v}}{t}$$

10. How do you find the momentum of an explosive force? Explain with one example.

Ans: When a shell explodes in mid-air, its fragments fly off in different directions. The total momentum of all its fragments equals the initial momentum of the shell.

Suppose a falling bomb explodes into two pieces. The momentum of the bomb fragments combines by vector addition equal to the original momentum of the falling bomb.

11. When a bullet is fired from a riffle. Why does the riffle move backward?

Ans: When the bullet is fired, the total momentum of bullet and riffle still remains zero. Since no external force has acted on them. Thus if v' is the velocity of riffle.

$$\mathbf{mv + Mv' = 0}$$

$$\mathbf{Mv' = -mv}$$

$$\mathbf{v' = -\frac{mv}{M}}$$

The momentum of the riffle thus equal and opposite to that of the bullet. Since mass of riffle is much greater than the bullet that's why the riffle move backs or recoils.

12. What is principle of rocket propulsion?

Ans: Motion of rocket is based on the law of conservation of momentum and Newton's third law of motion.

Principle of rocket propulsion

Rocket moves up by ejecting burning gasses from its rear part. When fuel is burned, high pressure gasses come out from the engine with high velocity. The rocket gains momentum equal to the momentum expelled gasses but in opposite direction. Rocket continues to gain more and more momentum. So, the speed of rocket goes on increasing as long as engine are operating.

13. Define ballistic missile, ballistic flight and ballistic trajectory.

Ans: Ballistic Missile:

Ballistic missiles are un-powered, unguided and useful only for short range.

Ballistic flight:

When a projectile is given an initial push and is then allowed to move freely due to inertia and under the action of gravity, such a flight is called ballistic missile.

Ballistic trajectory:

The path followed by the ballistic missile is called ballistic trajectory.

14. Why a safety of a motorcycle's is padded?

Ans: A motorcycle's helmet is padded so as to extend the time of any collision to prevent serious injury.

$$\vec{I} = \vec{F} \times \Delta t$$

Through this relation time is inversely proportional to the force so increases the time so decrease the force so this is why safety helmet is padded to prevent the serious injury.

Exercise Short Questions

1. What is the difference between uniform and variable velocity? From the explanation of variable velocity, define acceleration. Give SI units of velocity and acceleration.

Ans:

Uniform Velocity	Variable Velocity
• When a body covers **equal** displacement in equal intervals of time then the body moves with **uniform** velocity. • In this case **acceleration** is **zero**.	• When a body covers **unequal** displacement in equal intervals of time then the body moves with **variable** velocity. • In this case **acceleration** is has **some value**.

Acceleration: -

The time rate of change of a body is called acceleration.

If the velocity of a body changes from by an amount $\Delta\vec{V}$ in time Δt .then

$$a_{av} = \frac{\Delta\vec{V}}{\Delta t} = \frac{V_f - V_i}{\Delta t}$$

- The SI unit of velocity is ms^{-1}.
- The SI unit of acceleration is ms^{-2}.

2. An object is thrown vertically upward. Discuss the sign of acceleration due to gravity, relative to velocity, while the object is in air?

Ans: Sign of acceleration due to gravity relative to velocity is **negative.**

Explanation: -

As acceleration due to gravity is directed downward but the velocity is directed upward. Therefore, the sign of acceleration due to gravity relative to velocity is negative and when it moves in the downward direction acceleration and velocity are parallel. So, sign of acceleration will be positive.

3. Can the velocity of an object reverse direction when acceleration is constant? If so, given an example?

Ans: Yes, it is possible.

Example: -

When a body is thrown vertically upward, its velocity decreases because of downward force of gravity and becomes zero at the highest point and the body starts moving downward and reverses its direction of velocity, but the acceleration remains constant during whole flight (i.e. $9.8ms^{-2}$.)

4. Specify the correct statement:

(a) An object can have a constant velocity even its speed is changing.

(b) An object can have a constant velocity even its velocity is changing.

(c) An object can have a zero velocity even its acceleration is not zero.

(d) An object subjected to a constant acceleration can reverse its velocity.

(a) As when speed changes, velocity also changes so it is not true statement.

(b) When object moves along a circle with constant speed, velocity changes due to change in direction. So, it is true statement.

(c) When a body thrown vertically upward. At the maximum height its velocity becomes zero, but the acceleration is not zero. So, it is true statement.

(d) When an object is thrown vertically up, after reaching its maximum height, its velocity reverses but its acceleration remains same (i.e. $9.8ms^{-2}$.) So, it is also true statement.

5. A man is standing on the top of a tower throws a ball straight up with initial velocity V_i and at the same time throws a second ball straight downward with the same speed. Which bass will have larger speed when it strikes the ground? Ignore air friction.

Ans: Both the balls hit the ground with the same speed.

Explanation: -

The ball which is thrown vertically up with velocity V_i will have same velocity V_i when it reaches back to the top of the tower. So, the two balls have same downward velocity at top of the tower, hence they hit the ground with the same final velocity.

6. Explain the circumstances in which the velocity $\vec{V}$ and acceleration $\vec{a}$ of car are;

(i) Parallel **(ii) Anti-Parallel** **(iii) Perpendicular to one another**

(iv) v is zero but a is not zero **(v) a is zero but v is not zero**

(i) When the velocity of the car is increasing in a Straight line then $\vec{v}$ and $\vec{a}$ are parallel.

(ii) When the velocity of the car is decreasing in a straight line the $\vec{v}$ and $\vec{a}$ are anti-parallel.

(iii) When a car moves in a circle the $\vec{v}$ and $\vec{a}$ are perpendicular to each other.

(iv) When an opposing force is acting. The car slow-downs and at the end point $\vec{v}$ is zero but acceleration $\vec{a}$ is not zero $\vec{a}$.

(v) When a car is moving with uniform velocity then $\vec{a}$ is zero but $\vec{v}$ is not zero.

7. Motion with constant velocity is a special case of motion with constant acceleration. Is this statement true? Discuss.

Ans: Yes, this statement is true.

Explanation: -

The acceleration depends upon change in velocity. When a body moves with constant velocity $\Delta\vec{v} = 0, \vec{a} = \frac{\Delta v}{\Delta t} = 0$. It means velocity changes at a constant rate i.e. zero meter per second. Hence acceleration will remain constant (zero) during motion. This is a special case of motion with constant acceleration.

8. Find the change in momentum for an object subjected to a given force for a given time and state law of motion in terms of momentum?

Ans: The time rate of change of momentum of a body is equal to applied force.

Proof: -

Let a force $\vec{F}$ acts on a body of mass m, its velocity changes from $\vec{V}_i$ **to** $\vec{V}_f$ in time t second. Then the acceleration produced is

$$\vec{a} = \frac{\vec{V}_f - \vec{V}_i}{\Delta t}$$

$$\vec{a} = \frac{\vec{F}}{m}$$

$$\frac{\vec{F}}{m} = \frac{\vec{V}_f - \vec{V}_i}{\Delta t}$$

$$\vec{F} = \frac{m\vec{V}_f - m\vec{V}_i}{\Delta t}$$

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

Hence, it is proved.

9. Define impulse and show that how it is related to linear momentum?

Ans: impulse:

When a large force acts on a moving body for a short interval of time then the product of force and time is called impulse.

Relation:

$$\vec{I} = \vec{F} \times t$$

$$\vec{F} = \frac{m\vec{V}_f - m\vec{V}_i}{\Delta t}$$

$$\vec{F} \times t = m\vec{V}_f - m\vec{V}_i$$

$$\vec{I} = m\vec{V}_f - m\vec{V}_i$$

So, the impulse is equal to the change in momentum.

10. State the law of conservation of linear momentum, pointing out the importance of isolated system. Explain, why under certain conditions, the law is useful even though the system is not completely isolated?

Ans: Statement: -

Total linear momentum of an isolated system always remains constant.

Importance: -

- For an isolated system, total change in linear momentum due to mutually interacting forces is zero.
- Law of conservation of momentum holds only for the isolated system otherwise it is not valid.

Example:

Firing of a bullet from gun.

Application:

When the effect of external force (like frictional and gravitational force) is negligible small as compared to the forces between the interacting objects, then this law becomes applicable.

11. Explain the difference between elastic and inelastic collision. Explain how would a bouncing ball behave in each case? Give plausible reasons for the fact that K.E is not conserved in most cases?

Ans:

Elastic Collision	Inelastic Collision
• The collision in which the K.E is conserved is called elastic collision. • For example, bouncing of hard ball from marble floor.	• The collision in which the K.E is not conserved is called inelastic collision. • For example, bouncing of hard ball from sandy floor.

But the total linear momentum and total energy of the system remains constant.

Behaviour of bouncing ball:

When a hard ball is dropped from a certain height. If it has elastic collision on striking the floor, it will come at the original height but in case of inelastic collision, ball will lose some part of K.E and will not bounce back at the same height.

Solid reason for loss of kinetic energy:

In case of inelastic collision, the loss of kinetic energy is due to

- Friction of ball with floor
- Friction of ball and air
- Sound

12. Explain what is meant by projectile motion? Derive the expression for

(a) The time of flight (b) The range of projectile

Show that the range of projectile is maximum when projectile is thrown at an angle of 45° with horizontal.

Ans: The two-dimensional motion under the constant acceleration due to gravity and inertia is called projectile motion.

Example:

1) A football kicked by a player.
2) A ball thrown by a cricketer.
3) A missile fired from launching pad.

Time of flight:

The time taken by body to cover the distance from the place of projection to the place where it just hit the ground is called time of flight.

Since the projectile covers no vertical distance after its total time of flight. So, S = h = 0. If $\mathbf{V_i \sin\theta}$ is the vertical component of initial velocity. Then,

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

$$0 = (v_i \sin\theta)t - \frac{1}{2} g t^2$$

$$\frac{1}{2} g t^2 = (v_i \sin\theta)t$$

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

Range of projectile:

Maximum distance which a projectile cover in the horizontal distance is called range of the projectile. If $v_i \cos\theta$ is horizontal of initial velocity then range of projectile R for the total time of flight t can be expressed as,

$$R = V_{ix} \times t$$

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

$$R = \frac{V_i^2 (2 \text{Sin}\theta \cos\theta)}{g}$$

$$R = \frac{V_i^2 \text{Sin} 2\theta}{g}$$

Maximum Range:

The range of the projectile is maximum when the value of Sinθ has maximum value. The maximum value of sine function is one. Thus

$$\text{Sin} 2\theta = 1$$

$$2\theta = \text{Sin}^{-1}(1)$$

$$2\theta = 90^\circ$$

$$\theta = 45^\circ$$

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

$$R_{max} = \frac{v_i^2 \sin 2(45^\circ)}{g}$$

$$R_{max} = \frac{v_i^2 \sin 90^\circ}{g}$$

$$R_{max} = \frac{v_i^2}{g}$$

13. At what point or points in its path does a projectile have its minimum speed, its maximum speed?

Ans: Minimum Speed:

The speed of the ball is minimum at its **maximum height** because at this point the vertical component of velocity becomes zero.

Maximum Speed: -

The speed of ball is maximum at

- Its point of projection.
- The point just to hit the ground (Point of landing)

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Chapter # 04 (Work and Energy)
Important Short Questions

1. Define work done. Write its formula and unit.

Ans:

Work done: -

The product of magnitude of displacement and component of force in the direction of the displacement is called work done.

$$w = \vec{F}.\vec{d}$$

$$w = Fd\cos\theta$$

- Its SI unit is **Joule** that is equal to **Nm**. And its dimension is **$[ML^2T^{-2}]$**
- It is a scalar quantity.

2. What is positive and negative work done?

Ans:

Positive Work	Negative Work
• When a body falls freely under the action of gravity, force of gravity and displacement are in same direction ($\theta=0^0$). Then work done will be positive. • If $\theta < 90^0$, Work will be positive.	• When a body moves against gravity, force of gravity and displacement are opposite to each other ($\theta = 180^0$). Then work done will be negative. • If **$270^0 > \theta > 90^0$**, work done will be negative.

3. Define energy and watt.

Ans: Energy:

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

Watt: The power of body will be one watt if t does 1J work in one second.

$$1W = \frac{1J}{1s}$$

4. Define conservative field. Give one example.

Ans: Conservative field:

The field in which work is independent of the path follower is called conservative field.

OR

The field, in which work done along a closed path is zero is called conservative field.

Examples:

- Gravitational field
- Electric field

5. Differentiate between conservative and non-conservative forces. Give examples.

Ans:

Conservative forces	Non-conservative forces
• The force that does zero work in closed path is called conservative force. • For example, (i) Gravitational force (ii) Elastic spring force (iii) Electric force	• The force that does not do zero work in a closed path is called non-conservative force. • For example, (i) Frictional force (ii) Air resistance

6. Define power, Write its formula and unit.

Ans: The rate of doing work is called power.

$$P = \frac{w}{t}$$

Average Power: The ration between total work done and total time is called average power.

$$P_{av} = \frac{\Delta w}{\Delta t}$$

Instantaneous Power: The limiting value of $\frac{\Delta w}{\Delta t}$ as time Δt approaches to zero is called instantaneous power.

$$P_{ins} = \text{Lim}_{\Delta t \to 0} \frac{\Delta w}{\Delta t}$$

- Its SI unit is **Watt** that is equal to **Js^{-1}.** And its dimension is **$[ML^2T^{-3}]$**
- It is a scalar quantity.

7. Prove that P = F.V

Ans: Proof: -

Let $\vec{F}$ is the constant force acting on a moving body and $\vec{v}$ is constant velocity of the body. Then the power delivered to the body at any instant is given by

$$P = \text{Lim}_{\Delta t \to 0} \frac{\Delta w}{\Delta t}$$

$$P = \text{Lim}_{\Delta t \to 0} \frac{\vec{F}.\Delta \vec{d}}{\Delta t} \qquad [\Delta w = \vec{F}.\Delta \vec{d}]$$

$$P = \vec{F}.\left(\text{Lim}_{\Delta t \to 0} \frac{\Delta \vec{d}}{\Delta t}\right) \qquad [\text{Lim}_{\Delta t \to 0} \frac{\Delta \vec{d}}{\Delta t} = \vec{v}]$$

$$P = \vec{F}.\vec{v}$$

8. Define KWH, show that 1Kwh=3.6MJ

Ans: The commercial unit of electrical energy is **kilowatt-hour**.

