

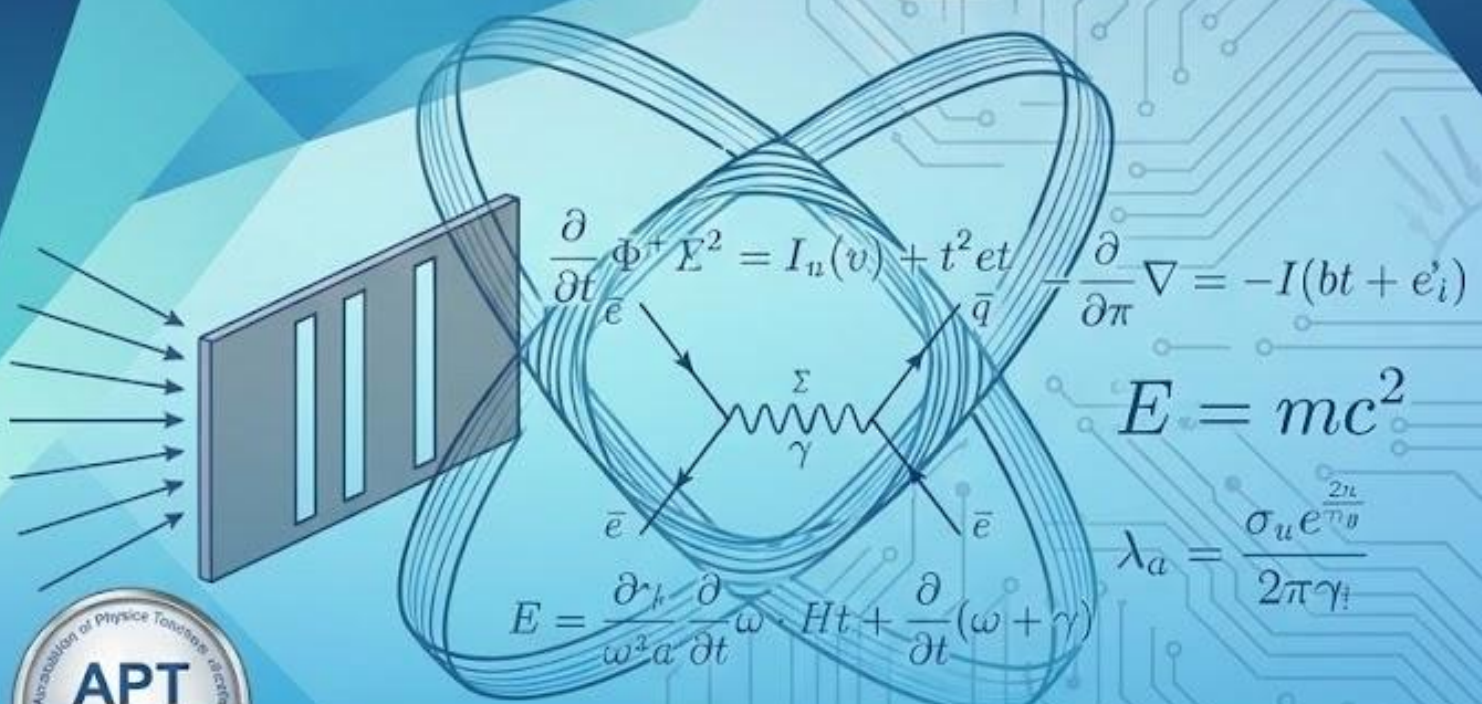
PLUS ONE PREVIOUS YEAR QUESTION BANK



For Higher Secondary Physics

✓ **COMPLETELY
SOLVED &
CHAPTERWISE**

Coverage from
2021 to 2025



CHAPTER 1

UNITS AND MEASUREMENTS

1. Define plane angle.

Ans: Plane angle is the ratio of the length of an arc to the radius of the circle in which the arc lies.

2. Write the SI unit and dimensional formula of energy.

Ans: SI unit of energy is joule (J)

Dimensional formula of energy is $[ML^2T^{-2}]$

3. Fill in the blanks.

Name of base quantity	Name of SI unit
Length	metre
Mass	
.....	second
Electric current	
Thermodynamic temperature	
.....	mole
.....	candela

Ans: Mass – kilogram

Time – second

Electric current – ampere

Thermodynamic temperature – kelvin

Amount of substance – mole

Luminous intensity -- candela

4. (a) State the principle of Homogeneity of dimensions.
(b) A planet moves around the Sun in nearly circular orbits. Its period depends on radius (r) of the orbit, mass of the Sun (M) and gravitation constant (G). Derive the expression for its time period of the planet using method of dimensions.

Ans: (a) Refer question 11.(a)

(b) $T \propto r^a M^b G^c$

$$[T] \propto [L^a] [M^b] [g^c]$$

$$[T] \propto [L^a] [M^b] [M^{-1}L^3T^{-2}]^c$$

$$[T] \propto [L^a] [M^b] [M^{-c}L^{3c}T^{-2c}]$$

$$[M^0L^0T] \propto [L^{a+3c}] [M^{b-c}] [T^{-2c}]$$

Equating the powers of M, L and T on both sides

$$c = -\frac{1}{2} \quad b = -\frac{1}{2} \quad a = \frac{3}{2}$$

So equation for time period

$$T \propto r^{\frac{3}{2}} M^{-\frac{1}{2}} G^{-\frac{1}{2}}$$

Or

$$T = k \sqrt{\frac{r^3}{GM}}$$

5. Fill in the blanks in the table below:

Quantity	SI Unit	Symbol of SI unit
Time	second	-----
Electric current	-----	A
-----	steradian	Sr
-----	mole	mol

Ans:

Quantity	SI Unit	Symbol of SI unit
Time	second	s
Electric current	ampere	A
Solid angle	steradian	Sr
Amount of substance	mole	mol

6. Centripetal force (F) depends on mass (m) of the object, its velocity (v) and radius (R) of the circle. Using the method of dimensions derive an equation for centripetal force.

Ans: $F \propto m^a v^b R^c$

$$[F] \propto [m^a] [v^b] [R^c]$$

$$[F] \propto [m^a] [v^b] [R^c]$$

$$[MLT^{-2}] \propto [M^a] [LT^{-1}]^b [L^c]$$

$$[MLT^{-2}] \propto [M^a L^{b+c} T^{-c}]$$

equating the powers of M, L and T on both sides

$$a = 1 \quad b = 2 \quad c = -1$$

so centripetal force, $F \propto \frac{mv^2}{R}$

or, $F = k \frac{mv^2}{R}$

[2021 IMPROVEMENT]

7. The restoring force developed in a spring extended by a length 'x' is, $F = kx$. The dimensional formula of 'k' is

Ans: $[K] = [MT^{-2}]$

8. Check the dimensional correctness of the relation:

$$v = \sqrt{\frac{GM}{R}}$$

Where v is the orbital velocity, G is the gravitational constant and R is the radius of earth.

Ans: According to the principle of homogeneity if the given equation is dimensionally correct

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

$$\left[\sqrt{\frac{GM}{R}} \right] = \sqrt{\frac{[M^{-1}L^3T^{-2}][M]}{[L]}} = \sqrt{[L^2T^{-2}]} = [LT^{-1}]$$

Which means [LHS] = $[LT^{-1}]$

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

So the given relation is dimensionally correct

[2022 MARCH]

9. Light year is the unit of _____

- (a) time
(b) distance

(c) velocity

Ans: distance

10. 1 Å (angstrom) = _____
(i) 10^{10} m (ii) 10^{-15} m
(iii) 10^{15} m (iv) 10^{-10} m
Ans: (iv) 10^{-10} m

11. (a) What do you mean by principle of homogeneity of dimensions ?
(b) Using this principle, check whether the following equation is dimensionally correct :

$$\frac{1}{2} mv^2 = mgh$$

- (c) State the number of significant figures in the following :

- (i) 0.060607 m²
(ii) 6.0320 N m⁻²

Ans: (a) According to the principle of homogeneity only quantities of the same dimensions can be added, subtracted, or equated

- (b) by principle of homogeneity

Above equation is dimensionally correct if

$$\left[\frac{1}{2} mv^2 \right] = [mgh]$$

$$\left[\frac{1}{2} mv^2 \right] = [ML^2T^{-2}]$$

$$[mgh] = [ML^2T^{-2}]$$

So this equation is dimensionally correct

- (c) i) 5
ii) 5

[2023 MARCH]

12. Which of the following is a fundamental quantity ?

- (a) Volume (b) Mass
(c) Density (d) Pressure

Ans: Mass

13. (a) Using the principle of homogeneity of dimensions check whether the equation

$$\frac{1}{2} mv^2 = mgh \quad \text{is dimensionally correct.}$$

- (b) There is a famous relation in physics which relates moving mass 'm' with rest mass 'm₀' and velocity 'v'. A boy recalls the relation almost correctly as

$$m = \frac{m_0}{(1 - v^2)^{\frac{1}{2}}}$$

but forget to put the velocity of light 'c' in the equation. Where is the correct position of 'c' in the above equation ?

Ans: a) Refer Question 11.(b)

b)

$$m = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

[2023 IMPROVEMENT]

14. The dimensional formula of gravitational constant

- a) $[MLT^{-2}]$ (b) $[ML^2T^{-2}]$
c) $[M^{-1}L^3T^{-2}]$ (d) $[M^{-1}L^2T^{-2}]$

Ans: $[M^{-1}L^3T^{-2}]$

15. Write two uses of dimensional analysis

Ans: 1. To check the correctness of a physical equation

2. To derive the relation between physical quantities

16. State number of significant figures in

(i) 6.320 J (ii) 2370 g cm⁻³

Ans: i) 4

ii) 3

[2024 MARCH]

17. Find out the fundamental quantity from among the physical quantities given below:

- a) Velocity
- b) Temperature
- c) Force
- d) Density

Ans: b) Temperature

18. (a) State the principle of homogeneity of dimensions.

(b) Consider a simple pendulum, having a bob attached to a string that oscillates under the action of the force of gravity. Suppose that the period of oscillation of the simple pendulum depends on its length (l), mass of the bob (m) and acceleration due to gravity (g). Derive the expression for its time period using method of dimensions.

Ans: $T \propto m^a l^b g^c$

$$[T] \propto [m^a] [l^b] [g^c]$$

$$[T] \propto [M^a] [L^b] [L^c T^{-2c}]$$

$$[M^0 L^0 T] \propto [M^a L^{b+c} T^{-2c}]$$

Comparing the powers of M, L and T on both sides

$$a = 0 \qquad b = \frac{1}{2} \qquad c = -\frac{1}{2}$$

so time period of simple pendulum, $T \propto l^{\frac{1}{2}} g^{-\frac{1}{2}}$

$$\text{or,} \qquad T = k \sqrt{\frac{l}{g}}$$

[2025 MARCH]

CHAPTER 2

MOTION IN A STRAIGHT LINE

1. A player throws a ball vertically upwards. What is the velocity and acceleration of the ball at the highest point of its motion?

SEPTEMBER 2021

Ans: Velocity = 0

Acceleration = -g

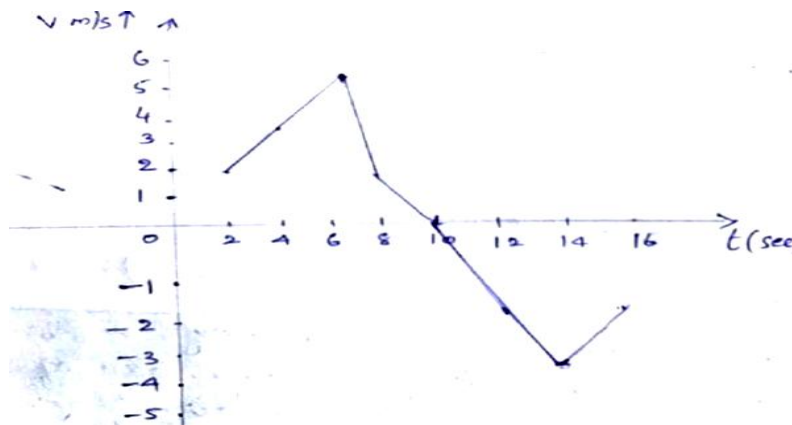
2. An astronaut in a space shuttle moves along a straight line. The data given below shows the measured velocities starting from $t=2s$.

Time(s)	2	4	6	8	10	12	13	16
Velocity(m/s)	2	4	6	2	0	-2	-4	-2

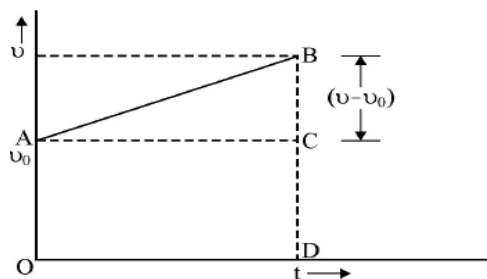
Draw velocity –time graph from $t=2s$ to $t=16s$ (use of graph is not required)

SEPTEMBER 2021

Ans:



3. Velocity –time graph of an object with uniform acceleration is given below.



Using this graph derive the relation $x = v_0 t + \frac{1}{2}at^2$ and $v^2 = v_0^2 + 2ax$

SEPTEMBER 2021

Ans:

(a) Displacement = area of v-t graph

= Area of triangle ABC + Area of rectangle OACD

$$= \frac{1}{2}(v - v_0)t + v_0 t$$

$$= \frac{1}{2}at^2 + v_0 t$$

$$= x$$

Displacement = Area of trapezium OABCD = $\frac{1}{2} \times \text{sum of parallel sides} \times \text{height}$

$$x = \frac{1}{2} \times (OA + BD) \times OD$$

$$= \frac{1}{2} \times (v_0 + v) \times t$$

$$= \frac{1}{2} \times (v_0 + v) \times \frac{(v-v_0)}{a}$$

$$2ax = v^2 - v_0^2$$

$$v^2 = v_0^2 + 2ax$$

4. State whether the following statements are true or false:

- (i) The magnitude of displacement may or may not be equal to the path length traversed by an object.
- (ii) During motion magnitude of displacement may be zero but the corresponding path length is not zero

JANUARY 2022

Ans : (i) true

(ii) true

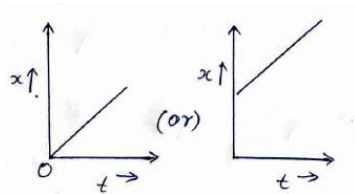
5. (a) Define average velocity

(b) Draw position-time graph of an object moving with constant positive velocity

JANUARY 2022

Ans: (a) Average velocity = $\frac{\text{displacement}}{\text{time interval}} = \frac{\Delta x}{\Delta t}$

(b)



6. An object is moving with uniform acceleration 'a'.

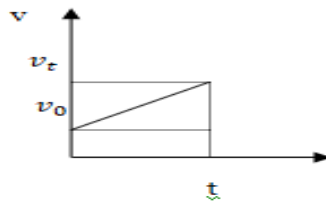
(a) Write the equation connecting the velocity of object with time.

