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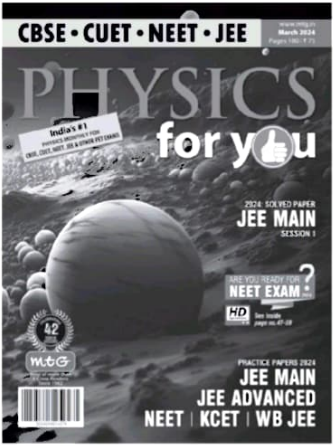

PHYSICS for you

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SOLVED PAPER

Held on
27th Jan, Morning Shift
(Session - 1)

JEE MAIN 2024

SECTION-A (MULTIPLE CHOICE QUESTIONS)

1. A proton moving with a constant velocity passes through a region of space without any change in its velocity. If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic fields respectively, then the region of space may have

(A) $E = 0, B = 0$ (B) $E = 0, B \neq 0$

(C) $E \neq 0, B = 0$ (D) $E \neq 0, B \neq 0$

Choose the most appropriate answer from the options given below.

(a) (B), (C) and (D) only
(b) (A), (B) and (C) only
(c) (A), (B) and (D) only
(d) (A), (C) and (D) only

2. 0.08 kg air is heated at constant volume through 5°C. The specific heat of air at constant volume is 0.17 kcal/kg°C and J = 4.18 joule/cal. The change in its internal energy is approximately

(a) 284 J (b) 142 J (c) 298 J (d) 318 J

3. A body of mass 1000 kg is moving horizontally with a velocity 6 m/s. If 200 kg extra mass is added, the final velocity (in m/s) is

(a) 2 (b) 5 (c) 6 (d) 3

4. A wire of resistance R and length L is cut into 5 equal parts. If these parts are joined parallely, then resultant resistance will be

(a) $25\,R$ (b) $\frac{1}{25}R$ (c) $5\,R$ (d) $\frac{1}{5}R$

5. Given below are two statements :

Statement (I) : Viscosity of gases is greater than that of liquids.

Statement (II) : Surface tension of a liquid decreases due to the presence of insoluble impurities.

In the light of the above statements, choose the most appropriate answer from the options given below :

(a) Statement I is incorrect but Statement II is correct
(b) Statement I is correct but Statement II is incorrect
(c) Both Statement I and Statement II are incorrect
(d) Both Statement I and Statement II are correct

6. Given below are two statements :

Statement (I) : Planck's constant and angular momentum have same dimensions.

Statement (II) : Linear momentum and moment of force have same dimensions.

In the light of the above statements, choose the correct answer from the options given below :

(a) Both Statement I and Statement II are false
(b) Statement I is true but Statement II is false
(c) Both Statement I and Statement II are true
(d) Statement I is false but Statement II is true

7. A convex lens of focal length 40 cm forms an image of an extended source of light on a photoelectric cell. A current I is produced. The lens is replaced by another convex lens having the same diameter but focal length 20 cm. The photoelectric current now is

(a) $2\,I$ (b) $4\,I$ (c) $I/2$ (d) I

8. The average kinetic energy of a monoatomic molecule is 0.414 eV at temperature
(Use $K_B = 1.38 \times 10^{-23}$ J/mol-K)

(a) 3200 K (b) 3000 K
(c) 1500 K (d) 1600 K

9. The acceleration due to gravity on the surface of earth is g. If the diameter of earth reduces to half of its original value and mass remains constant, then acceleration due to gravity on the surface of earth would be

(a) $4\,g$ (b) $2\,g$ (c) $g/2$ (d) $g/4$

10. A train is moving with a speed of 12 m/s on rails which are 1.5 m apart. To negotiate a curve of radius 400 m, the height by which the outer rail should be raised with respect to the inner rail is (Given, $g = 10\ m/s^2$)
(a) 5.4 cm (b) 4.8 cm (c) 4.2 cm (d) 6.0 cm

11. Two bodies of mass 4 g and 25 g are moving with equal kinetic energies. The ratio of magnitude of their linear momentum is
(a) 2 : 5 (b) 3 : 5 (c) 4 : 5 (d) 5 : 4

12. An electric charge $10^{-6}\ \mu C$ is placed at origin (0, 0)m of $X - Y$ co-ordinate system. Two points P and Q are situated at $(\sqrt{3}, \sqrt{3})$m and $(\sqrt{6}, 0)$m respectively. The potential difference between the points P and Q will be
(a) $\sqrt{3}$ V (b) $\sqrt{6}$ V (c) 3 V (d) 0 V

13. Identify the physical quantity that cannot be measured using spherometer
(a) Thickness of thin plates
(b) Specific rotation of liquids
(c) Radius of curvature of concave surface
(d) Radius of curvature of convex surface

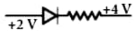
14. If the refractive index of the material of a prism is $\cot\left(\frac{A}{2}\right)$, where A is the angle of prism then the angle of minimum deviation will be
(a) $\frac{\pi}{2} - A$ (b) $\pi - 2A$
(c) $\frac{\pi}{2} - 2A$ (d) $\pi - A$

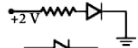
15. A rectangular loop of length 2.5 m and width 2 m is placed at 60° to a magnetic field of 4 T. The loop is removed from the field in 10 s. The average emf induced in the loop during this time is
(a) +1 V (b) −2 V (c) −1 V (d) +2 V

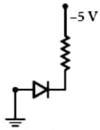
16. A wire of length 10 cm and radius $\sqrt{7} \times 10^{-4}$ m is connected across the right gap of a meter bridge. When a resistance of 4.5 Ω is connected on the left gap by using a resistance box, the balance length is found to be at 60 cm from the left end. If the resistivity of the wire is $R \times 10^{-7}\ \Omega$m, then value of R is
(a) 66 (b) 35 (c) 63 (d) 70

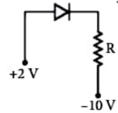
17. A plane electromagnetic wave propagating in x-direction is described by
$E_y = (200\ Vm^{-1}) \sin [1.5 \times 10^7 t - 0.05\ x]$.
The intensity of the wave is
(Use $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$)
(a) 53.1 Wm^{-2} (b) 35.4 Wm^{-2}
(c) 26.6 Wm^{-2} (d) 106.2 Wm^{-2}

18. Which of the following circuits is reverse-biased?

(a) 

(b) 

(c) 

(d) 

19. Position of an ant (S in metres) moving in Y - Z plane is given by $S = 2t^2\hat{j} + 5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at t = 1 s will be
(a) 4 m/s in y-direction
(b) 9 m/s in z-direction
(c) 16 m/s in y-direction
(d) 4 m/s in x-direction

20. The radius of third stationary orbit of electron for Bohr's atom is R. The radius of fourth stationary orbit will be
(a) $\frac{16}{9}R$ (b) $\frac{3}{4}R$ (c) $\frac{9}{16}R$ (d) $\frac{4}{3}R$

SECTION - B (NUMERICAL VALUE TYPE)

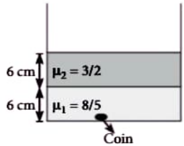
Attempt any 5 questions out of 10.

21. A thin metallic wire having cross sectional area of $10^{-4}\ m^2$ is used to make a ring of radius 30 cm. A positive charge of 2π C is uniformly distributed over the ring, while another positive charge of 30 pC is kept at the centre of the ring. The tension in the ring is ________ N; provided that the ring does not get deformed (neglect the influence of gravity).
$\left(\text{given, } \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ SI units}\right)$

22. If average depth of an ocean is 4000 m and the bulk modulus of water is $2 \times 10^9\ Nm^{-2}$, then fractional compression $\Delta V/V$ of water at the bottom of ocean is $\alpha \times 10^{-2}$. The value of α is ______.
(Given $g = 10\ ms^{-2}$, $\rho = 1000\ kg\ m^{-3}$)

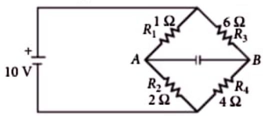
23. Two coils have mutual inductance 0.002 H. The current changes in the first coil according to the relation $i = i_0 \sin\omega t$, where i_0 = 5 A and $\omega = 50\pi$ rad/s. The maximum value of emf in the second coil is $\frac{\pi}{\alpha}$ V. The value of α is _____.

24. Two immiscible liquids of refractive indices 8/5 and 3/2 respectively are put in a beaker as shown in the figure. The height of each column is 6 cm. A coin is placed at the bottom of the beaker. For near normal vision, the apparent depth of the coin is $\alpha/4$ cm. The value of α is ______.



25. In a nuclear fission process, a high mass nuclide (A = 236) with binding energy 7.6 MeV/Nucleon dissociated into middle mass nuclides (A = 118), having binding energy of 8.6 MeV/Nucleon. The energy released in the process would be ____ MeV.

26. The charge accumulated on the capacitor connected in the following circuit is ____ μC.
(Given C = 150 μF)

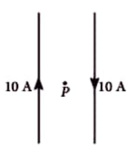


27. A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is $\sqrt{\alpha}$ cm, where α = ____.

28. Four particles each of mass 1 kg are placed at four corners of a square of side 2 m. Moment of inertia of system about an axis perpendicular to its plane and passing through one of its vertex is ____ kgm^2.

29. A particle starts from origin at t = 0 with a velocity $5\hat{i}$ m/s and moves in x-y plane under action of a force which produces a constant acceleration of $(3\hat{i}+2\hat{j})$ m/s^2. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}$ m/s. The value of α is ____.

30. Two long, straight wires carry equal currents in opposite directions as shown in figure. The separation between the wires is 5.0 cm. The magnitude of the magnetic field at a point P midway between the wires is _____ μT.
(Given : $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1})



SOLUTIONS

1. **(c) :** The velocity of the moving charge will remain constant in combination (A), (B) and (D). As in presence of only electric field, its velocity will get change.

2. **(a) :** By first law of thermodynamics, $\Delta Q = \Delta U + W$
As volume is constant, $W = P\Delta V = 0$
$\Delta Q = \Delta U$

$$\Rightarrow \left(\frac{\Delta Q}{\Delta T}\right)_V = \frac{\Delta U}{\Delta T} \Rightarrow \Delta U = \left(\frac{\Delta Q}{m\Delta T}\right)_V m\Delta T$$
$$= C_V m\Delta T$$
$\Delta U = 0.17 \times 10^3 \times 4.18 \times 0.08 \times 5 = 284$ J

3. **(b):** Given : $m_1 = 1000$ kg, $v_1 = 6$ m/s, $m_2 = 200$ kg
By conservation of momentum, $m_1v_1 = (m_1 + m_2)v$
$$v = \frac{1000 \times 6}{1200} = 5 \text{ m/s}$$

4. **(b):** Resistance, $R = \frac{\rho l}{A}$
As given wire is cut into five equal parts, $R' = \frac{\rho l}{5A} = \frac{R}{5}$
On joining these resistances in parallel combination,
$$\frac{1}{R_{eq}} = \frac{5 \times 5}{R} \Rightarrow R_{eq} = \frac{R}{25}$$

5. **(a) :** Viscosity of liquids is greater than that of a gas. And surface tension decreases is case of insoluble impurities while increases in case of soluble impurities.
Hence, statement I is incorrect but statement II is correct.

6. **(b):** Plank's constant and angular momentum have same dimensions as, $L = mvr = n\hbar$.
Dimension of linear momentum, $[P] = [MLT^{-1}]$
Dimension of moment of force $(\tau) = [ML^2T^{-2}]$
Hence, statement II incorrect.

7. **(d):** Photocurrent produced by image via lens depends on the diameter of the lenses. As in both cases, diameter of the lens taken are same, the photocurrent will be same in both cases.

8. **(a) :** Average kinetic energy of monoatomic molecule, $E = \frac{3}{2}kT$
Given, $E = 0.414$ eV; $k_B = 1.38 \times 10^{-23}$ J/mole – K
$$T = \frac{2 \times 0.414 \times 1.6 \times 10^{-19}}{3 \times 1.38 \times 10^{-23}}; \ T = 3200 \text{ K}$$

9. **(a) :** Acceleration due to gravity, $g = \frac{GM}{R^2}$ ...(i)

As given, $M' = M$, $D' = \frac{D}{2} \Rightarrow R' = \frac{R}{2}$;

$g' = \frac{GM'}{R'^2} = \frac{GM4}{R^2}$ = 4 g (By equation (i))

10. **(a) :** Given, $v = 12$ m/s, $r = 400$ m

Bending from vertical position is given by,

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

Height raised $= \frac{v^2}{rg} \times$ Distance between rails

$= \frac{12\times12\times1.5}{400\times10}$; $h = 0.054$ m = 5.4 cm

11. **(a) :** Given, $m_1 = 4$g, $m_2 = 25$ g, $(\text{K.E})_1 = (\text{K.E})_2 = K$

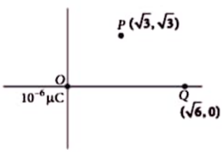
Linear momentum, $p = \sqrt{2mK}$

Ratio of linear momentums

$= \sqrt{\frac{2m_1(\text{K.E})_1}{2m_2(\text{K.E})_2}} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{4}{25}} = \frac{2}{5}$

12. **(d):** $r_{OP} = \sqrt{(0-\sqrt{3})^2 + (0-\sqrt{3})^2} = \sqrt{6}$ m

$r_{OQ} = \sqrt{6}$ m



$\Rightarrow V_P = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r_{OP}}$

$= \frac{9\times10^9\times10^{-12}}{\sqrt{6}}$

$\Rightarrow V_Q = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r_{OQ}} = \frac{9\times10^9\times10^{-12}}{\sqrt{6}}$

$\Rightarrow V_P - V_Q = 0$ V

13. **(b):** Spherometer works on the principle of micrometer screw. It can be used to measure thickness of flat surfaces or radius of curvature of curved surfaces. Specific rotations of liquids can not be measured by spherometer.

14. **(b):** Given, Refractive index (μ) = cot $A/2$

For a prism of angle A, $\mu = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin A/2} = \frac{\cos A/2}{\sin A/2}$

$\Rightarrow \sin\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\left(\frac{\delta_m + A}{2}\right)$

$\Rightarrow \frac{\pi}{2} - \frac{A}{2} = \frac{\delta_m}{2} + \frac{A}{2} \Rightarrow \frac{\pi - \delta_m}{2} = A$

$\Rightarrow \pi - \delta_m = 2A \Rightarrow \delta_m = \pi - 2A$

15. **(a) :** Given, $A = lb = 5$ m^2, $\theta = 60°$, $B = 4$T, $t = 10$ s

Induced emf $= -\frac{d\phi}{dt} = -\frac{d(BA\cos\theta)}{dt}$

$= -5\times\frac{1}{2}\frac{(0-4)}{10} = 1$ V

16. **(a) :** Resistance of a wire of resistivity ρ is,

$R = \frac{\rho l}{A} = \frac{R\times10^{-7}\times10\times10^{-2}}{\frac{22}{7}\times7\times10^{-8}} = \frac{R}{22}$

By meter bridge, $\frac{R}{S} = \frac{l_1}{100 - l_1}$

(where, R and S are resistances connected in left and right end)

$\Rightarrow \frac{4.5}{R/22} = \frac{60}{40} \Rightarrow R = \frac{4.5\times40\times22}{60} \Rightarrow R = 66$ cm

17. **(a) :** E_y = (200 V/m) sin[1.5 × 10^7 t - 0.05 x]

On comparing with standard equation

E = 200 V/m, ω = 1.5 ×10^7 /Radian

Intensity of em wave $= \frac{1}{2}\varepsilon_0 c E^2$

$= \frac{1}{2}\times8.85\times10^{-12}\times3\times10^8\times40000 = 53.1$ W/m^2

18. **(a) :** Circuit given in option (a) is reverse biased as negative terminal is at higher potential comparative to positive terminal.

19. **(a) :** Position of ant, $\vec{S} = 2t^2\hat{j} + 5\hat{k}$; $\vec{v} = \frac{ds}{dt} = 4t\hat{j}$

For t = 1 s, $\vec{v} = 4\hat{j}$ m/s

20. **(a) :** According to Bohr's model, $r_n \propto n^2$

$r_3 = K \times 9 = R$ (Given)

$r_4 = K \times 16 = \frac{R}{9}\times16 = \frac{16}{9}R$

21. **(3) :** For ring, linear charge density $\lambda = \frac{q}{2\pi R}$

Tension force in the ring due to positive charge (q) at centre

$= \frac{Q\cdot\lambda}{4\pi\varepsilon_0 R} = \frac{Qq}{4\pi\varepsilon_0 R^2\times2\pi}$

$= \frac{2\pi\times30\times10^{-12}\times9\times10^9}{2\pi\times(30)^2\times10^{-4}} = \frac{90}{30} = 3$ N

22. **(2) :** Bulk modulus, $B = \frac{-P}{\Delta V/V} = \frac{-hdg}{\Delta V/V}$

Fractional compression

$= \frac{-\Delta V}{V} = \frac{hdg}{B} = \frac{4000\times10^3\times10}{2\times10^9}$ = 2 × 10^{-2}

Hence, α = 2

23. (2) : As, current change in first coil results is flux change in second coil. Thus, $MI_1 = \phi_2$

$$\text{Emf} = \frac{-d\phi_2}{dt} = \frac{-d(MI_1)}{dt} = \frac{-Md(i_0 \sin \omega t)}{dt}$$

$= - Mi_0 \cos \omega t.\omega$ (As, $I = i_0 \sin\omega t$)

$= - 0.002 \times 5 \times \cos(50\pi t) \times 50\pi$

For max. value of emf, $\cos \omega t = 1$

$$\varepsilon = -0.5\pi = \frac{-\pi}{2}$$

Where, –ve sign represents that emf oppose the cause by which it is produced. Hence, on comparing $\alpha = 2$

24. (31) : Apparent depth $= \frac{\text{Real depth}}{\text{Refractive index}}$

$$= \frac{6}{8/5} + \frac{6}{3/2} = \frac{6 \times 5}{8} + \frac{6 \times 2}{3} = \frac{31}{4}$$. Hence, $\alpha = 31$

25. (236) : Binding energy of high mass nuclide

$= 236 \times 7.6$ MeV

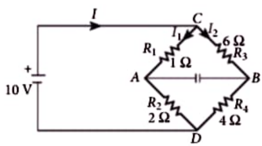
$E_1 = 1793.6$ MeV

Binding energy of middle mass nuclides

$= 2 \times 118 \times 8.6$ MeV; $E_2 = 2029.6$ MeV

Energy released, $\Delta E = E_2 - E_1 = 236$ MeV

26. (400) : In steady state, capacitor behaves like open circuit.



So, $\frac{1}{10} + \frac{1}{3} = \frac{1}{R_{eq}}$; $R_{eq} = \frac{30}{13}$; $I = \frac{10}{30} \times 13 \Rightarrow \frac{13}{3}$ A

$3I_1 = 10I_2$ ...(i); $I_1 + I_2 = \frac{13}{3}$ ...(ii)

Solving (i) and (ii), we get $I_1 = \frac{10}{3}$A, $I_2 = 1$A

Applying *KVL* in loop *ACB*,

$$-V_A - \frac{10}{3}(1) + 6(1) + V_B = 0$$

$$\Rightarrow V_A - V_B = 6 - \frac{10}{3} \Rightarrow \frac{8}{3} \text{ volt}$$

$\therefore$ Charge across capacitor, $Q = C(V_A - V_B)$

$$= 150 \times \frac{8}{3} \Rightarrow 400\ \mu\text{C}$$

27. (12) : In SHM, $v = -\omega\sqrt{A^2 - x^2}$

At mean position, $v = 10 = \omega.A$

(Negative sign shows direction)

$$\omega = \frac{10}{4} = \frac{5}{2} \text{ Radian/Sec}$$

Case-II

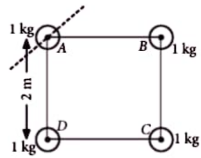
$$\Rightarrow v = 5 = \omega\sqrt{(4)^2 - x^2}$$

$$\Rightarrow \frac{2 \times 5}{5} = \sqrt{16 - x^2} \Rightarrow 16 - x^2 = 4$$

$\Rightarrow x^2 = 12$; $x = \sqrt{12}$ $\Rightarrow$ Hence, $\alpha = 12$

28. (16) : $m_A = m_B = m_C = m_D = 1$ kg

Moment of Inertia of the system about an axis perpendicular to the plane and passing through one of its vertex is (let say about vertex *A*)



$$= m_A r_A^2 + m_B r_B^2 + m_C r_C^2 + m_D r_D^2$$

$$I = 1 \times 0 + 1 \times (2)^2 + 1 \times (2\sqrt{2})^2 + 1 \times (2)^2$$

$= 4 + 8 + 4$; $I = 16$ kg m^2

29. (673) : $u = 5\hat{i}$ m/s, $a = (3\hat{i} + 2\hat{j})$ m/s^2

x coordinate of particle = 84 m

$$\Rightarrow S = ut + \frac{1}{2}at^2 \Rightarrow 84 = 5t + \frac{1}{2}3t^2$$

$\Rightarrow 3t^2 + 10t = 168 \Rightarrow 3t^2 + 10t - 168 = 0$

$\Rightarrow 3t^2 + 28t - 18t - 168 = 0$

$\Rightarrow t(3t + 28) - 6(3t + 28) = 0 \Rightarrow t = 6$

Also, $v = u + at$

$$= 5\hat{i} + (3\hat{i} + 2\hat{j}) \times 6 = 5\hat{i} + 18\hat{i} + 12\hat{j} = 23\hat{i} + 12\hat{j}$$

$\therefore$ Speed of particle, $v = \sqrt{673}$

$\alpha = 673$

30. (160) : Magnetic field by a straight long wire,

$$B = \frac{\mu_0 I}{2\pi r}$$

At point *P*, *B* magnetic field by both wires $= 2 \times \frac{\mu_0 I}{2\pi r}$

Given, separation, $d = 5$ cm, $r = 2.5$ cm

$$I = 10 \text{ A}; B = \frac{2 \times 4\pi \times 10^{-7} \times 10}{2\pi \times 2.5} = 160 \times 10^{-6} \text{ T}$$

$B = 160\ \mu$T

PRACTICE PAPER 2024
JEE MAIN

Exam Dates
Session-2
Between 4th April and 15th April 2024

SECTION-A (MULTIPLE CHOICE QUESTIONS)

1. A 15 g ball is shot from a spring gun whose spring has a force constant 600 N m^{-1}. The spring is compressed by 5 cm. The greatest possible horizontal range of the ball for this compression (Take $g = 10$ m s^{-2})
(a) 6 m (b) 8 m (c) 10 m (d) 12 m

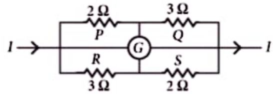
2. The minimum force required to start pushing a body up a rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ with the horizontal such that $\tan\theta = 2\mu$,then the ratio $\frac{F_1}{F_2}$ is
(a) 4 (b) 1 (c) 2 (d) 3

3. A gas bubble from an explosion under water oscillates with a time period T, depends upon static pressure p, density of water ρ and the total energy of explosion E. Find the expression for the time period T. k is a dimensionless constant.
(a) $T = kp^{-5/6}\rho^{1/2}E^{1/3}$ (b) $T = kp^{-4/7}\rho^{1/2}E^{1/3}$
(c) $T = kp^{-5/6}\rho^{1/2}E^{1/2}$ (d) $T = kp^{-4/7}\rho^{1/3}E^{1/2}$

4. A charged particle of mass m and charge q is released from rest in an electric field of constant magnitude E. The kinetic energy of the particle after time t is
(a) $\frac{E^2q^2t^2}{2m}$ (b) $\frac{2E^2t^2}{qm}$
(c) $\frac{Eqm}{2t}$ (d) $\frac{Eq^2m}{2t^2}$

5. The intensity of magnetic field at a point X on the axis of a small magnet is equal to the field intensity at another point Y on its equatorial axis. The ratio of distances of X and Y from the centre of the magnet will be
(a) $(2)^{-3}$ (b) $(2)^{-1/3}$ (c) 2^3 (d) $2^{1/3}$

6. **Assertion (A) :** The given figure does not show a balanced Wheatstone bridge.