Kilowatt-hour: -

The work done in one hour by an agency whose power is one kilowatt is called one kilowatt-hour.

1 kWh = 1000 W × 3600 sec

1 kWh = 3600000 J

1 kWh = 3.6×10^6 J

1 kWh = 3.6 MJ

9. Define K.E and P.E. Write down their formulae.

Kinetic Energy	Potential Energy
• The energy possessed by the body due to its motion is called kinetic energy. • For example, running water has K.E. $K.E = \frac{1}{2}mv^2$	• The energy possessed by the body due to its position is called Potential energy. • For example, Water stored in a dam has P.E. P.E = mgh

10. Differentiate between gravitational P.E and Elastic P.E.

Ans:

Gravitational P.E.	Elastic P.E.
• The energy possessed by the body due to its height is called gravitational P.E. **P.E = mgh**	• The energy stored in a compressed or stretched string is called elastic P.E. $\mathbf{P.E = \frac{1}{2}kx^2}$

11. Define work energy principle, Write its mathematical form.

Ans: Work-Energy Principle: -

Work done on a body is equal to the change in its kinetic energy.

Proof:

The work done on the body is

$$\text{Work done} = Fd \quad \text{-----------------} (i)$$

According to equation of motion

$$2ad = v_f^2 - v_i^2$$

$$d = \frac{1}{2a}\left(v_f^2 - v_i^2\right) \quad \text{-----------------} (ii)$$

According to Newton's 2nd law of motion

$$F = ma \quad \text{-----------------} (iii)$$

By putting equations (ii) and (iii) in (i), we get

$$\text{Work done} = ma \times \frac{1}{2a}\left(v_f^2 - v_i^2\right) = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

$$\text{Work done} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Work done = final K.E – initial K.E

Work done = Change in K.E

12. Define absolute P.E. Write its formula.

Ans: Absolute P.E:

The absolute P.E of an object at a certain position is the work done by gravitational force in displacing the object from that position to infinity where the force of gravity becomes zero.

$$\mathbf{U_g = -\frac{GMm}{R}}$$

13. What is escape velocity? Write its value and mathematical form.

Ans: Escape velocity

The initial velocity of a body with which it goes out of the earth's gravitational field is called escape velocity.

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$v_{esc} = \sqrt{2gR}$$

As, $g = 9.81\ ms^{-2}$ and $R = 6.4 \times 10^6$ m

Then,

$$v_{esc} = \sqrt{2\times 9.81\times 6.4 \times 10^{6}}$$
$$v_{esc} = 11.2 \times 10^{3}\ ms^{-1}$$
$$\mathbf{v_{esc} = 11.2\ kms^{-1}}$$

14. Differentiate between Geyser and aquifer.

Ans:

Geyser	Aquifer
• Geyser is a hot spring, which out steam and hot water in air. • They are present usually in volcanic areas.	• Aquifer is a rock layer holding water, which allows water to percolate through it with pressure. • Aquifer permeable rock which can contain or transmit ground water.

15. State law of conservation of energy. Give one example of energy conversion in our daily life.

Ans: Law of conservation of energy:

Energy neither created not destroyed. It can be converted from one form into another, but the total energy remains constant.

Conversion of Mechanical Energy: -

The K.E and P.E are the different forms of the energies. The total mechanical energy of the body is equal to the sum of K.E and P.E.

P.E may change into K.E, Similarly K.E may also be converted into P.E but the total energy remains constant.

Mathematically, we can write.

Total energy = K.E + P.E

16. How electrical energy can be obtained by using tides?

Ans: Electrical energy is obtained from tides.

Explanation:

Gravitational force of the moon produces tides in the sea. The tides raise the water in the sea roughly twice a day. water at high tide can be trapped in a basin by constructing a dam. Dam is filled at high tide. Then, water is released in a controlled way at low tide to derive the turbines. The dam is filled again for next high tide and the fall of water also derive the turbines and turbines run generators. This process is used to generate the electricity from tides.

17. What is geothermal energy?

Ans: Geo-thermal energy:

"The heat energy that is extracted from inside the Earth in the form of hot water or steam is called geothermal energy."

Process of Geothermal Energy Generation: -

(i) Radioactive decay
(ii) Residual heat of Earth
(iii)Compression of materials
(iv)Through bacterial action in the absence of air

18. What is meant by solar constant?

Ans: Solar Constant:

"Solar constant at normal incidence outside the earth's atmosphere per second per unit area is about **$1.4\ kW/m^2$** which is called solar constant.

19. How can we obtain the energy from biomass?

Ans: Energy from biomass:

The energy from all the organic materials including crop residue, natural vegetable trees, animal dung and sewage is called biomass energy.

There are many methods used for the conversion of biomass into fuels:

i. Direct Combustion
ii. Fermentation

20. Write sources of energies which are renewable and non-renewable.

Ans:

Renewable Energy Source	Non-renewable Energy Source
• Such energy from a source which does not deplete when used is called renewable energy source. • **For example,** (i) Hydroelectric (ii) Wind (iii) Geothermal (iv)Sunlight	• Such energy from a source which deplete when used is called non- renewable energy source. • **For example,** (i) Coal (ii) Natural Gas (iii) Oil (iv)

Exercise Short Questions

1- A person holds hold a bag of groceries while standing still, talking to a friend. A car is stationary with its engine running. From the stand point of work, how are these two situations similar?

Ans: In both cases work done is zero.

Reason: -

As the person and the car both are at rest. So the displacement is zero.

$$\text{Work done} = Fd\cos\theta$$
$$W = F\,(0)\cos\theta$$
$$W = 0$$

So, the word done is zero.

2- Calculate the work done in kilo joules in lifting a mass of 10 kg (at a steady velocity) through a vertical height of 10m.

Ans:

Given Data: -

$m = 10kg$
$h = 10\ m$
$W = ?$

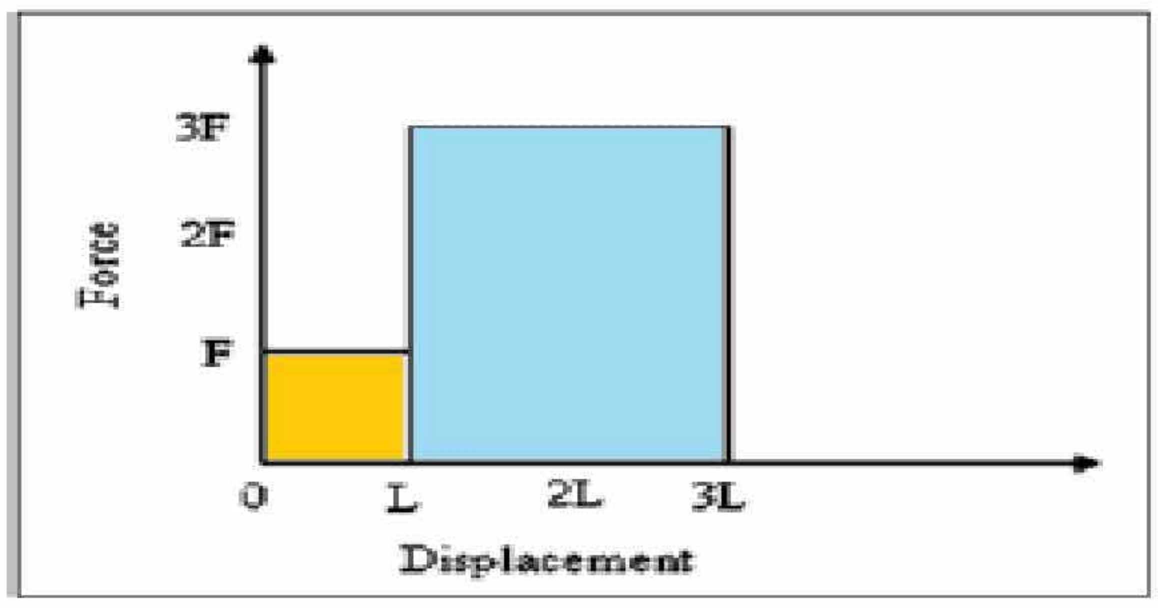
Calculations: -

As the work done is in the form of P.E.

$W = mgh$
$W = 10 \times 9.8 \times 10$
$W = 0.980\ J$

3- A Force F acts through a distance L. the force is then increased to 3F, and then acts through a further distance of 2L. Draw the work diagram to scale.

Ans: Force displacement graph: -



As area under the force displacement graph is equal to the work done by the body. So,

$W = (F)(L) + (3F)(2L)$
$W = FL + 6FL$
$W = 7FL$

4- In which case is work done? When a 50kg of books is lifted through 50cm, or when a 50kg crate is pushed through 2m across the floor with a force of 50N?

Ans: Case I: -

Mass = m_1 = 50 kg
Height = h = 50 cm = 0.50 m
$W_1 = ?$
$W_1 = m_1gh$
$W_1 = 50 \times 9.8 \times 0.5$
$W_1 = 245\ J$

Case II: -

Mass = m = 50 kg
Distance = d = 2m
Force = F = 50 N
$W_2 = Fd$
$W_2 = 50 \times 2$
$W_2 = 100J$

Result: The work done is greater in case I.

5- An object has 1J of potential energy. Explain what does it mean?

Ans: An object having one joule P.E means that body has a capacity to do a work of one joule. For example, if an object is lifted up ad one joule of work is done in doing so then this work done will be stored in the body in the form of P.E. When the same object i.e. having P.E of 1J, is allowed to fall it will do one joule work.

6- A ball of mass m is held at a height h_1 above a table. The table top is at height h_2 above the floor. One student says that ball has potential energy mgh_1, but another says that it is $mg(h_1 + h_2)$. Who is correct?

Ans: Both of them are correct.

Reason: -

Since P.E is always with respect to some reference point. Therefore, we can say that first student has measure P.E with respect to table top.

P.E with **respect to table top** = mgh_1

And the 2nd student measure P.E with respect to floor.

P.E with **respect to floor** = $mg(h_1 + h_2)$

7- When a rocket re-enters the atmosphere, its nose cone becomes very hot. Where does this heat energy come from?

Ans: Source of Heat energy: -

When the rocket re-enters the atmosphere, then some of its K.E is used in doing work done against friction with dust particles and air, which is converted into heat. Due to this heat energy, its nose cone becomes very hot.

8- What sort of energy is in the following?

(a) Compressed spring.
(b) Water in high dam.
(c) A moving car.

Ans: (a) A compressed spring has **Elastic P.E.**
(b) Water in the high dam has **gravitational P.E.**
(c) A moving car has **Kinetic Energy.**

9- A girl drops a cup from a certain height, which breaks into pieces. What energy changes are involved?

Ans: Energy Changes: -

A cup thrown from certain height losses its gravitational P.E and gain its K.E. When it strikes the ground then a part of this K.E is used to break the cup and rest of the energy converts into sound energy and heat energy.

10- A body uses a catapult to thrown a stone which accidently smashes a green-house window. List the possible energy changes?

Ans: Possible Energy Changes: -

The following energy changes occur,

1) When the boy throws the stone the elastic P.E into K.E.
2) When stone hits the window, a part of K.E used to break the window into pieces.
3) Rest of energy converted into heat and sound.

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Chapter # 05 (Circular Motion)
Important Short Questions

1. Define angular displacement. And write its unit.

Ans: **"**The angle subtended at the center of a circle by a body moving along the circumference in a given time is called angular displacement. It is denoted by $\Delta\theta$**"**
Unit: Its S.I unit is radian.

2. State right hand rule to find the direction of angular displacement.

Ans: Right hand rule:
Grasp the axis of rotation in right hand with fingers curling in the direction of rotation then the erect thumb indicates the direction of angular displacement.

3. What is the difference between a degree and radian?

Ans:

Degree	Radian
• The unit of measurement which is used to measure in plane angles is called degree. • $1^o = \frac{\pi}{180}$	• A unit of measurement which is used to measure angles is called radian. • A radian is equal to 180^o. • **π radian = 180^o**

4. Prove that S = rθ

Ans: Proof:
Consider a body moving in a circle of radius "r". After a small interval of time, it moves from A to B. If "O" is the center of the circle, then $\angle AOB = \theta$ is called angular displacement.

$$\text{Angular displacement} = \frac{\text{arc length}}{\text{radius}}$$

$$\theta = \frac{\overset{\frown}{AB}}{r}$$

$$\theta = \frac{S}{r}$$

$$\mathbf{S = r\theta}$$

5. Define angular velocity (angular frequency). Give its formula and unit. How can we find the direction of angular velocity?

Ans: Angular velocity:
"The time rate of change of angular displacement is called angular velocity**"**

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

Unit: Its S.I unit is $rads^{-1}$.
Direction:
It is a vector quantity. Its direction is along the axis of rotation and can be determined by right hand rule.

Right hand rule:

Grasp the axis of rotation in right hand with fingers curling in the direction of rotation then the erect thumb indicates the direction of angular velocity.

6. Define angular acceleration and instantaneous acceleration. Write its formula and unit.

Ans: Angular Acceleration:

"The time rate of change of angular velocity is called angular acceleration"

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

Instantaneous Acceleration:

"The limiting value of Δθ/Δt as the time interval Δt. Following the time t, approaches to zero is called instantaneous acceleration"

$$\alpha_{ins} = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$$

Unit: Its S.I unit is $rads^{-2}$.

7. Define positive angular acceleration and negative angular acceleration.

Ans: Positive Angular Acceleration:

"When a body covers angular displacement Δθ in counter clock wise direction then acceleration is produced in this body called positive angular acceleration"

Negative Angular Acceleration:

"When a body covers angular displacement Δθ in clock wise direction then acceleration is produced in this body called negative angular acceleration"

$$\alpha_{ins} = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$$

Unit: Its S.I unit is $rads^{-2}$.