(b) Using suitable velocity-time graph, derive the equation $x = v_0 t + \frac{1}{2} a t^2$.

January 2022, March 2023, September 2023, March 2024

Ans : (a) $v_t = v_0 + at$

(b)



Displacement = area under v-t graph

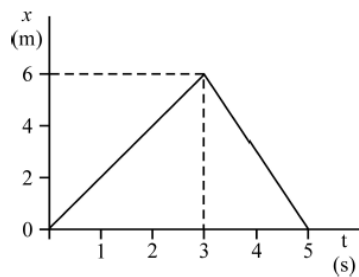
= area of triangle + area of rectangle

$$= \frac{1}{2} (v_t - v_0) t + v_0 t$$

$$= \frac{1}{2} a t^2 + v_0 t$$

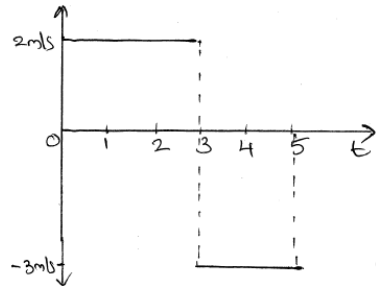
$$= x$$

7. The position-time graph of an object is given below. Draw the velocity-time graph and find the total displacement.



MARCH 2022

Ans :



$$\begin{aligned}\text{Displacement} &= \text{area under } v\text{-}t \text{ graph} \\ &= (3 \times 2) + (2 \times -3) = 0\end{aligned}$$

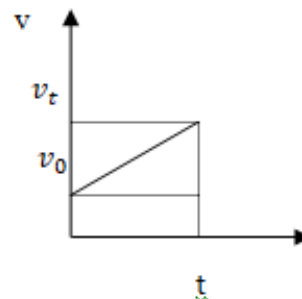
8. A particle is moving along X-axis with uniform positive acceleration.

(a) Obtain an expression for displacement by drawing velocity –time graph.

(b) A ball is thrown vertically upwards with a velocity of 20m/s from the top of a tower of height 25m from ground. How long does it remain in air? ($g=10\text{m/s}^2$)

Ans: (a)

$$\begin{aligned}\text{Displacement} &= \text{area under } v\text{-}t \text{ graph} \\ &= \text{area of triangle} + \text{area of rectangle} \\ &= \frac{1}{2}(v_t - v_0)t + v_0t \\ &= \frac{1}{2}at^2 + v_0t \\ &= x\end{aligned}$$



(b) Time taken to reach maximum height from the top of the tower

$$v = u + at$$

$$0 = 20 - 10t$$

$$t = 2\text{s}$$

Maximum height reached above the tower

$$v^2 - u^2 = 2as$$

$$0 - 400 = -2 \times 10 \times s$$

$$s = 20\text{m}$$

Total height from the ground = 45m

Time taken to fall from maximum height

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

$$-45 = 0 \times t + \frac{1}{2} \times -10 \times t^2$$

$$t = 3\text{s}$$

total time the ball remains in air = 5s

9. Distinguish between average velocity and instantaneous velocity

OCTOBER 2022

Ans : average velocity = $\frac{\text{displacement}}{\text{time interval}} = \frac{\Delta x}{\Delta t}$

Instantaneous velocity, $v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

10. For uniformly accelerated body, prove that

(a) $x = v_0 t + \frac{1}{2} a t^2$

(b) $v^2 = v_0^2 + 2ax$

OCTOBER 2022

Ans:

(a) $x = \left(\frac{v+v_0}{2} \right) t = \left(\frac{v_0+at+v_0}{2} \right) t$
 $x = v_0 t + \frac{1}{2} a t^2$

(b) $ax = \left(\frac{v-v_0}{a} \right) \left(\frac{v+v_0}{2} \right) t$
 $v^2 = v_0^2 + 2ax$

11. A ball is thrown vertically upwards with an initial velocity u. Calculate the time taken to reach maximum height.

MARCH 2023

Ans:

$v = u + at$ $v = 0, a = -g$

$t = \frac{v-u}{a} = \frac{u}{g}$

12. Give an example for a body processing zero velocity which is accelerating

Ans: A body at maximum height

MARCH 2023

13. Area under velocity –time graph gives.....

SEPTEMBER 2023

Ans: Displacement

14. Derive the relation $v = u + at$

Ans : $a = \frac{v-u}{t}$
 $at = v - u$
 $v = u + at$

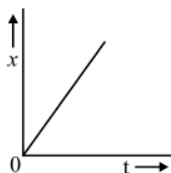
15. What is the significance of velocity-time graph of uniformly accelerated motion

MARCH 2024

Ans: area under velocity time graph = displacement

Slope of velocity –time graph = acceleration

16. A graph of position-time graph of an object is given.



Choose the correct answer related to this graph

- (a) Velocity of object increases
- (b) Object is stationary
- (c) Object has constant velocity

MARCH 2025

Ans: (c) Object has constant velocity

17. A car moving along a straight highway with speed of 126 km hr^{-1} is brought to a stop within a distance of 200m. What is the retardation of the car (Assumed uniform)

MARCH 2025

Ans: $v^2 - u^2 = 2as$

$$a = \frac{v^2 - u^2}{2s} = \frac{0 - 35^2}{2 \times 200} = -3.06 \text{ ms}^{-2}$$

$$126 \text{ km hr}^{-1} = 35 \text{ ms}^{-1}$$

18. State true or false

Magnitude of displacement is either less or equal to the pathlength of an object between two points

MARCH 2025

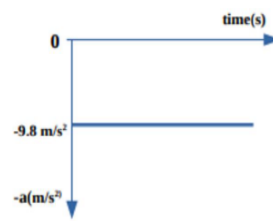
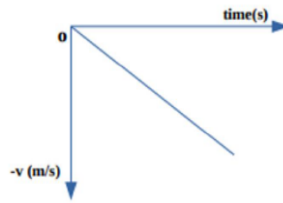
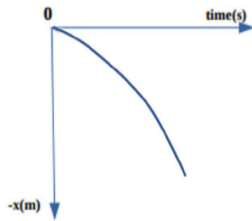
Ans: True

19. Draw the following graphs related to freely falling particle

- (a) Position -time graph
- (b) Velocity -time graph
- (c) Acceleration -time graph

MARCH 2025

Ans:



CHAPTER 3

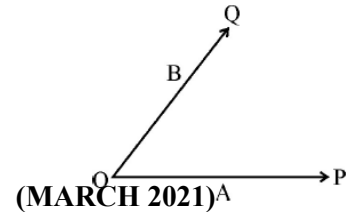
MOTION IN A PLANE

1. Momentum is a _____ quantity. (vector/scalar) (1)

Ans: Vector

2. Two vectors A and B are given below. (2)

(MARCH 2021)



Redraw the figure and show the vector sum using parallelogram method.

(MARCH 2021)

Ans:

From figure, $\vec{R} = \vec{OA} + \vec{OB}$

$$\cos\theta = \frac{AD}{AB} = \frac{AD}{B} \text{ or } AD = B \cos\theta$$

$$\sin\theta = \frac{CD}{AB} = \frac{CD}{B} \text{ or } CD = B \sin\theta$$

Applying Pythagoras theorem, Magnitude of resultant

$$|R| = \sqrt{OD^2 + CD^2}$$

$$= \sqrt{(OA + AD)^2 + DC^2}$$

$$= \sqrt{(A + B \cos\theta)^2 + (B \sin\theta)^2}$$

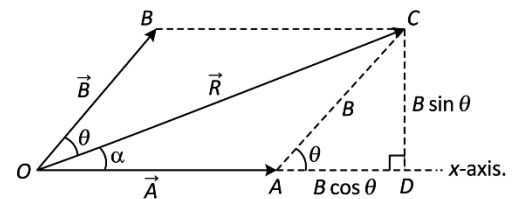
$$= \sqrt{A^2 + B^2 \cos^2\theta + 2AB \cos\theta + B^2 \sin^2\theta}$$

$$= \sqrt{A^2 + B^2 + 2AB \cos\theta}$$

Direction, i.e. the angle between horizontal and resultant

$$\tan\alpha = \frac{CD}{OD} = \frac{B \sin\theta}{A + B \cos\theta}$$

$$\alpha = \tan^{-1} \left(\frac{B \sin\theta}{A + B \cos\theta} \right)$$



3. What are the conditions for equality of two vectors ? (1)

(MARCH 2021)

Ans: Both magnitude and direction must be same

4. $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$, then the angle between $\vec{A}$ and $\vec{B}$? (1)

(MARCH 2022)

Ans: 90°

5. A javeline is projected at an angle of 30° with an initial velocity of 5 ms^{-1} from the ground. What are its velocity and acceleration at highest point ? (2)

Ans: Vertical velocity will be zero. There it will have only horizontal velocity

$$\text{Horizontal Velocity, } v_h = u \cos\theta = 5 \times \cos 30^\circ = 5 \times \frac{\sqrt{3}}{2} = 4.33 \text{ ms}^{-1}$$

6. A projectile is projected with a velocity v_0 making an angle θ with the horizontal. Find the expression for

(i) maximum height

(ii) time of flight

(IMP 2022)

Ans:

(i) Vertical velocity when object reaches max height = 0

Initial Vertical velocity = $u \sin\theta$

Vertical acceleration = $-g$

We have velocity- position relation,

$$v^2 = u^2 + 2as$$

$$\text{Or, } 0 = (u \sin\theta)^2 - 2gH$$

Or , $H = \frac{u^2 \sin^2 \theta}{2g}$

- (ii) Displacement when the projectile re-touches the ground $s = 0$
 Initial vertical velocity $v = u \sin \theta$
 Acceleration $a = -g$

We have P-T relation

$$s = ut + \frac{1}{2}at^2$$

$$\text{Or, } 0 = u \sin \theta \cdot t - \frac{1}{2}gt^2$$

$$\text{or } T = \frac{2u \sin \theta}{g}$$

7. (a) What is meant by uniform circular motion ? (2)
 (b) Derive the expression for centripetal acceleration (3)

Ans:

- (a) .If a body travelling in a circular path travels equal distances in equal intervals of time then it is said to be executing uniform circular motion. Or, the radius vector sweeps equal angle in equal interval of time.

- (b) From figure,

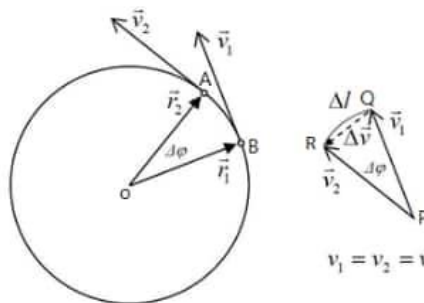
$$\frac{|\Delta v|}{v} = \frac{|\Delta r|}{r}$$

$$|\Delta v| = \frac{|\Delta r|}{r} \cdot v$$

Dividing Both sides by Δt

$$\frac{|\Delta v|}{\Delta t} = \frac{|\Delta r|}{\Delta t} \cdot \frac{v}{r}$$

$$\text{or, } a = \frac{v}{r} \cdot v = \frac{v^2}{r}$$



8. Obtain an expression for centripetal acceleration of a body in uniform circular motion. (3)

Ans: Ref Q 7

9. What is a null (zero) vector ? Give any two properties. (2) **(MARCH 2023)**

Ans: Any vector with an arbitrary direction and zero magnitude . When it is added to a vector , nothing happens to that vector. Its magnitude is always zero.

10. A boy throws a cricket ball with velocity u at an angle θ with the horizontal.

- (a) What is the trajectory of the ball ? (1)
 (b) Deduce an expression for maximum height reached by the ball. (2)
 (c) If the boy can throw the ball to a maximum height 'h', what is the maximum horizontal distance to which he can throw ? (2) **(MARCH 2023)**

Ans: a). A Parabola

b). **Refer 1.i**

$$\text{c. maximum height he can throw } h = \frac{u^2}{2g} \quad \theta = 90^\circ$$

$$\text{or, } v^2 = 2gh$$

$$\text{Maximum Range } R = \frac{v^2 \sin 2\theta}{g} = \frac{(v^2)}{g} = \frac{2gh}{g} = 2h$$

11. The parallelogram law is used to find the resultant of two vectors. Find the magnitude of resultant of two vectors in terms of their magnitudes and angle between them. (3) **(IMP 2023)**

Ans: Refer 1

12. When a body is projected into air with certain initial velocity making an angle 'Q' with the horizontal, it will travel in a parabolic path :

- (a) What is the horizontal and vertical component of velocity at the highest point ? (1)
 (b) Derive expressions for Time of flight and Maximum height. (4) **(IMP 2023)**

Ans: a. $v_h = u \cos \theta, v_v = 0$

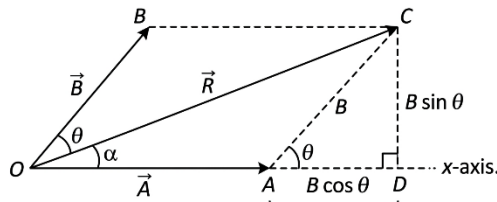
b. Refer 6

13. State and explain parallelogram law of vector addition. (3) **(MARCH 2024)**

Ans: a). If two forces acting simultaneously on a particle are represented in magnitude and direction by two adjacent sides of a parallelogram, their resultant is represented in magnitude and direction by the diagonal of the parallelogram passing through the common point.

b.

$$R = \sqrt{A^2 + B^2 + 2AB \cos \theta}$$



14. Figure shows the path of a projectile motion of a body. (2) **(MARCH 2024)**

- (a) Derive the expression for maximum height attained by the body. (2)
 (b) A ball is thrown at a speed of 28 ms^{-1} in a direction 30° from the horizontal range. Calculate its horizontal range. (2)
 (c) At what angle of projection is the horizontal range maximum ? (2)

Ans: a). Refer 6

$$\text{b). } = \frac{v^2 \sin 2\theta}{g} = 28^2 \times \left(\frac{\sin (2 \times 30)}{g} \right) = 28 \times 28 \times \frac{\sqrt{3}}{2} \times \frac{1}{9.8} = 69.28 \text{ m}$$

15. It was Galileo who stated the independency of vertical and horizontal components of projectile motion.

(MARCH 2025)

- a. Write down the horizontal and vertical components of projectile motion. (1)
 b. Derive an expression for maximum height reached by a projectile (2)
 c. A cricket ball is thrown at a speed of 28 ms^{-1} in a direction 30° above the horizontal. Calculate the maximum height. (2)

Ans: a). $v_h = u \cos \theta, v_v = u \sin \theta$

b). Refer 6

$$\text{c). Maximum Height } H = \frac{u^2 \sin^2 \theta}{2g} = 28^2 \times \sin^2 30 \times \frac{1}{2 \times 9.8} = 10 \text{ m}$$

CHAPTER 4

LAWS OF MOTION

1. (a) State Newton's second law of motion.
(b) Derive the equation of force using the above law. (1+2)

2025 MARCH

Ans:

(a) Newton's second law states that the rate of change of momentum of a body is directly proportional to the applied force and the change takes place in the direction of force.

$$(b) \vec{F} \propto \frac{d\vec{p}}{dt}$$

$$\vec{F} \propto \frac{d(m\vec{v})}{dt}$$

$$\vec{F} \propto m \frac{d\vec{v}}{dt} \quad \text{but } \vec{a} = \frac{d\vec{v}}{dt}$$

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

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

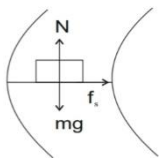
$$\text{if } k=1, \text{ then } \vec{F} = m\vec{a}$$

2. A car is moving in a circular level road with uniform speed.

2025 MARCH

- (a) Draw a diagram showing all forces acting on it.
(b) Obtain the equation for maximum velocity of the car.
(c) Comment on any method to increase the maximum safe velocity of car. (1.5+2.5+1)

Ans: a)



- b) The force of friction provides the necessary centripetal force .

$$f_s = \frac{mv^2}{R}$$

$$\mu_s N = \frac{mv^2}{R}$$

$$\mu_s mg = \frac{mv^2}{R}$$

$$v^2 = \mu_s Rg$$

$$v_{max} = \sqrt{\mu_s Rg}$$

- c) Any one method

i) Banking of roads

ii) Increase the radius of the circular path

iii) Increase the coefficient of friction

3. State Newton's 2nd law of motion and show $F=ma$.

2024 MARCH

Ans : Refer Q 1.