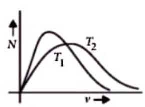


Reason (R) : For a balanced bridge small current should flow through the galvanometer.
(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A)
(c) Assertion (A) is true, but Reason (R) is False.
(d) Assertion (A) is false, but Reason (R) is true.

7. A circular platform is mounted on a frictionless vertical axle. Its radius $R = 2$ m and its moment of inertia about the axle is 200 kg m^2. It is initially at rest. A 50 kg man stands on the edge of the platform and begins to walk along the edge at the speed of 1 m s^{-1} relative to the ground. Time taken by the man to complete one revolution with respect to disc is
(a) π s (b) $\frac{3\pi}{2}$ s (c) 2π s (d) $\frac{\pi}{2}$ s

8. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then
(a) $36 > x > 18$ (b) $18 > x$
(c) $x > 54$ (d) $54 > x > 36$

9. Maxwell's velocity distribution curve is given for the same quantity at two different temperatures. For the given curves



(a) $T_1 > T_2$ (b) $T_1 < T_2$
(c) $T_1 \leq T_2$ (d) $T_1 = T_2$

10. Two capacitors of 25 μF and 100 μF are connected in series to a source of 120 V. Keeping their charges unchanged, they are separated and connected in parallel to each other. Find out energy loss in the process.
(a) 5.2 J (b) 52 J (c) 50.2 J (d) 0.052 J

11. A boat covers a given distance in 6 h moving down stream of a river. It covers the same distance in 10 h moving upstream. The time (in hour) it takes to cover the same distance in still water is
(a) 6 h (b) 7.5 h (c) 10 h (d) 15 h

12. A gas is at pressure 6×10^5 N m^{-2} and volume 1 m^3 and its pressure falls to 4×10^5 N m^{-2} when its volume is 3 m^3. Given that the indicator diagram is a straight line, work done by the system is
(a) 6×10^5 J (b) 3×10^5 J
(c) 4×10^5 J (d) 10×10^5 J

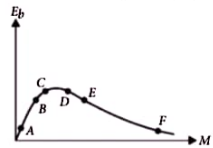
13. A non conducting ring of radius R has charge Q distributed unevenly over it. If it rotates with an angular velocity ω, the equivalent current will be
(a) zero (b) $Q\omega$
(c) $Q\dfrac{\omega}{2\pi}$ (d) $Q\dfrac{\omega}{2\pi R}$

14. An irregular closed loop carrying a current has a shape such that the entire loop cannot lie in a single plane. If this is placed in a uniform magnetic field, the force acting on the loop
(a) must be zero (b) can never be zero
(c) may be zero
(d) will be zero only for one particular direction of the magnetic field

15. Given below are two statements:
Statement I : In hydrogen atom, the frequency of radiation emitted when an electron jumps from lower energy orbit (E_1) to higher energy orbit (E_2), is given as $hf = E_1 - E_2$.
Statement II : The jumping of electron from higher energy orbit (E_2) to lower energy orbit (E_1) is associated with frequency of radiation given as $f = (E_2 - E_1)/h$
This condition is Bohr's frequency condition.
In the light of the above statements, choose the correct answer from the options given here:
(a) Both statement I and statement II are true.
(b) Both statement I and statement II are false.
(c) Statement I is correct but statement II is false.
(d) Statement I is incorrect but statement II is true.

16. In a parallel-plate capacitor, the region between the plates is filled by a dielectric slab. The capacitor is charged from a cell and then disconnected from it. The slab is now taken out.
(a) The potential difference across the capacitor is reduced.
(b) The potential difference across the capacitor is increased.
(c) The energy stored in the capacitor is reduced.
(d) No work is done by an external agent in taking the slab out.

17. Given figure is a plot of binding energy per nucleon E_b, against the nuclear mass M. A, B, C, D, E and F correspond to different nuclei. Consider four reactions
(i) $A + B \rightarrow C + Q$
(ii) $C \rightarrow A + B + Q$
(iii) $D + E \rightarrow F + Q$
(iv) $F \rightarrow D + E + Q$
where Q is the energy released.



In which reactions is Q positive?
(a) (i) and (iv) (b) (i) and (iii)
(c) (ii) and (iv) (d) (ii) and (iii)

18. One requires 11 eV of energy to dissociate a carbon monoxide molecule into carbon and oxygen atoms. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in
(a) visible region (b) infrared region
(c) ultraviolet region (d) microwave region

19. When an unpolarised light of intensity I_0 is incident on a polarising sheet, the intensity of the light which does not get transmitted is
(a) $\dfrac{I_0}{2}$ (b) $\dfrac{I_0}{4}$ (c) zero (d) I_0

20. In the List-I here, four different paths of a particle are given as functions of time. In these functions, α and β are positive constants of appropriate dimensions and α ≠ β. In each case, the force acting on the particle is either zero or conservative.

In List-II, five physical quantities of the particle are mentioned : $\vec{p}$ is the linear momentum, $\vec{L}$ is the angular momentum about the origin, K is the kinetic energy, U is the potential energy and E is the total energy. Match each path in List-I with those quantities in List-II, which are conserved for that path.

List-I		List-II	
P.	$\vec{r}(t)=\alpha t\hat{i}+\beta t\hat{j}$	1.	$\vec{p}$
Q.	$\vec{r}(t)=\alpha\cos\omega t\,\hat{i}+\beta\sin\omega t\,\hat{j}$	2.	$\vec{L}$
R.	$\vec{r}(t)=\alpha(\cos\omega t\,\hat{i}+\sin\omega t\,\hat{j})$	3.	K
S.	$\vec{r}(t)=\alpha t\,\hat{i}+\frac{\beta}{2}t^2\,\hat{j}$	4.	U
		5.	E

(a) P → 1, 2, 3, 4, 5; Q → 2, 5; R → 2, 3, 4, 5; S → 5
(b) P → 1, 2, 3, 4, 5; Q → 3, 5; R → 2, 3, 4, 5; S → 2, 5
(c) P → 2, 3, 4; Q → 5; R → 1, 2, 4; S → 2, 5
(d) P → 1, 2, 3, 5; Q → 2, 5; R → 2, 3, 4, 5; S → 2, 5

SECTION-B (NUMERICAL TYPE QUESTIONS)

Attempt any 5 questions out of 10.

21. A 0.5 kg ball moving with a speed of 12 m/s strikes a hard wall at an angle of 30° with the wall. It is reflected with the same speed at the same angle. If the ball is in contact with the wall for 0.25 seconds, find the average force (in N) acting on the wall.

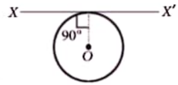
22. The angle of projection θ for which range is equal to maximum height attained by projectile is $\tan^{-1}(X)$, where X is ________.

23. A simple pendulum has a time period T_1 when on the earth's surface, and T_2 when taken to a height R above the earth's surface, where R is the radius of the earth. The value of T_2/T_1 is $X : 1$, where X is ________.

24. Dipole is placed parallel to the electric field. If W is the work done in rotating the dipole by 60°, then work done in rotating it by 180° is XW, where X is ________.

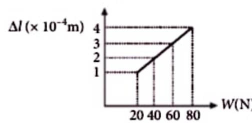
25. A transverse wave propagating along x-axis is represented by $y(x, t) = 8 \sin(0.5\pi x - 4\pi t - \pi/4)$ where x is in metres and t is in seconds. Find the speed (in m/s) of the wave.

26. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown.



The moment of inertia of the loop about the axis XX' is $\frac{3L^3\rho}{M\pi^2}$, where value of M is ________.

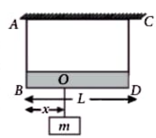
27. The adjacent graph shows the extension (Δl) of a wire of length 1 m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross-sectional area of the wire is 10^{-6} m^2, the Young's modulus of the material of the wire is 2×10^X N/m^2, where X is ________.



28. An ideal gas is filled in a closed rigid and thermally insulated container. A coil of 100 Ω resistor carrying current 1 A for 5 minute supplies heat to the gas. What is the change in internal energy (in kJ) of the gas?

29. A pipe of length l_1, closed at one end is kept in a chamber of gas of density ρ_1. A second pipe open at both ends is placed in a second chamber of gas of density ρ_2. The compressibility of both the gases is equal. Calculate the length of the second pipe if frequency of first overtone in both the cases is equal $\frac{X_1}{X_2}l_1\sqrt{\frac{A_1}{A_2}}$, the value of $X_1 + X_2$ is ________.

30. A massless rod of length L is suspended by two identical strings AB and CD of equal length. A block of mass m is suspended from point O such that BO is equal to x.



Further it is observed that the frequency of 1st harmonic in AB is equal to 2nd harmonic frequency in CD. $x = \frac{L}{P}$, where value of P is ________.

SOLUTIONS

1. **(c) :** Here, $R_{max} = \frac{u^2}{g} = \frac{1}{2}mu^2 \times \frac{2}{mg}$

But $\frac{1}{2}mu^2 = \frac{1}{2}kx^2$

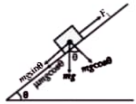
$\therefore R_{max} = \frac{1}{2}kx^2 \times \frac{2}{mg} = \frac{kx^2}{mg} = \frac{600\times(0.05)^2}{0.015\times 10} = 10\text{ m}$

2. **(d):** The minimum force required to start pushing a body up a rough inclined plane is

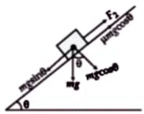
$F_1 = mg\sin\theta + \mu mg\cos\theta$ ...(i)

Minimum force needed to prevent the body from sliding down the inclined plane is

$F_2 = mg\sin\theta - \mu mg\cos\theta$ ...(ii)



(a)



(b)

Divide (i) by (ii), we get

$\frac{F_1}{F_2} = \frac{\sin\theta + \mu\cos\theta}{\sin\theta - \mu\cos\theta} = \frac{\tan\theta + \mu}{\tan\theta - \mu}$

$= \frac{2\mu + \mu}{2\mu - \mu} = 3$ ($\because \tan\theta = 2\mu$ (Given))

3. **(a) :** Time period, $T \propto p^a\rho^bE^c$ or $T = kp^a\rho^bE^c$

k is a dimensionless constant.

According to homogeneity of dimensions,

LHS = RHS

$\therefore$ $[T] = [ML^{-1}T^{-2}]^a[ML^{-3}]^b[ML^2T^{-2}]^c$

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

Comparing the powers, we obtain

$a + b + c = 0$

$-a - 3b + 2c = 0$

$-2a - 2c = 1$

On solving, we get $a = -\frac{5}{6}, b = \frac{1}{2}, c = \frac{1}{3}$

4. **(a) :** Here, $u = 0$, $a = \frac{F}{m} = \frac{qE}{m}$

$v = u + at = 0 + \frac{qE}{m}t$

$KE = \frac{1}{2}mv^2 = \frac{mq^2E^2t^2}{2m^2} = \frac{E^2q^2t^2}{2m}$

5. **(d):** If d_1 is the distance of point X on axial line and d_2 is distance of point Y on equatorial line, then

$B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d_1^3}, B_2 = \frac{\mu_0}{4\pi}\frac{M}{d_2^3}$

As $B_1 = B_2$

$\therefore \frac{\mu_0}{4\pi}\frac{2M}{d_1^3} = \frac{\mu_0}{4\pi}\frac{M}{d_2^3}$; $d_1^3 = 2d_2^3$; $\frac{d_1}{d_2} = 2^{1/3}$

6. **(c) :** The balanced condition is $\frac{P}{Q} = \frac{R}{S}$, here it is not verified.

No current will flow through galvanometer.

Assertion is correct, Reason is incorrect.

7. **(c) :** Using angular momentum conservation,

$L_i = 0$, $L_f = mvR - I\omega$, so, $mvR = I\omega$

$\omega = \frac{mvR}{I} = \frac{50\times 1\times 2}{200} = \frac{1}{2}$

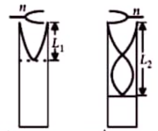
For one complete revolution, $(v + \omega R)t = 2\pi R$

or $\left(1 + \frac{1}{2}\times 2\right)t = 2\pi \times 2 \Rightarrow t = 2\pi$ s

8. **(c) :** $v_1 = \sqrt{\frac{\gamma RT}{M}}$ assuming M is the average molar mass of the air (*i.e.*, nitrogen) and γ is also for nitrogen.

$v_1 = \sqrt{\frac{\gamma RT_1}{M}}$; $v_2 = \sqrt{\frac{\gamma RT_2}{M}}$

where T_1 and T_2 stand for winter and summer temperatures.



1st resonance 2nd resonance

$L_1 = \frac{v_1}{n} = \frac{\lambda}{4} = 18$ cm at temperature T_1.

At T_2, summer, $v_2 > v_1$.

$L_2 = \frac{v_2}{n} = \frac{3\lambda}{4} > 3\times 18.$ $\therefore L_2 > 54$ cm

9. **(b):** Higher is the temperature, greater is the most probable velocity.

10. **(d)**

11. **(b):** Let v_w be velocity of water and v_b be the velocity of motor boat in still water. If x is the distance covered, then as per question

$x = (v_b + v_w) \times 6 = (v_b - v_w) \times 10$

On solving, $v_w = v_b/4$

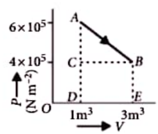
$\therefore$ $x = (v_b + v_b/4) \times 6 = 7.5\ v_b$

Time taken by motor boat to cross the same distance in still water is, $t = \frac{x}{v_b} = \frac{7.5v_b}{v_b} = 7.5$ h

12. **(d):** According to question, the figure can be drawn as shown. Now, work done by the system

= Area under P-V diagram

= Area of rectangle $BCDE$ + area of ΔABC



$= 4\times 10^5 \times 2 + \frac{2\times 10^5\times 2}{2} \Rightarrow W = 10\times 10^5$ J

13. **(c) :** With each rotation, charge Q crosses any fixed point P near the ring.
Number of rotations per second = $\omega/2\pi$.
$\therefore$ Charge crossing P per second = current = $\frac{Q\omega}{2\pi}$

14. **(a) :** A closed, current-carrying loop of any shape placed in any uniform magnetic field, experiences no force.

15. **(d) :** If E_1 is the total energy of electron in an lower orbit and E_2 is its total energy in the higher orbit then frequency of radiation (υ) emitted on jumping from higher orbit to lower orbit is given by

$$h\upsilon = E_2 - E_1 \text{ or } \upsilon = \frac{E_2 - E_1}{h}$$

16. **(b) :** When a charged capacitor is disconnected from the cell to which it was connected, its charge remains constant. Any change in the capacitor may change its capacitance, its stored energy and its potential difference.

17. **(a) :** When two nuclei combine to form a single nucleus, and energy is released, we have fusion reaction. If a single nucleus splits into two, it is fission. The possibility of fusion is more for light elements and fission takes place for heavy elements. Out of the choices given for fusion, only A and B are light elements and D and E are heavy elements. Therefore, $A + B \rightarrow C + Q$ is correct. The possibility of fission is only for F and not for C.
Therefore, $F \rightarrow D + E + Q$ is the correct choice.

18. **(c) :** $E = 11 \text{ eV} = 11 \times 1.6 \times 10^{-19} = h\upsilon$

$$\text{or } \upsilon = \frac{11 \times 1.6 \times 10^{-19}}{h} = \frac{11 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}}$$

$$= 2.65 \times 10^{15} \text{ Hz}$$

It comes in range of ultraviolet region.

19. **(a) :** As intensity of transmitted light, $I = I_0 \cos^2\theta$ and the average value of $\cos^2\theta = \frac{1}{2}$, $I = \frac{I_0}{2}$.

Intensity of light which is not transmitted

$$= I_0 - \frac{I_0}{2} = \frac{I_0}{2}$$

20. **(a) :** For $\vec{r}(t) = \alpha t\hat{i} + \beta t\hat{j}$

$$\vec{v} = \frac{d\vec{r}(t)}{dt} = \alpha\hat{i} + \beta\hat{j}; \ \vec{a} = \frac{d\vec{v}}{dt} = 0$$

$$K = \frac{1}{2}mv^2 \text{ (remains constant)}$$

$$\vec{F} = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j}\right] = 0 \Rightarrow U = \text{constant}$$

$E = K + U$ = constant

$$\frac{d\vec{L}}{dt} = \vec{\tau} = \vec{r} \times \vec{F} = 0\,; \ \vec{L} = \text{constant}$$

For $\vec{r}(t) = \alpha\cos(\omega t)\hat{i} + \beta\sin(\omega t)\hat{j}$

$$\vec{v} = \frac{d\vec{r}}{dt} = -\alpha\omega\sin(\omega t)\hat{i} + \beta\omega\cos(\omega t)\hat{j}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = -\alpha\omega^2\cos(\omega t)\hat{i} - \beta\omega^2\sin(\omega t)\hat{j}$$

$$= -\omega^2[\alpha\cos(\omega t)\hat{i} + \beta\sin(\omega t)\hat{j}]$$

$$\vec{a} = -\omega^2\vec{r}$$

$$\vec{\tau} = \vec{r} \times \vec{F} = 0 \quad (\because \ \vec{r} \text{ and } \vec{F} \text{ are parallel})$$

So, $\vec{L}$ = constant

$$U = -\int \vec{F}\cdot d\vec{r} = +\int_0^r m\omega^2 . r dr = m\omega^2\left[\frac{r^2}{2}\right]$$

$$U \propto r^2$$

$$r = \sqrt{\alpha^2\cos^2(\omega t) + \beta^2\sin^2(\omega t)}$$

r is a function of time (t).
U depends on r hence it will change with time.
Total energy remains constant because force is central.

For $\vec{r}(t) = \alpha(\cos\omega t\hat{i} + \sin(\omega t)\hat{j})$

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = \alpha(-\omega\sin\omega t\hat{i} + \omega\cos\omega t\hat{j})$$

$|\vec{v}| = \alpha\omega$ (Speed remains constant)

$$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = \alpha[-\omega^2\cos(\omega t)\hat{i} - \omega^2\sin(\omega t)\hat{j}]$$

$$= -\alpha\omega^2[\cos(\omega t)\hat{i} + \sin(\omega t)\hat{j}] \; ; \; \vec{a}(t) = -\omega^2\vec{r}$$

$\vec{\tau} = \vec{r} \times \vec{F} = 0 \quad \therefore \vec{L} = \text{constant}$

$|\vec{r}| = \alpha$ (remains constant)

Force is central in nature and distance from fixed point is constant.
Potential energy remains constant.
Kinetic energy is also constant.
($\because$ Speed is constant)

For $\vec{r} = \alpha t\hat{i} + \frac{\beta}{2}t^2\hat{j}$

$\vec{v} = \frac{d\vec{r}}{dt} = \alpha\hat{i} + \beta t\hat{j}$ (speed of particle depends on t)

$\vec{a} = \frac{d\vec{v}}{dt} = \beta\hat{j}$ (constant)

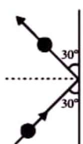
$\vec{F} = m\vec{a}$ (constant)

$$U = -\int \vec{F}\cdot d\vec{r} = -m\int_0^t \beta\hat{j}\cdot(\alpha\hat{i} + \beta t\hat{j})dt$$

$$U = \frac{-m\beta^2t^2}{2}; \; K = \frac{1}{2}mv^2 = \frac{1}{2}m(\alpha^2 + \beta^2t^2)$$

$E = K + U = \frac{1}{2}m\alpha^2$ (remains constant)

21. (24) : Components of momentum parallel to the wall add each other and components of momentum perpendicular to the wall are opposite to each other.



Therefore change of momentum is final momentum – initial momentum
i.e., $mv\sin\theta$ (after collision) – $(-mv\sin\theta)$
(before collision) $F \times t$ = change in momentum
$= 2mv\sin\theta$

$$\therefore F = \frac{2mv\sin\theta}{t} = \frac{2\times0.5\times12\times\sin30^\circ}{0.25} = 24\text{ N}$$

22. (4): Maximum height = maximum range

$$\frac{u^2\sin^2\theta}{2g} = \frac{u^2\sin2\theta}{g} \Rightarrow \frac{\sin^2\theta}{2} = 2\sin\theta\cos\theta$$

$\Rightarrow \tan\theta = 4 \Rightarrow \tan^{-1}(4) = \theta.$

23. (2): For a simple pendulum, $T = 2\pi\sqrt{\frac{l}{g}}$

$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{g_1}{g_2}}$$

Now, $g_1 = \frac{GM}{R^2}, g_2 = \frac{GM}{(2R)^2} = \frac{GM}{4R^2}$

$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{GM}{R^2}\times\frac{4R^2}{GM}} = \sqrt{\frac{4}{1}} = \frac{2}{1} \quad \therefore \frac{T_2}{T_1} = \frac{2}{1}$$

24. (2): Work done = $-pE\cos\theta$

$W = -pE\cos60^\circ$

$$W = \frac{-pE}{2} \Rightarrow |W| = \left|\frac{pE}{2}\right|$$

where p is dipole moment of dipole and E is the electric field applied.
The work done required to rotate dipole by 180° is
$W' = -pE\cos180^\circ = pE = 2W.$

25. (8): $y(x,t) = 8.0\sin\left(0.5\pi x - 4\pi t - \frac{\pi}{4}\right)$

Compare with a standard wave equation,

$$y = a\sin\left(\frac{2\pi x}{\lambda} - \frac{2\pi t}{T} + \phi\right)$$

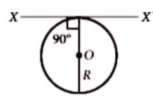
we get $\frac{2\pi}{\lambda} = 0.5\pi$ or $\lambda = \frac{2\pi}{0.5\pi} = 4$ m.

$\frac{2\pi}{T} = 4\pi$ or $T = \frac{2\pi}{4\pi} = \frac{1}{2}$ sec.

$\upsilon = 1/T = 2$ Hz.

Wave velocity, $v = \lambda\upsilon = 4 \times 2 = 8$ m/sec.

26. (8): Let I denote moment of inertia of the loop about the axis XX'.



$$\therefore I = \frac{mR^2}{2} + mR^2 = \frac{3}{2}mR^2$$

Now m = mass of loop
or $m = L\rho$

Again $2\pi R = L$ or $R = \frac{L}{2\pi}$

$$\therefore I = \frac{3}{2}(L\rho)\left(\frac{L}{2\pi}\right)^2 \text{ or } I = \frac{3L^3\rho}{8\pi^2}.$$

27. (11) : $Y = \frac{F/A}{\Delta l/l} = \frac{F}{A}\frac{l}{\Delta l}$

$$Y = \frac{20\times1}{10^{-6}\times10^{-4}} = 2\times10^{11}\text{ N m}^{-2}$$

$\therefore X = 11.$

28. (30) : Internal energy = Heat supplied, as $\Delta W = 0$.

$\therefore \quad \Delta U = I^2Rt = (1)^2 \times (100) \times (5 \times 60) = 30{,}000\text{ J} = 30\text{ kJ}.$

29. (7) : The first pipe is closed. Its length is l_1.