8. Drive the relation between linear velocity and angular velocity. OR Prove that v = rω

Ans: Proof:

As we know that

$$S = r\theta$$
$$\Delta S = r\Delta\theta$$

Dividing both side by time

$$\frac{\Delta S}{\Delta t} = r\frac{\Delta\theta}{\Delta t}$$

Now applying limit on both sides.

$$\lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t} = \lim_{\Delta t \to 0} r\frac{\Delta\theta}{\Delta t}$$

$$\lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t} = r\left(\lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}\right)$$

$$\mathbf{v = r\omega}$$

9. Drive the relation between linear acceleration and angular acceleration. OR Prove that a = rα

Ans: Proof:

As we know that

$$v = r\omega$$
$$\Delta v = R\omega$$

Dividing both side by time

$$\frac{\Delta v}{\Delta t} = r\frac{\Delta \omega}{\Delta t}$$

Now applying limit on both sides.

$$\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \lim_{\Delta t \to 0} r\frac{\Delta \omega}{\Delta t}$$
$$\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = r\left(\lim_{\Delta t \to 0} \frac{\Delta \omega}{\Delta t}\right)$$
$$\mathbf{a = r\alpha}$$

10. Define centripetal acceleration and centripetal force.

Ans: Centripetal Acceleration:

"The instantaneous acceleration of an object travelling with uniform speed in a circle is directed towards the center of the circle is called centripetal acceleration"

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

Centripetal Force:

"The force which compels a body to move in a circular path is called centripetal force"

OR

"The force which bends the normally straight path of a particle intro circular path is called centripetal force"

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

Examples:

- Force acting on electrons in fixed orbits around the nucleus.
- Force acting on earth around the sun

11. Define moment of inertia. How it is related to torque.

Ans: Moment of Inertia:

"The moment of inertia of a particle is defined as the product of mass and the square of its perpendicular distance from axis of rotation."

Mathematically,

$$I = mr^2$$

How it is related to torque?

$$F = ma$$
$$F = m(r\alpha) \qquad \text{As } a = r\alpha$$

Multiply both sides of "r"

$$rF = mr(r\alpha)$$

$$rF = mr^2 \alpha$$
$$\boldsymbol{\tau = I\alpha}$$

12. Give practical uses of rotational K.E by fly wheels.

Ans: Uses of rotational K.E:

Practically, rotational K.E is used by fly wheels, which are essential parts of many engines. A fly wheel stores energy between the power strokes of pistons. So, that energy is uniformly distributed over the full revolution of the crank shaft and hence, the rotation remains smooth.

13. What is difference between real and apparent weight?

Ans:

Real Weight	Apparent Weight
• The gravitational pull of the Earth on the body is called real weight. • It depends upon mass and gravitational acceleration. • Its formula is W = mg	• The reading of the spring balance when the object is accelerating up or down is called apparent weight. • It depends upon the acceleration of upward or downward moving objects. • Its formulae are **Increase in Weight:** T = w + ma **decrease in Weight** T = w - ma

14. What is artificial gravity? Write down expression for its frequency.

Ans: Artificial Gravity:

"The gravity like effect produced in an orbiting satellite by spinning it around its own axis is called artificial satellite"

Expression for frequency:

For the creation of artificial gravity, the artificial satellite set into rotation with a particular frequency around own axis.

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$$

15. Define geostationary satellites. And write down its uses.

Ans: Geostationary Satellites:

"The satellite which completes its one revolution around Earth in 24 hours is called geo-stationary satellites"

Uses of Geostationary Satellites:

There are a lot of applications of geostationary satellites. Some of them are following.

- Weather forecasting
- GPS navigation
- Military purposes
- Telecommunication

16. What is meant by INTELSAT? AT what frequencies the, INTELSAT – IV operates?

Ans: INTELSAT means international telecommunication satellite organization. It is managed by 126 countries. It works at the microwave frequencies of 4,6,11 and 14 GHz and has the capacity of 30,000 two-way telephone circuit plus three T.V channels.

17. What is the main difference between Newton's and Einstein view of gravitation?

Ans:

Newton's view of gravitation	Einstein's view of gravitation
• According to Newton's theory, the gravitation is the intrinsic property of matter that every particle of matter every other particle with a force that is directly proportional to the product of their masses and is inversely proportional to the square of distance between them. • Gravitation is due to force between them.	• According to Einstein's view of gravitation, gravity is due to the curvature of space and time caused by masses. • In Einstein's view, we don't speak about gravity acting on bodies, but we say that bodies and light rays move along geodesics in curved space.

Exercise Short Questions

1. Explain the difference between tangential velocity and the angular velocity, if one of these given for a wheel of known radius, how will you find the other?

Ans:

Tangential Velocity	Angular Velocity
• Velocity of a body along the tangent is known as tangential velocity. • Its unit is ms^{-1}. • Its direction is along the tangent. $v_t = \frac{\Delta \vec{d}}{\Delta t}$, $v = r\omega$	• The rate of change of angular displacement is called angular velocity. • Its unit is $rads^{-1}$. • Its direction is along the axis of rotation. $\vec{\omega} = \frac{\Delta \vec{\theta}}{\Delta t}$, $\omega = \frac{v}{r}$

If one of the them is given for a wheel of known radius, then the other can be calculated using the relation $v = r\omega$

2. Explain what is meant by centripetal force and why it must be furnished to an object if the object is to follow a circular path?

Ans: The force which bends the normally straight path into circular path is called centripetal force.

OR

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

Mathematically,

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

Significance:

It is perpendicular to the tangential velocity and directed towards the centre of the circular path. Without centripetal force body will move along the tangent.

3. What is meant by moment of inertia? Explain its significance.

Ans: The moment of inertia of a particle is defined as the product of mass and the square of its perpendicular distance from axis of rotation.

Mathematically,

$$I = mr^2$$

Physical meaning:

The moment of inertia plays same role during angular motion which plays mass during linear motion. Mass is the measure of linear inertia while moment of inertia measures of rotational inertia of a body. Moment of inertia determine the angular acceleration while mass determine the linear acceleration.

4. What is meant by angular momentum? Explain the law of conservation of angular momentum?

Ans: The product of moment of inertia and angular velocity of a rotating body is called angular momentum. It is denoted by $\vec{L}$. Mathematically,

$$\vec{L} = \vec{r} \times \vec{P}$$

$$\vec{L} = r\,p\sin\theta$$

$$\vec{L} = m\,v\,r\sin\theta$$

Law of conservation of momentum:

The total angular momentum of the system remains constant, when no external torque acts on it.

Mathematically,

$$L_{total} = L_1 + L_2 + L_3 + \ldots\ldots\ldots = I\omega = \text{Constant}$$

5. Show that orbital angular momentum $L_o = mvr$

Ans: Proof:

Consider particle of mass m moving in a circle of radius r as shown in figure.

As

$$\vec{L} = \vec{r} \times \vec{P}$$

$$L_o = r\,p\sin\theta$$

Where θ is the angle between **r** and **P**.

$$L_o = r\,(mv)\sin\theta \qquad (P = mv)$$

$$L_o = m\,v\,r\sin\theta$$

As the angle between **r** and **P** is 90°.

$$L_o = m\,v\,r\sin 90$$

$$L_o = m\,v\,r\,(1)$$

$$L_o = m\,v\,r$$

Hence, it is proved.

6. Describe what should be the minimum velocity, for a satellite, to orbit close to the earth around it.

Ans: Critical Velocity:

The minimum velocity needed to orbit a satellite close to the earth is called critical velocity.

Calculation:

Consider a satellite of mass m is moving with velocity v in a circle of radius R (radius of the earth). Since, gravitational force provides the necessary centripetal force.

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

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

$$v^2 = gR$$

So,

$$v = \sqrt{gR}$$

$$v = \sqrt{9.8 \times 6.4 \times 10^6}$$

$$v = 7900\ ms^{-1}$$

$$v = 7.9\ kms^{-1}$$

7. State the direction of the following vectors in simple situation; angular momentum and angular velocity.

Ans: The direction of angular momentum and angular velocity is determined by right hand rule.

For Angular Momentum:

We know that $\vec{L} = \vec{r} \times \vec{P}$

This shows that the direction of angular momentum is perpendicular to the plane containing $\vec{r}$ and $\vec{P}$.

In case of circular motion, angular momentum is perpendicular to the plane of circle and is along axis of rotation.

8. Explain why an object, orbiting the earth, is said to be freely falling. Use your explanation to point out why objects appear weightless under certain circumstances.

Ans: Explanation:

When the object is thrown horizontally fast enough from a certain height, so that the curvature of its path will match with the curvature of earth then the object simply revolves round the Earth. Now, the motion of the object is under the constant acceleration due to gravity (equal to centripetal acceleration). Hence, we can say the orbiting body is freely falling body.

Weightlessness of the body:

A freely falling body moves only under the action of gravitational force so that the object is said to be in state of weightlessness.

9. When mud flies off the tyre of a moving bicycle, in what direction does it fly? Explain it.

Ans: The mud flies off along the tangent to the tyre.

Reason:

When speed of bicycle increases then adhesive force (Sticking force) between the mud and the tyre is not sufficient to provide the necessary centripetal force so that mud leaves the tyre and moves along tangent to tyre.

10. A disc and a hoop start moving down from the top of an inclined plane at the same time. Which one will be moving faster on reaching the bottom?

Ans: Disc will be moving faster on reaching the ground.

Proof:

Speed of hoop at the bottom of inclined plane is,

$$v_{hoop} = \sqrt{gh}$$

Speed of the disc moving down the inclined plane is,

$$v_{disc} = \sqrt{\frac{4}{3}gh} = \sqrt{\frac{4}{3}} \times \sqrt{gh}$$

$$v_{disc} = 1.15v_{hoop}$$

$$v_{disc} > v_{hoop}$$

11. Why does a diver change its positions before and after diving in the pool?

Ans: The diver changes his body to make extra somersaults.

Explanation:

When a diver lifts off from the living board, his legs and arms are full extended. In this case his moment of inertia is large (I_1) but angular velocity (ω_1) is small.

When the legs and arms of the diver are drawn into the closed tuck position, its moment of inertia is reduced considerably so that its angular velocity will increase to conserve the angular momentum.

$$I_1\omega_1 = I_2\omega_2$$

12. A student holds two dump-bells stretched arms while sitting on a turn table. He is given a push until he is rotating at certain angular velocity. The student then pulls the dumb-bells towards his chest. What will be the effect on rate of rotation?

Ans: Rate of rotation increases when student pulls the dumb-bells towards its chest.

Reason:

When the student pulls the dumb-bells towards its chest, his moment of inertia decreases and to conserve angular momentum, his angular velocity increases and he spins faster.

13. Explain how many minimum number of geo-stationary satellites are required for global coverage of T.V transmission.

Ans: Minimum three correctly positioned geo-stationary satellites are required for the global coverage of T.V transmission.

Explanation:

As each satellite in geo-stationary orbit covers 120° of longitude so that whole populated Earth's surface can be covered by three correctly positioned geo-stationary satellites.

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Chapter # 06 (Fluid Dynamics)
Important Short Questions

1. What is Stoke's law? Write its formula and limitation.

Ans: Stoke's Law:

This law states that the drag force "F" acting on a sphere of radius "r" moving slowly with velocity "v" in a fluid of viscosity "η" is given by

$$F = 6\pi\eta rv$$

Limitation:

This law is valid only for spherical bodies among slowly. For high speeds drag force is not simply proportional to velocity.

2. Define terminal velocity. Write its formula and unit.

Ans: Terminal Velocity:

"The maximum and constant velocity of an object falling vertically downward is called terminal velocity."

$$v_t = \frac{2gr^2\rho}{9\eta}$$

Its unit is ms^{-1}.

3. What are the conditions for ideal fluid?

Ans: Condition for ideal fluid:

The conditions for ideal fluid are given below:

- The fluid is non-viscous i.e., there is no internal frictional force between adjacent layers of fluid.
- The fluid is incompressible i.e., its density is constant.
- The fluid motion is steady.
- The fluid is irrotational flow.

4. State equation of continuity. Write its equation.

Ans: Equation of Continuity:

"For an ideal fluid, the product of cross-sectional area of the pipe and the fluid speed at any point along the pipe is a constant."

OR

"For an ideal fluid, the volume flow per second of the fluid (flow rate) always remains constant."

$$A_1 v_1 = A_2 v_2$$

$$Av = \text{constant}$$

5. State Bernoulli's equation. Write its equation.

Ans: Bernoulli's Equation:

"The sum of pressure, K.E. per unit volume and P.E. per unit volume of an incompressible, non-viscous fluid flowing in steady state is constant at each point along a stream line."

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{Constant}$$

6. State Torricelli's theorem. Write its equation.

Ans: Torricelli's Theorem:

"The speed of efflux is equal to the velocity gained by the fluid in falling through the distance $(h_1 - h_2)$ under the action of gravity"

$$v_2 = \sqrt{2g(h_1 - h_2)}$$

7. Explain how the lift is produced in an aeroplane?

Ans: Lift on an aeroplane:

The lift on an aeroplane is due to the effect, where speed of fluid is high, its pressure will be low.

Explanation:

The design of wing deflects the air in such a way that streamlines are closer together above the wing than lower side. Air moves faster at the upper side of the wing than the lower side. Pressure is lower at the top of the wing. Hence, the wing experiences a net upward force.