4. (a) State and prove the law of conservation of linear momentum.

2024 MARCH

(b) What is friction? Mention its different types.

(c) At equilibrium the net force acting on a body is ----- (2+2+1)

Ans:

a) If there is no external force acting on a system of particles, then their total momentum will remain constant.

By Newton's second law, $F_{ext} = \frac{dP}{dt}$ If $F_{ext} = 0$ $dP=0 \therefore P = \text{constant}$

b) Friction is the force that opposes relative motion between two surfaces in contact.

Types of friction -1) static friction 2) kinetic friction
c) zero

5. The optimum speed of a car on a banked road to avoid wear and tear on its tyre is given by
(a) $\sqrt{Rg \tan \theta}$ (b) $\sqrt{Rg \cot \theta}$ (c) $\sqrt{Rg \sin \theta}$ (d) $\sqrt{Rg \cos \theta}$ (1) **2024 MARCH**

Ans: a) $\sqrt{Rg \tan \theta}$

6. A batsman hits back a ball straight into the direction of the bowler without changing its initial speed of 12 m/s. If the mass of the ball is 0.15kg, determine the impulse imparted to the ball. (2)

Ans:

Impulse = change in momentum

$$I = m(v - u)$$

$$I = 0.15 \times 12 - (0.15 \times -12)$$

$$= 3.6 \text{ Ns}$$

7. Static friction opposes impending motion :

(a) Write the mathematical equation connecting the limiting value of static friction with normal reaction.

(b) Derive expression for maximum safe speed on a level road.

(c) A cyclist speeding at 18 km/h on a level road takes a sharp circular turn of radius 3 m without reducing the speed. The coefficient of static friction between the tyre and the road is 0.1. Will the cyclist slip while taking the turn. Why? (1+2+2) **SEP 2023**

Ans:

a. $F_s = \mu_s N$

b. Refer Q 2

c.
$$v_{max} = \sqrt{\mu_s Rg}$$

$$v_{max} = \sqrt{0.1 \times 3 \times 9.8}$$

$$= \sqrt{2.94}$$

$$= 1.71 \text{ m/s}$$

$$V_{\text{cycle}} = 18 \text{ km/hr.} = 5 \text{ m/s} > 1.71$$

The cyclists will slip while turning

8. ----- is the measure of inertia

MARCH 2023

Ans: Mass

9. While firing a bullet the gun recoils.

(a) Which conservation law helps you to explain this phenomenon?

(b) "In the firing process, the speed of the gun is very low compared to the speed of bullet".

Substantiate the above statement mathematically. (3)

MARCH 2023

Ans :

(a) Law of conservation of momentum.

(b) Total momentum before firing = Total momentum after firing

$$0 = MV + mv$$

$$V = \frac{-mv}{M}$$

M = mass of gun, m = mass of bullet

V = velocity of gun. v = velocity of bullet

$V \propto \frac{1}{M}$ M is very large . hence V is small

10. (a) Sketch the schematic diagram of a vehicle on a banked road and mark various forces acting on it.

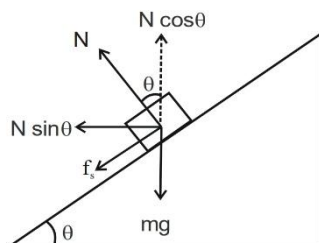
(b) Obtain an expression for maximum safe speed for a vehicle in the banked road. (without considering friction)

(2 + 2)

MARCH 2023

Ans:

a)



$$b) mg = N \cos \theta \quad \text{--- (1)}$$

$$\frac{mv^2}{R} = N \sin \theta \quad \text{--- (2)}$$

$$(2) / (1) \quad \frac{\frac{mv^2}{R}}{mg} = \frac{N \sin \theta}{N \cos \theta}$$

$$\frac{v^2}{Rg} = \tan \theta$$

$$V = \sqrt{Rg \tan \theta}$$

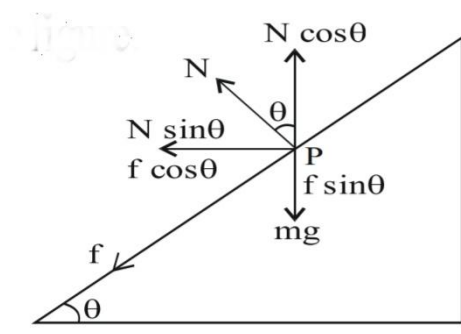
11. State and prove Newton's second law of motion .(3)

OCT 2022

Ans: Refer Q1

12. Derive the expression for maximum speed of a car on a banked road considering friction.(3) **OCT 2022**

Ans :



The vehicle is under the action of the following forces

- i) Its weight mg acting vertically downward
- ii) the normal reaction N of the ground on the car acting along the normal to the banked road.
- iii) the frictional force f_s between the tyres and the road.

The car does not have any vertical motion ,
therefore

$$mg + f_s \sin \theta = N \cos \theta$$

$$mg = N \cos \theta - f_s \sin \theta$$

$$mg = N \cos \theta - \mu_s N \sin \theta \quad \text{--- (1)}$$

The forces $N \sin \theta$ and $f_s \cos \theta$ together provide the necessary centripetal force

$$\frac{mv^2}{R} = N \sin \theta + f_s \cos \theta$$

$$\frac{mv^2}{R} = N \sin \theta + \mu_s N \cos \theta \quad \text{--- (2)}$$

$$\frac{(2)}{(1)} \quad \frac{\frac{mv^2}{R}}{mg} = \frac{N \sin \theta + \mu_s N \cos \theta}{N \cos \theta - \mu_s N \sin \theta}$$

$$\frac{v^2}{Rg} = \frac{\sin \theta + \mu_s \cos \theta}{\cos \theta - \mu_s \sin \theta}$$

$$\frac{V^2}{Rg} = \frac{\tan \theta + \mu_s}{1 - \mu_s \tan \theta}$$

$$V^2 = \frac{Rg(\tan \theta + \mu_s)}{1 - \mu_s \tan \theta}$$

$$V = \sqrt{\frac{Rg(\tan \theta + \mu_s)}{1 - \mu_s \tan \theta}}$$

13. The limiting value of static friction is

JAN 2022

- (i) proportional to area of contact
- (ii) inversely proportional to area of contact
- (iii) proportional to square of area of contact
- (iv) independent of area of contact

,(1)

Ans

- (iv) Independent of area of contact

14. State Newton's second law of motion and derive the equation $F = ma$.(3)

JAN 2022

Ans –Refer Q1

15. The various forces acting on a car (P) on a banked road are shown in the figure.

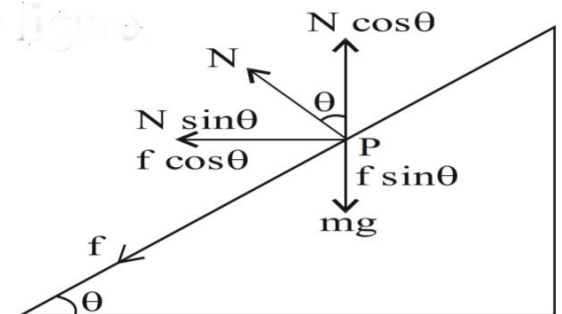
JAN 2022

- (a) Name the forces labelled N and f.
- (b) The sum of the forces ----- and ----- provides the necessary centripetal force for the car.(3)

Ans

a) N – Normal Reaction. f –force of friction

b) N Sin θ and f Cos θ



16. (a) State Newton's third law of motion.

- (b) Two billiard balls each of mass 0.05 kg moving in opposite directions with speed 6 m/s collide and rebound with the same speed. What is the impulse imparted to each ball due to the other ?(4)

JAN 2022

Ans:

a) Newton's third law states that, To every action there is an equal and opposite reaction.

b) Impulse = change in momentum

$$= mv - mu = m(v-u) = 0.05 [6 - (-6)] = 0.6 \text{ Ns}$$

17. A car of mass m is taking a circular turn of radius R on a horizontal road. The coefficient of static friction between the tyres and the road is μ

(a) Derive an expression for the maximum possible safe speed of the car.

(b) Let $\mu = 0.1$ and $R = 20\text{m}$. If the car moves at a speed of 5 m/s, will the car slip while taking the turn ?

JAN 2022

Ans:

a) Refer Q2

$$b) V_{max} = \sqrt{\mu Rg}$$

$$V_{max} = \sqrt{0.1 \times 20 \times 9.8} = 4.42 \text{ m/s}$$

Since velocity of car = 5 m/s > V_{max} car will slip

18. A light and a heavy body have equal momentum. Which one has greater kinetic energy ?(1)

Ans : lighter body

JAN 2022

19. A person firing a bullet from a gun experiences a backward jerk :

(a) Write the principle behind this.

(b) A bullet of mass 15 g fired with a velocity of 100 m/s from a gun of mass 2 kg. Find the recoil speed of gun (2)

JUN 2022

Ans:

(a) Law of conservation of linear momentum Or Newton's third law

(b) Recoil speed, $|V| = \frac{mv}{M} = \frac{0.05 \times 100}{2} = \frac{0.75m}{s}$

20. A child of mass 30 kg is standing inside a lift.

(a) What happens to the apparent weight of the child if the lift is moving up with a uniform acceleration ?

(b) Write an expression for the apparent weight of the child.

(c) Find the apparent weight of the child, if the lift is moving down with constant acceleration of 5 m/s^2 (1 + 1 + 2)

Ans :

JUNE 2022

a) apparent weight increases

b) Apparent weight = $mg + ma$

c) when the lift goes down with constant acceleration,

Apparent weight = $mg - ma$

$$= m(g - a)$$

$$= 30(9.8 - 5)$$

$$= 144 \text{ N}$$

21. Banking of roads helps to increase the limit of maximum

safe speed of a vehicle at a curve.

(a) Draw the schematic diagram of a vehicle on a banked road and mark the various force acting on it.

JUNE 2022

(b) Obtain an expression for the maximum safe speed of a vehicle at a banked road with frictional force (2 + 3)

Ans: Refer Q12

22. Momentum is a ----- quantity. (vector/scalar)

SEPT 2021

Ans: vector

23. State Newton's second law of motion and write the equation of force. (3) **SEPT 2021**

Ans: Ref Q1

24. State the laws of static friction. (3)

SEPT 2021

Ans:

i). The limiting static friction is independent of the area of the surfaces in contact.

ii). The limiting static friction f_s is directly proportional to Normal reaction N .

$$f_s = \mu_s N$$

25. Various forces acting on a car in circular motion through a banked road is shown.

(a) Write the name of forces A and B.

(b) A cyclist travelling on a level road takes a sharp circular turn of radius 3 m without reducing the speed. The co-efficient of static friction between the tyres and the roads is 0.1. Calculate the maximum permissible speed to avoid slipping. (2 + 3 = 5)

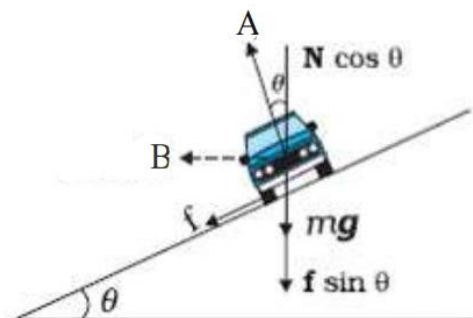
SEP 2021

Ans :

(a) A . normal reaction (N)

B – centripetal force or $N \sin \theta + f \cos \theta$

b) $v_{\max} = \sqrt{\mu_s R g}$
 $= \sqrt{0.1 \times 3 \times 9.8}$
 $= \sqrt{2.94}$
 $= 1.715 \text{ m/s}$



CHAPTER 5

WORK, ENERGY AND POWER

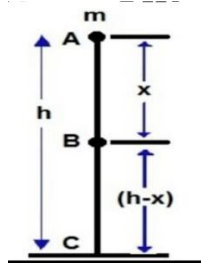
MARCH 2025

1. (a) Illustrate the conservation of mechanical energy for a ball of mass m dropped from a height h

(b) State true or false:-

The workdone by any force in a closed path is zero (3+1)

Ans:



Consider a body of mass ' m ' at a height h from the ground.

Total energy at the point A

The potential energy of A,

$$PE = mgh$$

$$\text{Kinetic energy, } KE = \frac{1}{2} mv^2$$

(since the body is at rest, $v = 0$)

$$\therefore \text{Total mechanical energy} = PE + KE$$

$$= mgh + 0$$

$$= mgh$$

Total energy at the point B

The body travels a distance x when it reaches B.

The velocity at B can be found using the formula.

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2gx$$

$$\therefore KE \text{ at B} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} m2gx$$

$$= mgx$$

$$P.E. \text{ at B} = mg(h - x)$$

$$\text{Total mechanical energy} = PE + KE$$

$$= mg(h - x) + mgx$$

$$= mgh$$

Total energy at C

Velocity at C can be found using the formula

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2gh$$

$$\therefore KE \text{ at C} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} m2gh$$

$$= mgh$$

$$P.E. \text{ at C} = 0$$

$$\text{Total energy} = PE + KE$$

$$= 0 + mgh$$

$$= mgh$$

Total energy remains constant.

(b) .False

(MARCH 2024)

2. Define power. Write its unit and dimension (2)

Ans: Power of a body is defined as the rate of doing work by the body.

Unit: J/S= Watt (W)

Dimension: $M L^2 T^{-3}$

3. (a).State work- energy theorem

(b).What is collision? Explain different types (2+2)

Ans: (a) According to this principle, the workdone by a force is equal to change in the kinetic energy of the body.