$\therefore$ For first overtone, $l_1 = \dfrac{3\lambda_1}{4} \quad \therefore \quad \lambda_1 = \dfrac{4l_1}{3}$

$\therefore$ Frequency $= \dfrac{\text{Velocity in gas}}{\lambda_1} = \dfrac{1}{\lambda_1}\sqrt{\dfrac{E}{\rho_1}}$

or $f = \dfrac{3}{4l_1}\sqrt{\dfrac{E}{\rho_1}}$ ...(i)

The second pipe is open. Let its length be l_2.

$\therefore$ For first overtone, $l_2 = \lambda_2$

$\therefore$ Frequency $= \dfrac{v_2}{\lambda_2} = \dfrac{1}{\lambda_2}\sqrt{\dfrac{E}{\rho_2}}$

or frequency $= \dfrac{1}{l_2}\sqrt{\dfrac{E}{\rho_2}}$ ...(ii)

Equate the two frequencies,

$\therefore \dfrac{1}{l_2}\sqrt{\dfrac{E}{\rho_2}} = \dfrac{3}{4l_1}\sqrt{\dfrac{E}{\rho_1}}$ or $l_2 = \dfrac{4l_1}{3}\sqrt{\dfrac{\rho_1}{\rho_2}}$.

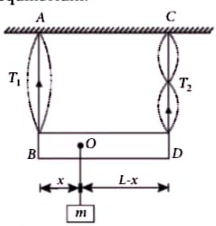
30. (5) : Frequency of first harmonic in $AB = f_1$

Frequency of second harmonic in $CD = f_2$

$f_1 = f_2$ (given)

$\therefore \dfrac{1}{2l}\sqrt{\dfrac{T_1}{\mu}} = \dfrac{1}{l}\sqrt{\dfrac{T_2}{\mu}}$ or $T_1 = 4T_2$ ...(i)

Equate torques due to T_1 and T_2 about O for rotational equilibrium.



$\therefore \quad T_1x = T_2(L - x)$ ...(ii)

For translational equilibrium,

$T_1 + T_2 = mg$ ...(iii)

From (i) and (iii),

$T_1 = \dfrac{4mg}{5}$ and $T_2 = \dfrac{mg}{5}$

Put these values in (ii).

$\therefore \dfrac{4mg}{5} \times x = \dfrac{mg}{5}(L - x)$ or $4x = L - x$ or $x = \dfrac{L}{5}$.

Happy π DAY!

π is a mathematical mystery that has captivated people for thousands of years. The first calculation of π was done by **Archimedes of Syracuse** (287–212 BC), one of the greatest mathematicians of the ancient world and showed that π is between 3 1/7 and 3 10/71. There's even a holiday dedicated to this mystery— π Day, which falls on 3/14. **Albert Einstein**, the famous physicist, was born in 1879 on March 14, a date that reminds us of 3.14, the approximate value of π.

The physical constant theory reveals that physical constants of the universe are all related and justified by π, leading to similarity in value patterns and links with π codes showing the relationships. The physical constant theory is about the physical constants but there's more to π and its importance. In the year 2018, 20 year old Prince Jessii named his discovery about the origin of the universe as "Ultimate Relativity" which simply reveals that there was an originator and facilitator of the universe which has a value in physics and mathematics as 3.125, this value is the actual value of π. Thus, it further implies that; generally, everything in the universe are related and they all originate from π.

PRACTICE PAPER

NEET 2024

SECTION - A

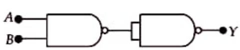
1. Which one of the following phenomena is not explained by Huygen's construction of wavefront?
(a) Refraction (b) Reflection
(c) Diffraction (d) Origin of spectra

2. A thermally insulated vessel containing a gas whose molar mass is M and ratio of specific heat γ moves with velocity v. What is the change in temperature of the gas if the vessel is suddenly stopped?
(a) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2$ (b) $\frac{(\gamma-1)}{2\gamma R}Mv^2$
(c) $\frac{\gamma Mv^2}{2R}$ (d) $\frac{(\gamma-1)Mv^2}{2R}$

3. A car starts from rest, attains a velocity of 36 km h^{-1} with an acceleration of 0.2 m s^{-2}, travels 9 km with this uniform velocity and then comes to halt with a uniform deceleration of 0.1 m s^{-2}. The total time of travel of the car is
(a) 1050 s (b) 1000 s
(c) 950 s (d) 900 s

4. If N is the number of turns in a coil, the value of self inductance varies as
(a) N^0 (b) N (c) N^2 (d) N^{-2}

5. Identify the logic operation of the following logic circuit.



(a) NAND (b) AND
(c) NOR (d) OR

6. A particle at the end of a spring executes simple harmonic motion with a period T_1 while the corresponding period for another spring is T_2. If the period of oscillation with the two springs in parallel is T, then
(a) $T^{-2}=T_1^{-2}+T_2^{-2}$ (b) $T^2=T_1^2+T_2^2$
(c) $T=T_1+T_2$ (d) $T^{-1}=T_1^{-1}+T_2^{-1}$

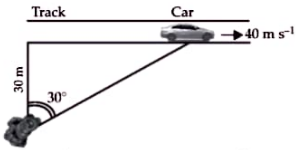
7. Interference fringes are produced in Young's double slit experiment using light of wavelength 5000 Å. When a film of material 2.5×10^{-6} m thick was placed over one of the slits, the fringe pattern shifted by a distance equal to 2 fringe widths. The refractive index of the material of the film is
(a) 1.25 (b) 1.33 (c) 1.4 (d) 1.5

8. A string is under tension so that its length is increased by $\frac{1}{n}$ times its original length. The ratio of fundamental frequency of longitudinal vibrations and transverse vibrations will be
(a) $1:n$ (b) $n^2:1$
(c) $\sqrt{n}:1$ (d) $n:1$

9. Four solid spheres each of diameter $\sqrt{5}$ cm and mass 0.5 kg are placed with their centers at the corners of a square of side 4 cm. The moment of inertia of the system about the diagonal of the square is
(a) 3×10^{-4} kg m^2 (b) 6×10^{-4} kg m^2
(c) 9×10^{-4} kg m^2 (d) 4×10^{-4} kg m^2

10. **Assertion :** A large force is required to draw apart normally two glass plates enclosing a thin water film.
Reason : Water works as glue and sticks two glass plates.
(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c) Assertion is true but Reason is false.
(d) Both Assertion and Reason are false.

11. A racing car is travelling along a track at a constant speed of 40 m s^{-1}. A TV cameraman is recording the event from a distance of 30 m directly away from the track as shown in figure. In order to keep the car under view, at what angular speed must the camera be rotated?



(a) 1 rad s^{-1} (b) 2 rad s^{-1}
(c) 4 rad s^{-1} (d) 5 rad s^{-1}

12. If λ_1 and λ_2 are the wavelengths of the first members of the Lyman and Paschen series respectively, then $\lambda_1 : \lambda_2$ is
(a) 1 : 3 (b) 1 : 30 (c) 7 : 50 (d) 7 : 108

13. A rope is wound round a hollow cylinder of mass 3 kg and radius 40 cm. If the rope is pulled with a force of 30 N, angular acceleration of the cylinder will be
(a) 10 rad s^{-2} (b) 15 rad s^{-2}
(c) 20 rad s^{-2} (d) 25 rad s^{-2}

14. A particle is projected from a horizontal plane with velocity of $5\sqrt{2}$ m s^{-1} at an angle. At highest point its velocity is found to be 5 m s^{-1}. Its range will be (Take g = 10 m s^{-2})
(a) 3 m (b) 5 m (c) 7 m (d) 9 m

15. The momentum of a photon of energy 1 MeV in kg m s^{-1} will be
(a) 5.3×10^{-22} (b) 0.33×10^{6}
(c) 7×10^{-24} (d) 10^{-22}

16. Water is conveyed through a uniform tube of 8 cm in diameter and 3140 m in length at the rate 2×10^{-3} m^3 per second. The pressure required to maintain the flow is
(Viscosity of water = 10^{-3} SI units)
(a) 6.25×10^{3} N m^{-2} (b) 0.625 N m^{-2}
(c) 0.0625 N m^{-2} (d) 0.00625 N m^{-2}

17. A fish at a depth of 12 cm in water is viewed by an observer on the bank of a lake. To what height is the image of fish raised?
(Refractive index of lake water $= \frac{4}{3}$)
(a) 3 cm (b) 6 cm (c) 9 cm (d) 12 cm

18. A plane electromagnetic wave is propagating along the z direction. If the electric field component of this wave is in the direction $(\hat{i} + \hat{j})$, then which of the following is the direction of the magnetic field component?
(a) $(-\hat{i} + \hat{j})$ (b) $(\hat{i} - \hat{j})$
(c) $(-\hat{i} - \hat{j})$ (d) $(\hat{i} + \hat{k})$

19. A uniform magnetic field, B points vertically up and is slowly changed in magnitude, but not in direction. The rate of change of the magnetic field is α. A conducting ring of radius r and resistance R is held perpendicular to the magnetic field, and is totally inside it. The induced current in the ring is
(a) zero (b) $\frac{2\pi rB}{R}$ (c) $\frac{r\alpha}{R}$ (d) $\frac{\pi r^2 \alpha}{R}$

20. Given below are two statements :
An insulating solid sphere of radius R has a uniformly positive charge density ρ. As a result of this uniform charge distribution there is a finite value of electric potential at the centre of the sphere, at the surface of the sphere and also at a point outside the sphere. The electric potential at infinity is zero.
Statement-I : When a charge q is taken from the centre to the surface of the sphere, its potential energy changes by $\frac{q\rho}{3\varepsilon_0}$.
Statement-II : The electric field at a distance $r (r < R)$ from the centre of the sphere is $\frac{\rho r}{3\varepsilon_0}$.
(a) Both statement-I and statement-II are true.
(b) Both statement-I and statement-II are false.
(c) Statement-I is true but statement-II is false.
(d) Statement-I is false but statement-II is true.

21. A thin uniform rod of mass m moves translationally with acceleration a due to two antiparallel forces of lever arm l. One force is of magnitude F and acts at one extreme end. The length of the rod is
(a) $\frac{mal}{ma + F}$ (b) $\frac{2(F + ma)l}{ma}$
(c) $l\left(1 + \frac{F}{ma}\right)$ (d) $\frac{(F + ma)l}{2ma}$

22. The amount of work done in stretching a spring from a stretched length of 10 cm to a stretched length of 20 cm is
(a) equal to the work done in stretching it from 20 cm to 30 cm
(b) less than the work done in stretching it from 20 cm to 30 cm
(c) more than the work done in stretching it from 20 cm to 30 cm
(d) equal to the work done in stretching it from 0 to 10 cm.

23. The rms value of the electric field of the light coming from the sun is 720 N C^{-1}. The average total energy density of the electromagnetic wave is

(a) 3.3×10^{-3} J m^{-3}
(b) 4.58×10^{-6} J m^{-3}
(c) 6.37×10^{-9} J m^{-3}
(d) 81.35×10^{-12} J m^{-3}

24. In Young's double slit experiment, one of the slits is wider than the other, so that the amplitude of the light from one slit is double that from the other slit. If I_m is the maximum intensity, the resultant intensity when they interfere at phase difference ϕ is given by

(a) $\frac{I_m}{3}\left(1+2\cos^2\frac{\phi}{2}\right)$ (b) $\frac{I_m}{5}\left(1+4\cos^2\frac{\phi}{2}\right)$

(c) $\frac{I_m}{9}\left(1+8\cos^2\frac{\phi}{2}\right)$ (d) $\frac{I_m}{9}\left(8+\cos^2\frac{\phi}{2}\right)$

25. A compound microscope has an eye piece of focal length 10 cm and an objective of focal length 4 cm. Calculate the magnification, if an object is kept at a distance of 5 cm from the objective, so that the final image is formed at the least distance of distinct vision 20 cm.

a) 12 (b) 11 (c) 10 (d) 13

26. The electric field E is measured at a point $P(0, 0, d)$ generated due to various charge distributions and the dependence of E on d is found to be different for different charge distributions. List-I contains different relations between E and d. List-II describes different electric charge distributions, along with their locations. Match the functions in List-I with the related charge distributions in List-II.

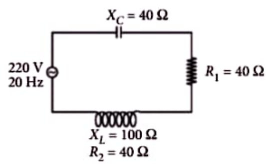
List-I		List-II	
P.	E is independent of d	1.	A point charge Q at the origin
Q.	$E \propto \frac{1}{d}$	2.	A small dipole with point charge Q at $(0, 0, l)$ and $-Q$ at $(0, 0, -l)$. Take $2l << d$.
R.	$E \propto \frac{1}{d^2}$	3.	An infinite line charge coincident with the x-axis, with uniform linear charge density λ
S.	$E \propto \frac{1}{d^3}$	4.	Two infinite wires carrying uniform linear charge density parallel to the x-axis. The one along $(y = 0, z = l)$ has a charge density $+l$ and the one along $(y = 0, z = -1)$ has a charge density $-\lambda$. Take $2l << d$.
		5.	Infinite plane charge coincident with the xy-plane with uniform surface charge density.

(a) P → 5; Q → 3, 4; R → 1; S → 2
(b) P → 5; Q → 3; R → 1, 4; S → 2
(c) P → 5; Q → 3; R → 1, 2; S → 4
(d) P → 4; Q → 2, 3; R → 1; S → 5

27. In a galvanometer 5% of the total current in the circuit passes through it. If the resistance of the galvanometer is G, the shunt resistance S connected to the galvanometer is

(a) $19G$ (b) $\frac{G}{19}$ (c) $20G$ (d) $\frac{G}{20}$

28. The power factor of the circuit as shown in figure is



(a) 0.2 (b) 0.4 (c) 0.8 (d) 0.6

29. At ordinary temperature, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperatures they may also have vibrational energy. As a result of this at higher temperatures

(C_V = molar heat capacity at constant volume)

(a) $C_V = \frac{3}{2}R$ for a monoatomic gas

(b) $C_V > \frac{3}{2}R$ for a monoatomic gas

(c) $C_V > \frac{5}{2}R$ for a diatomic gas

(d) $C_V = \frac{5}{2}R$ for a diatomic gas

30. A body is projected vertically upwards with a velocity of 10 m s^{-1}. It reaches the maximum height h in time t. In time $t/2$, the height covered is

(a) $\frac{h}{2}$ (b) $\frac{2}{5}h$ (c) $\frac{3}{4}h$ (d) $\frac{5}{8}h$

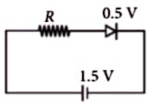
31. A wheel is subjected to uniform angular acceleration about its axis. Initially, its angular velocity is zero. In the first 2 s, it rotates through an angle θ_1, in the next 2 s, it rotates through an angle θ_2. The ratio of $\frac{\theta_2}{\theta_1}$ is

(a) 1 (b) 2 (c) 3 (d) 5

32. A uniform chain of mass m and length l is lying on a table with $\frac{l}{4}$ of its length hanging freely from the edge of the table. The amount of work done in dragging the chain on the table completely is

(a) $\frac{mgl}{4}$ (b) $\frac{mgl}{8}$ (c) $\frac{mgl}{32}$ (d) $\frac{mgl}{16}$

33. The diode used in the circuit shown in the figure has a constant voltage drop at 0.5 V at all currents and a maximum power rating of 100 milliwatts. What should be the value of the resistor R, connected in series with diode, for obtaining maximum current?



(a) 6.76 Ω (b) 20 Ω (c) 5 Ω (d) 5.6 Ω

34. On shining light of wavelength 6.2×10^{-6} m on a metal surface photo-electrons are emitted. The work function of the metal is 0.1 eV. Find the kinetic energy of a photo-electron (in eV)

(a) 0.1 (b) 0.2 (c) 0.3 (d) 0.4

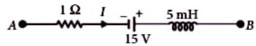
35. A mass of 0.2 kg is attached to the lower end of a massless spring of force constant 200 N m^{-1}, the upper end of which is fixed to a rigid support. Which of the following statement is not true?

(a) The frequency of oscillation will be nearly 5 Hz.
(b) In equilibrium, the spring will be stretched by 2 cm.
(c) If the mass is raised till the spring is unstretched state and then released, it will go down by 2 cm before moving upward
(d) If the system is taken to a planet, the frequency of oscillation will be the same as on the earth.

SECTION - B

Attempt any 10 questions out of 15.

36. The network shown in the figure is part of a complete circuit. If at a certain instant, the current I is 5 A, and is decreasing at a rate 10^3 A s^{-1} then $V_B - V_A$ is



(a) 20 V (b) 15 V (c) 10 V (d) 5 V

37. A plane electromagnetic wave of frequency 25 MHz travels in a free space along the x-direction. At the particular point in space and time, $E = 6.3\hat{j} \text{ V m}^{-1}$. What is the magnetic field at that point?

(a) $2.1\times10^{-8}\hat{k}$ T (b) $3.1\times10^{-4}\hat{k}$ T
(c) $5.0\times10^{-6}\hat{k}$ T (d) 0

38. Both Earth and Moon are subject to the gravitational force of the Sun. As observed from the Sun, the orbit of the Moon

(a) will be elliptical
(b) will not be strictly elliptical because the total gravitational force on its is not central
(c) is not elliptical but will necessarily be a closed curve
(d) deviates considerably from being elliptical due to influence of planets other than Earth.

39. A circular loop of radius R, carrying current I, lies in x-y plane with its centre at origin. The total magnetic flux through x-y plane is

(a) directly proportional to I
(b) directly proportional to 5
(c) inversely proportional to R
(d) zero.

40. For a heavily doped n-type semiconductor, Fermi level lies

(a) a little below the conduction band
(b) a little above the valence band
(c) a little inside the valence band
(d) at the centre of the band gap

41. Given below are two statements :

Statement-I : A point particle of mass m moving with speed v collides with stationary point particle of mass M. If the maximum energy loss possible is given as

$h\left(\frac{1}{2}mv^2\right)$ then $h = \left(\frac{m}{M+m}\right)$

Statement-II : Maximum energy loss occurs when the particles get stuck together as a result of the collision.

(a) Both statement-I and statement-II are true.
(b) Both statement-I and statement-II are false.
(c) Statement-I is true but statement-II is false.
(d) Statement-I is false but statement-II is true.

42. Two containers of equal volume contain the same gas at pressures P_1 and P_2 and absolute temperatures T_1 and T_2 respectively. On joining the vessels, the gas reaches a common pressure P and a common temperature T. The ratio P/T is equal to

(a) $\frac{P_1}{T_1}+\frac{P_2}{T_2}$ (b) $\frac{1}{2}\left[\frac{P_1}{T_1}+\frac{P_2}{T_2}\right]$

(c) $\frac{P_1T_2+P_2T_1}{T_1+T_2}$ (d) $\frac{P_1T_2-P_2T_1}{T_1-T_2}$

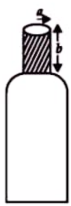
43. An iceberg is floating partly immersed in sea water, the density of sea water is 1.03 g cm^{-3} and that of ice is 0.92 g cm^{-3}. The fraction of the total value of the iceberg above the level of sea water is

(a) 8.1% (b) 11% (c) 34% (d) 0.8%

44. The radius of electron orbit and the speed of electron in the ground state of hydrogen atom is 5.30×10^{-11} m and 2.2×10^6 m s^{-1} respectively, then the orbital period of this electron in second excited state will be

(a) 1.21×10^{-14} s (b) 1.21×10^{-12} s
(c) 1.21×10^{-10} s (d) 1.21×10^{-15} s

45. A bottle has an opening of radius a and length b. A cork of length b and radius $(a + \Delta a)$ where $(\Delta a << a)$ is compressed to fit into the opening completely (see figure). If the bulk modulus of cork is B and frictional coefficient between the bottle and cork is μ then the force needed to push the cork into the bottle is



(a) $(\pi\mu Bb)a$ (b) $(2\pi\mu Bb)\Delta a$
(c) $(\pi\mu Bb)\Delta a$ (d) $(4\pi\mu Bb)\Delta a$

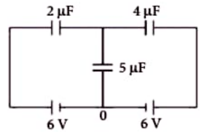
46. A wheel with 20 metallic spokes each of length 0.8 m long is rotated with a speed of 120 revolution per minute in a plane normal to the horizontal component of earth magnetic field H at a place. If $H = 0.4 \times 10^{-4}$ T at the place, then induced emf between the axle and the rim of the wheel is

(a) 2.3×10^{-4} V (b) 3.1×10^{-4} V
(c) 2.9×10^{-4} V (d) 1.61×10^{-4} V

47. Assertion : A secondary rainbow have inverted colours than the primary rainbow.
Reason : The secondary rainbow is formed by single total internal reflection.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

48. In the circuit shown, charge on the 5 μF capacitor is



(a) 18.00 μC (b) 10.90 μC
(c) 16.36 μC (d) 5.45 μC

49. A fork A has frequency 2% more than the standard fork and B has a frequency 3% less than the frequency of same standard fork. The forks A and B when sounded together produced 6 beats s^{-1}. The frequency of fork A is

(a) 116.4 Hz (b) 120 Hz
(c) 122.4 Hz (d) 238.8 Hz

50. The far point of a near sighted person is 6.0 m from her eyes, and she wears contacts that enable her to see distant objects clearly. A tree is 18.0 m away and 2.0 m high. How high is the image formed by the contacts?

(a) 1.0 m (b) 1.5 m (c) 0.75 m (d) 0.50 m

SOLUTIONS

1. (d) : Huygen's construction of wavefront does not apply to origin of spectra which is explained by quantum theory.

2. (d) : When the vessel is suddenly stopped, its kinetic energy is used to increase the temperature of the gas.

$$\therefore \ \frac{1}{2}mv^2 = nC_V\Delta T; \quad \frac{1}{2}mv^2 = \left(\frac{m}{M}\right)C_V\Delta T$$

$$\left(\because n = \frac{m}{M}\right) \ \Delta T = \frac{Mv^2}{2C_V}$$

$$= \frac{Mv^2(\gamma-1)}{2R} \qquad \left(\because C_V = \frac{R}{\gamma-1}\right)$$

3. **(a) :** 

Let the car be accelerated from A to B. It moves with uniform velocity from B to C and then moves with uniform deceleration from C to D.

For the motion of car from A to B,

$$u = 0,\ v = 36\ \text{km h}^{-1} = 36 \times \frac{5}{18}\ \text{m s}^{-1} = 10\ \text{m s}^{-1},$$

$a = 0.2\ \text{m s}^{-2}$

$$\text{Time taken, } t_1 = \frac{v-u}{a} = \frac{10\ \text{m s}^{-1} - 0}{0.2\ \text{m s}^{-2}} = 50\ \text{s}$$

For the motion of car B to C

$S = 9\ \text{km} = 9000\ \text{m}$

$$\text{Time taken, } t_2 = \frac{9000\ \text{m}}{10\ \text{m s}^{-1}} = 900\ \text{s}$$

For the motion of car C to D,

$v = 0,\ u = 10\ \text{m s}^{-1},\ a = -0.1\ \text{m s}^{-2}$

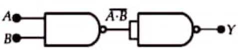
$$\text{Time taken, } t_3 = \frac{0 - 10\ \text{m s}^{-1}}{-0.1\ \text{m s}^{-2}} = 100\ \text{s}$$

Total time taken $= t_1 + t_2 + t_3$

$= 50\ \text{s} + 900\ \text{s} + 100\ \text{s} = 1050\ \text{s}$

4. **(c) :** $L = \frac{N\phi}{I};\ \phi = BA;\ B = \mu_0 nI = \frac{\mu_0 NI}{l}$

$$L = \frac{\mu_0 N^2}{l} A = \mu_0 n^2 A l$$

5. **(b) :** 

The Boolean expression for the output Y is

$Y = \overline{\overline{A \cdot B}} = A \cdot B$

This is the Boolean expression for the AND gate. Therefore, the given logic circuit perform the function of a AND gate.