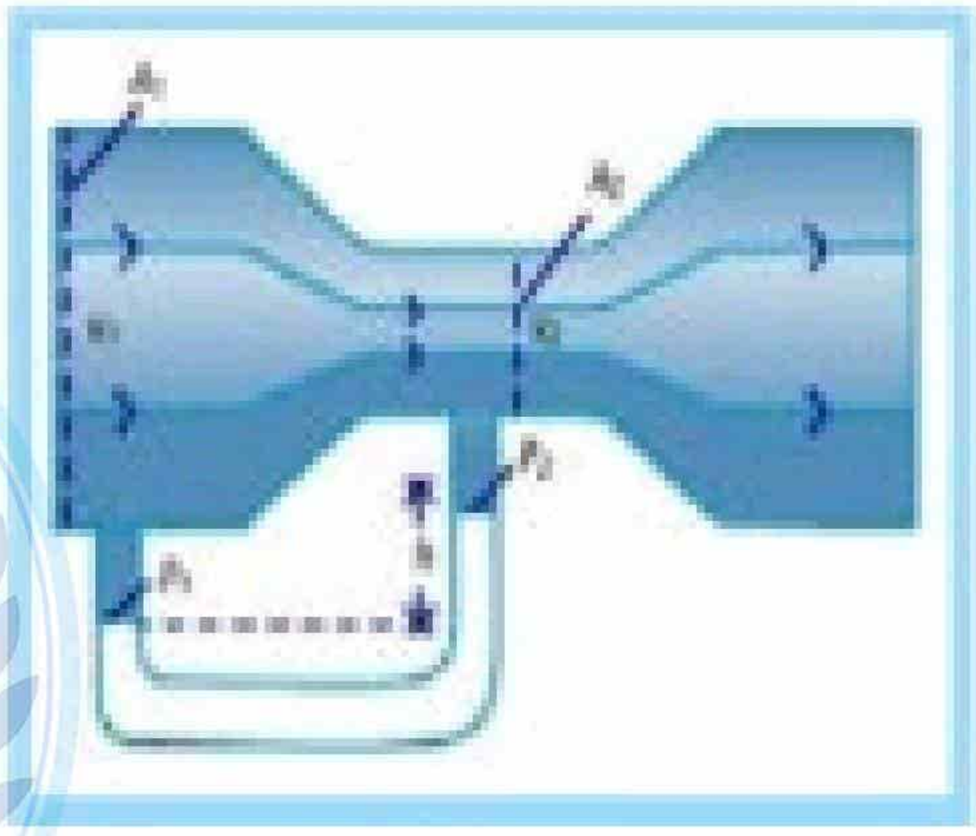
8. Drive Venturi relation. OR Drive the relation between speed and pressure of the fluid.

Ans: Derivation of Venturi relation:

Suppose that an ideal fluid flows through a horizontal pipe system. The area of cross section of pipe at A_2. The speed of fluid at A_2 is greater than at A_1.

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$$

As the pipe system is horizontal, therefore $h_1 = h_2$



$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

$$P_1 - P_2 = \frac{1}{2}\rho V_2^2 - \frac{1}{2}\rho V_1^2$$

$$P_1 - P_2 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

Special Case:

If $A_1 >> A_2$, therefore $v_1 << v_2$

$$A_1V_1 = A_2V_2$$

$$v_1 = \left(\frac{A_2}{A_1}\right)v_2 \approx 0$$

$$P_1 - P_2 = \frac{1}{2}\rho\left(V_2^2 - 0\right)$$

$$P_1 - P_2 = \frac{1}{2}\rho V_2^2$$

9. What is difference between systolic pressure and diastolic pressure?

Ans:

Systolic Pressure	Diastolic Pressure
• The maximum pressure in the arteries when the heart contracts is called systolic pressure. • The value of systolic pressure is **120 torr**.	• The minimum pressure in the arteries when the heart is at rest is called diastolic pressure. • The value of diastolic pressure is **75 – 80 torr**

Exercise Short Questions

1. Explain what do you mean by terminal velocity?

Ans: The frictional effect between different layers of a flowing fluid is called viscosity of fluid.

Example:

(i) Glycerine, honey and thick tar has highest viscosity.
(ii) Water has low viscosity.

- It measures that how much force is required to slide one layer of the liquid over layer.
- It is represented by "η". And its unit is $kgm^{-1}s^{-1}$ or $Nm^{-2}s$
- Its dimension is $[ML^{-1}T^{-1}]$.

2. What is meant by drag force? What are the factors upon which drag force acting upon a small sphere of radius r moving down through a liquid, depend?

Ans: Drag Force:

When an object moving through a fluid, it experience a retarding force called drag force.

Factors:

According to Stoke's law, drag force is given by,

$$F = 6\pi \eta r v_t$$

This equation shows that drag force depends upon;

- Speed of sphere (v)
- Radius of Sphere (r)
- Coefficient of viscosity of medium (η)

3. Why fog droplets appear to be suspended in air?

Ans: Fog droplets appear to be suspended in air.

Reason:

Terminal velocity of a fog droplet is

$$v_t = \frac{mg}{6\pi\eta r}$$

$$v_t \propto mg$$

As the weight of a fog droplets is very small, the drag force becomes equal to its weight very quickly. Thus, terminal velocity is very small and hence the droplet appears to be suspended.

4. Explain the difference between laminar flow and turbulent flow?

Ans:

Laminar Flow	Turbulent Flow
• If every particle that passes a particular point moves along exactly the same path, as following by the particle which passed that point earlier, then the fluid is called laminar flow. • In this case, each particle of fluid moves along a smooth path called streamline or laminar. **Examples** • Flow of gentle breeze. • Flow of water around dolphins.	• The irregular or unsteady flow of the fluid is called turbulent flow. • In turbulent flow, there is great disorder and a constantly changing pattern. **Examples** • Flow of water from the top of mountain. • Water flow at sea shores. • Flow of water in the form of water fall.

5. State the Bernoulli's relation for a liquid in motion and describe some of its application?

Ans: It states that;

"For an ideal fluid, the sum of pressure, kinetic energy per unit volume and the P.E per unit volume at any point along a streamline always remains constant."

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{Constant}$$

Applications:

- The swing of ball
- Lift on an aeroplane
- Working of carburettor
- Blood flow

6. A person is standing near a fast-moving train. Is there any danger that he will fall towards it?

Ans: Yes, there is danger that he will fall towards the train.

Reason:

When fast moving train passes near the person, speed of air between the train and the person increases. According to Bernoulli's equation;

"Where the speed of fluid is high, its pressure will be low."

So, pressure between train and the person decreases. Hence large pressure behind the person pushes him towards the train.

7. Identify the correct answer. What do you infer from Bernoulli's theorem?

(a) Where the speed of liquid is high the pressure will be low?

(b) Where the speed of the liquid is high the pressure is also high?

(c) This theorem is valid only for turbulent flow of the liquid?

Ans: Where the speed of liquid is high the pressure will be low.

8. Two row boats moving parallel in the same direction are pulled towards each other. Explain?

Ans: When the two row boats moving parallel in the same direction then the speed of water between the boats is greater than the speed of water on the other sides of the boats.
According to Bernoulli's equation;

"Where the speed of fluid is high, its pressure will be low."

Therefore, the pressure of between the boats decreases and they are pulled towards each other.

8. Explain, how the swing is produced in a fast-moving cricket ball?

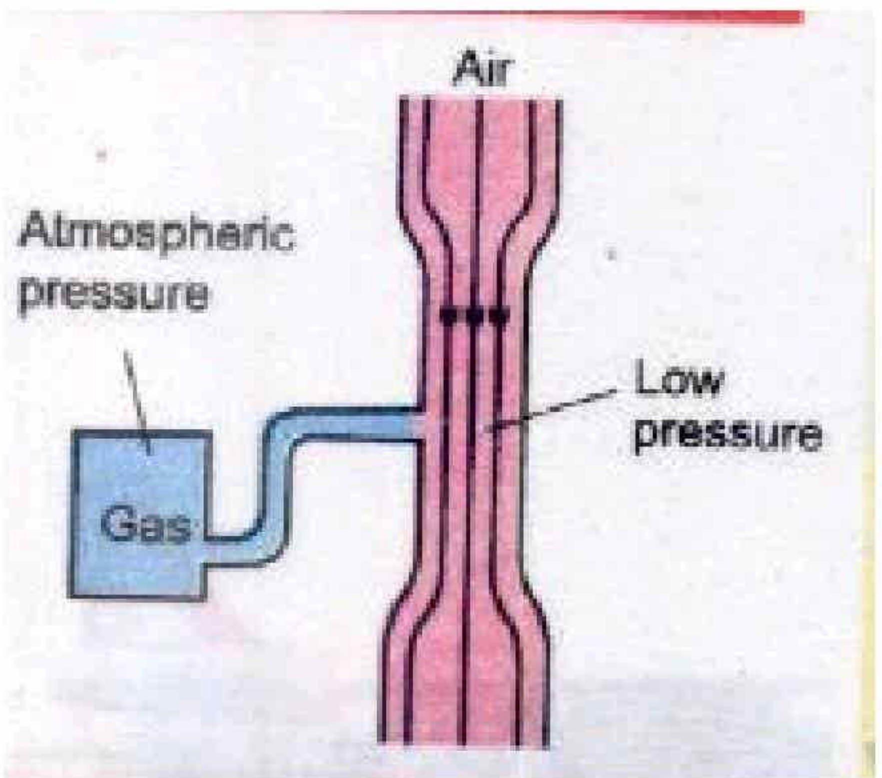
Ans: When the ball moves forwards as well as spins, the speed of air on its one side becomes greater as compared to the other. According to Bernoulli's equation;

"Where the speed of fluid is high, its pressure will be low."

So, at that side, the pressure of air decrease. A net force acts on the ball extra curvature to the ball called swing.

9. Explain the working of a carburettor of a motorcar using Bernoulli's principle.

Ans: The carburettor of a car engine uses a Venturi duct to feed the correct mature of air and fuel (Petrol) to the cylinders. Air is drawn through the duct and along the pipe to the cylinders. A tiny inlet at the side of duct is fed with petrol, the air through the duct moves very fast, creating low pressure in the duct, which draws petrol vapours into the air stream.



10. For what position will be maximum blood pressure (Systolic pressure) in the body having the smallest value. **(a) Standing Up** **(b) Sitting** **(c) Lying horizontal** **(d) Standing on one's head?**

Ans: Lying horizontal.

(a) Standing upright, systolic pressure has maximum value in the neck.
(b) Sitting, systolic pressure has maximum value in the neck.
(d) In this case, pressure has maximum value in the legs.

11. In an orbiting space station, would the blood pressure in major arteries in the leg ever be greater than the blood pressure in major arteries in the neck?

Ans: Blood pressure would be same.

Reason: -

In a orbiting space station, everything is in a state of weightlessness. So, pressure will be same in major arteries of both in neck and legs.

Chapter # 07 (Oscillations)

Important Short Questions

1. What is harmonic oscillator? Give two examples.

Ans: Harmonic Oscillator:

A body executing simple harmonic motion is called harmonic oscillator.

Example:

- Mass spring system
- Simple pendulum

2. Define SHM. Give two examples.

Ans: Simple Harmonic Motion:

The oscillator motion, in which acceleration of the body at any instant is directly proportional to the displacement from the mean position and always directed towards the mean position is called simple harmonic motion.

Example:

- Motion of simple pendulum
- Motion of mass attached to spring

3. Define instantaneous displacement and amplitude.

Ans: Instantaneous Displacement:

The distance of the vibrating body at any instant from its mean position is called instantaneous displacement.

It is denoted by "x". The value of instantaneous displacement is zero at mean position while it has maximum value at the extreme position.

Amplitude:

The maximum value of displacement of the vibrating body on either sides from its mean position is called amplitude.

It is denoted by "x_o".

4. Define vibration, time period and frequency.

Ans: Vibration:

One complete round trip of a vibrating body about its mean position is called one vibration.

Time Period:

The time required to complete one vibration is called time period.

It is represented by "T". Its unit is "sec".

Frequency:

The number of vibrations completed in one second by the vibrating body is called frequency.

It is represented by "f". Its unit is Hertz (Hz)

$$f = \frac{1}{T}$$

5. Define Hook's law. Write its formula.

Ans: Hook's Law:

The restoring force is directly proportional to the displacement from the mean position.

$$\mathbf{F \propto -x}$$

$$\mathbf{F = -kx}$$

6. Define spring constant. Write its formula and unit.

Ans: Spring Constant:

The ratio of restoring force to the displacement from the mean position is called spring constant.

$$\mathbf{K = \frac{F}{x}}$$

Its unit is Nm^{-1}.

7. On which factors time period of mass spring system depends?

Ans: The formula for the time period of mass spring system is given as

$$\mathbf{T = 2\pi\sqrt{\frac{m}{k}}}$$

It depends upon:

- Mass of the body
- Spring constant

8. Define simple pendulum. Write the formula of its time period.

Ans: Simple Pendulum:

An ideal simple pendulum consists of a small mass suspended by a weightless, flexible and inextensible string with a frictionless support and medium.

$$\mathbf{T = 2\pi\sqrt{\frac{l}{g}}}$$

9. What is second pendulum? Calculate its frequency and length.

Ans: Second Pendulum:

The pendulum whose time period is 2 second is called second pendulum.

Frequency:

$$f = \frac{1}{T}$$

$$f = \frac{1}{2}$$

$$\mathbf{f = 0.5Hz}$$

Length:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T^2 = 4\pi^2 \times \left(\frac{l}{g}\right)$$

$$l = \frac{gT^2}{4\pi^2}$$

As T = 2 sec

$$l = \frac{9.81 \times (2)^2}{4(3.14)^2}$$

l = 99.2 cm

10. What is the difference between free oscillations and forced oscillation?

Ans:

Free Oscillation	Forced Oscillation
• A body is said to be executing free vibrations if it oscillates with its natural frequency without the interference of an external force. • A simple pendulum vibrates freely with its natural frequency that depends only upon the length of the pendulum.	• A body is said to be executing forced oscillation if it oscillates with interference of an external force. • If the mass of vibrating pendulum is struck repeatedly, then forced oscillation is produced.

11. What is resonance? Explain it with examples.

Ans: Resonance:

"The phenomenon in which the amplitude of a vibrating body increases when the frequency of an applied force is equal to the natural frequency of the harmonic oscillator is called resonance."