(b) Collision between twobodies is defined as the process of mutual interaction of bodies for a very short interval of time due to which energy and momentum of the interacting bodies get changed.

i) Elastic collision: Collision in which both momentum and kinetic energy of the system are conserved is called perfectly elastic collision.

ii) Inelastic collision: Collision in which momentum of the system is conserved but kinetic energy of the system is not conserved is called inelastic collision.

MARCH 2023

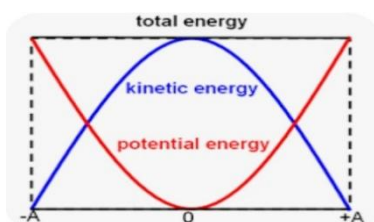
4. (a) Choose the correct option:

The spring force is a conservative/non-conservative force. (1)

(b) Draw the variation of potential and kinetic energies of a spring with its displacement from the equilibrium position. (1)

Ans:

(a) Conservative



(b)

5. (a) A car and a lorry have equal kinetic energy, which one will have greater momentum? Explain.

(1)

(b) State and prove work-energy theorem. (3)

Ans:

(a) $KE_{\text{lorry}} = KE_{\text{car}}$

$P = \sqrt{2m \times KE}$ —————

$KE = \text{constant}$

$\therefore P \propto \sqrt{m}$

The mass of the lorry is large compared to the mass of the car.

Hence the momentum of the lorry is greater than that of the car.

(b) The change in kinetic energy of a particle is equal to the work done on it by the net force.

Proof: We know $v^2 = u^2 + 2as$

$v^2 - u^2 = 2as$

Multiplying both sides by $m/2$

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mas$

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = W$

Final kinetic energy - Initial kinetic energy = Workdone.

Change in K E = Workdone.

SEPTEMBER 2023

6. State work- energy theorem for conservative force (2)

Ans: According to this principle, the workdone by a force is equal to change in the kinetic energy of the body.

7. (a).What is a conservative force

(b) Show that the total mechanical energy of a system is conserved if the force doing work on it are conservative (1+3)

Ans: (a) A force is said to be conservative, if the workdone by that force is independent of the path followed, but depend only on initial and final points..

(b) Ref. Q 1

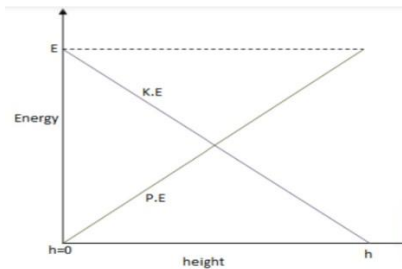
JUNE2022

8. A light body and a heavy body have equal momentum, which one has greater kinetic energy (1)

Ans: Light body

9. Draw variation of kinetic energy and potential energy of a freely falling body with height (2)

Ans:



10. Show that total mechanical energy of a freely falling body is constant. (3)

Ans: Refer Q 1

SEPTEMBER 2021

11. Write whether the work done in the following cases is positive, negative or zero (a). The work done by the frictional force during the motion of an object

(b). The work done by the gravitational force during the motion of an object on a horizontal surface (2)

Ans: (a) Negative

(b) Zero

12. Write the SI Unit and dimensional formula of energy (2)

Ans: Jule or $\text{Kgm}^2\text{s}^{-2}$ or Kwh or Nm

$$[E] = \text{ML}^2\text{T}^{-2}$$

13. What is the difference between elastic and inelastic collisions

Ans: i) Elastic collision: Collision in which both momentum and kinetic energy of the system are conserved is called perfectly elastic collision.

ii) Inelastic collision: Collision in which momentum of the system is conserved but kinetic energy of the system is not conserved is called inelastic collision.

14. Prove that mechanical energy for a ball of mass m dropped from a height h is conserved. Consider a body of mass ' m ' at a height h from the ground.

Ans: Ref Q 1

CHAPTER 6

SYSTEM OF PARTICLES AND ROTATIONAL MOTION

1.a) Define moment of inertia [MODEL 2026]

b) State any two factors on which the moment of inertia of a rigid body depends

Ans: a)) The inability of a body to change the state of rest or uniform rotation by itself is called moment of inertia. it is r as the product of mass of the particle and square of distance from axis of rotation

b)i) mass of the body

ii) position and orientation of body

[MODEL 2026]

2. a) The rotational analogue of mass in linear motion is

b) Derive the relation between torque and angular momentum

Ans: a) Moment of inertia

b)) $\vec{l} = \vec{r} \times \vec{p}$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{r} \times \vec{F} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

3. a) Define moment of inertia [MODEL 2025]

b) what are the factors on which the moment of inertia of a rigid body depends

Ans: a) The inability of a body to change the state of rest or uniform rotation by itself is called moment of inertia. it is r as the product of mass of the particle and square of distance from axis of rotation

b) i) mass of the body

ii) position and orientation of body

(iii) size and shape of body

(iv) distribution of mass about axis

4. a) State the law of conservation of angular

Momentum

[MODEL 2025]

b) The angular momentum of a rotating body is , $\vec{l} = \vec{r} \times \vec{p}$

Using this relation arrive at the equation $\frac{d\vec{l}}{dt} = \vec{\tau}$

Ans: a) When no external torque act on the body ,the net angular momentum of a rotating rigid body remains constant

b)) $\vec{l} = \vec{r} \times \vec{p}$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{\tau} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

[MARCH 2025]

5. a) In rotation of a rigid body about a fixed axis ,every particle of the body has same.....(linear velocity/angular velocity)

b) The quantity angular velocity is(scalar/vector)

Ans: a) Angular velocity

b) vector

[MARCH 2025]

6. a) Write the expression for kinetic energy of a rotating body

b) A solid cylinder of mass 20kg rotates about its axis with angular speed of 100 rad/s. The radius of the cylinder is 0.25m. What is the kinetic energy associated with the rotation of cylinder?

Ans: a) Rotational KE = $\frac{1}{2} I \omega^2$

$$b) I = \frac{1}{2} MR^2 = \frac{1}{2} \times 20 \times (0.25)^2 = 0.625 \text{ kgm}^2$$

$$\text{Rotational KE} = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 0.625 \times (100)^2 = 3125 \text{ J}$$

7.a) Define moment of inertia of a body [MODEL 2024]

b) Which physical quantity is represented by the product of moment of inertia and angular velocity?

Ans: a) The inability of a body to change the state of rest or uniform rotation by itself is called moment of inertia. it is r as the product of mass of the particle and square of distance from axis of rotation

b) Angular momentum

[MODEL 2024]

8. a) The rotational analogue of mass in linear motion is...

b) The angular momentum of a rotating body is , $\vec{l} = \vec{r} \times \vec{p}$

Using this relation arrive at the equation $\frac{d\vec{l}}{dt} = \vec{\tau}$

Ans: a) moment of inertia

$$b) \vec{l} = \vec{r} \times \vec{p}$$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{\tau} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

9,a)state and explain

[MARCH 2024]

(i) Torque

(ii) Angular momentum

b) Write the relation between torque and angular momentum

Ans: a) (i) When an external force acting on a body has a tendency to rotate the body about an axis, then the force is said to exert a torque. It is measured as the product of magnitude of force and perpendicular distance between the line of action of the force and axis of rotation i.e. torque $\vec{\tau} = \vec{r} \times \vec{F}$

(ii) the moment of linear momentum of a particle about an axis is called angular momentum. It is measured as the product of magnitude of linear momentum and perpendicular distance of the particle from the axis of rotation i.e. angular momentum $\vec{l} = \vec{r} \times \vec{p}$

$$b) \vec{l} = \vec{r} \times \vec{p}$$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{\tau} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

10. The moment of inertia of a disc about an axis passing through

The centre and perpendicular to its plane is... [MARCH 2024]

Ans: $I = \frac{1}{2} MR^2$

11.a) What is moment of force?

[MODEL 2023]

b) Under what conditions, the torque due to an applied force is zero?

Ans: a) torque or rotating effect of force

b) i) when force is applied on origin or axis of rotation

ii) when angle between position vector and force

is zero or 180°

[MODEL 2023]

12. a) State law of conservation of angular momentum

b) What is the torque of the force $\vec{F} = (2\hat{i} - 5\hat{j} + 4\hat{k})$ acting at the point $\vec{r} = (3\hat{i} + 3\hat{j} + 3\hat{k})$ about the origin

Ans: a) When no external torque act on the body, the net angular momentum of a rotating rigid body remains constant

$$\begin{aligned} \text{b) } \vec{\tau} &= \vec{r} \times \vec{F} \\ &= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 3 & 3 \\ 2 & -5 & 4 \end{vmatrix} \\ &= \hat{i}(12 - 15) - \hat{j}(12 - 6) + \hat{k}(-15 - 6) = 27\hat{i} - 6\hat{j} - 21\hat{k} \end{aligned}$$

13. The point at which the whole mass of the body is supposed to be concentrated is called.....

Ans: centre of mass [MARCH 2023]

14. What are the factors affecting moment of inertia of an object

Ans: i) mass of the body [MARCH 2023]

ii) position and orientation of body

(iii) size and shape of body

(iv) distribution of mass about axis

15. a) State law of conservation of angular momentum

b) Based on law of conservation of angular momentum, how does the speed of a ballet dancer vary when

i) Outstretching her arms and legs

ii) Folding her arms and legs

Ans: a) When no external torque act on the body, the net angular momentum of a rotating rigid body remains constant

b) $L = I\omega$ i) on out stretching radius r increases therefore

I increases, ω decreases

ii) On folding radius r decreases therefore

I decreases, ω increases

[Model 2022]

16. The angular momentum of a rotating body is, $\vec{L} = \vec{r} \times \vec{p}$

Using this relation arrive at the equation $\frac{d\vec{L}}{dt} = \vec{\tau}$

Ans:) $\vec{l} = \vec{r} \times \vec{p}$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{r} \times \vec{\tau} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

[MODEL 2022]

17 i) What are analogues of mass and force in rotational motion

ii) Derive an expression for kinetic energy of a rotating body

Ans: i) moment of inertia and torque

ii) KE of a particle = $\frac{1}{2}mv^2$

but $v = r\omega$

$$KE = \frac{1}{2}mr^2\omega^2$$

$$KE \text{ of whole body} = \sum \frac{1}{2}mr^2\omega^2 = \frac{1}{2}\omega^2 \sum mr^2$$

but $\sum mr^2 = I$

$$KE = \frac{1}{2}I\omega^2$$

[JUNE 2022]

18 The angular speed of a rotating body changes from ω_1 to ω_2 without applying an external torque but due to change in moment of inertia. Find the ratio of radii of gyration in the two cases.

Ans: $I_1\omega_1 = I_2\omega_2$ but $I = MK^2$

$$MK_1^2 \omega_1 = MK_2^2 \omega_2$$

$$\frac{K_1}{K_2} = \sqrt{\frac{\omega_2}{\omega_1}}$$

[JUNE 2022]

19.a) τ is the torque and L is the angular momentum of rotating

rigid body show that $\frac{d\vec{L}}{dt} = \vec{\tau}$

b) Calculate the duration of a day when earth shrinks to $\frac{1}{8}$ of

its initial volume

Ans: a) $\vec{l} = \vec{r} \times \vec{p}$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt} (\vec{r} \times \vec{p})$$

$$= \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$$= \vec{v} \times \vec{p} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m \vec{v} + \vec{\tau} \quad (\text{but } \vec{v} \times \vec{v} = 0)$$

$$\therefore \frac{d\vec{l}}{dt} = \vec{\tau}$$

$$\text{b) } I_1\omega_1 = I_2\omega_2$$

$$V_2 = \frac{1}{8} V_1$$

$$\therefore R_2 = \frac{R_1}{2}$$

$$\text{For sphere } I = \frac{2}{5} MR^2 \quad \text{and} \quad \omega = \frac{2\pi}{T}$$

$$\frac{2}{5} MR_1^2 \times \frac{1}{T_1} = \frac{2}{5} MR_2^2 \times \frac{1}{T_2}$$

$$\frac{R_1^2}{T_1} = \frac{R_2^2}{T_2}$$

$$\frac{R_1^2}{T_1} = \frac{\left(\frac{R_1}{2}\right)^2}{T_2}$$

$$T_2 = \frac{T_1}{4} = \frac{24}{4} \text{ hrs}$$

CHAPTER 7

GRAVITATION

1. Identify the fundamental force in nature from the following; **SEPTEMBER 2021**

- (i) Gravitational force
- (ii) Elastic force
- (iii) Restoring force
- (iv) Frictional force

Ans : Gravitational force

2. Name the branch of Science which deals with the study of stars. **SEPTEMBER 2021**

Ans : Astrophysics

3. State Newton's universal law of gravitation **SEPTEMBER 2021**

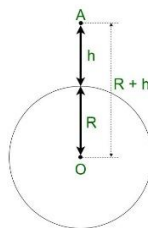
Ans :: Any two material bodies in the universe experience a force of attraction which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

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

Derive the expression for acceleration due to gravity at any point above the surface of earth.

September 2021, IMPT 2022, IMPT 2023

4.



Ans :

On the surface of earth, $g = \frac{GM}{R^2}$

At a height 'h' from the surface of earth, $g' = \frac{GM}{(R+h)^2}$

$$\frac{g'}{g} = \frac{R^2}{(R+h)^2}$$

$$g' = g \frac{R^2}{(R+h)^2}$$

$$\text{If } h \ll R, \quad g' = g \left(1 - \frac{2h}{R}\right)$$

5. Derive an expression for escape velocity of an object from the surface of earth.

SEPTEMBER 2021

Or

Derive an expression for the escape velocity of an object from the surface of earth

MARCH 2023

Or

What do you mean by escape speed?

MARCH 2024, 2025, IMPT 2022

Ans:

Escape velocity (v_e) is the minimum speed needed for an object to escape a planet's gravitational pull
At the surface

$$KE = \frac{1}{2}mv_e^2 \text{ and } PE = \frac{GMm}{R}$$

At infinity both KE and PE are zero,

According to the conservation of energy, $\frac{1}{2}mv_e^2 + -\frac{GMm}{R} = 0$

$$\text{Solving, } v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2Rg}$$

The value of escape velocity from the surface of earth is 11.2 km/s

6. (a) Write unit and dimensional formula of gravitational constant. **September 2021**

Unit Nm^2kg^{-2}

Dimension $M^{-1}L^3T^{-2}$

- (b) Derive an expression for acceleration due to gravity at a depth below the surface of earth
OR

The value of acceleration due to gravity decreases with depth.

,MARCH 2022,IMPT2022

- (i) Derive an expression for acceleration due to gravity at a depth 'd' below the surface of earth
(ii) What is the weight of a body at the centre of Earth?