6. **(a) :** The time period of spring pendulum

$$T = 2\pi\sqrt{\frac{m}{k}},$$

where k is the spring constant of the spring

For the first spring

$$T_1 = 2\pi\sqrt{\frac{m}{k_1}} \quad \text{or} \quad T_1^2 = \frac{4\pi^2 m}{k_1} \quad \text{...(i)}$$

For second spring

$$T_2 = 2\pi\sqrt{\frac{m}{k_2}} \quad \text{or} \quad T_2^2 = \frac{4\pi^2 m}{k_2} \quad \text{...(ii)}$$

When these two springs are connected in parallel, the effective spring constant is

$k_{eff} = k_1 + k_2$

$\therefore$ The time period of oscillation is

$$T = 2\pi\sqrt{\frac{m}{k_{eff}}} = 2\pi\sqrt{\frac{m}{k_1 + k_2}} \quad \text{or} \quad T^2 = \frac{4\pi^2 m}{k_1 + k_2}$$

$$\text{or} \quad \frac{1}{T^2} = \frac{k_1 + k_2}{4\pi^2 m} = \frac{k_1}{4\pi^2 m} + \frac{k_2}{4\pi^2 m}$$

$$\text{or} \quad \frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2} \quad \text{(Using (i) and (ii))}$$

$$\text{or} \quad T^{-2} = T_1^{-2} + T_2^{-2}$$

7. **(c) :** Here, $\lambda = 5000\ \text{Å} = 5 \times 10^{-7}\ \text{m}$

$t = 2.5 \times 10^{-6}\ \text{m}$

$x = 2\beta,\ \mu = ?$

$$x = (\mu - 1)t\frac{D}{d} \quad \text{But } \beta = \frac{\lambda D}{d} \quad \therefore \frac{D}{d} = \frac{\beta}{\lambda}$$

$$\therefore \quad x = (\mu - 1)t\frac{\beta}{\lambda}$$

$$2\beta = \frac{(\mu - 1)(2.5 \times 10^{-6})\beta}{5 \times 10^{-7}} \quad \mu - 1 = 0.4 \text{ or } \mu = 1.4$$

8. **(c) :** Velocity of longitudinal waves, $v_1 = \sqrt{\frac{Y}{\rho}}$

Velocity of transverse waves, $v_2 = \sqrt{\frac{T}{\mu}}$

If A is area of cross-section of string, then

$$\mu = \frac{\text{Mass}}{\text{Length}} = \frac{\text{Mass}}{\text{Volume}} \times \text{Area} = \rho A \quad \therefore \quad v_2 = \sqrt{\frac{T}{\rho A}}$$

TRIO

ANSWERS FEBRUARY 2024

The three letter sequence is **M O M**.

M O M E N T U **M**

S E I S **M O M** E T E R

O S **M O M** E T E R

D Y N A **M O M** E T E R

Winners : Arnab Sur (Kolkata), Arnab Monal (West Bengal) Sri Datha Sai Subramanya (Andhra Pradesh), Veera Satya Varalakshmi (Andhra Pradesh)

$$\frac{v_1}{v_2}=\sqrt{\frac{Y}{\rho}\frac{\rho A}{T}}=\sqrt{\frac{YA}{T}}$$

As $Y=\frac{F}{A(\Delta l/l)}=\frac{T}{A(\Delta l/l)}$

$$\therefore\ \frac{v_1}{v_2}=\sqrt{\frac{T}{A\left(\frac{\Delta l}{l}\right)}\frac{A}{T}}=\left(\frac{\Delta l}{l}\right)^{-1/2}\quad \frac{\Delta l}{l}=\frac{1}{n}\ \text{(Given)}$$

$$\therefore\ \frac{v_1}{v_2}=\left(\frac{1}{n}\right)^{-1/2}=\sqrt{n}$$

If υ_1, υ_2 are the corresponding fundamental frequencies of longitudinal and transverse vibrations, then

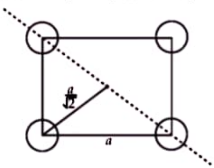
$v_1=\upsilon_1\lambda$ and $v_2=\upsilon_2\lambda$

$$\therefore\ \frac{\upsilon_1}{\upsilon_2}=\frac{v_1}{v_2}=\sqrt{n}$$

9. (c) : Here, Mass of each sphere, $M = 0.5$ kg

Radius of each sphere, $R=\frac{\sqrt{5}}{2}\text{ cm}=\frac{\sqrt{5}}{2}\times 10^{-2}\text{ m}$

Side of a square, $a = 4\text{ cm} = 4\times 10^{-2}$ m



Moment of inertia of the system about the diagonal of the square is

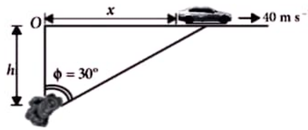
$$I=\frac{2}{5}MR^2+\left(\frac{2}{5}MR^2+M\left(\frac{a}{\sqrt{2}}\right)^2\right)$$
$$+\frac{2}{5}MR^2+\left(\frac{2}{5}MR^2+M\left(\frac{a}{\sqrt{2}}\right)^2\right)$$

$$=\frac{8}{5}MR^2+Ma^2\quad=\left[\frac{8}{5}\times 0.5\times\left(\frac{\sqrt{5}}{2}\right)^2+0.5\times 4^2\right]\times 10^{-4}$$

$= [1 + 8]\times 10^{-4}\text{ kg m}^2 = 9\times 10^{-4}\text{ kg m}^2$

10. (a) : In this case, atmospheric pressure does not come into play because it acts in all directions. The force which is effective in case of water between two pieces of glass is adhesive force. As adhesive forces are considered between two different bodies; cohesive forces are internal forces of a body, resulting from attraction between the molecules of it. The attractive force between water and glass (the glass contain sillicon atoms, negatively charged and water is a polar molecule so that the positive side of water is attached and causes part of the bound) keep them firmly together. Due to the big surface of the glass slide, the resultant force is also big. So we have to apply a large force in order to separate two glass plates enclosed with water film.

11. (a) : Let x be distance of car from the point O.



Then from figure, $\tan\phi=\frac{x}{h}$

$x=h\tan\phi,\ \frac{dx}{dt}=h\sec^2\phi\frac{d\phi}{dt}$

$v=h\sec^2\phi\ \omega\qquad\left(\because\ v=\frac{dx}{dt},\ \ \omega=\frac{d\phi}{dt}\right)$

$\omega=\frac{v}{h\sec^2\phi}$

$=\frac{v}{h}\cos^2\phi\qquad\left(\because\ \cos^2\phi=\frac{1}{\sec^2\phi}\right)$

Substituting the given values, we get

$$\omega=\frac{40}{30}\cos^2 30^\circ=\frac{40}{30}\times\left(\frac{\sqrt{3}}{2}\right)^2=1\text{ rad s}^{-1}$$

12. (d)

13. (d) : Moment of inertia of the hollow cylinder about its axis is

$I = MR^2 = (3\text{ kg})(0.4\text{ m})^2 = 0.48\text{ kg m}^2$

Torque applied on the cylinder

$\tau = FR = 30\text{ N}\times 0.4\text{ m} = 12\text{ N m}$

Angular acceleration (α) of the cylinder

$$\alpha=\frac{\tau}{I}=\frac{12}{0.48}=25\text{ rad s}^{-2}$$

14. (b) : Here, velocity of projection, $u=5\sqrt{2}\text{ m s}^{-1}$

At highest point velocity of projectile, $v = u\cos\theta$

$$\therefore\ 5=5\sqrt{2}\cos\theta\quad \cos\theta=\frac{1}{\sqrt{2}}\ \Rightarrow\ \theta=45^\circ$$

$$\text{Range}=\frac{u^2\sin 2\theta}{g}=\frac{(5\sqrt{2})^2\sin 2\times 45^\circ}{10}=\frac{25\times 2}{10}=5\text{ m}$$

15. (a) : Energy of photon, $E = 1$ MeV

Momentum of photon, $p=\frac{E}{c}$,

where c is the speed of light.

$$\therefore p=\frac{E}{c}=\frac{1\times 10^6\times 1.6\times 10^{-19}\text{ J}}{3\times 10^8\text{ m s}^{-1}}=0.53\times 10^{-21}\text{ kg m s}^{-1}$$

$= 5.3\times 10^{-22}\text{ kg m s}^{-1}$

16. (a) : According to Poiseuille formula,

Rate of flow, $V = \dfrac{\pi P r^4}{8\eta l}$,

where the symbols have their usual meanings.

$\therefore \quad P = \dfrac{V 8\eta l}{\pi r^4}$ Here, $V = 2 \times 10^{-3}\ \text{m}^3\ \text{s}^{-1}$

$r = \dfrac{8}{2}\text{cm} = 4\ \text{cm} = 4 \times 10^{-2}\ \text{m}$

$l = 3140\ \text{m},\ \eta = 10^{-3}\ \text{N s m}^{-2}$

Substituting the given values, we get

$$P = \frac{(2\times10^{-3}\ \text{m}^3\ \text{s}^{-1})(8)(10^{-3}\ \text{N s m}^{-2})(3140\ \text{m})}{(3.14)(4\times10^{-2}\ \text{m})^4}$$

$= 6.25 \times 10^3\ \text{N m}^{-2}$

17. (a) : As, $\mu = \dfrac{\text{Real depth}}{\text{Apparent depth}}$

Apparent depth $= \dfrac{12}{(4/3)} = 9\ \text{cm}$

The height through which image of fish is raised

$= 12 - 9 = 3\ \text{cm}$

18. (a) : The magnetic field component is perpendicular to the direction of propagation and the direction of electric field.

Using vector algebra, $\vec{E} \times \vec{B}$ should be in z direction

$\therefore \quad (\hat{i} + \hat{j}) \times (-\hat{i} + \hat{j}) = 2\hat{k}$

19. (d) : The magnitude of the induced emf in the ring is $|\varepsilon| = \dfrac{d\phi}{dt} = \dfrac{d}{dt}(BA) = A\dfrac{dB}{dt} = \pi r^2 \alpha$

The induced current in the ring is, $I = \dfrac{|\varepsilon|}{R} = \dfrac{\pi r^2 \alpha}{R}$

20. (b) : Potential at the centre of the sphere, $V_C = \dfrac{R^2\rho}{2\varepsilon_0}$

Potential at the surface of the sphere, $V_S = \dfrac{1}{3}\dfrac{R^2\rho}{\varepsilon_0}$

When a charge q is taken from the centre to the surface, the change in potential energy is

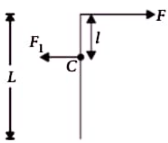
$$\Delta U = (V_C - V_S)q = \left(\frac{R^2\rho}{2\varepsilon_0} - \frac{1}{3}\frac{R^2\rho}{\varepsilon_0}\right)q = \frac{1}{6}\frac{R^2\rho q}{\varepsilon_0}$$

Statement-I is false.

Statement-II is true.

21. (b) : Let L be the length of the rod of mass m, with centre of mass at C. Suppose F_1 is the magnitude of other force. Let $F_1 > F$.

$\therefore \quad F_1 - F = ma$ or $F_1 = F + ma$



As the rod moves translationally and there is no rotation, therefore, net torque about C must be zero.

$$\therefore \quad F\left(\frac{L}{2}\right) = F_1\left(\frac{L}{2} - l\right) = (F + ma)\left(\frac{L}{2} - l\right)$$

$$F\left(\frac{L}{2}\right) = F\left(\frac{L}{2}\right) - Fl + ma\frac{L}{2} - mal$$

$$ma\frac{L}{2} = l(F + ma) \quad \therefore \quad L = \frac{2(F + ma)l}{ma}$$

22. (b) : $W = \dfrac{1}{2}K\left(x_2^2 - x_1^2\right) = \dfrac{1}{2}K(20^2 - 10^2) = 150\ \text{kJ}$

which is less than work done in stretching it from 20 cm to 30 cm.

$$\left[\text{viz. } \frac{1}{2}K(30^2 - 20^2) = 250\ \text{kJ}\right]$$

23. (b) : Total average energy density of electromagnetic wave is

$$\langle u \rangle = \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2 + \frac{1}{2\mu_0}B_{\text{rms}}^2$$

$$= \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2 + \frac{1}{2\mu_0}\left(\frac{E_{\text{rms}}^2}{c^2}\right) \qquad \left(\because B_{\text{rms}} = \frac{E_{\text{rms}}}{c}\right)$$

$$= \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2 + \frac{1}{2\mu_0}E_{\text{rms}}^2\varepsilon_0\mu_0$$

$$= \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2 + \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2 = \varepsilon_0 E_{\text{rms}}^2$$

$= (8.85 \times 10^{-12}) \times (720)^2 = 4.58 \times 10^{-6}\ \text{J m}^{-3}$

EXAM ALERT 2024

Exam	Date
JEE Main Session 2	Between 4th April and 15th April
KARNATAKA CET MATHS/BIOLOGY	18th April
KARNATAKA CET PHYSICS/CHEMISTRY	19th April
WB JEE	28th April
NEET	5th May
COMEDK (Engg.)	12th May
CUET	Between 15th May and 31st May
JEE Advanced	26th May
BITSAT Session 1	Between 21st May to 26th May
BITSAT Session 2	Between 22nd June to 26th June
CBSE Class 12th	
CBSE Physics	4th March
CBSE Mathematics	9th March
CBSE Biology	19th March

24. (c) : Here, $A_2 = 2A_1$

$\because$ Intensity $\propto$ (Amplitude)^2

$\therefore \quad \frac{I_2}{I_1} = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{2A_1}{A_1}\right)^2 = 4 \,;\, I_2 = 4I_1$

Maximum intensity, $I_m = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$= \left(\sqrt{I_1} + \sqrt{4I_1}\right)^2 = \left(3\sqrt{I_1}\right)^2 = 9I_1 \text{ or } I_1 = \frac{I_m}{9}$ ...(i)

Resultant intensity, $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$= I_1 + 4I_1 + 2\sqrt{I_1(4I_1)}\cos\phi$

$= 5I_1 + 4I_1\cos\phi = I_1 + 4I_1 + 4I_1\cos\phi = I_1 + 4I_1(1 + \cos\phi)$

$= I_1 + 8I_1\cos^2\frac{\phi}{2}$ $\quad \left(\because 1 + \cos\phi = 2\cos^2\frac{\phi}{2}\right)$

$= I_1\left(1 + 8\cos^2\frac{\phi}{2}\right)$

Putting the value of I_1 from eq. (i), we get

$I = \frac{I_m}{9}\left(1 + 8\cos^2\frac{\phi}{2}\right)$

25. (a) : Here, $u_o = -5$ cm, $f_o = 4$ cm

$f_e = 10$ cm, $D = 20$ cm

According to lens formula, $\frac{1}{v_o} = \frac{1}{4} + \frac{1}{-5} = \frac{1}{4} - \frac{1}{5} = \frac{1}{20}$

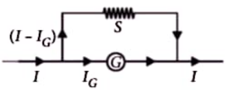
$v_o = 20$ cm

Magnification, $M = \frac{v_o}{|u_o|}\left(1 + \frac{D}{f_e}\right) = \frac{20}{5}\left(1 + \frac{20}{10}\right) = 12$

26. (b)

27. (b) : As shunt is a small resistance S in parallel with a galvanometer (of resistance G) as shown in figure.

$(I - I_G)S = I_G G$



$S = \frac{I_G G}{(I - I_G)}$

Here, $I_G = \frac{5}{100}I$

$\therefore \quad S = \frac{\frac{5}{100}IG}{I - \frac{5}{100}I} = \frac{G}{19}$

28. (c) : Resistance of the circuit,

$R = R_1 + R_2 = 40\ \Omega + 40\ \Omega = 80\ \Omega$

Impedance of the circuit,

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(80)^2 + (100 - 40)^2}$

$= \sqrt{(80)^2 + (60)^2} = 100\ \Omega$

Power factor, $\cos\phi = \frac{R}{Z} = \frac{80}{100} = 0.8$

29. (c) : Monoatomic gas $C_V = \frac{3}{2}R$

This value is same for high temperature also.

In case of diatomic gas, $C_V = \frac{5}{2}R$ (at low temperature)

Also, $C_V > \frac{5}{2}R$ (at high temperature due to vibrational kinetic energy)

30. (c) : As $v^2 - v_0^2 = 2gh$, $0 - (10)^2 = 2(-10)\,h$

or $\quad h = 5$ m

Also, $v = v_0 + at$, $0 = 10 + (-10)\,t$ or $\quad t = 1$ s

Height covered in time $t/2$, *i.e.*, (1/2 s),

$h' = v_0 t + \frac{1}{2}(-g)t^2 = 10 \times \frac{1}{2} - \frac{1}{2} \times 10 \times \left(\frac{1}{2}\right)^2$

$= 3.75 \text{ m} = (3/4)\,h$

31. (c) : As $\theta_1 = \omega_0 t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2}\alpha(2)^2 = 2\alpha$

$(\theta_1 + \theta_2) = \omega_0 t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2}\alpha(4)^2 = 8\alpha$

Thus, $\theta_2 = 6\alpha$ or $\frac{\theta_2}{\theta_1} = 3$

32. (c)

33. (c) : As $R_D = \frac{V_D^2}{P_D} = \frac{(0.5\text{ V})^2}{0.1\text{ W}} = 2.5\ \Omega$

$I_D = \frac{V_D}{R_D} = 0.2$ A

Total resistance required in the circuit,

$R_{eq} = \frac{V}{I_D} = \frac{1.5}{0.2} = 7.5\ \Omega$

Resistance of the series resistor, $R = R_{eq} - R_D$

$= 7.5 - 2.5 = 5\ \Omega$

34. (a) : Here, $\lambda = 6.2 \times 10^{-6}$ m, $\phi_0 = 0.1$ eV

Energy of the incident photon, $E = h\upsilon = \frac{hc}{\lambda}$

or $E=\frac{(6.6\times10^{-34})(3\times10^{8})}{6.2\times10^{-6}}$ J

$=\frac{6.6\times3\times10^{-26}}{(6.2\times10^{-6})(1.6\times10^{-19})}$ eV $=0.2$ eV

As $E=K+\phi_0$, $K=E-\phi_0$ = 0.2 eV – 0.1 eV = 0.1 eV

35. (b) : $\upsilon=\frac{1}{2\pi}\sqrt{\frac{k}{m}}=\frac{1}{2\pi}\sqrt{\frac{200}{0.2}}=5$ Hz

In equilibrium, $kx = mg$

or $x=\frac{mg}{k}=\frac{0.2\times10}{200}=0.01$ m

When mass is raised till the spring is unstretched, the work $=\frac{1}{2}kx^2=mgx$

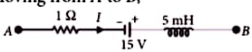
When the mass is released from the unstretched position of spring, then total work done

$mgx'=(mgx)+\frac{1}{2}kx^2=2mgx$

or $x' = 2x = 2\times0.1 = 0.02$ m

As υ of spring is independent of g so that the frequency of oscillation will be the same as that on the earth.

36. (b) : Moving from A to B,



$V_A-V_B=IR-V+L\frac{dI}{dt}$

$V_A - V_B = 1\times5 - 15 + 5\times10^{-3}(-10^3) = -15$ V

[$\frac{dI}{dt}$ is negative as I is decreasing]

or $V_B - V_A = 15$ V

37. (a) : As, $B=\frac{E}{c}=\frac{6.3}{3\times10^8}=2.1\times10^{-8}$ T

Since B is perpendicular to the direction of propagation of EM waves as well as the electric field. So $\vec{B}=2.1\times10^{-8}\hat{k}$ T

38. (b) : Moon is moving under the combined gravitatinal pull acting on it due to Earth and the Sun. So force on the moon will not be central.

39. (d) : Total magnetic flux passing through whole of the x - y plane will be zero.

The magnetic lines form a closed loop. The number of lines moving downwards in x - y plane will be same in number to that coming from upwards of the plane. Net flux will therefore be zero.

40. (a) : In n-type semiconductor fermi level indicates extra electron energy levels due to impurity.

41. (d) : Loss of energy is maximum when collision is inelastic.

Maximum energy loss $=\frac{1}{2}\frac{mM}{(M+m)}u^2$ $\therefore$ $h=\frac{mM}{(M+m)}$

Hence, Statement-I is false, Statement-II is true.

42. (b) : For a closed system, the total mass of gas or the number of moles remains constant.

For two vessels, $P_1V = n_1RT_1$, $P_2V = n_2RT_2$,

After joining the two vessels, $P(2V) = (n_1 + n_2)RT$

or $\frac{P}{T}=\frac{1}{2}\left(\frac{n_1R}{V}+\frac{n_2R}{V}\right)=\frac{1}{2}\left(\frac{P_1}{T_1}+\frac{P_2}{T_2}\right)$

43. (b) : Let V be the volume of the iceberg and x be the volume of iceberg out of sea water. The iceberg is floating in sea water, then

$V\times0.92\times g=(V-x)\times1.03\times g$

or $1.03\,V - 0.92\,V = 1.03x$ or $\frac{x}{V}=\frac{0.11}{1.03}$

$\therefore$ % fraction of the volume of iceberg above the level of sea water $=\frac{x}{V}\times100=\frac{0.11\times100}{1.03}\approx11\%$

44. (d) : Here, $r_1 = 5.30\times10^{-11}$ m, $v_1 = 2.2\times10^6$ m s^{-1}

In the second excited state, $r_n = n^2 r_1$, $v_n=\frac{v_1}{n}$

$\therefore$ $r_2 = 4r_1 = 4\times5.30\times10^{-11}$ m $= 2.12\times10^{-10}$ m

and $v_2=\frac{v_1}{2}=\frac{2.2\times10^6}{2}$ m s^{-1} $=1.1\times10^6$ m s^{-1}

Since, orbit period $(T)=\frac{2\pi r_2}{v_2}$

$=\frac{2\times3.14\times2.12\times10^{-10}}{1.1\times10^6}=\frac{13.31\times10^{-16}}{1.1}=1.21\times10^{-15}$ s.

45. (d) : Bulk modulus, $B=\frac{\text{Normal stress}}{\text{Volumetric strain}}$

$P=\frac{N}{A}=\frac{N}{(2\pi a)b}$

Motivational Quote

"Look at the sky, we are not alone. The whole universe is friendly to us and conspires only to give the best to those who dream and work."

– APJ Abdul Kalam

Volumetric strain $= \dfrac{2\pi a\,\Delta a \times b}{\pi a^2 \times b} = \dfrac{2\Delta a}{a}$

$\therefore \quad B = \dfrac{N}{2\pi ab} \times \dfrac{a}{2\Delta a}$; $N = 4\pi b\,\Delta a \times B$

$\therefore$ Required force = Frictional force = $\mu N = (4\pi\mu Bb)\Delta a$

46. (d) : Here, $H = B = 0.4 \times 10^{-4}$ T, $l = 0.8$ m

$\upsilon = 120$ rpm $= 2$ rps

Emf induced across the ends of each spoke $\varepsilon = \dfrac{1}{2}B\omega l^2$

$= \dfrac{1}{2}B(2\pi\upsilon)l^2 \qquad (\because\ \omega = 2\pi\upsilon)$

$= B\pi\upsilon l^2$ $\therefore$ $\varepsilon = 0.4 \times 10^{-4} \times \pi \times 2 \times (0.8)^2 = 1.61 \times 10^{-4}$ V

Note : Number of spokes is not relevant because the emfs across the spoke area is parallel.

47. (c) : In the formation of secondary rainbow, light suffers two total internal reflections instead of one. In this, ray undergoes two internal partial reflections having a maximum deviation of about 50° for red and 54° for violet. Also secondary rainbow will sometimes be formed with inverted colours. Secondary rainbow is fainter than the primary for two reason (i) the light has undergone two internal reflections and has thereby being weakened, (ii) there is greater angular dispersion in this rainbow than in the primary.