(i) Suspension Bridge:

The column of soldiers, while marching on a bridge of long span are advised to break their steps. Their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure.

(ii) Turning of a radio:

Turning of radio is a good example of electrical resonance. We turn the knob of a radio. It changes the natural frequency of electrical circuit of receiver until it becomes equal to the frequency of the transmitter. So, resonance is produced and energy absorption is maximum. Hence, station is tuned.

12. What is difference between damped oscillations and un-damped oscillations?

Ans:

Damped Oscillations	Un-damped Oscillations
• The oscillation in which amplitude decreases with time due to energy dissipation are called damped oscillation. • Shock absorber is an example of damped oscillation.	• The oscillation in which amplitude remain same with time are called un-damped oscillation. • Oscillation of an ideal pendulum is an example of un-damped oscillation.

13. What is difference between simple harmonic oscillator and driven harmonic oscillator?

Ans:

Simple Harmonic Oscillator	Driven Harmonic Oscillator
• A harmonic oscillator is a system in which an object vibrates with a certain amplitude and frequency. • The amplitude of simple harmonic oscillator always remains same.	• A physical system under going forced vibrations is known as driven harmonic oscillator. • The amplitude of driven harmonic oscillator decreases gradually.

Exercise Short Questions

1. Name two characteristics of simple harmonic motion.

Ans: The characteristics of simple harmonic motion are given below:

- Restoring force is directly proportional to the displacement from mean position $\vec{F} \propto -\vec{x}$
- Acceleration is directly proportional to displacement from mean position and is directed towards the mean position. $\vec{a} \propto -\vec{x}$
- Total energy of system is conserved in SHM. [T.E = K.E + P.E]

2. Does frequency depends on amplitude for harmonic oscillations?

Ans: No, it does not depend upon amplitude of harmonic oscillator.

Reason:

In case of simple pendulum is,

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

In case of mass spring system,

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

These equations show that frequency of simple harmonic oscillator is independent of amplitude.

3. Can we realize an ideal simple pendulum?

Ans: No, we cannot realize an ideal simple pendulum.

Reason:

An ideal simple pendulum consists of point mass suspended by massless and inextensible string. In practical, it is not possible.

4. What is the total distance travelled by an object moving with SHM in a time equal to its period, if its amplitude is A?

Ans: The total distance covered by the body is 4A.

Explanation:

Time period is the time during which the vibrating body completes one round trip. In one round trip

Total distance covered = A + A + A + A = 4A

5. What happens to the time period of the simple pendulum if its length is doubled? What happens if the suspended mass is doubled?

Ans: The time period of the simple pendulum is,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Effect of doubling the length:

- If $l' = 2l$

$$T' = 2\pi\sqrt{\frac{2l}{g}}$$

$$T' = \sqrt{2}\left(2\pi\sqrt{\frac{l}{g}}\right)$$

$$T' = \sqrt{2}\ T$$

Effect of doubling the mass: -

When mass become doubled, the time period remains same. Because time period of simple pendulum is independent of mass. So, it does not change with mass.

6. Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain?

Ans: No, it does not constant.

Reason:

The acceleration of the body executing SHM is,

$$\vec{a} = -\omega^2\vec{x}$$

$$\vec{a} \propto -\vec{x}$$

This shows that acceleration varies directly with displacement.

Zero Acceleration:

Above equation shows that acceleration is zero at mean position where the value of displacement is zero ($x = 0$).

7. What is meant by phase angle? Does it define the angle between maximum displacement and the driving force?

Ans: Phase angle:

"The angle which specifies the displacement as well as direction of motion of point executing SHM. Is called phase angle.**"**

$$\boldsymbol{\theta = \omega t + \varphi}$$

No, it does not define the angle between maximum displacement and the driving force. It is the angle between the rotating vector and reference line. Phase angle $\theta = \omega t$, where ω is angular frequency and t is any instant od time.

8. Under what conditions does the addition of two simple harmonic motions produce a resultant, which is also simple harmonic?

Ans: The addition of two simple harmonic motions produce a resultant, which is also simple harmonic when,

Conditions:

The two simple harmonic motions have:

- Same frequency
- Same nature and parallel to each other (mechanical waves cannot be superposed with electromagnetic waves)
- Constant phase difference

9. Show that in SHM the acceleration is zero when the velocity is greatest and the velocity is zero where the acceleration is greatest?

Ans: Acceleration is zero where velocity is greatest: -

We know that $a = -\omega^2 x$ and $v = \omega\sqrt{x_o^2 - x^2}$

When $x = 0$ $a = 0$ and $v = \omega x_o$

Therefore, at mean position acceleration is zero and velocity is maximum.

Velocity is zero when acceleration is greatest:

When $x = x_o$ $a = -\omega^2 x_o$ and $v = 0$

Therefore, at extreme position acceleration is maximum and velocity is zero.

10. In relation to SHM, explain the equations;

(i) $y = A\sin(\omega t + \varphi)$ (ii) $a = -\omega^2 x$

Ans:

(i) $y = A\sin(\omega t + \varphi)$

Wave form of SHM is sinusoidal.

- Y = instantaneous displacement.
- A = amplitude
- φ = initial angle
- $\omega t + \varphi$ = phase angle

(ii) $a = -\omega^2 x$

Acceleration of SHM depends directly proportional to displacement and directed towards mean position.

- a = instantaneous acceleration
- x = instantaneous displacement
- ω^2 = angular frequency

11. Explain the relation between total energy, potential energy for a body oscillating with SHM?

Ans: The total energy for a body oscillating with SHM remains constant.

- At extreme position, the whole energy is in the form of P.E. $(P.E)_{max} = \frac{1}{2}kx_o^2$
- At mean position, the whole energy is in the form of K.E. $(K.E)_{max} = \frac{1}{2}kx_o^2$
- At any point between mean and extreme position, total energy during SHM remains constant.

12. Describe some common phenomenon in which the resonance plays an important role?

Ans:

(i) Suspension Bridge:

The column of soldiers, while marching on a bridge of long span are advised to break their steps. Their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure.

(ii) Turning of a radio:

Turning of radio is a good example of electrical resonance. We turn the knob of a radio. It changes the natural frequency of electrical circuit of receiver until it becomes equal to the frequency of the transmitter. So, resonance is produced and energy absorption is maximum. Hence, station is tuned.

13. If a mass spring system is hung vertically and set into oscillation, why does motion eventually stop?

Ans: It eventually stops due to friction.

Reason:

When a mass spring system vibrates, it gradually loses its energy in doing work against frictional forces. So, amplitude of vibration becomes smaller and smaller and hence the motion eventually stops.

Chapter # 08 (Waves)

Important Short Questions

1. Differentiate between mechanical waves and electromagnetic waves.

Ans:

Mechanical Waves	Electromagnetic Waves
• Waves which require any medium for their propagation are called mechanical waves. • For example, Water waves, Sound waves.	• Waves which do not require any medium for their propagation are called electromagnetic waves. • For example, Radio waves, Television waves.

2. Differentiate between longitudinal waves and transverse waves.

Ans:

Longitudinal waves	Transverse waves
• The waves in which the particles of the medium move back and forth along the direction of propagation of wave is called the longitudinal waves. • For example, Sound waves, Waves produced in slinky.	• The waves in which the vibratory motion of particles of the medium is perpendicular to the direction of waves is called transverse waves • For example, Water waves, string waves and waves produced in slinky.

3. Why did Newton's fail to calculate the velocity of sound accurately?

Ans: Newton's failed to calculate the speed of sound accurately.

Reason:

Newtons assumed that it is **isothermal process**. The temperature of the air during a compression or refraction remains constant but the temperature of air does not remain constant. As it is an **adiabatic process.**

4. What are the effects of pressure and density on speed of sound?

Ans: Effect of Pressure:

There is no effect of pressure on speed of sound.

Reason:

As we know that,

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Since density is directly proportional to the pressure. When pressure of gas is increases, density of gas also increases, so the speed of sound remains same.

Effect of density:

At constant pressure and temperature having same value of γ, the speed of sound is inversely proportional to the square root of their densities.

$$v = \sqrt{\frac{\gamma p}{\rho}}$$

$$v = \sqrt{\gamma P} \times \frac{1}{\sqrt{\rho}}$$

$$v = \text{constant } \frac{1}{\sqrt{\rho}}$$

$$v \propto \frac{1}{\sqrt{\rho}}$$

Example:

The speed of sound in hydrogen is **four times** to its speed of sound in oxygen because density of oxygen is **sixteen times** as that of hydrogen.

5. Why sound travel faster in hydrogen than in oxygen?

Ans: Sound travel faster in hydrogen than in oxygen.

Reason:

The speed of sound in hydrogen is **four times** to its speed of sound in oxygen because density of oxygen is **sixteen times** as that of hydrogen.

6. What is effect of temperature on the speed of sound?

Ans: Effect of temperature:

The speed of sound increases by increasing the temperature of gas. When a gas is heated at constant pressure then density is increased.

Reason:

As we know that,

$$V_t = V_o + 0.61t$$

This equation shows that with one-degree Celsius rise in temperature, the speed of sound is increased by 0.61 ms^{-1}.

7. State the principle of super position. What are its different cases?

Ans: Principle of Super Position:

If a particle of medium is simultaneously acted upon by a number of waves then the resultant displacement of the particle is the algebraic sum of their individual displacements, this is called superposition principle.

$$y = y_1 + y_2 + y_3 + \ldots\ldots\ldots\ldots + y_n$$

Different cases:

- Two waves having **same frequency** and travelling in the **same direction** produce the phenomenon of interference.
- Two waves of **slightly different frequencies** and travelling in the **same direction** produces beats.
- Two waves of **same frequency** travelling in **opposite direction** produce stationary waves.

8. Define interference. What is constructive and destructive interference?

Ans: Interference:

When two identical waves meet each other in a medium then at some points they reinforce each other effect and at some points they cancel the effect of each other. This phenomenon is called interference.

(i) Constructive interference:

When two identical waves meet each other in a medium then at some points they reinforce each other effects and resultant amplitude becomes maximum. This phenomenon is called interference.

Condition for constructive interference:

Whenever path difference is an integral multiple of wavelength, displacements of two waves are added up. This effect is called constructive interference.

$\Delta S = n\lambda$ Where n = 0, ±1, ±2, ±3, ±4 , ……..

(ii) Destructive interference:

When two identical waves meet each other in a medium then at some points they cancel each other effects and resultant amplitude becomes minimum. This phenomenon is called interference.

Condition for destructive interference:

Whenever path difference is an integral multiple of $\frac{\lambda}{2}$, displacements of two waves cancel each other effects. This effect is called constructive interference.

$\Delta S = (2n+1)\frac{\lambda}{2} n\lambda$ Where n = 0, ±1, ±2, ±3, ±4 , ……..

$$\Delta S = \left(n + \frac{1}{2}\right)\lambda$$

9. What is path difference? What should be the path difference for construction and destructive interference?

Ans: Path Difference:

The distance between the starting point of two waves.

- If both waves start from the same point, then the path difference is equal to zero.
- If one wave starts to move at one point and other wave start to move from another point. Then the distance between these points is called path difference.

(i) Condition for constructive interference:

Whenever path difference is an integral multiple of wavelength, displacements of two waves are added up. This effect is called constructive interference.

$\Delta S = n\lambda$ Where n = 0, ±1, ±2, ±3, ±4 , ……..

(ii) Condition for constructive interference:

Whenever path difference is an integral multiple of wavelength, displacements of two waves cancel each other effects. This effect is called constructive interference.

$\Delta S = (2n+1)\frac{\lambda}{2} n\lambda$ Where n = 0, ±1, ±2, ±3, ±4 , ……..

$$\Delta S = \left(n + \frac{1}{2}\right)\lambda$$

10. What are beats? Write its formula and uses.

Ans: Beats:

When two waves of slightly different frequencies, travelling in the same direction overlap each other then there is a periodic variation of sound between maximum and minimum loudness called beats.

Beats frequency:

Number of beats per second is equal to the difference between frequencies of turning forks.

$$f_A - f_B = \pm n$$

Uses of beats:

Beats are used:

- Tune a string instrument such as piano or violin by beating a note against a note of known frequency.
- Find unknown frequency of vibrating body.
- Produce variety in music.

11. What is effect on phase of a wave when it is reflected from
(i) rare medium (ii) denser medium

Ans: Denser Medium:

If a transverse wave travelling in a rare medium is incident on a denser medium, it is reflected such that it undergoes a phase change of 180^0 (Path difference of $\lambda/2$).

Rare Medium:

If a transverse wave travelling in a denser medium is incident on a rare medium, it is reflected without any change in phase (no path difference).

12. What are stationary waves? How are they produced?

Ans: Stationary Wave:

The resultant wave produced by the superposition of two identical waves travelling in opposite direction is called stationary wave.

Production of Stationary Waves:

Two waves of **same frequency** travelling in **opposite direction** produce stationary waves.

13. On what factors does the fundamental frequency in a stretched string depends?

Ans: As we know that,

$$f = \frac{1}{2l}\sqrt{\frac{F}{m}}$$

Fundamental frequency in a stretched string depends upon:

- Length of string. (l)
- Tension in the string. (F)
- Mass of string per unit length. (m)

14. Which is richer in harmonics? An open organ pipe or a closed organ pipe?

Ans: Open organ pipe is richer in harmonics than a closed organ pipe.

Mathematically,

For organ pipe that is open at both ends:

$$f_n = \frac{nv}{2l}, \qquad n = 1, 2, 3, ...$$

For a closed organ pipe,

$$f_n = \frac{nv}{4l}, \qquad n = 1, 3, 5, ...$$

Open organ pipes due to open ends produce sounds of high frequencies (rich harmonic).

15. Define Doppler's effect. Give its example.

Ans: Doppler's Effect:

The apparent change in the frequency (Pitch) of waves due to the relative motion between the source and observer is called Doppler's effect.