Ans:

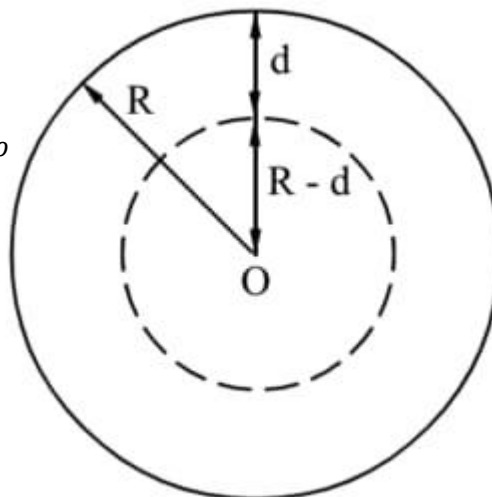
On the surface of earth, $g = \frac{GM}{R^2} = G \frac{4}{3} \frac{\pi R^3}{R^2} \rho$

At a depth 'd' from the surface of earth, $g' = G \frac{4}{3} \frac{\pi (R-d)^3}{R^2} \rho$

$$\frac{g'}{g} = \frac{(R-d)}{R}$$

$$g' = g \frac{(R-d)}{R}$$

$$g' = g \left(1 - \frac{d}{R}\right)$$

**Ans: (ii)**

$$g' = g \left(1 - \frac{d}{R}\right) \quad \text{At the centre of earth } d = R$$

$$g' = 0 \quad \therefore mg = 0, \text{ the weight of the body at the centre of earth equal to zero}$$

7. Write the value of escape velocity of an object from the surface of moon **MARCH 2022**

Ans: 2.3 km/s

8. Check the dimensional correctness of the relation: $v = \sqrt{\frac{GM}{R}}$

MARCH 2022

where v is orbital velocity, G is gravitational constant and R is radius of Earth.

Ans : $[v] = LT^{-1}$

$$\left[\sqrt{\frac{GM}{R}} \right] = \sqrt{\frac{M^{-1}L^3T^{-2}M}{L}} = LT^{-1}$$

[LHS] = [RHS]

The given equation is dimensionally correct.

9. Assuming satellite orbits around a planet to be circular,

MARCH 2022

- Obtain expressions for orbital velocity and time period of a satellite around earth.
- Write one use each for geostationary and polar satellites.

Ans: (i) $\frac{mv_o^2}{(r+h)} = \frac{GMm}{(R+h)^2}$

Orbital velocity, $v_o = \sqrt{\frac{GM}{(R+h)}}$

Time period, $T = \frac{2\pi(R+h)}{v_o} = \frac{2\pi(R+h)}{\sqrt{\frac{GM}{(R+h)}}} = \frac{2\pi(R+h)^{\frac{3}{2}}}{\sqrt{GM}}$

- Uses of geostationary satellites
 - Telecommunications and Broadcasting
 - Meteorology and Environmental monitoring
 - Defence, Intelligence Navigation

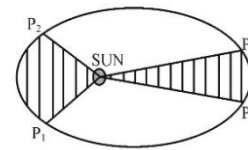
Uses of polar satellites

- Weather forecasting and Meteorology
- Earth Observation and Remote Sensing
- Environmental monitoring
- Military Surveillance
- Scientific Research
- Telecommunication

10. (a) Consider a planet moving in an elliptical orbit around the sun as shown in fig. If t_1 and t_2 be the time taken by the planet to go from P_1 to P_2 and from P_3 to P_4 respectively. The two shaded parts have equal area, then **March 2023**

- $t_1 < t_2$
- $t_1 = t_2$
- $t_1 > t_2$
- $t_2 = -t_1$

Ans: $t_1 = t_2$



- State the law which explains the above case.

Ans: Kepler's second law. Or Law of area.

Line joining the planet to the sun sweeps out equal areas in equal interval of time. .or

Areal velocity is constant, $\frac{dA}{dt} = \text{constant}$

11. Escape velocity from the surface of earth for a body of mass m is 11 km/s. **MARCH 2023**

- If the body is projected at an angle of 45° with the vertical, the escape velocity will be

- (i) $11/\sqrt{2}$ km/s (ii) $22\sqrt{2}$ km/s (iii) 22 km/s (iv) 11 km/s

Ans : 11 km/s

12 The moon has no atmosphere . Why?

MARCH 2023, MARCH 2025

Ans : Moon has no atmosphere .The escape speed of gases on the surface of moon is much less than the root mean square velocity of gases due to low gravity. Due to this, all the gases escape from the surface of moon.

13. State Kepler's laws of motion.

March 2024

Ans: Kepler's first law or law of orbit

Orbit of a planet is ellipse with sun at one of the foci

Kepler's second law. Or Law of area.

Line joining the planet to the sun sweeps out equal areas in equal interval of time. .or

Areal velocity is constant, $\frac{dA}{dt} = \text{constant}$

Kepler's third law or law of period.

Square of time period of revolution of a planet is directly proportional to cube of semi major axis

$$T^2 \propto a^3$$

14. Acceleration due to gravity is independent of ____ (mass of earth / mass of body)

MARCH 2025

Ans: mass of body

15. Potential energy is an energy relative to conservative force.

MARCH 2025 ,IMPT2023

(a) Define gravitational Potential energy.

(b) Derive the equation for gravitational potential energy of a particle on earth surface and hence derive gravitational potential

(c) Is gravitational Potential energy positive or negative? Comment on it.

Ans: (a) The gravitational potential energy of a body at a point is defined as the amount of work done in bringing the body from infinity to that point against the gravitational force.

(b)
$$dW = Fdx = \frac{GMm}{x^2} dx$$

Work done in bringing the body from infinity to on earth surface.

$$W = \int_{\infty}^R dW = \int_{\infty}^R \frac{GMm}{x^2} dx = -\frac{GMm}{R}$$

This work done is stored inside the body as its gravitational potential energy(U)

$$U = -\frac{GMm}{R}$$

Gravitational potential is the work done to bring unit mass from infinity to the point.

Gravitational potential = $-\frac{GM}{R}$

(c) Gravitational potential energy is negative.

It shows that it is a bound system

16. At what height above the earth's surface, the value of g is same as that in a mine 80km deep.

IMPT 2022

Ans:

$$\begin{aligned} g_h &= g_d \\ G\left(1 - \frac{2h}{R}\right) &= g\left(1 - \frac{d}{R}\right) \\ 2h &= d \\ h &= \frac{d}{2} = \frac{80}{2} = 40\text{km} \end{aligned}$$

17. At what height the value of g will be half of that on the surface of earth. **IMPT 2023**

Ans; $g' = g\left(1 - \frac{2h}{R}\right)$

$$\frac{g}{2} = g \left(1 - \frac{2h}{R}\right) \quad \therefore h = \frac{R}{4}$$

18. Acceleration due to gravity depends on mass and radius of the planet.

IMPT2022

(a) Write an equation for Acceleration due to gravity in terms of mass and radius of the planet

(b) A body weighs 63 N on the surface of earth. What is the gravitational force on it due to the earth at a height equal to half the radius of the earth.

Ans : (a) $g = \frac{GM}{R^2}$

(b) At a height equal to half the radius of the earth, $h = \frac{R}{2}$

$$g' = \frac{GM}{(R+h)^2} \text{ substituting for } h \text{ we get } g' = \frac{4}{9} g$$

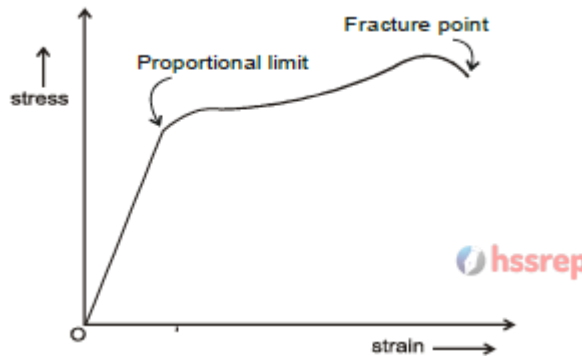
$$mg' = m \frac{4}{9} g = \frac{4}{9} mg = \frac{4}{9} \times 63 = 28 \text{ N}$$

CHAPTER 8

MECHANICAL PROPERTIES OF SOLIDS

MARCH 2025

1. State true or false : 'The stretching of a coil determined by it's shear modulus' (1)
Ans: True
2. (a) Draw typical stress-strain graph.
 (b) Mark the following points on graph : (i)proportional limit (ii)fracture point (1+2)
Ans:



MARCH 2024

3. Explain Young's modulus, write its unit. (3)
Ans:

Ratio of longitudinal stress to longitudinal strain is called Young's modulus.

$$Y = \frac{\text{Longitudinal Stress}}{\text{Longitudinal Strain}} = \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L} = \frac{mgL}{\pi r^2 \Delta L}$$

Unit : $\frac{N}{m^2}$ or Pascal

MARCH 2023

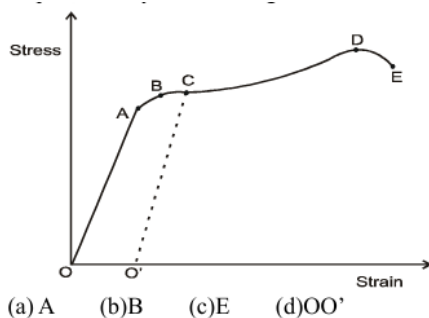
4. True or False : Elastomers do not obey Hooke's law. (1)
Ans: True
5. (a) Which type of elasticity is involved in stretching a wire ?
 (b) Steel is more elastic than rubber. Why? (c) If the bulk modulus of water is $2 \times 10^9 \text{ Nm}^{-2}$, find its compressibility. (1 + 1 + 1)
Ans: (a) Young's modulus or any explanation about elasticity

(b) For a given stress strain is less for steel

(c) Compressibility = $\frac{1}{\text{Bulk Modulus}} = \frac{1}{2 \times 10^9} = .5 \times 10^{-9}$

JUNE 2022

6. Stress-strain curve of steel wire is shown below. From the plot, identify the following : (2)



Ans:

7. (a) Proportional limit
 (b) Yield point / elastic limit
 (c) Fracture point / Breaking point
 (d) Permanent set / Residual strain (2)

(ii) Definition of longitudinal strain

8. Draw a typical stress – strain curve for a metal and mark the proportional limit. (2)

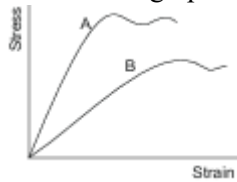
Ans: Draw the curve and mark the proportional limit

SAY 2023

9. Reciprocal of Bulk modulus is ----- (1)

Ans: Compressibility

10. Stress-strain graph for two materials is shown below :



(a) State the law which relates stress with strain

(b) Which of the materials has greater Young's Modulus, A or B ? (1+1)

Ans:

(a) Within elastic limit, stress is directly proportional to strain.

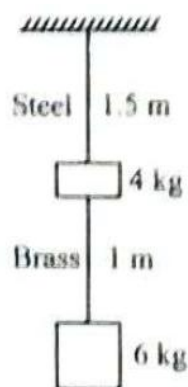
(b) A

SAY 2022

11. State Hookes Law (1)

Ans: Hookes law states that stress is directly proportional to strain within elastic limit

12. Two wires of diameter .25 cm one made of steel and the other made of brass are loaded as shown in the figure. The unloaded length of steel wire is 1.5 m and that of brass wire is 1 m .Compute the elongations of steel and brass wire (3)

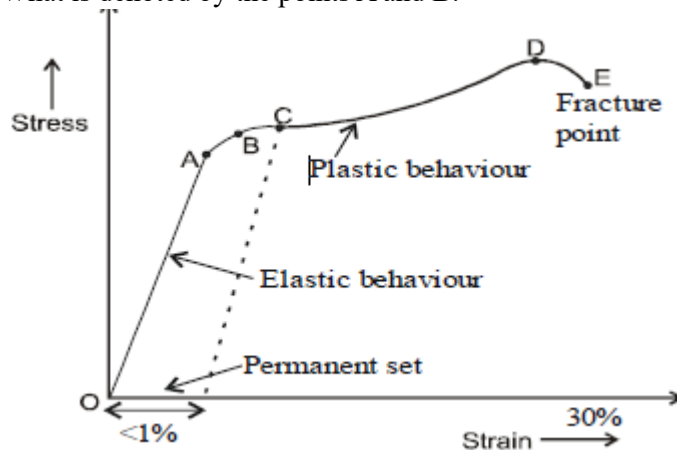


Ans:

SAY 2021

A typical stress-strain curve for a metal is given below.

13. What is denoted by the points A and B. (2)



Ans:

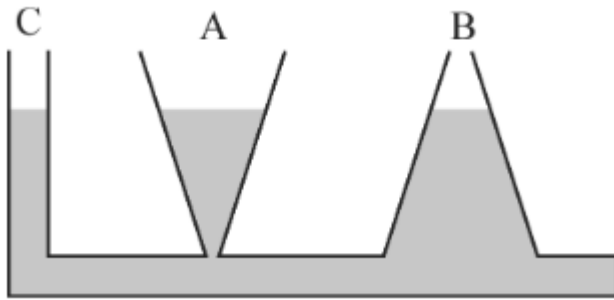
A – Proportional limit

B – Yield point

CHAPTER 9

MECHANICAL PROPERTIES OF FLUIDS

1. Three vessels A,B and C contain different amounts of liquid are shown in figure. All up to the same height. This phenomenon is an illustration of _____ (MARCH 2025)



Ans: Hydraustatic paradox

2. (a) The pressure at depth below the surface of a liquid open to atmosphere is greater than atmospheric pressure. Excess pressure at depth is called _____
(b) Calculate the pressure on a swimmer 10m below the surface of a lake. (MARCH 2025)

Ans: a) Gauge pressure

b) $P = P_a + h\rho g$

$$P = (1.013 \times 10^5) + (10 \times 10^3 \times 9.8)$$

$$P = 1.993 \times 10^5 \text{ Pa}$$

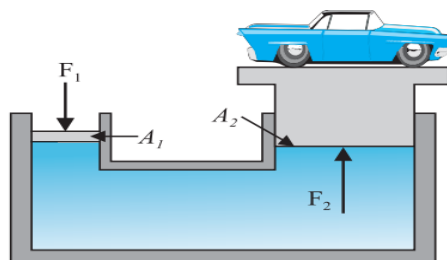
3. Hydraulic lift and Hydraulic brakes are applications of a famous law.
(a) Name and state the law.

(b) Draw the schematic diagram illustrating the principle behind the hydraulic lift and obtain the equation for mechanical advantage. (MARCH 2025) , (MARCH 2021)

Ans: a) Pascal's law

Statement: For a continuous incompressible fluid in equilibrium, the pressure applied at any point is equally transmitted in all directions and in the same amount.

b)



Pressure on first piston = Pressure on second piston

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

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

Mechanical advantage $\frac{A}{a} = \frac{F_2}{F_1}$

4. The excess pressure inside a soap bubble in air is

- a) 0 b) $\frac{S}{R}$ c) $\frac{2S}{R}$ d) $\frac{4S}{R}$

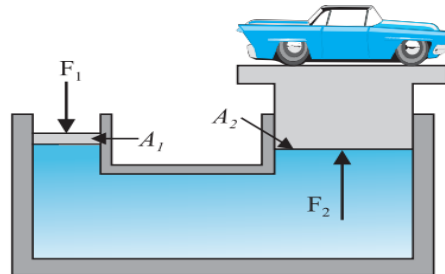
(MARCH 2024)

Ans: $\frac{4S}{R}$

5. Explain the working of hydraulic lift.

(MARCH 2024)

Ans:



The pressure on smaller piston $= \frac{F_1}{A_1}$

This pressure is transmitted equally to larger cylinder with a larger piston of larger area A_2 producing large upward force F_2 .