48. (c)

49. (c) : Let υ be frequency of standard fork. The frequency of A, $\upsilon_A = \upsilon + \dfrac{2}{100}\upsilon$

and the frequency of B, $\upsilon_B = \upsilon - \dfrac{3}{100}\upsilon$

According to question, $\upsilon_A - \upsilon_B = 6$

$\therefore \quad \left(\upsilon + \dfrac{2}{100}\upsilon\right) - \left(\upsilon - \dfrac{3}{100}\upsilon\right) = 6$

or $\quad \dfrac{5}{100}\upsilon = 6$ or $\upsilon = \dfrac{600}{5} = 120$ Hz

The frequency of A

$\upsilon_A = \left(\upsilon + \dfrac{2}{100}\upsilon\right) = 120 + \dfrac{2}{100} \times 120 = 122.4$ Hz

50. (d) : The far point of 6.0 m tell us that the focal length of the lens is $f = -6.0$ m, $u = -18$ m and $h = 2$ m

Using, $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u} \Rightarrow \dfrac{1}{v} = \dfrac{1}{f} + \dfrac{1}{u} = \dfrac{1}{-6.0} - \dfrac{1}{18.0}$

$\Rightarrow v = -4.5$ m

$\therefore$ The image size, $h' = h\left(\dfrac{-v}{u}\right) = 2 \times \left(-\dfrac{-4.5}{18.0}\right) = 0.50$ m

Exam on 26th May

JEE 2024 PRACTICE PAPER ADVANCED

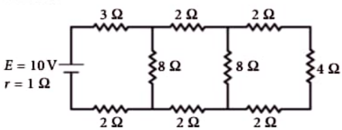
PAPER - I

SECTION 1 (MAXIMUM MARKS : 12)

- *This section contains THREE (03) questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme:*

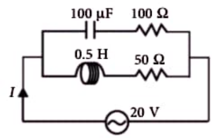
Full Marks : +4 ONLY if (all) the correct option(s) is(are) chosen;
Partial Marks : +3 If all the four options are correct but ONLY three options are chosen;
Partial Marks : +2 If three or more options are correct but ONLY two options are chosen, both of which are correct;
Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option;
Zero Marks : 0 If none of the options is chosen (i.e., the question is unanswered);
Negative Marks : –2 In all other cases.

1. An electric circuit shown in the figure.
Which of the following statement (s) is (are) correct?



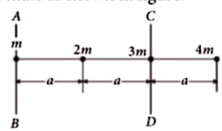
(a) Current through the 3 Ω resistance is 1 A.
(b) Current through the 3 Ω resistance is 0.5 A.
(c) Current through the 4 Ω resistance is 0.5 A.
(d) Current through the 4 Ω resistance is 0.25 A.

2. In the given circuit, the AC source has $\omega = 100$ rad/s. Considering the inductor and capacitor to be ideal, the correct choice(s) is/are



(a) the current through the circuit, I is 0.3 A
(b) the current through the circuit, I is $0.3\sqrt{2}$ A
(c) the voltage across 100 Ω resistor = $10\sqrt{2}$ V
(d) the voltage across 50 Ω resistor = 10 V

3. Four tiny masses are connected by a rod of negligible mass as shown in figure.



Which of the following statement(s) is(are) correct?
(a) The moment of inertia of the system about axis AB is $50\ ma^2$.
(b) The radius of gyration of the system about axis AB is $\sqrt{5}a$.
(c) The moment of inertia of the system about axis CD is $10\ ma^2$.
(d) The radius of gyration of the system about axis CD is a.

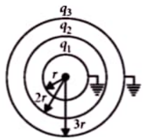
SECTION 2 (MAXIMUM MARKS : 12)

- *This section contains FOUR (04) questions.*
- *Each question has FOUR options (a), (b), (c) and (d). Only one of these four options is the correct answer.*
- *For each question, choose the option corresponding to the correct answer.*
- *Answer to each question will be evaluated according to the following marking scheme:*

Full Marks : +3 If ONLY the correct option is chosen;

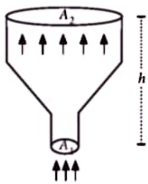
Zero Marks : *0 If none of the options is chosen (i.e., the question is unanswered);*
Negative Marks : *–1 In all other cases.*

4. What will be the nature of flow of water from a circular tap, when its flow rate increased from 0.18 L/min to 0.48 L/min? The radius of the tap and viscosity of water are 0.5 cm and 10^{-3} Pa s, respectively.
(Density of water : 10^3 kg/m^3)
(a) Remains turbulent flow
(b) Steady flow to unsteady flow
(c) Unsteady to steady flow
(d) Remains steady flow



5. A ray of light travelling in a transparent medium falls on a surface separating the medium from air at an angle of incidence of 45°. The ray undergoes total internal reflection. If μ is the refractive index of the medium with respect to air, select the possible value(s) of μ from the following.
(a) 1.3 (b) 1.4 (c) 1.5 (d) 1.2

6. An ideal gas of density $\rho = 0.2$ kg m^{-3} enters a chimney of height h at the rate of $\alpha = 0.8$ kg s^{-1} from its lower end, and escapes through the upper end as shown in the figure. The cross-sectional area of the lower end is $A_1 = 0.1$ m^2 and the upper end is $A_2 = 0.4$ m^2. The pressure and the temperature of the gas at the lower end are 600 Pa and 300 K, respectively, while its temperature at the upper end is 150 K. The chimney is heat insulated so that the gas undergoes adiabatic expansion.
Take $g = 10$ m s^{-2} and the ratio of specific heats of the gas $\gamma = 2$. Ignore atmospheric pressure.
Which of the following statement(s) is correct?



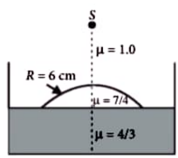
(a) The pressure of the gas at the upper end of the chimney is 300 Pa.
(b) The velocity of the gas at the lower end of the chimney is 40 m s^{-1} and at the upper end is 20 m s^{-1}.
(c) The height of the chimney is 590 m.
(d) The density of the gas at the upper end is 0.05 kg m^{-3}.

7. A particle executes simple harmonic motion and is located at $x = a$, b and c at times t_0, $2t_0$ and $3t_0$ respectively. The frequency of the oscillation is
(a) $\frac{1}{2\pi t_0}\cos^{-1}\left(\frac{a+b}{2c}\right)$
(b) $\frac{1}{2\pi t_0}\cos^{-1}\left(\frac{2a+3c}{b}\right)$
(c) $\frac{1}{2\pi t_0}\cos^{-1}\left(\frac{a+2b}{3c}\right)$
(d) $\frac{1}{2\pi t_0}\cos^{-1}\left(\frac{a+c}{2b}\right)$

SECTION 3 (MAXIMUM MARKS : 24)

- *This section contains SIX (06) questions.*
- *The answer to each question is a NON-NEGATIVE INTEGER.*
- *Answer to each question will be evaluated according to the following marking scheme:*
Full Marks : *+4 If ONLY the correct integer is entered;*
Zero Marks : *0 In all other cases.*

8. Water (with refractive index $= \frac{4}{3}$) in a tank is 18 cm deep. Oil of refractive index $\frac{7}{4}$ lies on water making a convex surface of radius of curvature $R = 6$ cm as shown.
Consider oil to act as a thin lens. An object S is placed 24 cm above water surface. The location of its image is at x cm above the bottom of the tank. Then x is ______.



9. The electric field in a plane electromagnetic wave is given by
$$\vec{E} = 200\cos\left[\left(\frac{0.5\times10^3}{m}\right)x - \left(1.5\times10^{11}\frac{\text{rad}}{\text{s}}\times t\right)\right]\frac{\text{V}}{\text{m}}\hat{j}.$$
If this wave falls normally on a perfectly reflecting surface having an area of 100 cm^2. If the radiation pressure exerted by the electromagnetic wave on the surface during a 10 minute exposure is $\frac{x}{10^9}\frac{\text{N}}{\text{m}^2}$. Find the value of x.

10. A bullet is fired normally on an immovable wooden plank. It loses 25% of its momentum in penetrating a thickness of 3.5 cm. The total thickness penetrated by the bullet, is _______ cm.

11. A parachutist bails out from an aeroplane and after dropping through a distance of 40 m, he opens the parachute and decelerates at 2 m s^{-2}. If he reaches the ground with a speed of 2 m s^{-1}. The height he bail out from the plane is h m. The value of h is _______.

12. A thin disk of dielectric material, having a total charge $+Q$ uniformly distributed over its surface is rotating with constant angular speed ω about its own axis. The magnetic field intensity at the centre of the disk is given by $\frac{\mu_0 Q\omega}{n\pi R^2}dx$, where radius of disk is R. The value of n, is _______.

13. A cubical block of mass M vibrates horizontally, with amplitude of 4.0 cm and a frequency of 2.0 Hz. A small block of mass m is placed on the bigger block. In order that the smaller block does not slide on the bigger block, the minimum value of the coefficient of static friction between the two blocks is $(0.16x)$. Find value of x. (Take $\pi^2 = 10$ and $g = 10$ m s^{-2})

SECTION 4 (MAXIMUM MARKS : 12)

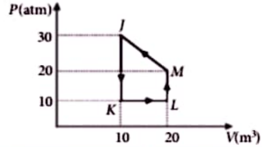
- ***This section contains FOUR (04) Matching list sets.***
- ***Each set has ONE Multiple Choice Question.***
- ***Each set has TWO lists : List-I and List-II.***
- ***List-I has Four entries (P), (Q), (R) and (S) and List-II has Five entries (1), (2), (3), (4) and (5).***
- ***FOUR options are given in each Multiple Choice Question based on List-I and List-II and ONLY ONE of these four options satisfies the condition asked in the Multiple Choice Question.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

  Full Marks : +3 ONLY if the option corresponding to the correct combination is chosen;

  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks : -1 In all other cases.

14. Heat given to process is positive, match the following option of List I with the corresponding option of List II.



	List I		List II
(P)	JK	(1)	$\Delta W > 0$
(Q)	KL	(2)	$\Delta Q < 0$
(R)	LM	(3)	$\Delta W < 0$
(S)	MJ	(4)	$\Delta Q > 0$

Which one of the following options is correct?

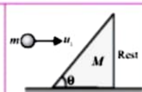
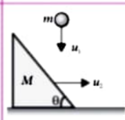
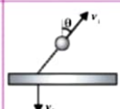
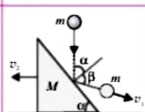
(a) (P) → (1), (Q) → (2), (R) → (3), (S) → (4)

(b) (P) → (1), (Q) → (4), (R) → (3), (S) → (1, 2)

(c) (P) → (2), (Q) → (1, 4), (R) → (4), (S) → (2, 3)

(d) (P) → (2, 1), (Q) → (1, 3), (R) → (4), (S) → (2)

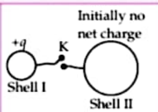
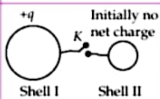
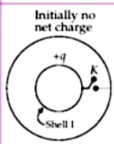
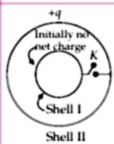
15. In the following situations a particle of mass m and wedge of mass M are shown just before collision. The collision is perfectly elastic and all surfaces are frictionless. Match List I with List II

	List I		List II
(P)		(1)	velocity of separation is $v_1\cos\theta + v_2$
(Q)		(2)	velocity of approach is $u_1\sin\theta$
(R)		(3)	velocity of separation is $v_1\cos\beta + v_2\sin\alpha$
(S)		(4)	velocity of approach is $u_1\cos\theta + u_2\sin\theta$
		(5)	velocity of approach will be zero

Which of the following options is correct?

(a) (P) → (1); (Q) → (2); (R) → (4); (S) → (3)
(b) (P) → (2); (Q) → (3); (R) → (4); (S) → (1)
(c) (P) → (3); (Q) → (1); (R) → (2); (S) → (4)
(d) (P) → (2); (Q) → (4); (R) → (1); (S) → (3)

16. List I gives certain situations involving two thin conducting shells connected by a conducting wire via key K. In all situations one sphere has net charge $+q$ and other sphere has no net charge. After the key K is pressed, List II gives some resulting effect. Match the figure in List I with statements in List II.

	List I		List II
(P)		(1)	Charge flows through connecting wire
(Q)		(2)	Potential energy of system of sphere decreases.
(R)		(3)	No heat is produced.
(S)		(4)	The sphere I has no charge after equilibrium is reached.
		(5)	Net Charge will become zero

Which of the following options is correct?

(a) (P)→(1, 2); (Q)→(1, 2); (R)→(1, 2, 4); (S)→(3, 4)
(b) (P)→(5, 3); (Q)→(5, 2); (R)→(5, 3, 4); (S)→(1, 4)
(c) (P)→(1, 2); (Q)→(1, 2); (R)→(5, 2, 4); (S)→ (5, 4)
(d) (P)→(5, 3); (Q)→(1, 2); (R)→(1, 2, 4); (S)→(3, 4)

17. A musical instrument is made using four different metal strings, 1, 2, 3 and 4 with mass per unit length μ, 2μ, 3μ and 4μ, respectively. The instrument is played by vibrating the strings by varying the free length in between the range L_0 and $2L_0$. It is found that in string-1 (μ) at free length L_0 and tension T_0 the fundamental mode frequency is f_0.
List-I gives the above four strings while list-II lists the magnitude of some quantity.

	List-I		List-II
(P)	String-1 (μ)	(1)	1
(Q)	String-2 (2μ)	(2)	1/2
(R)	String-3 (3μ)	(3)	$\frac{1}{\sqrt{2}}$
(S)	String-4 (4μ)	(4)	$\frac{1}{\sqrt{3}}$
		(5)	3/16

(a) (P) → (1); (Q) → (2); (R) → (5); (S) → (4)
(b) (P) → (1); (Q) → (3); (R) → (4); (S) → (2)
(c) (P) → (2); (Q) → (4); (R) → (3); (S) → (1)
(d) (P) → (2); (Q) → (1); (R) → (3); (S) → (5)

PAPER - II

SECTION 1 (MAXIMUM MARKS : 12)

- ***This section contains FOUR (04) questions.***
- ***Each question has FOUR options (a), (b), (c) and (d). Only one of these four options is the correct answer.***
- ***For each question, choose the option corresponding to the correct answer.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

Full Marks : +3 If ONLY the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e., the question is unanswered);
Negative Marks : –1 In all other cases.

1. Two observers moving with different velocities see that a point charge produces same magnetic field at the same point A. Their relative velocity must be parallel to $\vec{r}$, where $\vec{r}$ is the position vector of point A with respect to point charge. This statement is

(a) true
(b) false
(c) nothing can be said
(d) true only if the charge is moving perpendicular to the $\vec{r}$.

2. Let us consider a system of units in which mass and angular momentum are dimensionless. If length has dimension of L, which of the following statement is correct?
(a) The dimension of force is L^{-3}
(b) The dimension of power is L^{-4}
(c) The dimension of energy is L^{-2}
(d) All of these.

3. Students I, II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum. They use different lengths of the pendulum and/or record time for different number of oscillations. The observations are shown in the table. Least count for length = 0.1 cm
Least count for time = 0.1 s

Student	Length of the pendulum (cm)	No. of oscillations (n)	Total time for (n) oscillations (s)	Time period(s)
I	64.0	8	128.0	16.0
II	64.0	4	64.0	16.0
III	20.0	4	36.0	9.0

If E_I and E_{II} and E_{III} are the percentage errors in g, *i.e.* $\left(\frac{\Delta g}{g}\times 100\right)$ for students I, II and III respectively.
(a) $E_I = 0$ (b) E_I is minimum
(c) $E_I = E_{II}$ (d) E_{II} is maximum

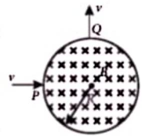
4. Which one of the following statements is WRONG in the context of X-rays generated from a X-ray tube?
(a) Wavelength of characteristic X-rays decreases when the atomic number of the target increases.
(b) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.
(c) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube.
(d) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube.

SECTION 2 (MAXIMUM MARKS : 12)

- *This section contains THREE (03) questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme:*

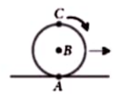
Full Marks : *+4 ONLY if (all) the correct option(s) is(are) chosen;*
Partial Marks : *+3 If all the four options are correct but ONLY three options are chosen;*
Partial Marks : *+2 If three or more options are correct but ONLY two options are chosen, both of which are correct;*
Partial Marks : *+1 If two or more options are correct but ONLY one option is chosen and it is a correct option;*
Zero Marks : *0 If unanswered;*
Negative Marks : *-2 In all other cases.*

5. A particle of charge q and mass m enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(s) is/are correct?



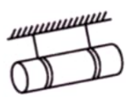
(a) $B = \frac{mv}{qR}$ (b) $T = \frac{\pi R}{2v}$
(c) $T = \frac{\pi m}{2qB}$ (d) none of these.

6. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact, B is the centre of the sphere and C is its topmost point. Then,



(a) $\vec{V}_C - \vec{V}_A = 2(\vec{V}_B - \vec{V}_C)$
(b) $\vec{V}_C - \vec{V}_B = \vec{V}_B - \vec{V}_A$
(c) $|\vec{V}_C - \vec{V}_A| = 2|\vec{V}_B - \vec{V}_C|$
(d) $|\vec{V}_C - \vec{V}_A| = 4|\vec{V}_B|$

7. A solid cylinder of mass M and radius R starts falling freely under gravity at $t = 0$ as shown in the figure. The tension in each string at any given time t is T. The instantaneous power developed by the gravitational force at time t is P. The linear acceleration of the cylinder is a. Then



(a) $T = \frac{Mg}{6}$ (b) $a = \frac{2g}{3}$
(c) $P = \frac{2}{3}Mg^2t$
(d) angular acceleration $= \frac{7g}{19R}$

SECTION 3 (MAXIMUM MARKS : 24)

- *This section contains SIX (06) questions.*
- *The answer to each question is a NON-NEGATIVE INTEGER.*
- *For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtua numeric keypad in the place designated to enter the answer.*
- *Answer to each question will be evaluated according to the following marking scheme:*
  Full Marks : +4 If ONLY the correct integer is entered;
  Zero Marks : 0 In all other cases.

8. In a hydrogen spectrum, λ be the wavelength of first transition line of Lyman series. The wavelength difference will be "$a\lambda$" between the wavelength of 3rd transition line of Paschen series and that of 2nd transition line of Balmer Series where a = ______.

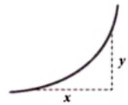
9. A long circular tube of length 10 m and radius 0.3 m carries a current I along its curved surface as shown. A wire-loop of resistance 0.005 ohm and of radius 0.1 m is placed inside the tube with its axis coinciding with the axis of the tube. The current varies as $I = I_0\cos(300t)$, where I_0 is constant. If the magnetic moment of the loop is $N\mu_0 I_0 \sin(300t)$, then value of N is ______.

10. Two vectors $\vec{A}$ and $\vec{B}$ are defined as $\vec{A} = a\hat{i}$ and $\vec{B} = a(\cos\omega t\,\hat{i} + \sin\omega t\,\hat{j})$, where a is a constant and $\omega = \pi/6$ rad s^{-1}. If $|\vec{A}+\vec{B}| = \sqrt{3}\,|\vec{A}-\vec{B}|$ at time $t = \tau$ for the first time, the value of τ, in seconds, is ______.

11. In a parallel plate capacitor set up, the plate area of capacitor is 2 m^2 and the plates are separated by 1 m. If the space between the plates are filled with a dielectric material of thickness 0.5 m and area 2 m^2 (see fig) the capacitance of the set-up will be ______ ε_0.
(Dielectric constant of the material = 3.2)
(Round off to the nearest integer)

12. In a Young's Double Slit Experiment, the source is red light of wavelength 7×10^{-7} m. When a thin glass plate of refractive index 1.5 at this wavelength is put in the path of one of the interfering beams, the central bright fringe shifts by 10^{-3} m to the position previously occupied by 5th bright fringe. The thickness of the plate is ______ µm.

13. A ramp is constructed in parabolic shape such that the height y of any point on its surface is given in terms of the point's horizontal distance x from the bottom of the ramp by $y = x^2/2L$. A block of granite is to be set on the ramp; the coefficient of static friction is 0.80. The maximum x coordinate x_M at which the block can be placed on the ramp and remain at rest, if L = 10 m is ______ m.



SECTION 4 (MAXIMUM MARKS : 12)

- *This section contains TWO (02) paragraphs.*
- *Based on each paragraph, there are TWO (02) questions.*
- *The answer to each question is a NUMERICAL VALUE.*
- *If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme :*
  Full Marks : +3 If ONLY the correct numerical value is entered in the designed place.
  Zero Marks : 0 In all other cases.

Paragraph I

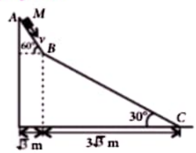
Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are the same. The two bodies emit total radiant power of the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by 1.00 mm. The temperature of A is 5802 K.

14. The temperature of B is ______ K.

15. The value of λ_B is $x \times 10^{-6}$. Find 'x' µm.

Paragraph II

A small block of mass M moves on a frictionless surface of an inclined plane, as shown in the figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic (g = 10 m/s^2).

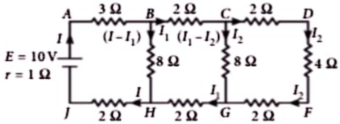


16. The speed of the block at point B immediately after it strikes the second incline is______ m/s.

17. If the collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is______ m/s.

PAPER-I

1. (a, d) : Let the distribution of current in various arms be as shown in figure.