Example:

- The pitch of whistle of an engine coming **towards** the platform appears to become **higher** to an observer standing on the platform.
- The pitch of whistle of an engine coming **away** the platform appears to become **slow** to an observer standing on the platform.

16. Define Doppler shift. Write down its formula.

Ans: Doppler's Shift:

The apparent change (increase or decrease) in wavelength of sound eave in one second is called Doppler's shift.

$$\Delta\lambda = \frac{u_s}{f}$$

17. What do you mean by red shift and blue shift?

Ans: Red Shift:

The frequency of light emitted by star **decreases (wavelength increases)** if it is moving **away** the Earth. Thus spectrum is shifted towards the **longer wavelength** i.e, towards the red end of the spectrum, which is called **red shift**.

Blue Shift:

The frequency of light emitted by star **increases (wavelength decreases)** if it is moving **towards** the Earth. Thus spectrum is shifted towards the **shorter wavelength** i.e, towards the blue end of the spectrum, which is called **blue shift**.

18. Write the applications of Doppler's effect.

Ans: Applications of Doppler's Effect:

Doppler's effect is used in:

- Radar System.
- Speed of Satellite.
- SONAR (Sound and Navigation and Ranging)
- Speed of Star.
- Speed of Car.

Exercise Short Questions

1. What features do longitudinal waves have common with transverse waves?

Ans: Common Features:

- Both types of waves **transport energy**.
- Both types of waves can produce **interference, diffraction, refraction** and **reflection**.
- For determination of **speed of wave**, $v = f\lambda$ is applicable for both waves.

2. The five possible waveforms obtained, When the output form from a microphone is fed into the Y-input of cathode ray of oscilloscope, with the times base on, are shown in fig. These waveforms obtained under the same adjustment of the cathode ray of oscilloscope controls. Indicate the waveform.

(a) Which trace represents the loudest note?

(b) Which trace represents the highest frequency?

Ans: Loudest Note:

In fig (d), the **amplitude** is **maximum**, so **loudness** is **maximum** for this case.

Maximum frequency:

In fig (b), the **number of waves** is **maximum**, so **frequency** is **maximum** in this case.

3. is it possible for two identical waves travelling in the same direction along a string to give rise to a stationary wave?

Ans: No, it is not possible.

Reason:

Stationary waves are produced only when **two identical waves** travelling in **opposite direction** along the same string superpose.

4. A wave is produced along the stretched string but some of its particles permanently show zero displacement. What type of wave is it?

Ans: These waves are stationary waves.

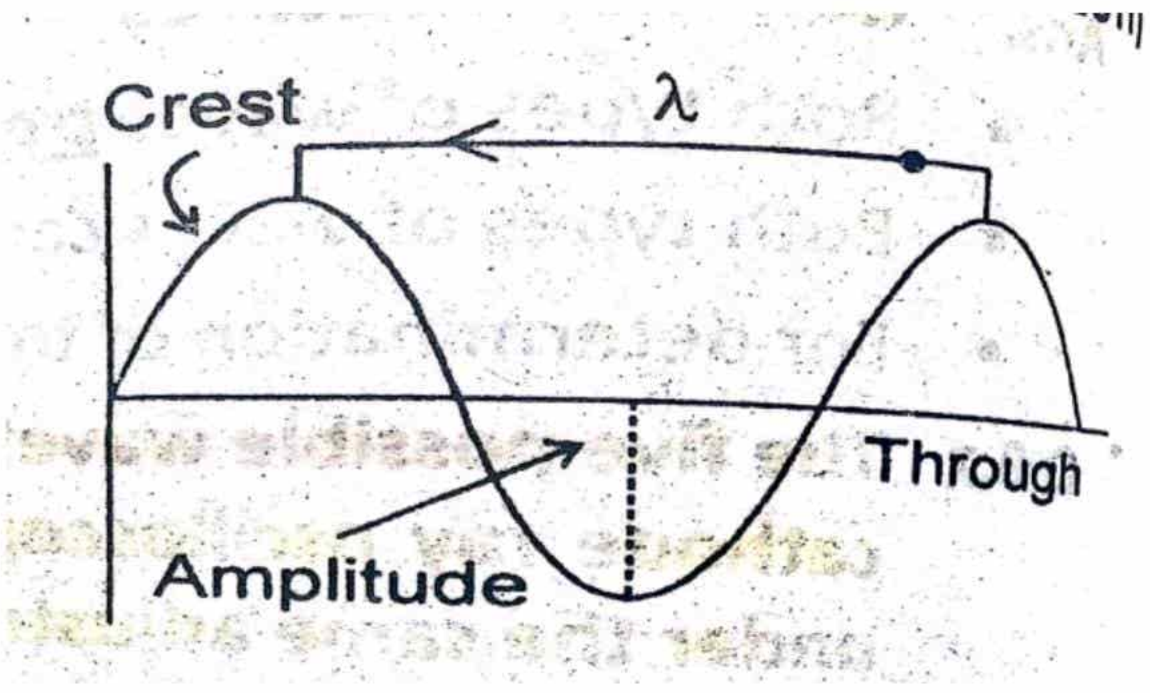
Reason:

Only in stationary waves some points show permanently **zero displacement** called **Nodes** and some points show, **maximum displacement** called **antinode**.

5. Explain the terms, crest, node and antinode.

Ans: Crest:

"The portion of the transverse wave **above** the mean position is called crest."

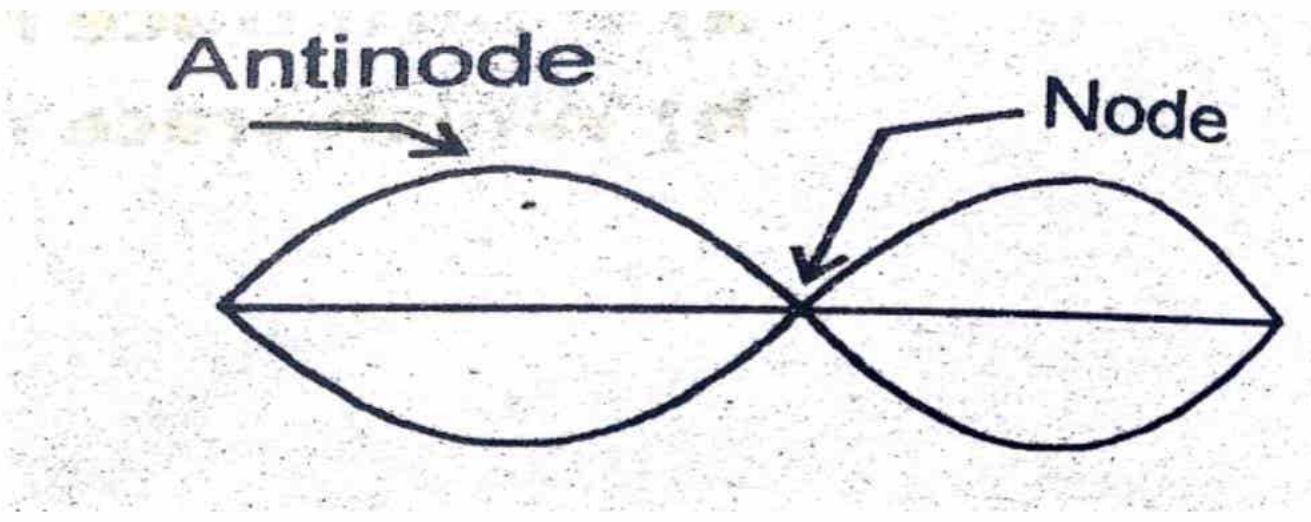


Trough:

"The portion of the transverse wave **below** the mean position is called trough."

Node:

"The points on the stationary wave which show **zero displacement** permanently are called nodes."



Antinode:

"The points on the stationary wave which show **maximum displacement** permanently are called antinodes."

6. Why does sound travel faster in solids than in gases?

Ans: Sound travels faster in solids than in gases.

Reason:

Speed of sound in given as

$$v = \sqrt{\frac{E}{\rho}}$$

Where E is modulus of elasticity ands density of medium. Although the density of solid is greater than ρ density of gases but modulus of elasticity for solids is much greater than for gases. So

$$\sqrt{\frac{E_{solid}}{\rho_{Solid}}} > \sqrt{\frac{E_{gas}}{\rho_{gas}}}$$

Hence, sound travel faster in solids than in gases.

7. How are beats useful in tuning musical instrument?

Ans: Tuning of Musical Instrument:

In order to tune a musical instrument, sound the instrument against the note of known frequency. If the two frequencies do not match, beats will be produced. Adjust the frequency of the unturned instrument by **tightening or loosening** the string. When **no beats** are heard, the instrument is said to be tuned.

8. When two notes of frequencies f_1 and f_2 are sounded together, beats are formed. If $f_1 > f_2$, what will be the frequency of beats?

(i) $f_1 + f_2$ ii) $\frac{1}{2}(f_1 + f_2)$

(iii) $f_1 - f_2$ iv) $\frac{1}{2}(f_1 - f_2)$

Ans: Since beat frequency is equal to the difference of individual interfering frequencies.

Beat frequency = $f_1 - f_2$

9. As a result of a distant explosion, an observer senses a ground tremor and then hears the explosion. Explain the time difference.

Ans: The observer senses the ground tremor first and then hears the explosion.

Reason:

The speed of sound is give as

$$v = \sqrt{\frac{E}{\rho}}$$

Since the **speed** of sound in **solids (earth)** is **much greater** than the speed of sound in **gases (air)** due to **much greater** value of **elastic modulus**. That is why the observer senses the ground tremor and then hears the sound of explosion.

10. Explain why sound travels faster in warm air than in cold air.

Ans: Sound always travel faster in warm air then in cold air.

Reason:

The speed of sound is given as

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Since, gases expand on heating. So, the **density** of warm air **decreases**. Hence, according to above equation, the speed of sound will be greater in warm air than in cold air.

11. How should a sound move with respect to an observer so that frequency of its sound does not change?

Ans: If the **relative velocity** between the source and observer is **zero**, there will be no change in frequency of sound.

Examples:

(a) When the observer is at origin and source moves along the circumference of the circle then their distance remains the same and the frequency of sound does not change.

(b) **Source** and **observer** are moving in **same direction** with **same velocity**.

Chapter # 09 (Physical Optics)

Important Short Questions

1. Define wave front and a ray of light.

Ans: Wavefront:

The surface on which all the points of waves have same phase of vibration is known as wavefront. It has two types:

- Spherical wavefront
- Plane wavefront

Ray of light:

The line normal to the wavefront which shows the direction of propagation of light is called a ray of light.

2. State Huygens's Principle.

Ans: Huygens's Principle:

If the location of the wavefront at any instant t is known then Huygen's principle enables us to determine shape and location of the new wavefront at a later time $t + \Delta t$.

It has two parts:

- Every point of wavefront may be considered as a source of secondary wavelets which spread out in forward direction with a speed equal to the speed of propagation of the wave.
- The new position of the wavefront after a certain interval of time can be found by constructing a surface that touches all the secondary wavelets.

3. What are the condition for detectable interference?

Ans: Condition for detectable interference patter:

The condition for detectable interference:

- The interfering beams must be monochromatic.
- The interfering beams of light must be coherent.
- The sources should be narrow and very close to each other.
- The intensity of the two sources be comparable.

4. What is meant by coherent source? Give one example.

Ans: Coherent Source:

The monochromatic sources of light which emit waves, having a constant phase difference are called coherent sources.

Example:

The coherent light beam is used a monochromatic source to illuminate a screen containing two small closely spaced holes, usually in the shape of slits. The light emerging from two slits us coherent because a single source produces the original beam.

5. Prove that $\Delta y = \frac{\lambda L}{d}$.

Ans: Proof:

In order to find the distance between two adjacent bright fringes on the screen mth and (m + 1)th fringes are considered.

$$\text{Position of the mth fringe} = Y_m = (m)\left(\frac{\lambda L}{d}\right)$$

$$\text{Position of the (m + 1)th fringe} = Y_{m+1} = (m+1)\left(\frac{\lambda L}{d}\right)$$

$$\Delta Y = Y_{m+1} - Y_m$$

$$\Delta Y = (m+1)\left(\frac{\lambda L}{d}\right) - (m)\left(\frac{\lambda L}{d}\right)$$

$$\Delta Y = (m+1-m)\left(\frac{\lambda L}{d}\right)$$

$$\boldsymbol{\Delta Y = \frac{\lambda L}{d}}$$

Hence proved.

6. Why central spot of Newton's rings is dark?

Ans: Dark Central Spot:

At the point of contact of the lens and the glass plate, the thickness of the film is effectively zero but due to reflection at the lower surface of air film from denser medium, an additional path difference of $\lambda/2$ is (phase change of 180^0) introduced. Consequently, the centre of Newton's rings is dark due to destructive interference.

7. Define Michelson's experiment. Write its uses.

Ans: Michelson's Interferometer:

Michelson's interferometer is an instrument that can be used to measure distance with extremely high precision. Albert A. Michelson devised this instrument in 1881, using the idea of interference of light rays.

Uses:

- It is used for the determination of wavelength of light.
- Michelson's measure the length of the standard meter in terms of wavelength of red cadmium light and prove that

  Standard meter = 1553163.5 wavelength of light
- If light of wavelength λ = 400 nm is used, then it can measure the thickness upto 10^{-4} mm (or 100 nm).
- It is used to observe the interference of light.

8. What is difference between interference and diffraction?

Ans: Interference:

When two identical light waves travelling in the same direction are superimposed to each other in such a way that they reinforce each other at some points while at some points they cancel the effect of each other. Such phenomenon is called interference of light.

Condition for constructive interference:

Path difference = $m\lambda$ where $m = 0,1,2,3,4,\ldots\ldots\ldots$

Condition for destructive interference:

Path difference = $\left(m + \frac{1}{2}\right)\lambda$ where $m = 0,1,2,3,4,\ldots\ldots\ldots$

Diffraction:

The property of bending of light around the obstacle and spreading of light waves intro the geometrical shadow of an obstacle is called diffraction.