The pressure on larger piston $= \frac{F_2}{A_2}$

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

$$F_2 = F_1 \frac{A}{a}$$

Thus the applied force has been increased by a factor of $\frac{A}{a}$ which is called mechanical advantage of a device.

6. (a) What is streamline flow?
(b) State Bernoulli's principle.

- (c) What is viscous force and explain coefficient of viscosity

(MARCH 2024)

Ans: (a) The flow of fluid is said to be steady, if at any given point, the velocity of each passing fluid particle remains constant in time.

(b) Bernoulli's principle states that, as we move along a streamline, the sum of pressure energy per unit volume, kinetic energy per unit volume and potential energy per unit volume, remains constant through out its flow.

(c) The internal frictional force acts when there is a relative motion between the layers of liquid and this opposing force is called viscous force.

$$F = 6\pi\eta r v$$

Coefficient of viscosity defined as the ratio of shearing stress to strain rate.

$$\eta = \frac{Fl}{vA}$$

7. (a) A drop of liquid under no external force is always spherical in shape. Why?

- (b) When a painting brush dipped in water, its hairs cling together. Why?

(MARCH 2023)

Ans: (a) Due to surface tension, liquid appears spherical in shape because out of different shapes with constant volume, spherical shape has least surface area.

(b) Due to the presence of the free liquid surface and surface tension comes in to play.

8. (a) When a water flowing in a broader pipe enters in to a narrow pipe, its pressure decreases. Do you agree with this statement? Explain?

(b) Define coefficient of viscosity.

(MARCH 2023)

Ans: (a) Yes. When a water flowing in a broader pipe enters in to a narrow pipe, its velocity increases and pressure decreases. According to Bernoulli's principle, when velocity of flow increases, pressure decreases.

(b) Coefficient of viscosity for a fluid is defined as the ratio of shearing stress to strain rate.

$$\eta = \frac{Fl}{vA}$$

9. Due to capillary action, water will rise inside a glass tube.

a) The angle of contact in this case is _____

- (i) Acute (ii) Obtuse (iii) 90° (iv) Zero

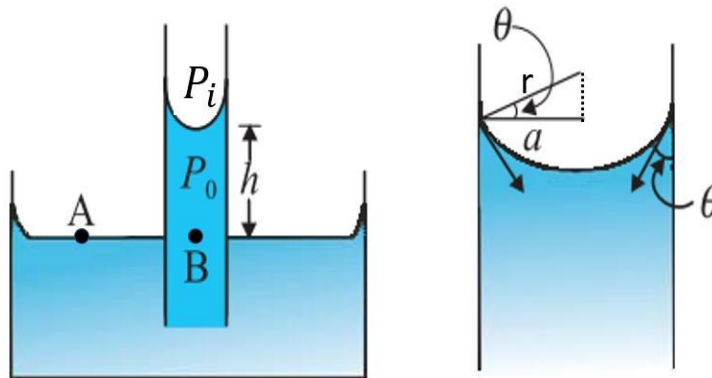
b) Obtain an expression for rise of the liquid in the tube.

c) Water rises to different heights in glass tubes of different radii. Give reason.

(MARCH 2023)

Ans: (a) (i) Acute (For pure water and glass (without grease), angle of contact is zero)

(b)



Consider a vertical capillary tube of circular cross section (radius a) inserted in to an open vessel of water.

The excess pressure on the concave meniscus, $(P_i - P_o) = \frac{2S}{R}$

$$\cos \theta = \frac{a}{r}$$

$$r = \frac{a}{\cos \theta}$$

$$(P_i - P_o) = \frac{\frac{2S}{a}}{\cos \theta}$$

$$(P_i - P_o) = \frac{2S \cos \theta}{a}$$

Consider two points A and B in same horizontal level. i.e, points are at same pressure.

Pressure at A = P_i

Pressure at B = $P = P_o + h\rho g$

$$P_i = P_o + h\rho g$$

$$(P_i - P_o) = h\rho g$$

$$h\rho g = \frac{2S\cos\theta}{a}$$

$$h = \frac{2S\cos\theta}{a\rho g}$$

This is the expression for capillary ascent.

(c) capillary ascent $h \propto \frac{1}{r}$

As radius of capillary tube increases, capillary rise decreases.

10. The excess pressure inside a liquid drop is _____
(IMPROVEMENT 2023)

Ans: $\frac{2S}{R}$

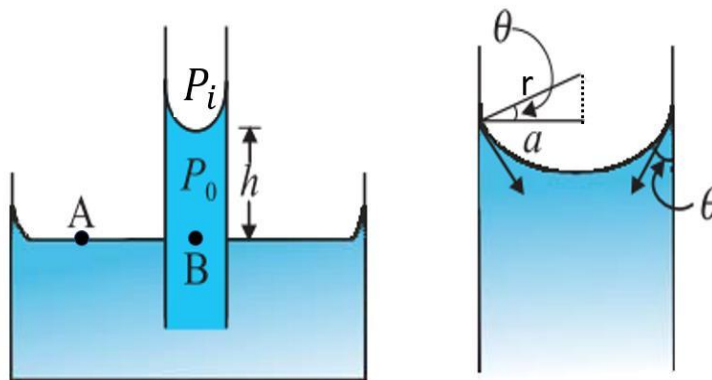
11. State Bernoulli's principle. (IMPROVEMENT 2023)

Ans: Bernoulli's principle states that, as we move along a streamline, the sum of pressure energy per unit volume, kinetic energy per unit volume and potential energy per unit volume, remains constant through out its flow.

12. When a narrow tube is dipped in water, water rises in the tube to a height 'h'.
(a) Name the phenomenon.
(b) Arrive at an expression for capillary rise 'h' in the tube.
(c) Will the water overflow, if the tube is cut at level 'A'? Justify your answer (IMPROVEMENT 2023)

Ans:(a) Capillary rise/ Capillarity

(b)



Consider a vertical capillary tube of circular cross section(radius a) inserted in to an open vessel of water.

The excess pressure on the concave meniscus, $(P_i - P_o) = \frac{2S}{R}$

$$\cos \theta = \frac{a}{r}$$

$$r = \frac{a}{\cos \theta}$$

$$(P_i - P_o) = \frac{\frac{2S}{a}}{\cos \theta}$$

$$(P_i - P_o) = \frac{2S\cos\theta}{a}$$

Consider two points A and B in same horizontal level. i.e, points are at same pressure.

Pressure at A = P_i

Pressure at B = $P = P_o + h\rho g$

$$P_i = P_o + h\rho g$$

$$(P_i - P_o) = h\rho g$$

$$h\rho g = \frac{2S\cos\theta}{a}$$

$$h = \frac{2S\cos\theta}{a\rho g}$$

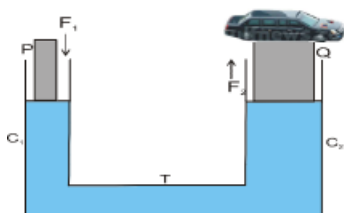
This is the expression for capillary ascent.

c) Water will not overflow. The radius of the liquid surface increases (flattens) to balance the pressure, and the liquid remains at the top of the cut edge. The product of radius of the liquid meniscus and the height of the liquid remains a constant.

13. When temperature of a liquid increases, its surface tension _____
(increases, decreases, remains the same) **(MARCH 2022)**

Ans: decreases

14. a) State Pascal's Law.
b)



The schematic diagram of a hydraulic lift is shown in figure. Using pascal's law, find the value of F_2 in terms of A_1 and A_2 . (A_1 and A_2 are area of pistons) **(MARCH 2022)**

Ans: (a) For a continuous incompressible fluid in equilibrium, the pressure applied at any point is equally transmitted in all directions and in the same amount.

(b) The pressure on smaller piston $P = \frac{F_1}{A_1}$

The pressure on larger piston $P = \frac{F_2}{A_2}$

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

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

15. A solid sphere of radius r and density ρ is falling through a viscous medium of density σ and coefficient of viscosity η .

(a) What are the different forces acting on the body.

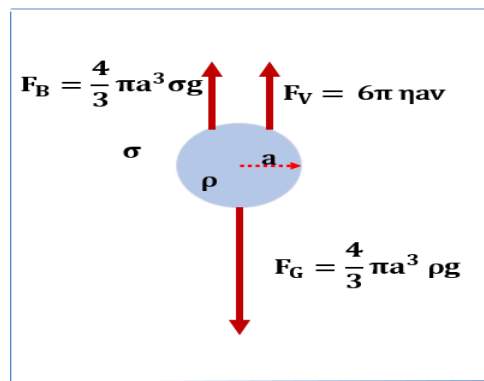
(b) Derive an expression for terminal velocity? **(MARCH 2022)**

Ans: (a) i) gravitational force $mg = V\rho g$ acting downwards

ii) Buoyant force (upthrust) $mg = V\sigma g$ acting upwards

iii) Viscous force $F = 6\pi r\eta V$ acting upwards

(b)



gravitational force = Buoyant force + Viscous force F

$$mg = V\sigma g + 6\pi\eta V_t$$

$$V\rho g = V\sigma g + 6\pi\eta V_t$$

$$V_t = \frac{V\rho g - V\sigma g}{6\pi\eta} = \frac{\left(\frac{4}{3}\right)\pi r^3(\rho - \sigma)g}{6\pi\eta}$$

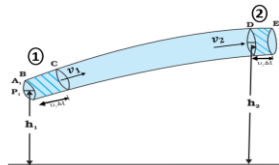
$$V_t = \frac{2}{9\eta} r^2 (\rho - \sigma) g$$

This is the equation for terminal velocity.

16. The flow of an ideal fluid in a pipe of varying area of cross section is shown below.

(a) State and prove Bernoulli's principle. **(IMPROVEMENT 2022), (MARCH 2021)**

(b) Write any characteristics of a fluid that obey Bernoulli's principle. **(MARCH 2022)**

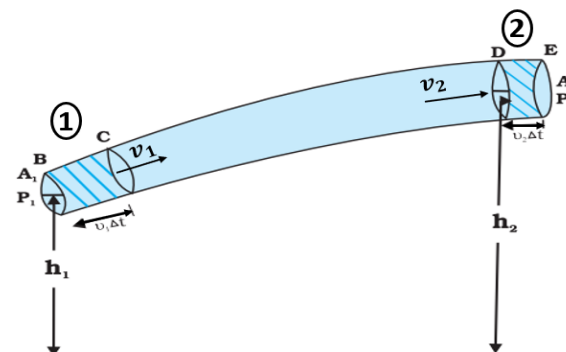


Ans: (a) Statement:

Bernoulli's principle states that, as we move along a streamline, the sum of pressure energy per unit volume, kinetic energy per unit volume and potential energy per unit volume, remains constant through out its flow.

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$$

Proof:



Consider the flow of an ideal fluid in a pipe of varying cross section from region 1 to region 2, as shown in figure. The fluid in two regions is displaced a length of $V_1 \Delta t$ and $V_2 \Delta t$ in time Δt .

Work done on the fluid at left end BC = $P_1 \Delta V$

Work done on the fluid at end DE = $-P_2 \Delta V$

The total work done on the fluid is $W = W_1 + W_2 = P_1 \Delta V - P_2 \Delta V$

A part of this work goes into change in kinetic energy of fluid and a part goes in to change in gravitational potential energy.

$$W_1 + W_2 = \Delta K.E + \Delta P.E$$

$$P_1 \Delta V - P_2 \Delta V = \left(\frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 \right) + (m g h_2 - m g h_1)$$

Divide each term by ΔV ,

$$P_1 - P_2 = \left(\frac{1}{2} \rho v_2^2 - \frac{1}{2} \rho v_1^2 \right) + (\rho g h_2 - \rho g h_1) \quad (m = \rho \Delta V)$$

$$P_1 - P_2 = \frac{1}{2} \rho v_2^2 - \frac{1}{2} \rho v_1^2 + \rho g h_2 - \rho g h_1$$

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2$$

$$P + \frac{1}{2} \rho v^2 + \rho g h = \text{constant} . \text{ This is Bernoulli's principle.}$$

(b) (i) Non – viscous fluid.

(ii) Incompressible fluid.

(iii) Steady flow/ Streamline flow

17. Principle of Hydraulic lift is _____

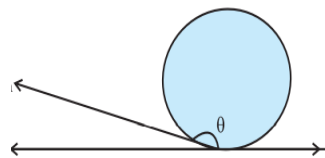
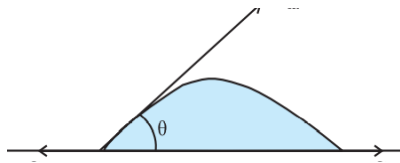
(IMPROVEMENT 2022)

Ans: Pascal's law

18. Define angle of contact?

Ans: Angle of contact (θ) is the angle between tangent to the liquid surface at the point of contact and solid surface inside the liquid.

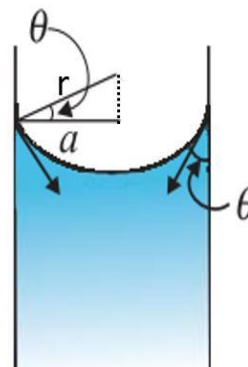
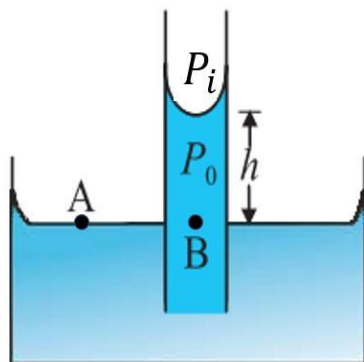
(IMPROVEMENT 2022)



19. Derive the expression for capillary height.

(IMPROVEMENT 2022)

Ans:



Consider a vertical capillary tube of circular cross section(radius a) inserted in to an open vessel of water.

The excess pressure on the concave meniscus, $(P_i - P_o) = \frac{2S}{R}$

$$\cos \theta = \frac{a}{r}$$

$$r = \frac{a}{\cos \theta}$$

$$(P_i - P_o) = \frac{\frac{2S}{a}}{\cos \theta}$$

$$(P_i - P_o) = \frac{2S \cos \theta}{a}$$

Consider two points A and B in same horizontal level. i.e, points are at same pressure.

Pressure at A = P_i

Pressure at B = $P = P_o + h\rho g$

$$P_i = P_o + h\rho g$$

$$(P_i - P_o) = h\rho g$$

$$h\rho g = \frac{2S \cos \theta}{a}$$

$$h = \frac{2S \cos \theta}{a\rho g}$$

This is the expression for capillary ascent.