In closed circuit *ABHJA*

$3I + 8(I - I_1) + 2I + 1 \times I - 10 = 0$ ...(i)

In closed circuit *CDFGC*

$2I_2 + 4I_2 + 2I_2 - 8(I_1 - I_2) = 0$ ...(ii)

In a closed ciruit *BCGHB*

$2I_1 + 8(I_1 - I_2) + 2I_1 - 8(I - I_1) = 0$ ...(iii)

From (i) and (iii),

$7I - 4 \times \frac{I}{2} = 5$ or $I = 1$ A.

from (ii), $I_2 = \frac{I_1}{2} = \frac{I/2}{2} = \frac{I}{4} = \frac{1}{4} = 0.25$ A

2. (a, c) : Here, $\omega = 100$ rad/s, $L = 0.5$ H, $C = 100$ μF, $V = 20$ V

$\therefore$ $X_L = \omega L = 100 \times 0.5 = 50\ \Omega$

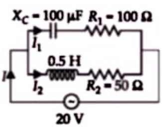
$$X_C = \frac{1}{\omega C} = \frac{1}{100 \times 100 \times 10^{-6}} = 100\ \Omega$$

Impedance across capacitor,

$$Z_1 = \sqrt{R^2 + X_C^2} = \sqrt{(100)^2 + (100)^2}$$

$$Z_1 = 100\sqrt{2}\ \Omega$$

$$\therefore\ I_1 = \frac{20}{100\sqrt{2}} = \frac{1}{5\sqrt{2}}\ \text{A}$$



Voltage across 100 Ω,

$$V = I_1 \times 100 = \frac{1}{5\sqrt{2}} \times 100 = 10\sqrt{2}\ \text{V}$$

Impedance across inductance,

$$Z_2 = \sqrt{R^2 + (X_L)^2} = \sqrt{(50)^2 + (50)^2}\ ;\ Z_2 = 50\sqrt{2}\ \Omega$$

$$\therefore\ I_2 = \frac{20}{50\sqrt{2}} = \frac{2}{5\sqrt{2}} = \frac{\sqrt{2}}{5}$$

Now voltage across 50 Ω $= \frac{\sqrt{2}}{5} \times 50 = 10\sqrt{2}$

$I_1 = \frac{1}{5\sqrt{2}}$ A at 45° leading ; $I_2 = \frac{\sqrt{2}}{5}$ A at 45° lagging

$\therefore$ Current through circuit,

$$I_{net} = \sqrt{I_1^2 + I_2^2} = \sqrt{\left(\frac{1}{5\sqrt{2}}\right)^2 + \left(\frac{\sqrt{2}}{5}\right)^2} = 0.3\ \text{A}$$

3. (a,b,c,d) : The moment of inertia about *AB* is

$I = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + m_4r_4^2$

$= m \times 0 + 2m \times (a)^2 + 3m \times (2a)^2 + 4m \times (3a)^2$

$= 0 + 2ma^2 + 12ma^2 + 36ma^2 = 50ma^2$

The radius of gyration *K* of the system about *AB* is given by

$I = MK^2 = (m_1 + m_2 + m_3 + m_4)K^2$

$= (m + 2m + 3m + 4m)K^2 = 10\ mK^2$

or $K = \sqrt{\frac{I}{10m}} = \sqrt{\frac{50ma^2}{10m}} = \sqrt{5}\,a$

The moment of inertia about *CD* is

$I = m \times (2a)^2 + 2m \times (a)^2 + 3m \times 0 + 4m \times (a)^2$

$= 4ma^2 + 2ma^2 + 0 + 4ma^2 = 10\ ma^2$

The radius of gyration of the system about *CD* is

$$= \sqrt{\frac{I}{10m}} = \sqrt{\frac{10ma^2}{10m}} = a$$

4. (b) : Nature of flow is denoted by Reynold's number

$R_e = \frac{\rho v D}{\eta}$ where, $v = \frac{\text{Rate of flow}}{\pi r^2}$

ρ = density of fluid, $D \rightarrow$ diameter,

η = coefficient of viscosity

If $R_e < 1000$, flow is steady.

$1000 < R_e < 2000$, flow becomes unsteady.

$R_e > 2000$, flow is turbulent.

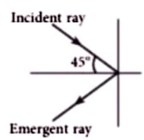
$$(R_e)_{\text{Initial}} = \frac{10^3 \times 0.18 \times 10^{-3} \times 10^{-2}}{\pi \times (0.5 \times 10^{-2})^2 \times 60 \times 10^{-3}} = 382.16$$

$$(R_e)_{\text{Final}} = 10^3 \times \frac{0.48 \times 10^{-3} \times 10^{-2}}{\pi \times (0.5 \times 10^{-2})^2 \times 60 \times 10^{-3}} = 1019.09$$

Steady flow to unsteady flow will be the nature of flow of water from the circular tap.

5. (d) : For total internal reflection to occur, $i >$ critical angle, C or $\sin i > \sin C$

or $\sin 45° > \frac{1}{\mu}$ or $\frac{1}{\sqrt{2}} > \frac{1}{\mu}$



or $\mu > \sqrt{2}$

or $\mu > 1.414$

Possible value of μ can be (c) 1.5.

6. **(b)**

7. **(d)**: Different positions of a particle excuting simple harmonic motion is given by

$a = A\sin\omega t_0$, $b = A\sin 2\omega t_0$, $c = A\sin 3\omega t_0$

Now, $a + c = A[\sin\omega t_0 + \sin 3\omega t_0] = 2A\sin 2\omega t_0 \cos\omega t_0$

$$\frac{a+c}{b} = 2\cos\omega t_0$$

$$\Rightarrow \omega = \frac{1}{t_0}\cos^{-1}\left(\frac{a+c}{2b}\right) \Rightarrow \upsilon = \frac{1}{2\pi t_0}\cos^{-1}\left(\frac{a+c}{2b}\right)$$

8. **(2)** : In case of refraction from a curved surface, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

Refraction at air-oil interface

Here, $u = -24$ cm, $v = v_1$, $m_1 = 1$,

$$\mu_2 = \frac{7}{4},\ R = +6\text{ cm} \qquad \therefore \frac{7}{4v_1} - \frac{1}{-24} = \frac{\left(\frac{7}{4} - 1\right)}{6}$$

$$\frac{7}{4v_1} + \frac{1}{24} = \frac{3}{24} \Rightarrow \frac{7}{4v_1} = \frac{1}{12} \Rightarrow v_1 = 21\text{ cm}$$

This image will act as object for the oil-water interface.

Refraction at oil-water interface

Here $u = +21$ cm, $v = v_2$,

$$\mu_1 = \frac{7}{4},\ \mu_2 = \frac{4}{3},\ R = \infty$$

$$\therefore \frac{4}{3v_2} - \frac{(7/4)}{21} = 0 \Rightarrow \frac{4}{3v_2} = \frac{7}{84}$$

or $v_2 = 16$ cm From bottom, $18 - 16 = 2$ cm

9. **(354)** : $\vec{E}$

$$= 200\cos\left[\left(\frac{0.5\times 10^3}{m}\right)\cdot x - (1.5\times 10^{11}\times t)\right]\frac{\text{V}}{m}\hat{j}$$

Area, $A = 100\text{ cm}^2$, Time, $t = 10$ min

The amplitude of electric field, $E_0 = 200$

Intensity is $I = \frac{1}{2}\varepsilon_0 E_0^2 C$

The radiation pressure is, $P = \frac{2I}{C} = \frac{2}{C}\times\frac{1}{2}\times\varepsilon_0 E_0^2 C$

$P = \varepsilon_0 E_0^2$; $P = 8.85\times 10^{-12}\times 200\times 200$

$= 8.85\times 10^{-8}\times 4$

$$P = \frac{354}{10^9}\ \text{N/m}^2$$

As per question, $P = \frac{x}{10^9}\frac{\text{N}}{\text{m}^2}$

By comparing, $x = 354$

10. **(8)** : Let u cm s^{-1} be the speed of the bullet. Since the mass of the bullet remains unchanged, its speed becomes $v = \frac{3u}{4}\text{ cm s}^{-1}$ after it penetrates a distance $x = 3.5$ cm. For the retardation a due to the resistance of the wooden plank,

$$u^2 - v^2 = 2ax \text{ or } u^2 - \left(\frac{3u}{4}\right)^2 = 2a\times 3.5$$

which gives $a = \frac{u^2}{16}\text{ cm s}^{-2}$. The bullet will come to rest when its velocity $v' = 0$. If x' is the thickness penetrated by the bullet, then

$u^2 - v'^2 = 2ax'$ or $x' = \frac{u^2}{2a}$. But $a = \frac{u^2}{16}\text{ cm s}^{-2}$.

$$\text{Therefore, } x' = \frac{u^2\times 16}{2u^2} = 8\text{ cm}$$

11. **(235)** : When the parachutist falls freely :

$u = 0$, $g = 9.8\text{ m s}^{-2}$, $s = 40$ m, $v = ?$

As, $s = ut + \frac{1}{2}gt^2$

$$\therefore 40 = 0 + \frac{1}{2}\times 9.8\times t^2 \text{ or } t = \sqrt{\frac{80}{9.8}} = 2.86\text{ s}$$

Also, $v = u + gt = 0 + 9.8\times 2.86 = 28\text{ m s}^{-1}$

Now, the second part says that the parachutist reached the ground with velocity 2 m s^{-1}, *i.e.*, $v = 2\text{ m s}^{-1}$.

Now, $u = 28\text{ m s}^{-1}$, $a = -2\text{ m s}^{-2}$

$$\therefore \text{ Time taken, } t' = \frac{v-u}{a} = \frac{2-28}{-2} = 13\text{ s}$$

$$\text{Distance, } s = ut + \frac{1}{2}at^2 = 28\times 13 - \frac{1}{2}\times 2\times(13)^2 = 195\text{ m}$$

Height at which parachutist bails out = 40 + 195 = 235 m

12. **(2)** : As the moving charge along a circle can be considered as a current carrying ring. Thus, we can use the expression of magnetic field due to a current carrying circular ring.

Consider an elemental ring of radius x and thickness dx.

$$dq = \frac{Q}{\pi R^2}\times 2\pi x\,dx;\ dI = \frac{dq}{T} = \frac{dq}{2\pi/\omega}$$

Magnetic field at centre due to this elemental ring is,

$$dB = \frac{\mu_0 dI}{2x};\ dB = \frac{\mu_0}{2x}\times\frac{Q}{R^2}\times\frac{2xdx}{2\pi}\times\omega = \frac{\mu_0 Q\omega}{2\pi R^2}\times dx$$

$\therefore n = 2$

13. **(4)** : $\mu g >$ maximum acceleration in SHM

$\therefore \mu g > \omega^2 A$

$\therefore \quad \mu > \frac{\omega^2 A}{g}$ or $\mu_{min} = \frac{(2\pi\upsilon)^2 A}{g}$

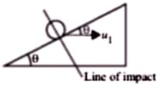
$\mu_{min} = \frac{4\times10\times(2)^2\times0.04}{10} = 0.64$

$0.16x = 0.64 \Rightarrow x = 4$

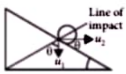
14. (c)

15. (d) : (P) → (2); (Q) → (4); (R) → (1); (S) → (3)

(P) → (2) : Velocity of approach = velocity along line of impact = $u_1 \sin\theta$.



(Q) → (4) : Velocity of approach $= u_1\cos\theta + u_2\sin\theta$

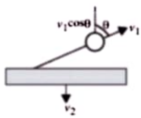


(R) → (1) : $\vec{v}_1 = v_1\cos\theta\,\hat{j} + u_1\sin\theta\,\hat{i}$

$\vec{v}_2 = -v_2\hat{j}$

$\vec{v}_1 - \vec{v}_2 = (v_1\cos\theta + v_2)\hat{j} + v_1\sin\theta\,\hat{i}$

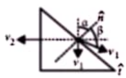
$\because\ \hat{j}$ will be line of impact,



Velocity of separation

$= v_1\cos\theta + v_2$

(S) → (3): $\vec{v}_1 = v_1\cos\beta\,\hat{n} + v_1\sin\beta\,\hat{t}$



$\vec{v}_2 = v_2\sin\alpha(-\hat{n}) + v_2\cos\alpha(-\hat{t})$

$\hat{n}$ is direction of line of impact,

Velocity of separation $= v_1\cos\beta + v_2\sin\alpha$.

16. (a) : (P) → (1, 2); (Q) → (1, 2); (R) → (1, 2, 4); (S) → (3, 4)

In situation P, Q and R, shells I and II are not at same potential. Hence, charge shall flow from sphere I to sphere II till both acquire same potential.

If charge flows, the potential energy of system decreases and heat is produced.

In situations P and Q charges shall divide in some fixed ratio, but in situation (R) complete charge shall be transferred to shell II for potential of shell I and II to be same.

In situation (S) both the shells are at same potential, hence no charge flows through connecting wire.

17. (d)

PAPER-II

1. (a) : Since, $\vec{B} = \frac{\mu_0}{4\pi} q \frac{\vec{v}_0\times\vec{r}}{r^3}$, $\vec{v}\times\vec{r}$ must be same

Where, $\vec{v}_0$ = velocity of charge with respect to observer.

Let A and B be the observers.

Then, $(\vec{v}_C - \vec{v}_A)\times\vec{r} = (\vec{v}_C - \vec{v}_B)\times\vec{r}$

or $(\vec{v}_A - \vec{v}_B)\times\vec{r} = 0$ or $(\vec{v}_A - \vec{v}_B)\parallel\vec{r}$

2. (d) : As per the question, mass and angular momentum are dimensionless.

So, dimension of mass = dimension of angular momentum

or $[M^1L^0T^0] = [M^1L^2T^{-1}]$

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

Now, dimension of power, $[P]$

$= [ML^2T^{-3}] = [L^2T^{-3}] = [L^2L^{-6}] = [L^{-4}]$

Dimension of energy, $[E] = [ML^2T^{-2}] = [L^2T^{-2}]$

$= [L^2L^{-4}] = [L^{-2}]$

Dimension of force, $[F] = [MLT^{-2}] = [LT^{-2}]$

$= [LL^{-4}] = [L^{-3}]$

3. (b) : The time period T of the simple pendulum is related to the acceleration due to gravity g as

$$T = 2\pi\sqrt{\frac{l}{g}} \text{ or } g = \frac{4\pi^2 l}{T^2} = \frac{4\pi^2 l}{t^2}\cdot n^2 \Rightarrow \frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta t}{t}$$

For student I

$$\left(100\times\frac{\Delta g}{g}\right)_I = E_I = \left(\frac{0.1}{64.0} + \frac{2\times0.1}{128.0}\right)\times100 = \frac{20}{64}$$

For student II

$$\left(100\times\frac{\Delta g}{g}\right)_{II} = E_{II} = \left(\frac{0.1}{64.0} + 2\times\frac{0.1}{64.0}\right)\times100 = \frac{30}{64}$$

For student III

$$\left(100\times\frac{\Delta g}{g}\right)_{III} = E_{III} = \left(\frac{0.1}{20.0} + 2\times\frac{0.1}{36.0}\right)\times100 = \frac{19}{18}$$

Values of E_I, E_{II} and E_{III} suggest that only alternative (b) is correct.

4. (b) : The cut off wavelength is given by, $\lambda_{min} = \frac{hc}{eV}$.

The cut off wavelength depends on the energy eV of the accelerated electrons and is independent of the atomic number of target.

5. (a, b, c) : The particle will move along an arc which is part of a circle of radius $r = \frac{mv}{Bq}$

From the figure, we can see $r = R$

$$\therefore \quad R = \frac{mv}{Bq} \Rightarrow B = \frac{mv}{qR};\ T = \frac{2\pi r/4}{v} = \frac{\pi r}{2v}$$

$$\because \quad r = R = \frac{mv}{Bq} \quad \therefore \quad T = \frac{\pi}{2v} \times \frac{mv}{Bq} = \frac{\pi m}{2qB}$$

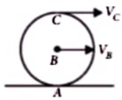
6. **(b, c) :** $\begin{cases} \vec{V}_C = 2\omega R \text{ about } A \\ \vec{V}_B = \omega R \text{ about } A \end{cases};\ \begin{cases} \vec{V}_B = \omega R \text{ about } A \\ \vec{V}_A = 0 \end{cases}$

$$|\vec{V}_C - \vec{V}_B| = |\vec{V}_B - \vec{V}_A|$$

$$|\vec{V}_C - \vec{V}_A| = 2\omega R - 0$$

$$|\vec{V}_B - \vec{V}_C| = |\omega R - 2\omega R| = |-\omega R|$$

$$\therefore \quad |\vec{V}_C - \vec{V}_A| = 2|\vec{V}_B - \vec{V}_C|$$



7. **(a, b, c) :** Applying equations

$Mg - 2T = Ma$ ...(i)

$2TR = I\alpha$ ...(ii)

and $a = R\alpha$ ...(iii)

$v = at$ ...(iv)

$P = Mgv$ ...(v)

By solving equations (i), (ii) and (iii), (iv), (v)

we get, $T = \dfrac{Mg}{6}$, $a = \dfrac{2g}{3}$ and $P = \dfrac{2}{3}Mg^2 t$

8. **(5) :** For first line of Lyman series:

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(1 - \frac{1}{4}\right) = \frac{3R}{4};\ \lambda = \frac{4}{3R} \quad \text{...(i)}$$

For second line of Balmer series.

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = R\left(\frac{1}{4} - \frac{1}{16}\right) = \frac{3R}{16}$$

For third line of Paschen series.

$$\frac{1}{\lambda_3} = R\left(\frac{1}{3^2} - \frac{1}{6^2}\right) = \frac{R}{12}$$

According to equation,

$$a\lambda = \lambda_3 - \lambda_2 = \frac{12}{R} - \frac{16}{3R} = \frac{30}{3R}$$

From eq. (i), $a \times \dfrac{4}{3R} = \dfrac{20}{3R}$, we get $a = 5$

9. **(6) :** According to Ampere's circuital law the magnetic field inside the tube is

$$B = \frac{\mu_0 I}{L} \quad \text{...(i)}$$

where L is the length of the tube.

Flux linked the wire loop is $\phi = B\pi r^2$

where r is the radius of the loop

$$\phi = \frac{\mu_0 I}{L}\pi r^2 = \frac{\mu_0 \pi r^2 I_0 \cos(300t)}{L} \quad \text{(Using (i))}$$

Induced emf in the loop is

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}\left(\frac{\mu_0}{L}\pi r^2 I_0 \cos(300t)\right)$$

$$= \frac{\mu_0 \pi r^2 I_0 300 \sin 300t}{L}$$

Induced current in the loop is

$$i = \frac{\varepsilon}{R} = \frac{300\mu_0 \pi r^2 I_0 \sin(300t)}{LR}$$

where R is the resistance of the loop

Magnetic moment of the loop $M = i\pi r^2$

$$= \frac{300\pi^2 r^4 \mu_0 I_0 \sin(300t)}{LR}$$

Substituting the given values, we get

$$M = \frac{300 \times 10 \times (0.1)^4}{10 \times 0.005}\mu_0 I_0 \sin 300t \ \ (\text{Take } \pi^2 = 10)$$

$= 6\mu_0 I_0 \sin 300t;\ M = N\mu_0 I_0 \sin 300t \ \therefore N = 6$

10. **(2.00) :** $\vec{A} = a\hat{i}$ and $\vec{B} = a(\cos\omega t\ \hat{i} + \sin\omega t\ \hat{j})$

$$|\vec{A} + \vec{B}| = |(a + a\cos\omega t)\hat{i} + a\sin\omega t\ \hat{j}| = 2a\cos\frac{\omega t}{2} \quad \text{...(i)}$$

Form IV

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For MTG Learning Media Pvt. Ltd.
Mahabir Singh
Director

$$|\vec{A}-\vec{B}|=|(a-a\cos\omega t)\hat{i}-\sin\omega t\,\hat{j}|=2a\sin\frac{\omega t}{2} \quad ...(ii)$$

Using equations (i) and (ii) in

$$|\vec{A}+\vec{B}|=\sqrt{3}\,|\vec{A}-\vec{B}|$$

$$2a\cos\frac{\omega t}{2}=\sqrt{3}\left(2a\sin\frac{\omega t}{2}\right) \Rightarrow \tan\frac{\omega t}{2}=\frac{1}{\sqrt{3}}$$

$$\Rightarrow \frac{\omega t}{2}=\frac{\pi}{6} \text{ or } \frac{\pi}{6}\cdot t=\frac{\pi}{3} \quad \left(\because \omega=\frac{\pi}{6}\right)$$

$\Rightarrow t = 2.00$ s

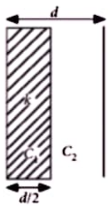
11. (3) : Given, area of plate, $A = 2\ m^2$

Distance between plates, $d = 1$ m,

Dielectric constant, $k = 3.2$

As this system can be considered as the combination of two capacitors in series.

So, equivalent capacitance,



$$C_{eq}=\frac{C_1C_2}{C_1+C_2}$$

$$=\frac{k\varepsilon_0\frac{A}{d/2}\cdot\varepsilon_0\frac{A}{d/2}}{\frac{k\varepsilon_0 A}{d/2}+\frac{\varepsilon_0 A}{d/2}}$$

$$=\frac{k\varepsilon_0\frac{A}{d/2}}{k+1}=2\frac{k}{d}\frac{\varepsilon_0 A}{(k+1)}$$

$$\text{or } C_{eq}=\frac{2k\varepsilon_0 A}{d(k+1)}=\frac{2\times3.2\times\varepsilon_0\times2}{1(3.2+1)}\approx3\varepsilon_0$$

$\therefore C_{eq} = 3\,\varepsilon_0$

12. (7) : Fringe shift, $\beta = \frac{D}{d}(\mu-1)t$

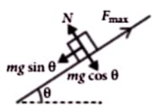
The position of 5th bright fringe $= \frac{5D\lambda}{d}$

Since central bright fringe shifts to the 5th maxima position,

$$\frac{D}{d}(\mu-1)t=\frac{5D\lambda}{d} \Rightarrow t=\frac{5\lambda}{\mu-1}=\frac{5\times7\times10^{-7}}{1.5-1}=7\ \mu\text{m}$$

13. (8) : $y=\frac{x^2}{2L} \Rightarrow \frac{dy}{dx}=\left(\frac{x}{L}\right)=\tan\theta$

When the block is placed at a slope 'tan θ', the free body diagram is as shown in the figure.



At x_{max},

$Mg\sin\theta = f_{max} = \mu N = \mu Mg\cos\theta$

$\Rightarrow \tan\theta = \mu = \frac{x_M}{L}$

$\Rightarrow x_M = \mu\times L \Rightarrow x_M = (0.8)(10\text{ m}) = 8$ m

14. (1934) : To calculate temperature of B

Power of body $A = e_A\sigma T_A^4\times(\text{area})$

Power of body $B = e_B\sigma T_B^4\times(\text{area})$

The two powers are equal.

$\therefore e_B\sigma T_B^4\times(\text{area}) = e_A\sigma T_A^4\times(\text{area})$

$$\text{or } T_B^4=\left(\frac{e_A}{e_B}\right)T_A^4 \text{ or } T_B^4=\left(\frac{0.01}{0.81}\right)\times(5802)^4$$

$$\text{or } T_B^4=\left(\frac{1}{3}\right)^4\times(5802)^4 \text{ or } T_B=\frac{5802}{3}=1934\text{ K}$$

15. (1.5) : According to Wien's displacement law,

$\lambda T = \text{constant} \;\therefore\; \lambda_A T_A = \lambda_B T_B$

$$\text{or } \frac{\lambda_A}{\lambda_B}=\frac{T_B}{T_A} \text{ or } \frac{\lambda_A}{\lambda_B}=\frac{1934}{5802}$$

$$\text{or } \frac{\lambda_A}{\lambda_B}=\frac{1}{3} \text{ or } \lambda_B=3\lambda_A$$

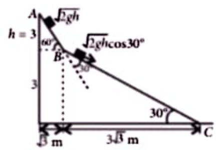
Given : $\lambda_B - \lambda_A = 1.0\times10^{-6}$ m

or $3\lambda_A - \lambda_A = 10^{-6}$ or $2\lambda_A = 10^{-6}$

or $\lambda_A = 0.5\times10^{-6}$ and $\lambda_B = 3\times0.5\times10^{-6}$

or $\lambda_B = 1.5\times10^{-6}$ m.

16. (6.70) : At point B the block has an inelastic collision with the incline, so component of velocity perpendicular to incline plane becomes zero and component parallel to second surface is retained.



Velocity immediately after it strikes the second line

$$v=\sqrt{2gh}\cos30°=\sqrt{2\times10\times3}\times\frac{\sqrt{3}}{2}=\sqrt{45}\text{ m/s}$$

$= 6.70$ m/s

17. (0) : The velocity of the block coming down from the incline AB makes an angle 30° with the incline BC. If the block collides with the incline BC elastically, the angle of velocity of the block after collision with the incline shall be 30°.

Hence, just after collision with incline BC, the velocity of block shall be horizontal. So, immediately after the block strikes the second incline, its vertical component of velocity will be zero.

◆◆

WORD GRID

Readers are requested to send their responses of word grid.
Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal and vertical by reading the clues given below.