9. What is meant by optical rotation?

Ans: Optical Rotation:

When a plane of polarized light is passed through certain crystals. They rotate the plane of polarization. Quartz and sodium chloride crystals are typical examples, which are termed optically active crystals.
A few millimeters thickness of such crystals will rotate the plane of polarization by many degrees. Certain organic substance, such as sugar and tartaric acid show optical rotation when they are in solution, this property of optical active substances can be used to determine the concentration in the solutions.

Exercise Short Questions

1. Under what conditions, the two sources of light behave as coherent sources?

Ans: Conditions for coherent sources: -

Two and more sources are said to be coherent if:

- The sources must emit waves of same wavelength (monochromatic).
- The waves emitted by the sources must have constant phase difference.

2. How is the distance between interference fringes affected by the separation between the slits of Young's experiment? Can fringe disappear?

Ans: By increasing the separation between slits fringe spacing is decreased and vise verse.

Explanation: -

The fringe spacing is given by,

$$\Delta y = \frac{\lambda L}{d}$$

This equation shows that the distance between fringes (Δy) is inversely proportional to the separation between the slits (d).

Fringe can disappear: -

When separation between the slits is made large enough, the fringes will be so close that they cannot be distinguished from one another and pattern will disappear.

3. Can the visible light produce interference fringes? Explain.

Ans: Yes, visible light (White light) can produce the interference fringes.

Explanation: -

White light consists of seven colours. Each spectral colour produces its own interference fringe pattern. These patterns overlap to give resultant coloured interference pattern.

4. In Young's experiment, one of the slits is covered with blue filter and other with red filter. What would be the pattern of light intensity on the screen?

Ans: No, interference pattern of bright and dark fringes is formed on screen.

Reason: -

Blue filter gives blue light and red light gives red light. For interference, the two waves must have same frequency, and constant phase difference. As in this case red and blue light have different wavelengths. Therefore, no interference take place and we will observe two coloured images on the screen with constant intensity.

5. Explain whether Young's experiment is an experiment for studying interference or diffraction effects of light.

Ans: Basically, it is an experiment to study the interference of light though it involves diffraction.

Explanation: -

As the light passes through the slits it bends around the slit (Diffraction). Then these diffracted rays superpose each other to produce the interference pattern effect of light. But in this experiment, we only study the interference effect of light.

6. An oil film spreading over a wet footpath shows colours? Explain how does it happen?

Ans: This happens due to the interference of light waves.

Reason: -

Oil film spread over a wet foot path acts like a thin film. A light beam is incident on the upper surface. Some part of light is reflected from the upper surface and rest of light is reflected from the lower surface of thin film of oil. The two reflected coherent beams superpose and an interference pattern of different colours is obtained.

7. Could you obtain Newton's rings with transmitted light? If yes, would the pattern be different from that obtained with reflected light?

Ans: Yes, the Newton's ring can be obtained by transmitted light.

Reason: -

The pattern obtained from transmitted light is exactly opposite to that of reflected light. There is no phase change in this case. Every dark ring is converted into bright ring and vice versa. So, the centre of Newton's ring is bright.

8. In white light spectrum obtained with diffraction grating, the third order image of wavelength coincides with fourth order image of second wavelength. Calculate the ratio of the two wavelengths?

Ans: For first wavelength $d\sin\theta = 3\lambda_1$ ____________ (1)

For second wavelength $d\sin\theta = 4\lambda_2$ ____________ (2)

Comparing equations (1) and (2), we get.

$$3\lambda_1 = 4\lambda_2$$

$$\frac{\lambda_1}{\lambda_2} = \frac{4}{3}$$

Hence, the ratio is 4 : 3

9. How would you manage to get more orders of spectra using grating?

Ans: As we know that,

$$d\sin\theta = n\lambda$$

$$n = \frac{d\sin\theta}{\lambda}$$

- For maximum value of n, $\sin\theta = 1$, $\theta = 90^\circ$.
- For a given diffraction, the grating element is constant.

$$n \propto \frac{1}{\lambda}$$

Hence, by decreasing the wavelength we can obtain more order of spectra.

10. Why Polaroid sunglasses are better than ordinary sun glasses?

Ans: Polaroid sunglasses are better than sunglasses. Because:

- They reduce the glare of light.
- Snow and rough road is partially polarized and produce glare, therefore the glare is reduced by the polaroid sunglasses.
- They protect the eyes from harmful and bright rays of sun light.

11. How would you distinguish between unpolarized and plane polarized light?

Ans: Ordinary light (Unpolarized light) has a number of planes of vibrations on the other hand in polarized light, vibration is confined in one plane only. The unpolarized and polarized light can be distinguished by using a polarized light.

- If the transmitted light is plane polarized, it becomes dimmer and disappear at certain orientation.
- If the transmitted light is unpolarized, it becomes dim but not completely blocked at any orientation.

12. Fill in the blanks.

Ans:

(i) According to **Huygens's principle**, each point on a wave front act as a source of secondary **wavelets**.

(ii) In Young's experiment, the distance between two adjacent bright fringes for violet light **smaller** than that for green light.

(iii) The distance between bright fringes in the interference pattern **increases** as the wavelength of the light used increases.

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Chapter # 10 (Optical Instrument)

Important Short Questions

1. What is least distance of distinct vision? Give its value. OR What is Near point?

Ans: Least distance of distinct vision:

The minimum distance from the eye at which an object appears to be distinct is called least distance of distinct vision or near point.

- It is denoted by 'd'
- Its value is 25 cm.

2. What is focusing at infinity, length of telescope?

Ans: Focusing at infinity:

When the image formed by the objective is at the focus of objective as well as eye piece. Then the telescope is in its normal adjustment or focused for infinity.

Length of Telescope:

In normal adjustment of telescope, the distance between eye piece and objective is called length of telescope.

$$L = f_o + f_e$$

3. Define spectrometer. Write its main path. Also write its uses.

Ans: Spectrometer:

The optical device which is used to study the spectrum of various sources of light is called spectrometer.

Main Parts:

- Collimator
- Turn Table
- Telescope

Uses of spectrometer:

It is used to:

i. Study the spectra of different light sources.
ii. Study the deviation of light by prism.
iii. Calculate the refractive index.
iv. Measure the wavelength of light prism.

4. Write function of collimator in spectrometer.

Ans: Function of collimator:

The function of collimator to make the rays coming from a nearby source parallel. At one end of the tube a convex lens is fixed and on the other hand an adjustable slit is provided. When slit is just at the focus of convex lens then light rays entering from slit become parallel after passing through the lens.

5. Define Total internal reflection. Write the conditions of total internal reflection.

Ans: Total Internal reflection:

When light enter from denser to rare medium in such a way that angle of incidence is greater than critical angle, then light totally reflected into the same denser medium. This phenomenon is called total internal reflection.

Conditions for total internal reflection:

- Light should enter from denser to rare medium.
- Angle of incidence should be greater than critical angle.

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6. Define critical angle and refractive index.

Ans: Critical Angle:

The angle of incidence at which angle of refraction becomes 90^o is called critical angle.

Refractive Index:

The ratio of speed of light in vacuum (c) to the speed of light in medium (v) is called refractive index.

$$n = \frac{c}{v}$$

---

7. Define Snell's Law. Write its mathematical form.

Ans: Snell's Law:

The ratio of sine of angle of incidence to the sine of angle of refraction is equal to constant. This is called Snell's law.

$$n = \frac{\text{Sin}\theta}{\text{Sin}\theta}$$

---

8. What are the types of optical fibre? Explain.

Ans: There are three type of optical fibre.

i. Single mode index fibre
ii. Multimode step index fibre
iii. Multimode step index fibre

(i) Single Mode Step Index Fibre:

- It has very thin core about 5μm diameter.
- It has a relatively large cladding.
- Monochromatic light source is required to send light signals through it.
- It can carry more than 14 TV channels or 14000 phone calls.

(ii) Multimode Mode Step Index Fibre:

- It is the optical fibre in which central core has a large diameter such as 50μm and high refractive index.
- It is useful for short distance only.

(iii) Multimode Graded Index Fibre:

- It is an optical fibre in which central core has high refractive index, its density gradually decreases towards its outer surface.
- The diameter of the core ranges from 50μm to 1000μm.
- It is used for long range distances.

9. What are the three major components of fibre optic communication system?

Ans: The fibre optic communication system consists of three major components.

- Transmitter
- Optical Fibre
- Receiver

Exercise Short Questions

1. What do you understand by linear magnification and angular magnification? Explain how a convex lens is used as a magnifier?

Ans: Linear Magnification:

The ratio of size of image to the size of object is called linear magnification.

OR

The ratio of image distance to the object distance is called linear magnification

$$M = \frac{I}{O} = \frac{q}{p}$$

Angular Magnification:

The ratio of angle subtended by the image as seen through the optical device to that angle subtended by the object at the unaided eye is called angular magnification.

$$M = \frac{\beta}{\alpha}$$

Convex lens as a magnifier:

When an object is placed within the focal length of a double convex lens then a magnified, erect and virtual image is obtained.

2. Explain the difference between angular magnification and resolving power of an optical instrument. What limits the magnification of an optical instrument?

Ans:

Angular Magnification	Resolving Power
• The ratio of angle subtended by the image as seen through the optical device to that angle subtended by the object at the unaided eye is called angular magnification. $M = \frac{\beta}{\alpha}$ • Angular magnification increases the apparent size of image of the object.	• The resolving power of an instrument is its ability to reveal the minor details of an object under examination. $R = \frac{D}{1.22\lambda}$ • The resolving power of an instrument separates the images of two very close objects.

Limitation:

Chromatic and spherical aberration are two main defects which limited the magnification of optical instrument and details of the object cannot be seen clearly.

3. Why would it be advantage to use blue light with a compound microscope?

Ans: When we use blue light with a compound microscope it increases the resolving power. And more details of the object can be seen.

Reason:

As we know that resolving power, $R = \frac{1}{\alpha_{min}} = \frac{D}{1.22\lambda}$

Since the blue light is of shorter wavelength. It produces less diffraction. Hence, it increases the resolving power of compound microscope.

4. One can buy a cheap microscope for use by the children. The image seen in such a microscope have coloured edges, why is this so?

Ans: It is due to chromatic aberration.

Reason:

In chromatic aberration, the lens behaves as a prism. When light passes through lens then all wavelengths are not focused at one point. Due to chromatic aberration of the lens the image seen in cheap microscopes have coloured edges.

5. Describe with help of diagrams, how (a) a single biconvex lens can be used as a magnifying glass. (b) biconvex lenses can be arranged to form a microscope.

Ans: For Single Biconvex lens:

A biconvex lens is used as a magnifying glass. When object is placed within the focal length of the lens them an erect, virtual and magnified image is obtained.

For Biconvex lenses:

In compound microscope, when the image formed by the objective lens is within focal length of the eyepiece then a virtual, inverted and magnified image is obtained.

6. If a person were looking through a telescope at full moon, how would the appearance of the moon be changed by covering half of the objective lens.

Ans: The apparent size of image of moon does not change. It looks dim only.

Reason:

As intensity of light depends upon the diameter of objective lens. If the objective lens is half covered then there is no effect on the size of image but the brightness of image is reduced.

7. A magnifying glass gives a five-times enlarged image at a distance of 25 cm from the lens. Find, by ray diagram, the focal length of the lens.

Ans:

$M = 5, \quad d = 25cm$

$f = ?$

$$M = 1 + \frac{d}{f}$$

$$5 = 1 + \frac{25}{f}$$

$$5 - 1 = \frac{25}{f}$$

$$4 = \frac{25}{f}$$

$$f = \frac{25}{4} = 6.25 \text{ cm}$$

8. Identify the correct answer.

(i) The resolving power of a compound microscope depends upon:

(a) The refractive index of the medium in which the object is placed.
(b) The diameter of the objective lens.
(c) The angle subtended by the objective lens at the object.
(d) The position of an observer's eye with regard to the eye lens.

Ans: (b) The diameter of the objective lens.

(ii) The resolving power of a astronomical microscope depends upon:

(a) The focal length of objective lens.
(b) The least distance of distinct vision of the observer.
(c) The focal length of the eye piece.
(d) The diameter of the objective lens

Ans: (d) The diameter of the objective lens.

9. Draw sketches showing the different light paths through a single-mode and a multi-mode fibre. Why is the single-mode fibre preferred in telecommunications?

Ans: The different light paths through single mode and multi-mode fibre are shown below.

Preference of single – mode fibre:

Single mode is preferred in telecommunication because:

- A strong mono – chromatic source is used in single mode fibre.
- There is no dispersion of light and hence no signal is lost.

10. How the light signal is transmitted through the optical fibre?

Ans: The signals are transmitted through optical fibre by:

- Total internal reflection
- Continuous refraction

In multimode step index fibre, the signal is transmitted by mean of total internal reflection while in case of multimode graded index fibre, the signal is transmitted by total internal reflection and continuous refraction.

11. How the power is lost in optical fibre through dispersion? Explain.

Ans: Power is lost in optical fibre through dispersion due to:

- When light signal is not perfectly monochromatic, then light will disperse on passing through the core of the optical fibre into different wavelengths λ_1, λ_2 and λ_3.
- When light signals travel along fibres by multiple reflection, some light is absorbed due to impurities in the glass.
- Some of it is scattered by groups of atoms which are formed at places such as joints when fibres are joined together.

Carefully manufacturing can reduce the power losses by scattering and absorption.

Chapter # 11 (Heat and Thermodynamics)

1. What are the main postulates of kinetic theory of gases?

Ans: Main Postulates:

(i) A finite volume of gas consists of very large number of molecules.
(ii) The size of molecules is much smaller than the separation between molecules.
(iii) The gas molecules are in random motion and may change their direction of motion after every collision.
(iv) Collision between gas molecules themselves and with the wall of container are assumed to be perfectly elastic.
(v) Molecules exert no force on each other except during a collision.