CHAPTER 10

THERMAL PROPERTIES OF MATTER

2025 MARCH

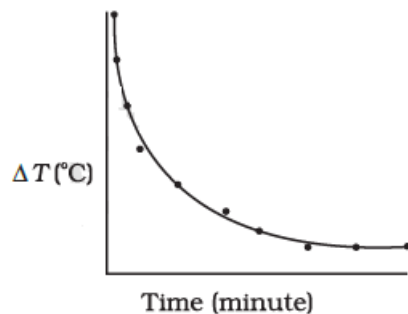
1. Name the substance which has the highest specific heat capacity.(1)

Ans: water

2. a) State Newton's law of cooling.
b) Draw the graph showing the cooling of hot water with time.
c) Specify the drawback of Newton's law of cooling. (1+1+1)

Ans: a) The rate of loss of heat of a body is directly proportional to the temperature difference between the body and its surroundings.

b)



c) Temperature difference should be small

2024 March

3. Explain anomalous behaviour of water related to thermal expansion.(2)

Ans: Most substances expand when heated and contract when cooled. However, water behaves differently between 0°C and 4°C. When water is heated from 0°C to 4°C, it contracts instead of expanding, and When cooled from 4°C to 0°C, it expands instead of contracting. Thus water has maximum density at 4°C.

4. State Newton's law of cooling.(2)

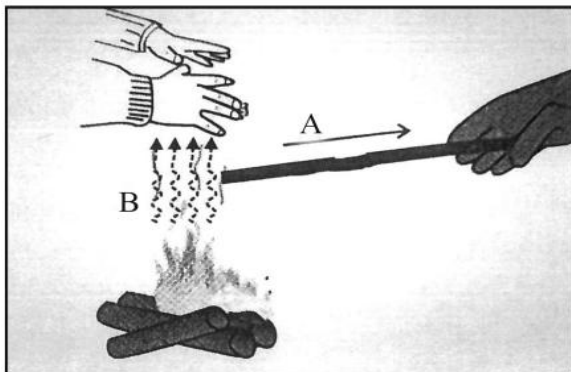
Ans: The rate of loss of heat of a body is directly proportional to the temperature difference between the body and its surroundings.

2023 MARCH

5. The change of state from liquid to solid is called(1)

Ans: Fusion or Freezing or Solidification

6. The modes of heat transfer is shown below. Identify A and B.(2)



Ans: A- conduction

2022

7. a) Among the various modes of heat transfer which one is fastest.
 b) A pan filled with hot water cools from 94°C to 86°C in 2 minutes, when the room temperature is at 20°C. How long will it take to cool from 71°C to 69°C (1+2)

Ans: a) Radiation

b) The average temperature of 94 °C and 86 °C is 90 °C, which is 70 °C above the room temperature. Under these conditions the pan cools 8 °C in 2 minutes.

$$\frac{\text{Change in temperature}}{\text{Time}} = K\Delta T$$

$$\frac{8^{\circ}\text{C}}{2 \text{ min}} = K (70^{\circ}\text{C}) \dots\dots(1)$$

The average of 69 °C and 71 °C is 70 °C, which is 50 °C above room temperature. K is the same for this situation as for the original.

$$\frac{2^{\circ}\text{C}}{\text{Time}} = K (50^{\circ}\text{C}) \dots\dots(2)$$

$$\frac{(1)}{(2)} \Rightarrow \frac{8^{\circ}\text{C}/2 \text{ min}}{2^{\circ}\text{C}/\text{time}} = \frac{K (70^{\circ}\text{C})}{K (50^{\circ}\text{C})}$$

$$\text{Time} = 0.7 \text{ min}$$

$$= 42 \text{ s}$$

2021

8. a) What is the difference between latent heat of fusion and latent heat of vaporization?
 b) Why burns from steam are usually more serious than those from boiling water.(3+1)

Ans: a) **Latent heat of fusion**- It is the heat required to convert one kilogram of a solid into liquid at its melting point without change in temperature.

Latent heat of vaporization- It is the heat required to convert one kilogram of a liquid into vapour at its boiling point without change in temperature.

b) The heat content of water vapour is more than that of the same amount of boiling water.

2023 IMP

9. At what temperature does water have maximum density and minimum volume?(1)

Ans: 4°C

10. Heat is transferred from one place to another due to temperature difference.

a) What is convection?

b) How does sea breeze occur, explain?(1+2)

Ans: a) It is the mode of transfer of heat in liquids and gases by the actual movement of their particles from one place to another.

b) During day time land heats up faster than the sea. The air above the land becomes hot and rises. Cooler air from the sea moves towards the land. This movement of cool air from the sea to the land is called sea breeze.

2022 IMP

11. What is sublimation(1)

Ans: Sublimation is the process of transition of solid state to vapour state without passing through the liquid state.

12. Why do metal utensils have wooden handles (2)

Ans: Metal utensils have wooden handles because wood has very low thermal conductivity.

So heat does not easily pass through the wooden handle, and we can hold the utensil without burning our hands.

2021 IMP

13. A transition of matter from any one state to another is called a change of state.

a) The temperature at which the solid and the liquid states of a substance are in thermal equilibrium is called its

b)“The value of latent heat of a substance depends on its pressure.” State whether the statement is true or false.

c) 0.3 kg of ice melts completely by absorbing 10^5 J of heat. Calculate heat of fusion of ice.(1+1+2)

Ans: a)Melting point

b)True

c)m= 0.3Kg

$$Q = 10^5 \text{ J}$$

$$Q = mL$$

$$L = Q/m = \frac{10^5 \text{ J}}{0.3 \text{ Kg}} = 3.33 \times 10^5 \text{ J/Kg}$$

CHAPTER 11

THERMODYNAMICS

2025 MARCH EXAM

1. Match the columns A & B (2)

	A	B
1	Isothermal process	Volume constant
2	Adiabatic process	Temperature constant
3	Isochoric process	No heat transfer
4	Isobaric process	Pressure constant

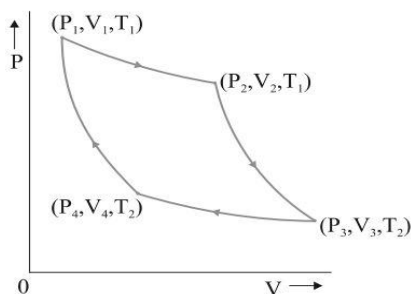
Ans:

	A	B
1	Isothermal process	Temperature constant
2	Adiabatic process	No heat transfer
3	Isochoric process	Volume constant
4	Isobaric process	Pressure constant

2. Sadi Carnot, the scientist arrived at a cycle of processes to be adopted to achieve the maximum efficiency of a heat engine.

- (a) Name the processes in the Carnot cycle.
 (b) Draw P-V diagram of Carnot cycle for a heat engine with an ideal gas as the work (2+1)

Ans:(a) Isothermal expansion, Adiabatic expansion, Isothermal compression, Adiabatic compression



- (b)

2024 MARCH EXAM

3. "The heat given to a system is used to increase the internal energy and doing external work". This is

- (a) Zeroth law in thermodynamics
 (b) First law in thermodynamics

(c) Second law in thermodynamics

(d) Newton's third in motion (1)

Ans:

First law in thermodynamics

4. (a) What are isothermal and adiabatic processes ?

(b) Derive the expression for work done in an isothermal process (2+2)

Ans:

(a) A process in which the temperature of the system is kept fixed throughout is called an isothermal process ($PV = \text{a constant}$).

A process in which there is no transfer of heat between the system and surroundings is called an isothermal process ($\Delta Q = 0$ or $PV^{\gamma} = \text{a constant}$)

$$(b) W = \int_{V_1}^{V_2} P dV$$

$$\text{Substitute } P = \frac{\mu RT}{V}$$

$$\text{Hence } W = \int_{V_1}^{V_2} \frac{\mu RT}{V} dV = \mu RT \int_{V_1}^{V_2} \frac{1}{V} dV = \mu RT [\ln V]_{V_1}^{V_2} = \mu RT \ln \left[\frac{V_2}{V_1} \right]$$

2023 MARCH EXAM

5. (a) State first law of thermodynamics.

(b) One mole of an ideal gas expands from volume V_1 to V_2 at a constant temperature T. Derive an expression for the work done. (1+2)

Ans:

(a) The heat absorbed by the gas is equal to the sum of change in internal energy and the work on the environment ($\Delta Q = \Delta U + \Delta W$).

(b) Refer Question-4(b).

2023 IMPROVEMENT EXAM

6. Thermodynamic variable whose value is equal for two systems in thermal equilibrium is called (1)

Ans:

Temperature

7. Thermodynamic state variables are of two kinds, extensive and intensive :

(a) Which of the following is extensive ?

(i) Pressure (ii) Temperature (iii) Density (iv) Mass

(b) Explain Carnot cycle.

(c) What is the difference between isothermal and adiabatic processes? (1+2+1)

Ans:

(a) Mass

(b) Carnot cycle consist of four operations- Isothermal expansion, Adiabatic expansion, Isothermal compression, Adiabatic compression

Or Draw figure of question No-2(b)

(c) Refer Question-4(a).

2022 JUNE EXAM

8. Write the equation of an isothermal process. (1+3+1)

(b) Obtain an expression for work done in an isothermal process.

(c) A carnot engine operates between the temperature 398 K and 293 K. Find its efficiency.

Ans:

(a) $PV = \text{a constant}$ or $PV = \mu RT$

(b) Refer Question-4(b).

(c) $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{293}{398} = 0.264 \text{ or } 26.4\%$

2022 IMPROVEMENT EXAM

9. Carnot engine is an ideal heat engine. Explain Carnot cycle. (4)

Ans:

Carnot cycle consist of four operations- Isothermal expansion, Adiabatic expansion, Isothermal compression, Adiabatic compression

Draw figure of Question-4(b) with above four operations

2021 SEPTEMBER EXAM

10. What is the difference between isobaric process and isochoric process? (1+1)

Ans:

Isobaric process - Pressure is constant during a thermodynamic process or $W = P\Delta V \neq 0$

Isochoric process - Volume is constant during a thermodynamic process or $W = P\Delta V = 0$

11. State first law of thermodynamics. (2)

Ans: Refer Question-5(a).

2021 IMPROVEMENT EXAM

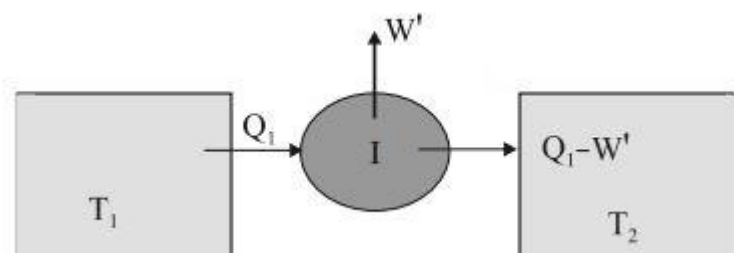
12. Derive an equation for the work done in an isothermal process. (2)

Ans:

Refer Question-4(b).

13. Draw the schematic diagram of a heat engine. (2)

Ans:



CHAPTER 12

KINETIC THEORY

1. Write perfect gas equation.

Ans:

$$PV = nRT$$

2. Using kinetic theory of an ideal gas, prove that the average kinetic energy of a molecule is proportional to the absolute temperature of the gas.

Ans:

Consider 1 mole of a gas having P,V,T and M as its pressure , volume , temperature and molecular mass respectively.

According to kinetic theory of an ideal gas of gas

$$PV = \frac{1}{3} M \overline{v^2}$$

By the ideal gas equation,

$$PV = NK_B T$$

So,

$$\frac{1}{3} M \overline{v^2} = NK_B T$$

Or,

$$\frac{2}{3} \frac{1}{2} M \overline{v^2} = NK_B T$$

$$\frac{1}{2} M \overline{v^2} = \frac{3}{2} NK_B T$$

$$\overline{KE} = \frac{3}{2} NK_B T$$

So,

$$\overline{KE} \propto T$$

Thus the average kinetic energy of a molecule is proportional to the absolute temperature of the gas.

[2021 MARCH]

3. Equation for the pressure of an ideal gas based on kinetic theory of gas.

Ans:

$$PV = \frac{1}{3} M \overline{v^2}$$

4. Using kinetic theory of an ideal gas, prove that the average kinetic energy of a molecule is proportional to the absolute temperature of the gas.

Ans: refer question 2

[2021 IMPROVEMENT]

5. The pressure exerted by a gas is given by the equation

$$P = \frac{1}{3} nm \overline{V^2}$$

N is the number density of molecules, m is mass of each molecule and $\overline{V^2}$ is the mean of squared speed. Find the average kinetic energy of a molecule.

Ans: According to kinetic theory of an ideal gas of gas

$$PV = \frac{1}{3} M \overline{v^2}$$

By the ideal gas equation,

$$PV = NK_B T$$

So,

$$\frac{1}{3} M \overline{v^2} = NK_B T$$

Or,

$$\frac{2}{3} \frac{1}{2} M \overline{v^2} = NK_B T$$

$$\frac{1}{2} M \overline{v^2} = \frac{3}{2} NK_B T$$

$$\overline{KE} = \frac{3}{2} NK_B T$$

[2022 MARCH]

6. State law of equipartition of energy.

Ans: The law States that “In any dynamical system in thermal equilibrium, the total energy is equally distributed in all possible energy mode, with each mode having an average energy equal to $\frac{1}{2} K_B T$ ”.

[2022 Improvement]

7. Kinetic energy of a gas molecule is directly proportional to the _____ of the gas.

Ans: Absolute temperature

8. a) State the law of equipartition of energy.

- (b) A box contains an equal number of molecules of hydrogen and oxygen. If there is a fine hole on top of the box, which gas will leak rapidly? Why?
- (c) When gas is heated, its temperature increases. Explain it on the basis of kinetic theory of gases.

Ans: (a) refer question 6

b) average kinetic energy of a molecule is, $\frac{1}{2} M \overline{v^2} = \frac{3}{2} K_B T$

so, $\overline{v^2} = \frac{3 K_B T}{M}$

$$v_{rms} \propto \frac{1}{\sqrt{M}}$$

As molecular mass of hydrogen < molecular mass of oxygen

Hydrogen will leak rapidly.

- c) According to the kinetic theory of gases, the temperature of a gas depends on the average kinetic energy of its molecules. When a gas is heated, its molecules gain kinetic energy and move faster. Therefore, the increase in molecular motion results in an increase in temperature.

[2023 MARCH]

9. Write short notes on :
- (a) Law of Equipartition of energy
- (b) Mean free path

Ans: (a) refer question 6

- b) Mean free path is the average distance travelled by a gas molecules between two successive collision.