F	W	T	A	N	D	L	F	O	C	U	S	G	M	H	O	Z
O	C	D	A	D	H	A	I	Y	O	C	A	C	Y	R	Y	A
R	A	Z	E	R	O	K	L	W	G	K	F	R	O	H	M	Q
C	O	T	D	I	C	O	N	C	A	V	E	V	P	L	L	G
E	B	Y	O	F	L	Q	Z	T	L	W	T	E	N	B	W	A
A	M	O	P	T	A	B	U	W	V	Y	O	A	J	H	T	U
W	E	B	L	H	J	Y	V	R	A	D	Z	C	E	M	C	S
O	N	I	F	F	M	O	M	E	N	T	U	M	R	Z	V	S
G	E	S	E	S	H	A	B	D	O	C	R	L	K	U	R	D
S	R	M	R	L	T	Q	C	K	M	U	G	U	N	I	T	Y
Y	G	U	M	E	E	F	B	R	E	W	S	T	E	R	C	A
T	Y	T	I	A	S	G	T	V	T	P	H	Y	S	W	O	N
C	O	H	B	Y	L	S	A	N	E	W	T	O	N	D	N	T
A	P	U	S	H	A	R	U	W	R	J	O	L	P	T	V	A
L	I	S	O	C	H	O	R	I	C	I	G	N	I	Z	E	Q
C	Z	K	H	Q	V	L	D	G	E	H	Y	B	W	C	X	H

Across

1. Value of acceleration when velocity is constant.
2. Quantity is conserved in both elastic and inelastic collision.
3. The person who discovered 'gravity'.
4. The process in which volume of the gas in constant.
5. SI unit of conductance.

Down

1. Motion of electrons under the influence of electric field.
2. Device used to detect presence of current.
3. CGS unit of magnetic field.
4. Capacity of doing work.
5. Mirror that gives virtual images only.

*Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.

QUIZ CLUB

Unlock Your Knowledge!

1. Sound waves are _______ in nature.
2. SI unit of solid angle is _______.
3. Frame of reference in which Newton's first law of motion holds good is _______ frame.
4. What is the trajectory followed by a projectile?
5. Bending of cyclist in a curved road is an example of _______ motion.
6. One horse power is equal to _______ Watts.
7. Moment of inertia is _______ proportional to the square of the radius of gyration.
8. The cube of which quantity is related to the square of the time period of revolution of a planet?
9. A beam fixed at one end and loaded at another end is called _______.
10. According to Wein's displacement law, if wavelength of radiation increases, then temperature _______.
11. Work done in an isochoric process is _______.
12. _______ motion of gas molecules is not taken into consideration for low temperature.
13. Electric field inside a conductor is zero because conductor is an _______ surface.
14. A _______ produces alternating current from mechanical energy.
15. Substances with negative susceptibility are _______.
16. Ohm's law is applicable for diodes and electrolytes. True/False.
17. Laplace's correction was because Newton considered sound wave propagation to be an _______ process.
18. Emission of electrons from metal due to heat energy is called _______emission.
19. Most stable nuclei according to binding energy per nucleon curve is _______.
20. Microscope magnifies the image, because angular magnification for image is _______ than object.

Readers can send their responses at editor@mtg.in or post us with complete address by 10^{th} of every month. Winners' names and answers will be published in next issue.

Contributed by : Arnab Sur

SOLUTIONS TO FEBRUARY 2024 WORD GRID

C	E	N	C	E	N	T	R	E	D	P	S	O	U	R	C	E	R	P
C	O	O	A	L	I	N	Z	G	S	R	O	U	N	D	I	E	C	O
I	I	P	P	T	C	C	E	N	T	O	F	M	A	S	S	N	T	T
N	N	R	A	F	R	E	R	E	O	C	C	O	L	D	O	E	U	E
C	V	O	C	O	U	L	O	M	B	C	O	N	E	R	C	R	R	N
R	O	C	I	E	F	T	E	C	T	S	O	I	F	O	H	G	N	T
E	L	S	T	R	A	N	S	F	O	R	M	E	R	L	O	Y	B	T
A	V	E	O	M	O	L	E	R	M	S	I	O	N	I	R	B	A	A
S	E	P	R	I	S	M	R	E	A	F	R	I	C	T	I	O	N	L
E	D	S	M	G	A	S	E	Q	U	S	A	V	O	G	C	A	C	E
S	C	S	A	L	W	A	Y	U	S	S	G	R	O	O	T	H	K	N
D	U	R	I	N	G	I	A	E	O	F	E	R	M	I	N	A	I	E
I	Y	D	D	U	R	I	N	N	M	E	A	N	S	Q	U	A	R	E
N	C	A	S	D	N	K	S	C	D	I	F	F	R	A	C	T	O	I
W	H	I	L	E	N	T	P	Y	E	K	I	N	E	T	I	C	N	G
T	L	E	N	E	R	B	H	Y	A	C	H	A	N	G	E	S	C	Y
C	I	C	M	O	L	E	C	U	L	E	B	O	L	T	Z	M	A	N
I	N	G	L	I	S	H	K	B	A	C	O	N	S	T	A	N	T	P

Across
1. Coulomb
2. Transformer
3. Prism
4. Fermi
5. Friction

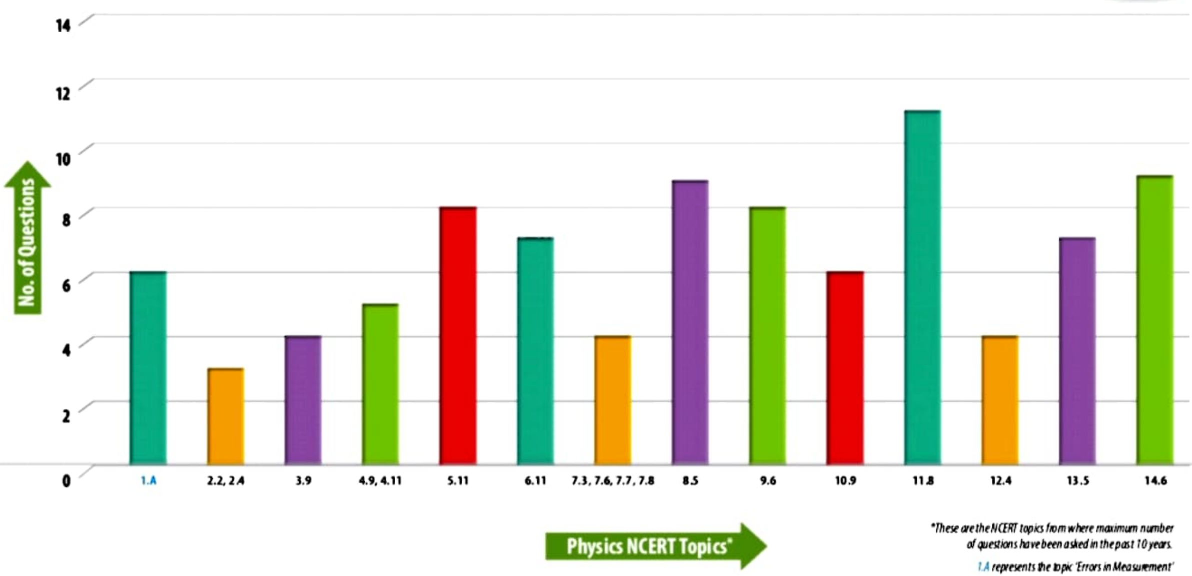
Down
1. Capacitor
2. Zero
3. Mirage
4. Frequency
5. Isochoric

Are You Ready for

NEET Exam 2024?

Class 11

Past 10 Years (2014-2023) Chapterwise Trend Analysis of NEET Questions



*These are the NCERT topics from where maximum number of questions have been asked in the past 10 years.

1.A represents the topic 'Errors in Measurement'

Units and Measurements

Errors in Measurement

Let a physical quantity a be measured n times. Let the measured values be $a_1, a_2, a_3 ..... a_n$. To eliminate random error, their arithmetic mean is taken as the best possible value.

$$\bar{a} = \frac{a_1 + a_2 + ... a_n}{n} = \frac{1}{n}\sum_{i=1}^{n} a_i$$

Mean absolute error : The arithmetic mean of the positive magnitudes of all the absolute errors is called mean absolute error.

$$\Delta\bar{a} = \frac{|\Delta a_1| + |\Delta a_2| + ... + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n}|\Delta a_i|$$

Absolute error : The magnitude of the difference between the true value and the measured value is called absolute error. Such errors are given by

$$\Delta a_1 = \bar{a} - a_1 \text{ ; } \Delta a_2 = \bar{a} - a_2 \text{ ; } \Delta a_3 = \bar{a} - a_3 \text{ ; } ....\Delta a_n = \bar{a} - a_n$$

Relative error : It is the ratio of the mean absolute error $\Delta\bar{a}$ to the mean value $\bar{a}$ of the quantity measured.

$$\text{Relative error} = \frac{\Delta\bar{a}}{\bar{a}}$$

Percentage error : The relative error expressed in percentage is called the percentage error.

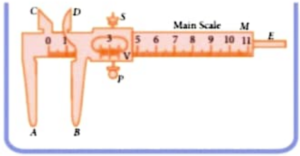
$$\text{Percentage error} = \frac{\Delta\bar{a}}{\bar{a}} \times 100\%$$

Propagation of Errors in Mathematical Operations

Operation	Formula Z	Absolute error ΔZ	Relative error $\Delta Z/Z$	Percentage error $\Delta Z/Z \times 100\%$
Sum	$A + B$	$\Delta A + \Delta B$	$\frac{\Delta A + \Delta B}{A + B}$	$\frac{\Delta A + \Delta B}{A + B} \times 100\%$
Difference	$A - B$	$\Delta A + \Delta B$	$\frac{\Delta A + \Delta B}{A - B}$	$\frac{\Delta A + \Delta B}{A - B} \times 100\%$
Multiplication	$A \times B$	$A\Delta B + B\Delta A$	$\frac{\Delta A}{A} + \frac{\Delta B}{B}$	$\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \times 100\%$
Division	$\frac{A}{B}$	$\frac{B\Delta A + A\Delta B}{B^2}$	$\frac{\Delta A}{A} + \frac{\Delta B}{B}$	$\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \times 100\%$
Power	A^n	$nA^{n-1}\Delta A$	$n\frac{\Delta A}{A}$	$n\frac{\Delta A}{A} \times 100\%$
Root	$A^{1/n}$	$\frac{1}{n}A^{\frac{1}{n}-1}\Delta A$	$\frac{1}{n}\frac{\Delta A}{A}$	$\frac{1}{n}\frac{\Delta A}{A} \times 100\%$

Least Count

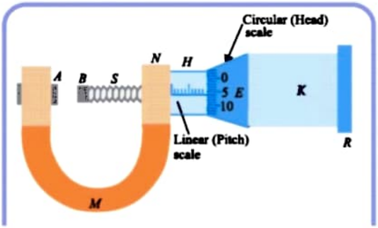
The smallest value of a physical quantity which can be measured accurately with an instrument is called the least count (L.C) of the measuring instrument.



Least count of Vernier Callipers – Suppose the size of one main scale division (M.S.D) is M units and that of one vernier scale division (V.S.D) is V units. Also let the length of 'a' main scale divisions is equal to the length of 'b' vernier scale divisions.

The quantity $(M - V)$ is called vernier constant (V.C) or least count (L.C) of the vernier callipers.

$$\text{L.C} = \left(\frac{b-a}{b}\right)M$$



Least Count of Screw Gauge :

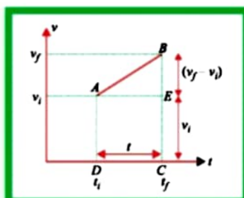
$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$

$$\text{Here, Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{Number of full rotations given}}$$

Motion in a Straight Line

Kinematic Equations for Uniformly Accelerated Motion

Consider a body moving with a uniform acceleration. The $v - t$ graph of this motion is shown in the figure.



Initial velocity = v_i at A, final velocity = v_f at B

Acceleration produced in the body = Slope of the given $v - t$ graph

$$a = \frac{v_f - v_i}{t_f - t_i} = \frac{\Delta v}{\Delta t} \Rightarrow a = \frac{v_f - v_i}{t} \quad \text{(here } t_f - t_i = t = \text{total time taken)}$$

$$\Rightarrow v_f = v_i + at \qquad \text{...(i)}$$

Now, we know that the area under the v-t graph gives the displacement covered by the body.

$\therefore$ Displacement x = Area of $ABCD$ = Area of triangle ABE + Area of rectangle $AECD$

$$\Rightarrow x = \frac{1}{2} \times t \times (v_f - v_i) + t \times v_i \qquad \text{...(ii)}$$

Using equation (i), we get

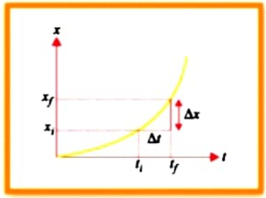
$$x = \frac{1}{2}\, t \times at + v_i t \quad \text{or} \quad x = v_i t + \frac{1}{2}at^2 \qquad \text{...(iii)}$$

Instantaneous Velocity and Speed

- **Instantaneous velocity :** The rate of change of position with time at any instant is called instantaneous velocity. Here, change of time (Δt) is infinitesimally small.

  i.e., $v_{inst} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

  Graphically, we can say it is the slope of $x - t$ curve at any instant (*i.e.*, $\Delta t \to 0$).



- **Instantaneous speed :** The speed of the body at any instant of time or at a particular position is called instantaneous speed.

  Let a body travel a distance Δx in the time interval Δt, then its average speed $= \frac{\Delta x}{\Delta t}$.

  When $\Delta t \to 0$, then average speed of the body becomes the instantaneous speed.

  $\therefore$ Instantaneous speed $= \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

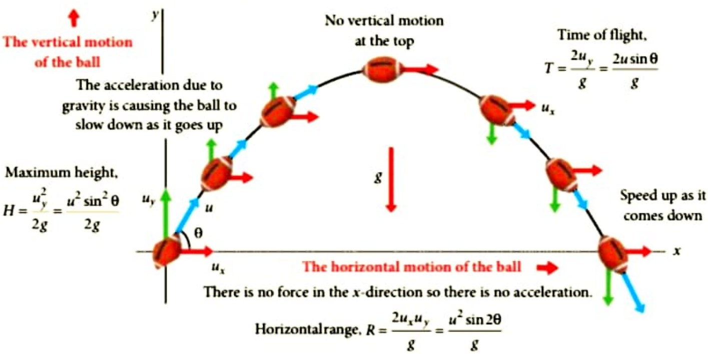
- For uniform motion, velocity is the same as the average velocity at all the instants.

Motion in a Plane

Projectile Motion

A particle thrown in the space which moves under the effect of gravity only is called a projectile. Projectile motion is the combination of two linear motions.

Projectile Motion = Horizontal Motion + Vertical Motion



Relative Velocity in a Plane

The relative velocity of object A, moving with velocity $\vec{v}_A$ w.r.t object B moving with velocity $\vec{v}_B$ is given by, $\vec{v}_{AB} = \vec{v}_A + (-\vec{v}_B) = \vec{v}_A - \vec{v}_B$

Let the two objects be moving in a plane and θ be the angle between the directions of motion of the objects A and B.

In magnitude, the relative velocity of A w.r.t B is given by $v_{AB} = \sqrt{v_A^2 + v_B^2 + 2v_A v_B \cos(180^\circ - \theta)}$

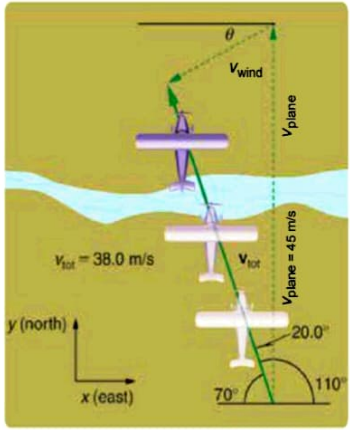
$$= \sqrt{v_A^2 + v_B^2 - 2v_A v_B \cos\theta}$$

If $\vec{v}_{AB}$ makes an angle β with the direction of $\vec{v}_A$, then

$$\tan\beta = \frac{v_B \sin(180^\circ - \theta)}{v_A + v_B \cos(180^\circ - \theta)} = \frac{v_B \sin\theta}{v_A - v_B \cos\theta}$$

Here, object A can be treated as plane and object B represented as wind.

So, v_{tot} = Relative velocity of plane and wind.

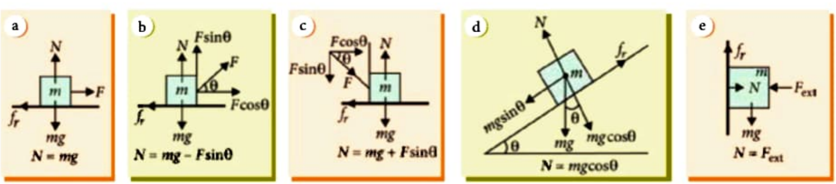


Laws of Motion

Solving Problems/Free Body Diagrams

Draw a separate diagram which shows this system and all the forces on the system by the remaining part of the assembly. Include also the forces on the system by other agencies. Do not include the forces on the environment by the system. A diagram of this type is known as 'a free-body diagram'.

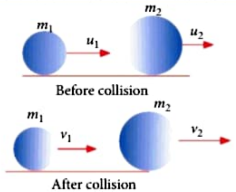
In a free-body diagram, include information about forces (their magnitudes and directions) that are either given or you are sure of (*e.g.*, the direction of tension in a string along its length). The rest should be treated as unknowns to be determined using laws of motion.



Work, Energy and Power

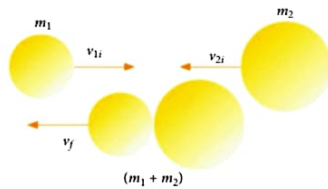
Elastic Collision

A collision in which both the momentum and kinetic energy of the body remains conserved.
There is absolutely no loss of kinetic energy. For example, collision between subatomic particles, collision between two billiard balls etc.



Inelastic Collision

A collision in which only the momentum of the system is conserved but kinetic energy is not conserved. There is some loss of kinetic energy in inelastic collision. For example, accident of two vehicles, collision between a mud ball and floor.



Oblique Collision

After collision, if two objects are not along the initial line of motion and move along different directions in a plane, then the collision is said to be oblique collision or two dimensional collision. There is some loss of kinetic energy in oblique collision. For example, collision between two carrom coins is oblique collision.

Systems of Particles and Rotational Motion

Dynamics of Rotational Motion about a Fixed Axis

Work done by a torque : Work done by a force $\vec{F}_1$ acting on a particle of a body rotating about a fixed axis; the particle describes a circular path with centre C on the axis; arc $P_1P_1'(ds_1)$ gives the displacement of the particle.

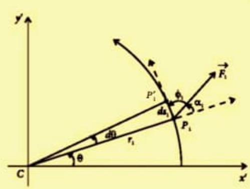
$dW_\perp = \tau_1 d\theta$

For more than one forces, $dW = (\tau_1 + \tau_2 + ...)\, d\theta = \tau d\theta$

$\Rightarrow$ Power $P = \dfrac{dW}{dt} = \tau\dfrac{d\theta}{dt} = \tau\omega$ ...(i)

Rate of change of kinetic energy $\dfrac{d}{dt}\left(\dfrac{I\omega^2}{2}\right) = I\dfrac{(2\omega)}{2}\dfrac{d\omega}{dt} = I\omega\alpha$ ...(ii)

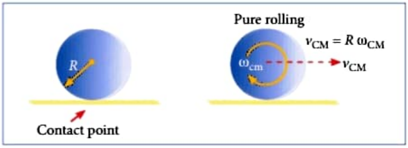
From eqn (i) and (ii) $\tau = I\alpha$



Rolling Motion

Rolling motion is a combination of rotation and translation.

If the velocity of the point of contact of the rolling body with the surface is zero then it is known as pure rolling.



Gravitation

Universal Law of Gravitation

Newton's law of gravitation states that every particle in this universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravitational force : The gravitational force F between two particles of masses m_1 and m_2, distance r apart is given by

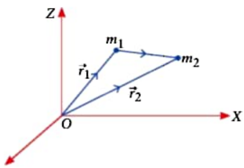
$$F = G\frac{m_1 m_2}{r^2}$$

where G is a constant, called the universal gravitational constant, and assumed to have the same value everywhere for all matter.

Vector form,

$$\vec{F} = G\frac{m_1 m_2}{r^2}(-\hat{r}) = -G\frac{m_1 m_2}{r^2}\hat{r} = -G\frac{m_1 m_2}{|\vec{r}|^3}\vec{r}$$

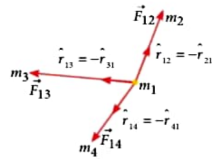
where G is the universal gravitational constant, $\hat{r}$ is the unit vector from m_1 to m_2 and $\vec{r} = \vec{r}_2 - \vec{r}_1$ as shown in figure.



If we have a collection of point masses, the force on any one of them is the vector sum of the gravitational forces exerted by the other point masses.

e.g., gravitational force on point mass m_1 is the vector sum of the gravitational forces exerted by m_2, m_3 and m_4 (see figure).

$$\vec{F}_1 = \frac{Gm_2 m_1}{r_{21}^2}\hat{r}_{21} + \frac{Gm_3 m_1}{r_{31}^2}\hat{r}_{31} + \frac{Gm_4 m_1}{r_{41}^2}\hat{r}_{41}$$

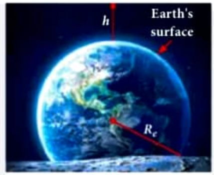


Variation of Acceleration due to Gravity

Due to altitude (h) : The acceleration due to gravity at height h above the Earth's surface is given by $g_h = \frac{GM_e}{(R_e+h)^2} = g\left(1+\frac{h}{R_e}\right)^{-2}$ $\left(\because g = \frac{GM_e}{R_e^2}\right)$

For $h << R_e$ $\therefore$ $g_h = g\left(1-\frac{2h}{R_e}\right)$

When we move above the Earth's surface, the value of acceleration due to gravity goes on decreasing.



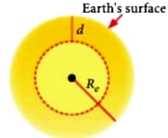
Earth

Due to depth (d) : The acceleration due to gravity at a depth d below the Earth's surface is given by

$$g_d = \frac{GM_e}{R_e^3}(R_e - d)$$

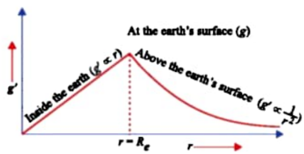
$$= g\left(\frac{R_e - d}{R_e}\right) = g\left(1-\frac{d}{R_e}\right)$$

At the centre of the earth, $d = R_e$; $\therefore$ $g_d = 0$.



When we move below the earth's surface, the value of acceleration due to gravity also decreases. The value of acceleration due to gravity is maximum at the earth's surface and becomes zero at the centre of the earth.

The variation of acceleration due to gravity (g') with distance from the centre of the earth (r) is as shown in the figure.



Due to rotation of the earth about its axis : The acceleration due to gravity at latitude λ is given by $g_\lambda = g - R_e\omega^2\cos^2\lambda$

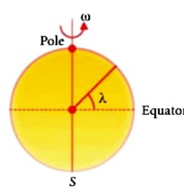
where ω is the angular speed of rotation of the earth about its axis and its value is 7.3×10^{-5} rad s^{-1}.

- At the equator, $\lambda = 0°$

  $g_\lambda = g_e = g - R_e\omega^2\cos^2 0° = g - R_e\omega^2$.
- At the poles, $\lambda = 90°$; $g_\lambda = g_p = g - R_e\omega^2\cos^2 90° = g$

The value of acceleration due to gravity increases from equator to the pole due to rotation of the earth.

$g_p - g_e = g - (g - R_e\omega^2) = R_e\omega^2$



If the earth stops rotating about its axis ($\omega = 0$), the value of g will increase everywhere, except at the poles. On the contrary, if there is increase in the angular speed of the earth, then except at the poles the value of g will decrease at all places.