2. Prove that $T \propto \langle \frac{1}{2}mv^2 \rangle$ OR $T \propto \langle K.E \rangle$

Ans: Proof:

According to ideal gas law:

$$PV = nRT \quad \text{\_\_\_\_\_ (i)}$$

$$n = \frac{N}{N_A}$$

Put in equation (i),

$$PV = \frac{NRT}{N_A}$$

$$PV = NkT \quad \text{\_\_\_\_\_ (ii)}$$

Here $k = \frac{R}{N_A}$. Its value is $1.38 \times 10^{-23}\,JK^{-1}$.

$$P = \frac{2}{3}\frac{N}{V}\langle \frac{1}{2}mv^2 \rangle$$

$$PV = \frac{2N}{V}\langle \frac{1}{2}mv^2 \rangle \quad \text{\_\_\_\_\_ (iii)}$$

Put value of PV = NkT in (iii),

$$NkT = \frac{2N}{3}\langle \frac{1}{2}mv^2 \rangle$$

$$T = \frac{2}{3k}\langle \frac{1}{2}mv^2 \rangle$$

$$T = \text{constant}\ \langle \frac{1}{2}mv^2 \rangle$$

$$T \propto \langle \frac{1}{2}mv^2 \rangle$$

$$T \propto \langle K.E \rangle$$

3. Define Boyle's law. How it can be derived the expression of gas.

Ans: Boyle's Law:

The volume of a give mass of a gas at constant temperature is inversely proportional to the pressure applied to the gas.

From kinetic molecular theory of gasses,

$$P = \frac{2}{3}\frac{N}{V} < \frac{1}{2}mv^2 >$$

$$PV = \frac{2N}{3} < \frac{1}{2}mv^2 >$$

Since, temperature is constant so, K.E is also constant.

$$PV = \text{constant}$$

$$P = \text{constant}\left(\frac{1}{V}\right)$$

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

4. Define Charles's law. How it can be derived the expression of gas.

Ans: Charles's Law:

The volume of given mass of a gas is directly proportional to the absolute temperature when the pressure is kept constant.

From kinetic molecular theory of gasses,

$$P = \frac{2}{3}\frac{N}{V} < \frac{1}{2}mv^2 >$$

$$V = \frac{2}{3}\frac{N}{P} < \frac{1}{2}mv^2 >$$

As pressure is constant,

$$V = \text{constant} < \frac{1}{2}mv^2 >$$

$$V \propto < \frac{1}{2}mv^2 > \propto T$$

$$V \propto T$$

5. Define internal energy. How can we increase internal energy?

Ans: Internal Energy:

The sum of all forms of molecular energies (kinetic and potential) of a substance is called internal energy.

How can we increase internal energy?

We can increase internal energy by two methods:

- By heating
- By doing mechanical work

6. State first law of thermodynamics and give its mathematical form.

Ans: Statement:

When the heat Q is added to a system, this energy appears as an increase in the internal ΔU stored in the system plus the work done W by the system on its surroundings.

$$Q = \Delta U + W$$

7. What is isothermal process?

Ans: Isothermal Process:

A process in which the temperature of the system is constant is called isothermal process.

Mathematical:

$$Q = \Delta U + W$$

As, temperature is constant, ($\Delta U = 0$)

$$Q = W$$

8. What is adiabatic process?

Ans: Adiabatic Process:

A process in which no heat enters or leaves the system is called adiabatic process.

Mathematical:

$$Q = \Delta U + W$$

As no heat enters, ($Q = 0$)

$$0 = \Delta U + W$$

Adiabatic Compression ($W = -\Delta U$)

Adiabatic Expansion ($-W = \Delta U$)

Examples:

- The rapid escape of air from a burst tyre.
- Cloud formation in the atmosphere

9. Define molar specific heat. Also discuss its types.

Ans: Molar Specific Heat:

Molar specific heat of the substance is the heat required to raise the temperature of one mole of a substance through 1K.

Molar specific heat at constant Pressure (C_P)	Molar specific heat at constant volume (C_V)
• The molar specific heat at constant pressure is the amount of heat required to raise the temperature of one mole of the gas through 1K at constant pressure. • It is represented by C_P • Its unit is $JMol^{-1}K^{-1}$	• The molar specific heat at constant volume is the amount of heat required to raise the temperature of one mole of the gas through 1K at constant volume. • It is represented by C_V • Its unit is $JMol^{-1}K^{-1}$

10. Differentiate between reversible and irreversible process.

Ans:

Reversible Process	Irreversible Process
• The process which can be retraced in exactly reverse order without producing any change in the surroundings is called reversible process. • Slow compression of a gas in a cylinder • The process of liquefaction and evaporation	• The process which cannot be retraced in exactly reverse order without producing any change in the surroundings is called irreversible process. • Work done against friction • Explosion

11. State second law of thermodynamics.

Ans: Statement:

It is impossible to make a heat engine which converts all the heat absorbed from a hot reservoir into work without rejecting any heat to sink

$$W = Q_1 - Q_2$$

12. Write down two statements of Carnot's Engine. Also write down its four steps.

Ans: Carnot's Engine:

- No heat engine can be more efficient than a Carnot engine separating between the same two temperatures.
- All Carnot's engines operating between the same two temperatures have the same efficiency, irrespective of the nature of working substance.

Steps of Carnot's Cycle:

(i) Isothermal expansion
(ii) Adiabatic expansion
(iii) Isothermal compression
(iv) Adiabatic Compression

13. What is triple point of water?

Ans: Triple point of water:

The temperature at which water, ice and water vapours are in equilibrium state which is obtained at particular temperature and pressure is called triple point of water.

$$T = (273.16)\frac{Q_1}{Q_2}$$

14. Name the four strokes of petrol engine.

Ans: Four strokes of petrol engine:

- Intake stroke
- Compression stroke
- Power stroke
- Exhaust stroke

15. Why spark plug is not needed in a diesel engine?

Ans: No spark plug is needed in the diesel engine. Diesel is sprayed into cylinder at maximum compression. Because air is at high temperature after compression the fuel mixture ignites on contact with air in cylinder and pushes the piston outward.

16. What is entropy? Give its mathematical form. Also write its unit.

Ans: Entropy:

It is the measure of disorder of molecules of a system.

It is denoted by ΔS.

$$\Delta S = \frac{\Delta Q}{T}$$

Unit: Its unit is JK^{-1}.

Sign Convention:

- When heat is added to system, entropy increases. Then entropy is positive.
- When heat is taken out from system, entropy decreases. Then entropy is negative.

Exercise Short Questions

1. Why the average velocity of the molecules in a gas container is zero but the average of the squares of velocities is not zero?

Ans: Average of velocity of molecule:

The motion of gas molecules is random motion. The number of molecules along positive x – axis is equal to the number of molecules along negative x – axis. This is true for y – axis and z – axis.

$$\langle V \rangle = \frac{V - V}{2} = 0$$

Average of velocity of molecule: -

But the average of square of velocities is not zero because square of a negative value is also positive.

$$\langle V^2 \rangle = \frac{V^2 + (-V)^2}{2} \neq 0$$

2. Why does the pressure of gas in a car tyre increases when it is driven through some distance?

Ans: Reason:

When the car is driven through some distance, then the work has to be done to overcome friction and a part of work done is converted into heat. As a result, temperature of a gas increases and hence K.E of molecules because $P \propto K.E$. So, the pressure of gas molecules increases.

3. A system undergoes from state P_1V_1 to P_2V_2 as shown in fig. What will be the change in internal energy?

Ans: As the temperature of the system remains constant. Therefore, the internal energy of the system remains same. Therefore, $\Delta U = 0$

4. A variation of volume by pressure is given in fig. 11.13. a gas is taken along the paths ABCDA, ABCA and A to A. What will be the change in internal energy?

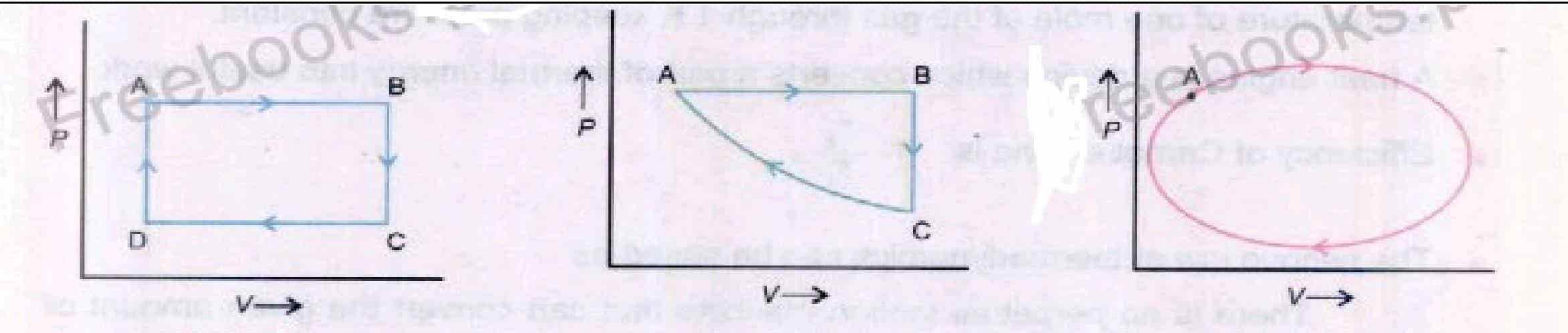

Fig.11.13(a) Fig.11.13(b) Fig.11.13(c)

Ans: As in each case, the system comes back to its initial state, therefore the internal energy remains constant. So, $\Delta U = 0$

5. Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why?

Ans: C_P is always greater than C_V.

Reason: -

When a gas is heated at constant volume.

- all the heat is absorbed is used to increase temperature through 1K.

When a gas is heated at constant pressure.

- A part of heat is used to do work on piston.
- Rest of heat is used to increase the temperature through 1K.

That is why the molar specific heat at constant pressure (C_P) is greater than molar specific heat at constant volume (C_V).

6. Give an example of a process in which no heat is transferred to or from the system but the temperature of the system changes.

Ans: The process in which no heat enters or leaves on system is called "Adiabatic Process"

$$Q = \Delta U + W$$

For adiabatic process $Q = 0$

$$0 = \Delta U + W$$

$$W = -\Delta U \text{ (Adiabatic Expansion)}$$

$$\Delta U = -W \text{ (Adiabatic Comprssion)}$$

So, by doing so whole mechanical energy is converted into heat energy.

Examples: -

- Rapid escape of air from a burst tyre.
- Rapid expansion and compression of air through which sound wave is passing.
- Cloud formation in the atmosphere.

7. Is it possible to convert internal energy into mechanical energy? Explain with an example.

Ans: Yes, it is possible to convert internal energy into mechanical energy.

Example: -

In an adiabatic process, when a gas expands, work is done on the surrounding by using internal energy. Due to which internal energy decreases.

$$W = -\Delta U$$

Gases can be liquefied by this process.

8. Is it possible to construct a heat engine that will not expel heat into the atmosphere?

Ans: No, it is impossible to construct a heat engine that will not expel heat into atmosphere.

Reason: -

According to second law of thermodynamics, in order to convert heat into work, a part of heat has to be rejected to the sink. (Cold reservoir).

If it is possible, then it will violation of second law of thermodynamics.

9. A thermos flask containing milk, as a system is shaken rapidly. Does the temperature of milk rise?

Ans: Yes, the temperature of the milk rises.

Reason: -

As we know that,

$$T \propto K.E$$

When we rapidly shake the thermos flask we do some work on it. This work done increases the K.E of molecules of milk. Hence, the temperature of milk increases.

10. What happens to the temperature of the room? When an air conditioner is left running on a table in the middle of the room?

Ans: The temperature of the room increases slightly.

Reason: -

When an air conditioned is left running on a table in the middle of the room, it absorbs as well as reject heat in the same room at the constant rate. So, the temperature of room is unchanged . But due to the working of compressor some heat is produced due to friction which increases the temperature of the room slightly.

11. Can the mechanical energy be converted completely into heat energy? If so give an example.

Ans: Yes, mechanical energy can be converted completely into heat energy.

Example: -

When brakes are applied to stop the running car, then the car stops due to friction and all the mechanical energy supplied to the car is converted into heat due to friction.

Also, during isothermal compression then work done on the system is converted into heat energy.

$$Q = \Delta U + W$$

$$\Delta U = 0 \text{ (For inothermal Process)}$$

$$Q = W$$

$$W = Q$$

12. Does entropy of a system increases or decreases due to friction?

Ans: Yes, the entropy of the system increases due to friction.

Reason: -

As the entropy of the system is given as.

$$\Delta S = \frac{\Delta Q}{T}$$

Due to friction, some mechanical energy is dissipated as heat to overcome friction. Its mean heat is added up into the system which increases the entropy of the system.

13. Give an example of a natural process that involves an increase in entropy?

Ans: In every natural process, the heat flows from a body at high temperature to a body at lower temperature. Therefore, entropy of the system and surroundings increases.

Example: -

When ice melts, it involves the increase in entropy. Ice absorbs temperature from the surroundings and changes its state (Solid to liquid). Thus, entropy increases.

$$\Delta S = \frac{\Delta Q}{T}$$

As ΔQ is Positive (+ ve). So, the entropy increases.

14. An adiabatic change is the one in which

(a) No heat is added to or taken out of the system.
(b) No change of temperature takes place.
(c) Boyle's law is applicable.
(d) Pressure and volume remains constant.

Ans: (a) No heat is added to or taken out of the system.

15. Which one of the following process in irreversible?

(a) Slow compressions of an elastic spring.
(b) Slow evaporation of a substance in an isolated vessel.
(c) Slow compression of a gas.
(d) A chemical explosion

Ans: (d) A chemical explosion is irreversible.

16- An ideal reversible heat engine has:

(a) 100% efficiency
(b) Highest efficiency
(c) an efficiency which depends on the nature of working substance.
(d) None of them

Ans: (b) Highest Efficiency