[2023 Improvement]

10. According to kinetic theory of gas “the collision between gas molecules are elastic” the statement is true/false

Ans: True

11. Write the c_v and c_p values of one mole of diatomic gas

Ans: $C_V = \frac{5}{2} R$

$$C_P = \frac{7}{2} R$$

[2024 MARCH]

12. write the expression between average kinetic energy of molecule and absolute temperature of the gas

Ans: $\overline{KE} = \frac{3}{2} N K_B T$

13. State law of equipartition of energy.

Ans: refer question 6

[2025 MARCH]

CHAPTER 13

OSCILLATIONS

1. Expression for displacement of particle in Simple Harmonic Motion is $x(t) = A \cos(\omega t + \phi)$. Derive the equation for particle's velocity and its acceleration. (2+2)

MARCH 2025

Ans: Velocity $v = \frac{dx}{dt}$
 $= \frac{d}{dt}(A \cos(\omega t + \phi))$
 $= -\omega A \sin(\omega t + \phi)$
 Acceleration $a = \frac{dv}{dt}$
 $= \frac{d}{dt}(-\omega A \sin(\omega t + \phi))$
 $= -\omega^2 A \cos(\omega t + \phi)$
 $= -\omega^2 x(t)$

2. The condition for simple harmonic motion is ----- (1) MARCH 2024

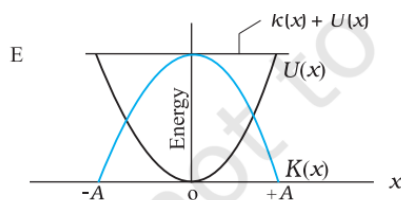
Ans: acceleration is proportional to displacement and it is directed towards the mean position

$$a \propto -x \text{ or } F \propto -x$$

3. Write the expression for kinetic energy and potential energy of a body executing SHM and draw their variations in graph. (3) MARCH 2024

Ans: Kinetic energy $K = \frac{1}{2}kA^2 \sin^2(\omega t + \phi)$ or $K = \frac{1}{2}k(A^2 - x^2)$

Potential energy $U = \frac{1}{2}kA^2 \cos^2(\omega t + \phi)$ or $U = \frac{1}{2}kx^2$



4. (a) Derive an expression for time period of oscillation of a Simple Pendulum. (2)
 (b) Can a pendulum clock show correct time inside a spaceship? Why? (1) MARCH 2023

Ans: a) $\tau = -L(mg \sin \theta)$ -----(1)

Also $\tau = I \alpha$ -----(2)

From eqn (1) and (2)

$$I \alpha = -Lmg \sin \theta$$

$$\alpha = -\frac{mgL}{I} \theta \text{ -----(3) (since } \theta \text{ is very small, } \sin \theta \approx \theta)$$

Acceleration of SHM, $a = -\omega^2 x$ -----(4)

Comparing eqns (3) and (4) $\omega^2 = \frac{mgL}{I}$

But

$$I = mL^2$$

Therefore

$$\omega^2 = \frac{mgL}{mL^2}$$

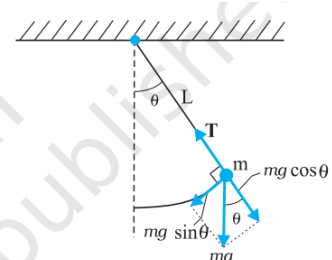
Or

$$\omega = \sqrt{\frac{g}{L}}$$

$$2\pi v = \sqrt{\frac{g}{L}}$$

$$v = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

Or period of simple pendulum $T = 2\pi \sqrt{\frac{L}{g}}$



(b) No, a pendulum clock cannot show the correct time inside a spaceship because it depends on gravity. In a satellite the body is in state of weightlessness and $g=0$. So the pendulum does not work.

5. (a) Define Simple Harmonic Motion(SHM) (1)

(b) For a SHM time period is $T=2s$, if the displacement from the mean position is $10cm$, calculate the instantaneous acceleration. (2)

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Ans: (a) A motion is said to be simple harmonic if the acceleration is proportional to displacement from mean position and it is directed towards the mean position. $a \propto -x$

(b) $\omega = \frac{2\pi}{T} = \frac{2 \times 3.14}{2} = 3.14$

$a = -\omega^2 x = -3.14^2 \times 10 \times 10^{-2} = -0.986 m/s^2$

6. The displacement of a particle executing SHM is, $y = A \sin \omega t$

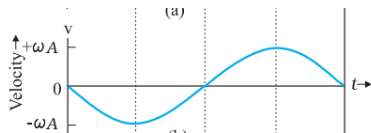
$A \rightarrow$ amplitude $\omega \rightarrow$ angular frequency

(a) Draw the variation of velocity of the particle with time. (1)

(b) A 2 kg body performs SHM of amplitude 20 cm and the restoring force acting at that position is 50 N. Find the acceleration and kinetic energy of the particle when the displacement is 10 cm. (2)

Ans: a)

HSE 2022



- (b) Given $A=20cm$, mass $m=2Kg$, $F=50N$, $x=10cm$

$k = \frac{F}{A} = \frac{50}{20 \times 10^{-2}} = 2.5 \times 10^2 N/m$

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{2.5 \times 10^2}{2}} = 11.2 rad/s$

$a = -\omega^2 x = -11.2^2 \times 10 \times 10^{-2} = 12.5 \frac{m}{s^2}$

$KE = \frac{1}{2} m \omega^2 (A^2 - x^2) = \frac{1}{2} \times 2 \times 11.2^2 \times [(20 \times 10^{-2})^2 - (10 \times 10^{-2})^2] = 3.76J$

7. (a) Show that the oscillations produced in a simple pendulum are simple harmonic. (2)

(b) Write an expression for time period of oscillation. (1)

(c) What is seconds pendulum ? Find the length of seconds pendulum. (2)

HSE 2022

Ans:

(a) $F = -mg \sin \theta$

$ma = -mg \sin \theta$

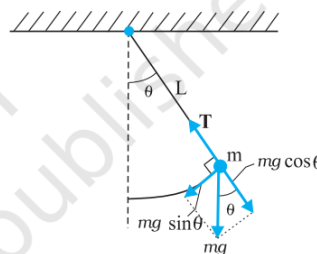
$a = -g \theta = -\frac{g}{l} x$

So $a \propto -x$. So the oscillations are simple harmonic.

(b) $T = 2\pi \sqrt{\frac{L}{g}}$

(c) it is a pendulum whose time period is 2 seconds.

Its length is 1m.



8. (a) Derive the expression for period of oscillation of a simple pendulum. (4)

(b) What is the length of second pendulum ? (1)

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Ans:

(a) Refer answer 4(a)

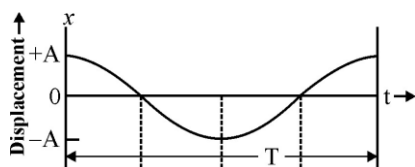
(b) Refer answer 7(c)

9. Derive an expression for period of a simple pendulum (4)

HSE 2021

Ans: Refer answer 4(a)

10. (a) The displacement – time relation of a simple harmonic motion is shown below.



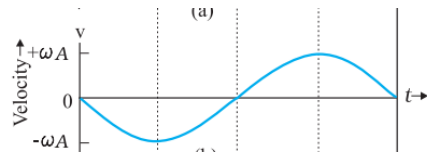
Draw a graph showing the corresponding velocity – time relation. (2)

(b) What is the length of a simple pendulum, which ticks seconds if value of acceleration due to gravity at the place is $9.8 ms^{-2}$? (2)

IMPROVEMENT 2021

Ans:

(a)



(b) $T=2s$

$$T^2 = 4\pi^2 \frac{l}{g}$$

$$l = \frac{gT^2}{4\pi^2} = \frac{9.8 \times 4}{4 \times 3.14^2} = 1m$$

CHAPTER 14

WAVES

2025 MARCH

1. A transverse harmonic wave on a string is described by $y(x,t) = 3.0\sin(36t+0.018x+\pi/4)$
Where x and y are in cm and t in s.
- (a) Is this travelling wave or a stationary wave?
 - (b) If it is travelling, what is its speed?
 - (c) What is its frequency?
 - (d) What is the initial phase at the origin?

(1+1+1+1)

Ans:

- (a) Travelling wave
- (b) General equations, $y = A \sin(\omega t + kx + \phi)$
Comparing with

$$Y(x,t) = 3 \sin(36t + 0.018x + \frac{\pi}{4})$$

$$\text{Speed of the wave} = \frac{\omega}{k}$$

$$= \frac{36}{0.018}$$

$$= 2000 \text{ cm/s} = 20 \text{ m/s}$$

(c) $\omega = 2\pi f = 36$

$$\text{Frequency, } f = \frac{\omega}{2\pi} = \frac{36}{2\pi} = 5.73 \text{ Hz}$$

(d) $\phi = \frac{\pi}{4}$

2024 MARCH

2. What are beats? 1
Ans.. The waxing and waning of intensity of sound due to the interference of two sound waves of close frequencies

3. Explain the speed of longitudinal wave and write the value of speed of sound at 0°C
After Laplace correction.

Ans.

3

Speed of longitudinal wave is,

$$V = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{rP}{\rho}}$$

$$V = 331 \text{ m s}^{-1} \text{ or } 331.3 \text{ m s}^{-1}$$

2023 MARCH

4. Most fundamental property of wave is
- (a) Temperature (b) Pressure
 - (c) Frequency (d) Wavelength

1

Ans : Frequency

2023 MARCH

5. (a) A string is stretched between two fixed supports and a note of sound is heard when it is plucked at its middle point.
- (i) How standing waves are produced ? 1
- (ii) Derive an expression for the frequency of sound produced by the first two modes of vibration. 2
- (b) Where will a man hear a louder sound in the case of stationary wave (node or anti node) ?

Ans :

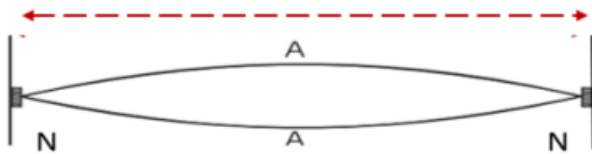
1

(a) (i) Superposition of incident and its own reflected wave in the string produces standing wave

(ii)

First mode

$$L = \frac{\lambda}{2}$$



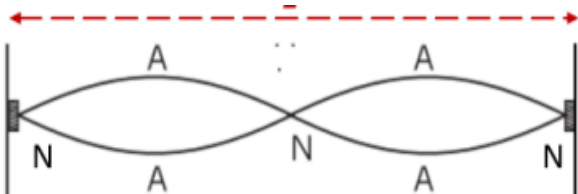
For First mode

$$L = \frac{\lambda}{2} \quad \lambda = 2L$$

$$v_1 = \frac{v}{\lambda} = \frac{v}{2L}$$

Second mode

$$L = 2 \frac{\lambda}{2}$$



For Second mode

$$L = 2 \frac{\lambda}{2}$$

$$\lambda = \frac{2L}{2}$$

$$v_2 = \frac{v}{\lambda} = \frac{v}{\frac{2L}{2}} = \frac{2v}{2L} = 2v_1$$

(b) Antinode

2023 (IMP)

6. (a) A transverse harmonic wave is described by $y = 3.0 \sin(0.018x + 36t)$, where x and y are in cm. The amplitude of this wave is..... 1
- (b) The figure below shows the fundamental mode or first harmonic in a stretched string when a standing wave is formed in the string



Draw the figure that shows the second harmonic in the string. If L is the length of string and v is the speed of the wave in the string, what are the equations of first and second harmonic frequencies ?

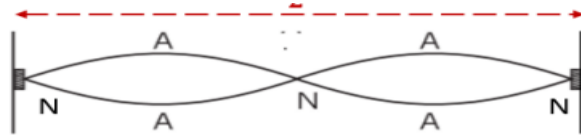
Ans :

(a) Amplitude = 3cm

3

1

$$L = 2 \frac{\lambda}{2}$$



For first harmonics, frequency $v_1 = \frac{v}{2L}$

(b) For second harmonics frequency $v_2 = 2 v_1 = 2\left(\frac{v}{2L}\right) = \frac{v}{L}$

2022 IMPROVEMENT

7. Write the equation for a speed of a transverse wave on a stretched string.

Ans :

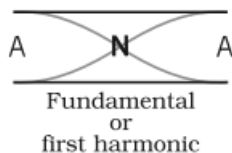
$$V = \sqrt{\frac{T}{\mu}}$$

T – Tension on string.

μ - Linear mass density

2

8. Find equations of the first, second and third harmonics of standing waves formed in an open pipe and show that $v_1 : v_2 : v_3 = 1 : 2 : 3$.



$$L = \frac{\lambda}{2} \quad \lambda = 2L$$

$$v = \frac{V}{\lambda} = \frac{V}{2L} = v_1, \text{ (fundamental frequency)}$$



$$L = \frac{2\lambda}{2}, \quad \lambda = \frac{2L}{2}$$

$$v_2 = \frac{V}{\lambda} = \frac{V}{\frac{2L}{2}} = \frac{2V}{2L} = 2v_1$$



$$L = 3\left(\frac{\lambda}{2}\right), \lambda = \frac{2L}{3}$$

$$v_3 = \frac{v}{\lambda} = \frac{v}{\frac{2L}{3}} = 3\left(\frac{v}{2L}\right) = 3 v_1$$

$$v_1 : v_2 : v_3 = 1:2:3$$

2022 JUNE

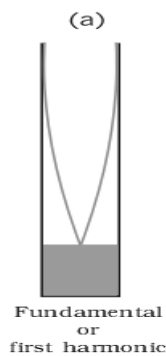
9. In the case of stationary waves, the displacement of a particle at positions of node is _____.

Ans : Zero

10. (a) Draw the pattern of waveforms of the first two harmonics in a closed pipe.

- (b) Show that in a closed pipe, the frequencies of first two harmonics are in the ratio 1 : 3.

Ans : (a)

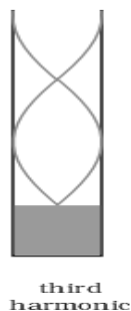


(b)

$$L = \frac{\lambda}{4} \quad \lambda = 4L$$

$$v = \frac{v}{\lambda} = \frac{v}{4L} = v_1$$

, fundamental frequency



$$L = 3\left(\frac{\lambda}{4}\right), \lambda = \frac{3L}{3}$$

$$v_2 = \frac{v}{\lambda} = \frac{v}{\frac{4L}{3}} = 3\left(\frac{v}{4L}\right) = 3 v_1$$

$$\text{Ratio } v_1 : v_2 = 1:3$$

2021 SEPTEMBER

11. A wave travelling along a string is described by, $y(x, t) = 0.005 \sin (80.0 x - 3.0 t)$, in which the numerical constants are in SI units. Calculate
- the amplitude,
 - the wavelength, and
 - the period and frequency of the wave.

Ans :

$$\text{Given } y(x, t) = 0.005 \sin (80 x - 3.0 t)$$

We have

$$\text{Std eqn, } y(x, t) = A \sin(kx - \omega t)$$

Comparing two equations,

$$(a) \text{ Amplitude, } A = 0.005 \text{ m}$$

$$(b) K = 80, \quad \text{wavelength } \lambda = \frac{2\pi}{K} = \frac{2\pi}{80} = 0.0785 \text{ m}$$

$$(c) \omega = 3, \quad \text{Period } T = \frac{2\pi}{\omega} = \frac{2\pi}{3} = 2.09 \text{ sec}$$

$$\text{Frequency } f = \frac{1}{T} = \frac{3}{2\pi} = \frac{1}{2.09} = 0.478 \text{ Hz}$$

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