Due to shape of the earth : Earth is not a perfect sphere but it is an ellipsoid. The earth's radius is 21 km larger at the equator than at the poles. Thus, the earth has an equatorial bulge and is flattened at the poles. Both, rotation and equatorial bulge contribute additively to keep the g smaller at the equator than at the poles.

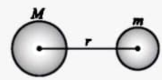
Gravitational Potential Energy

The gravitational potential energy of a body at a point in a gravitational field of another body is defined as the amount of work done in bringing the given body from infinity to that point.

Gravitational potential energy = Gravitational potential × mass of the body

The gravitational potential energy of mass m in the gravitational field of mass M at a distance r from it is

$U = -\frac{GMm}{r}$ where, r is the distance between M and m.



The gravitational potential energy of a mass m at a distance r (> R_e) from the centre of the earth is

$$U = mV = -\frac{GM_e m}{r}$$

Gravitational potential energy of a mass at infinite distance from the earth is zero.

Gravitational potential energy is a scalar quantity. Its dimensional formula is $[ML^2T^{-2}]$ and SI unit is J.

Gravitational potential energy of a body of mass m at height h above the earth's surface is given by

$$U_h = \frac{-GM_e m}{(R_e + h)}$$

Gravitational potential energy of a body of mass m on the earth's surface is given by $U_s = \frac{-GM_e m}{R_e}$

The change in potential energy when a body of mass m is moved vertically upwards through a height h from the earth's surface is given by

$$\Delta U = U_h - U_s = GM_e m\left[\frac{1}{R_e} - \frac{1}{R_e + h}\right] = \frac{GM_e mh}{R_e^2\left(1+\frac{h}{R_e}\right)} = \frac{mgh}{\left(1+\frac{h}{R_e}\right)} \quad \left(\because g = \frac{GM_e}{R_e^2}\right)$$

For $h << R_e$, $\Delta U = mgh$.

Escape Speed

- The escape speed on earth (or any planet) is defined as the minimum speed with which a body has to be projected vertically upwards from the surface of earth (or any other planet) so that it just crosses the gravitational field of earth (or of that planet) and never returns on its own. Escape speed v_e is given by

  $$v_e = \sqrt{\frac{2GM}{R}}$$

- For earth, $v_e = 11.2 \text{ km s}^{-1}$
- For a point close to earth's surface the escape speed and orbital speed are related as $v_e = \sqrt{2}\, v_o$

Mechanical Properties of Solids

Modulus of Elasticity

- It is defined as the ratio of stress to the corresponding strain produced within the elastic limit. Modulus of elasticity is of three types :

  – Young's modulus, $Y = \dfrac{\text{Normal stress}}{\text{Longitudinal strain}}$

  $$= \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L} = \frac{FL}{\pi r^2 \Delta L}$$

  – Bulk modulus, $B = \dfrac{\text{Normal stress}}{\text{Volumetric strain}}$

  $$= \frac{-F/A}{\Delta V/V} = -\frac{PV}{\Delta V}.$$

  –ve sign shows that with an increase in pressure, a decrease in volume occurs.

  – Modulus of rigidity,

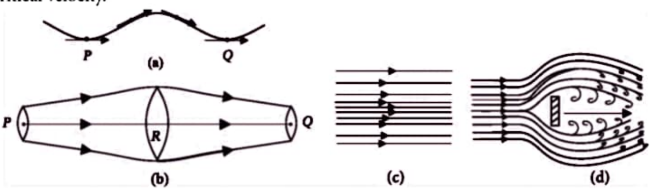
  $$G = \frac{\text{Tangential stress}}{\text{Shearing strain}} = \frac{F/A}{\theta} = \frac{F}{A\theta}.$$

  Modulus of rigidity is also called as shear modulus of rigidity.

Mechanical Properties of Fluids

Streamline Flow

- **Critical velocity :** The velocity of fluid upto which the flow is streamlined and above which it becomes turbulent is called critical velocity.



- **Equation of continuity**

  Assume a non-viscous fluid of density ρ flowing across a pipe of varying cross section. According to conservation of mass, mass of fluid entering per second at wider end = mass of fluid leaving per second at narrower end.

  $A_1 v_1 \rho_1 = A_2 v_2 \rho_2 \Rightarrow A_1 v_1 = A_2 v_2$

  [If fluid is incompressible $\rho_1 = \rho_2 = \rho$] or Av = constant

Bernoulli's Principle

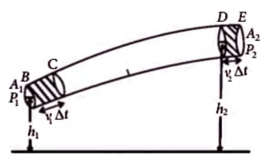
From work energy theorem $(P_1 - P_2)\,\Delta V = \Delta K + \Delta U$

$(P_1 - P_2)\,\Delta V = 1/2\,\rho\Delta V\,(v_2^2 - v_1^2) + \rho g\Delta V\,(h_2 - h_1)$

$\Rightarrow P_1 - P_2 = 1/2\,\rho v_2^2 - 1/2\,\rho\,v_1^2 + \rho g h_2 - \rho g h_1 \Rightarrow P_1 + 1/2\,\rho v_1^2 + \rho g h_1$

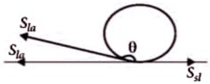
$= P_2 + 1/2\,\rho v_2^2 + \rho g h_2$

$\Rightarrow P + 1/2\,\rho v^2 + \rho g h$ = constant : This is known as **Bernoulli's equation**.

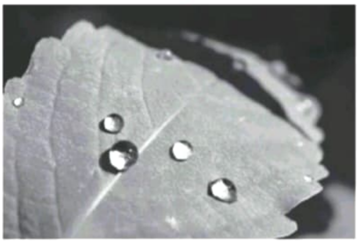


Surface Tension

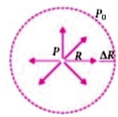
It is the property due to which the free surface of liquid tends to have minimum surface area and behaves like a stretched membrane. When the free surface of a liquid comes in contact with a solid, it becomes curved at the near the point of contact.



Shape of water drops with interfacial tensions as shown in figure on a lotus leaf.



A soap bubble has two surfaces which are in contact with air both inside and outside the bubble. The molecules, lying on the surface of liquid bubble will experience a resultant force acting inwards perpendicular to the surface due to surface tension. Since, the size of soap bubble cannot be reduced to zero, therefore the pressure inside the soap bubble must be greater than the pressure outside it. This excess of pressure inside the bubble will provide a force acting outwards perpendicular to the surface of bubble to counter balance the resultant force due to surface tension and the bubble is in equilibrium.



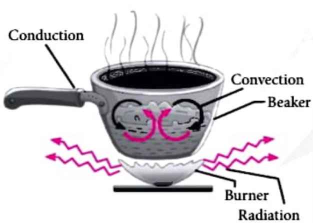
Work done by the excess pressure (P), $W = p \times 4\pi R^2 \times \Delta R$.

Thermal Properties of Matter

Heat Transfer

Three modes of heat transfer are as indicated in the diagram.

Here, heat is being transferred from one point (beaker) to other point (handle) of a substance in the direction of fall of temperature, without any actual motion of particles of the substance.



Heat transfer during boiling

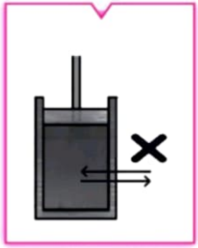
Heat is transmitted from one point to another due to actual motion of heated particles (here fluid particles) in liquids and gases.

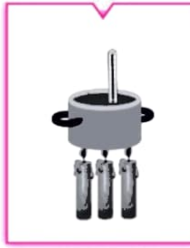
The process of heat transfer from one point (burner) to another point (surroundings) without heating the intervening medium is called radiation.

Thermodynamics

Thermodynamics Process

Isobaric Process	Isochoric Process	Adiabatic Process	Isothermal Process
Thermodynamic process in which the pressure remains constant.	Thermodynamic process in which the volume remains constant.	Thermodynamic process in which there is no heat transfer involved.	The process in which the temperature remains constant.



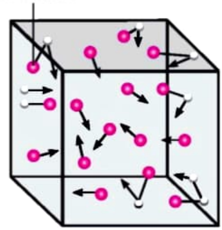


Cyclic process consists of a series of changes which return the system back to its initial state. In non-cyclic process, the series of changes involved do not return the system back to its initial state.

Kinetic Theory

Kinetic Theory of an Ideal Gas

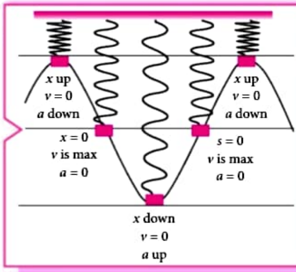
- Gas particles have random motions. Each time a particle collides with the walls of its container, there is a force exerted on the wall and hence on the gas particles.
- **Basic assumptions of kinetic theory**
  - Intermolecular distances are very large as compared to the size of molecules.
  - Collision between the molecules and the walls of container is perfectly elastic.
  - The energy possessed by molecules is purely kinetic energy.
  - The density remains uniform throughout the gas.



Oscillations

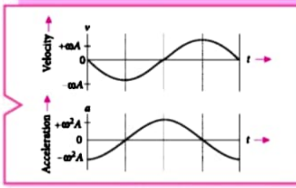
Velocity and Acceleration in Simple Harmonic Motion

Here, a block of mass m is attached to a spring having spring constant k is free to oscillate with angular velocity ω, as shown in figure.



- At any instant, the rate of change of displacement with respect to time of particle executing SHM is known as its velocity *i.e.*, $v(t)=\frac{dx(t)}{dt}=\frac{d}{dt}[A\cos(\omega t+\phi)] \Rightarrow v(t)=-\omega A\sin(\omega t+\phi)$
  where, $v(t)$ is the velocity of the projection of reference particle in S.H.M.
  $\Rightarrow v(t)=-\omega A\sqrt{1-\cos^2(\omega t+\phi)} \Rightarrow v(t)=-\omega\sqrt{A^2-x^2}$
  - For $x = 0$, *i.e.*, at mean position, velocity is maximum.
    $v(t)=-\omega A=-v_m$(velocity amplitude)
  - For $x = A$, *i.e.*, at extreme position, velocity is minimum, $v(t) = 0$.
- At any instant, the rate of change of velocity with respect to time of a particle executing simple harmonic motion is known as its acceleration *i.e.*,
  $a(t)=\frac{d}{dt}v(t)=\frac{-d}{dt}(\omega A\sin(\omega t+\phi))$
  $a(t)=-\omega^2 A\cos(\omega t+\phi) \Rightarrow a(t)=-\omega^2 x(t)$
  – For $x = 0$, *i.e.*, at mean position, $a(t) = 0$
  – For $x = A$, *i.e.*, at extreme position, $a(t) = -\omega^2 A$

Here, graphs show velocity and acceleration of a block in SHM.



Waves

Reflection of Waves

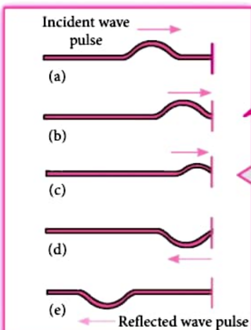
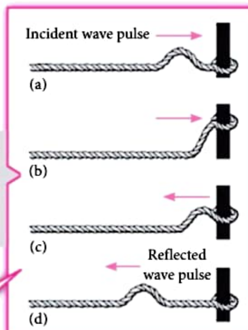


Figure shows, the reflection of a travelling wave pulse at the fixed end of stretched string. The reflected pulse is inverted, but its shape is otherwise unchanged.

What happens when a wave travelling in one medium reaches a boundary where two media are separated. The wave gets partly reflected back in the same medium and partly refracted (transmitted) to the other medium.

Figure shows, the reflection of a travelling pulse at the free end of stretched string. The reflected pulse is not inverted.



PRACTICE PAPER 2024

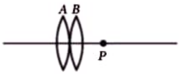
Karnataka CET

1. A beam of beryllium nucleus ($z = 4$) of kinetic energy 5.3 MeV is headed towards the nucleus of gold atom ($Z = 79$). What is the distance of closest approach?
   (a) 10.32×10^{-14} m (b) 8.58×10^{-14} m
   (c) 3.56×10^{-14} m (d) 1.25×10^{-14} m

2. 200 g of a solid ball at 20°C is dropped in an equal amount of water at 80°C. The resulting temperature is 60°C. This means that specific heat of solid is
   (a) one fourth of water (b) one half of water
   (c) twice of water (d) four times of water

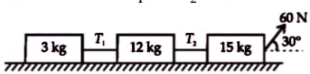
3. Light travels through a glass plate of thickness t and having refractive index μ. If c be the velocity of light in vacuum, time taken by the light to travel this thickness of glass is
   (a) $\frac{t}{\mu c}$ (b) $\frac{tc}{\mu}$
   (c) $\frac{\mu t}{c}$ (d) μtc

4. Two convex lenses A and B placed in contact form the image of a distant object at P. If the lens B is moved to the right a little, the image will



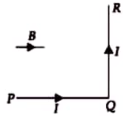
   (a) move to the left
   (b) move to the right
   (c) remain at P
   (d) move either to the left or right, depending upon focal length of the lenses.

5. Three masses are connected as shown in figure on a horizontal frictionless surface and pulled by a force of 60 N. The tensions T_1 and T_2 are in the ratio



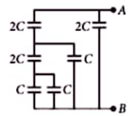
   (a) 1 : 1 (b) 1 : 5 (c) 1 : 4 (d) 4 : 5

6. A wire PQR is bent as shown in figure and is placed in a region of uniform magnetic field B. The length of $PQ = QR = l$. A current I ampere flows through the wire as shown. The magnitude of force on PQ and QR will be



   (a) BIl, 0 (b) $2BIl$, 0 (c) 0, BIl (d) 0, 0

7. The effective capacity between A and B of the given network is



   (a) $3C$ (b) $2C$
   (c) C (d) $\frac{C}{3}$

8. A susceptibility of a certain magnetic material is 400. What is the class of the magnetic material?
   (a) Ferromagnetic (b) Diamagnetic
   (c) Ferroelectric (d) Paramagnetic

9. A copper disc of radius 0.1 m is rotated about its centre with 10 revolutions per second in a uniform magnetic field of 0.1 T with its plane perpendicular to the field. The emf induced across the radius of disc is
   (a) $\frac{\pi}{10}$ V (b) $\frac{2\pi}{10}$ V
   (c) $\pi \times 10^{-2}$ V (d) $2\pi \times 10^{-2}$ V

10. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s. Then the coefficient of friction is
    (a) 0.02 (b) 0.03 (c) 0.06 (d) 0.01

11. Three particles of masses 1 kg, 2 kg and 3 kg are situated at the corners of an equilateral triangle of side b in the x-y plane with mass 1 kg at the origin and 2 kg on the x-axis. The coordinates of the centre of mass are

(a) $\left(\frac{7b}{12}, \frac{3\sqrt{3}b}{12}\right)$ (b) $\left(\frac{3\sqrt{3}b}{12}, \frac{7b}{12}\right)$

(c) $\left(\frac{b}{12}, \frac{3\sqrt{3}b}{12}\right)$ (d) $\left(\frac{7b}{12}, \frac{\sqrt{3}b}{12}\right)$

12. Diffusion current in a p-n junction is greater than the drift current in magnitude
(a) if the junction is forward-biased
(b) if the junction is reverse-biased
(c) if the junction is unbiased
(d) in no case.

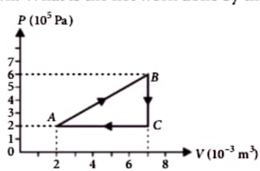
13. The displacement of a body is given by $x = 4t + 5t^3$, where x is in meter and t is in second. The difference between the average velocity of the body in the time-interval $t = 1$ s to $t = 2$ s and its instantaneous velocity at $t = 1$ s is
(a) 20.0 m s^{-1} (b) 22.5 m s^{-1}
(c) 27.0 m s^{-1} (d) 39.0 m s^{-1}

14. A wire made of aluminium having resistivity $\rho = 2.8 \times 10^{-8}\ \Omega$ m with a circular cross section and has a radius of 2×10^{-3} m. A current of 5 A flows through the wire. If the voltage difference between the ends is 1 V, what is the length of the wire in metres?
(a) 50 (b) 60 (c) 90 (d) 120

15. A conducting wire has length 'L_1' and diameter 'd_1'. After stretching the same wire length becomes 'L_2' and diameter 'd_2'. The ratio of resistance before and after stretching is
(a) $L_2d_2^4 : L_1d_1^4$ (b) $d_1^4 : d_2^4$
(c) $L_1d_2^2 : L_2d_1^2$ (d) $L_1d_1^2 : L_2d_2^2$

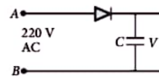
16. The range of nuclear force is of the order of
(a) 2×10^{-10} m (b) 1.5×10^{-20} m
(c) 1.2×10^{-4} m (d) 1.4×10^{-15} m

17. A gas is taken through the cycle $A \to B \to C \to A$, as shown. What is the net work done by the gas?



(a) Zero (b) – 2000 J
(c) 2000 J (d) 1000 J

18. A 220 V A.C. supply is connected between points A and B as shown in figure. What will be the potential difference V across the capacitor?



(a) 0 (b) $220\sqrt{2}$ V
(c) 220 V (d) 110 V

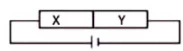
19. In the Young's experiment with sodium light, the slits are 0.589 m apart. What is the angular width of the fourth maximum? Given that $\lambda = 589$ nm.
(a) $\sin^{-1}(3 \times 10^{-6})$ (b) $\sin^{-1}(3 \times 10^{-8})$
(c) $\sin^{-1}(0.33 \times 10^{-6})$ (d) $\sin^{-1}(0.33 \times 10^{-8})$

20. The radius of a planet is R and its density is ρ. The escape velocity of a body from the surface of the planet is proportional to
(a) $V_e \propto R\sqrt{\rho}$ (b) $V_e \propto \frac{1}{\sqrt{\rho R}}$
(c) $V_e \propto \rho R$ (d) $V_e \propto \frac{\sqrt{\rho}}{R}$

21. Two identical conducting balls A and B have positive charges q_1 and q_2 respectively. But $q_1 \neq q_2$. The balls are brought together so that they touch each other and then kept in their original positions. The force between them is
(a) less than that before the balls touched
(b) greater than that before the balls touched
(c) same as that before the balls touched
(d) zero

22. The displacement of a particle is represented by the equation $y = 0.4\left\{\cos^2\left(\frac{\pi t}{2}\right) - \sin^2\left(\frac{\pi t}{2}\right)\right\}$ metre
The motion of a particle is
(a) a S.H.M. with amplitude 0.8 m
(b) oscillatory but not S.H.M.
(c) a S.H.M. with amplitude 0.4 m
(d) a S.H.M. with amplitude $0.4\sqrt{2}$ m

23. A semiconductor X is made by doping a germanium crystal with arsenic (Z = 33). A second semiconductor Y is made by doping germanium with indium (Z = 49). The two are joined end to end and connected to a battery as shown,



Which of the following statements is correct?
(a) X is p-type, Y is n-type and the junction is forward biased

(b) X is n-type, Y is p-type and the junction is forward biased
(c) X is p-type, Y is n-type and the junction is reverse biased
(d) X is n -type, Y is p-type and the junction is reverse biased.

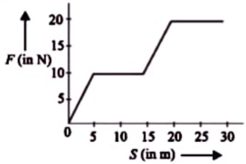
24. The energy released in the fission of 1 kg of $_{92}U^{235}$ is (Energy per fission = 200 MeV)
(a) 5.1×10^{26} eV (b) 5.1×10^{26} J
(c) 8.2×10^{13} J (d) 8.2×10^{13} MeV

25. The dimensions of $\frac{a}{b}$ in the equation $P = \frac{a - t^2}{bx}$, where P is pressure, x is distance and t is time are
(a) $[M^2LT^{-3}]$ (b) $[ML^0T^{-2}]$
(c) $[ML^3T^{-1}]$ (d) $[M^0LT^{-3}]$

26. A hemisphere is positively charged uniformly. The electric field at a point on a diameter away from the centre is directed
(a) perpendicular to the diameter
(b) parallel to the diameter
(c) at an angle tilted towards the diameter
(d) at an angle tilted away from the diameter.

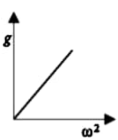
27. If the tube length of astronomical telescope is 105 cm and magnifying power is 20 for normal setting, calculate the focal length of the objective lens.
(a) 100 cm (b) 10 cm (c) 20 cm (d) 25 cm

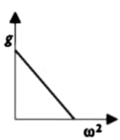
28. The work done by a force acting on a body is as shown in the graph. The total work done in covering an initial distance of 20 m is

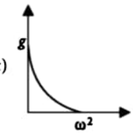


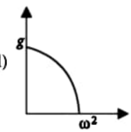
(a) 225 J (b) 200 J (c) 400 J (d) 175 J

29. The graph that represents variation of g at the equator with square of angular velocity of rotation of earth is

(a) 

(b) 

(c) 

(d) 

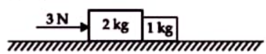
30. If in a transformer the number of turns of primary coil and secondary coil are 5 and 4 respectively and 220 V is applied to primary coil, then the ratio of current in primary and secondary coil is
(a) 4 : 5 (b) 5 : 4 (c) 5 : 10 (d) 8 : 12

31. Two vectors are given by $\vec{A} = 3\hat{i} + \hat{j} + 3\hat{k}$ and $\vec{B} = 3\hat{i} + 5\hat{j} - 2\hat{k}$. Find the third vector $\vec{C}$ if $\vec{A} + 3\vec{B} - \vec{C} = 0$
(a) $12\hat{i} + 14\hat{j} + 12\hat{k}$ (b) $13\hat{i} + 17\hat{j} + 12\hat{k}$
(c) $12\hat{i} + 16\hat{j} - 3\hat{k}$ (d) $15\hat{i} + 13\hat{j} + 4\hat{k}$

32. If 3.8×10^{-6} is added to 4.2×10^{-5} giving due regard to significant figures, then the result will be
(a) 4.58×10^{-5} (b) 4.6×10^{-5}
(c) 4.5×10^{-5} (d) none of these.

33. In which of the following Bohr's orbit (n), a hydrogen atom emits the photons of lowest frequency?
(a) $n = 2$ to $n = 1$ (b) $n = 4$ to $n = 2$
(c) $n = 4$ to $n = 1$ (d) $n = 4$ to $n = 3$

34. Two blocks of 2 kg and 1 kg are in contact on a frictionless table. If a force of 3 N is applied on 2 kg block, then the force of contact between the two blocks will be



(a) 0 N (b) 1 N (c) 2 N (d) 3 N

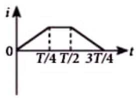
35. Two metal spheres, one of radius R and the other of radius $2R$ respectively have the same surface charge density σ. They are brought in contact and separated. What will be the new surface charge densities on them ?
(a) $\sigma_1 = \frac{5}{6}\sigma, \sigma_2 = \frac{5}{2}\sigma$ (b) $\sigma_1 = \frac{5}{2}\sigma, \sigma_2 = \frac{5}{6}\sigma$
(c) $\sigma_1 = \frac{5}{2}\sigma, \sigma_2 = \frac{5}{3}\sigma$ (d) $\sigma_1 = \frac{5}{3}\sigma, \sigma_2 = \frac{5}{6}\sigma$

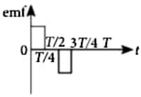
36. An electron is travelling with velocity $\vec{v} = 3\hat{i} + 5\hat{j}$ m s^{-1} in a magnetic field $\vec{B} = 6\hat{i} + 4\hat{j}$ tesla. What is the magnitude and direction of the force $\vec{F}$ acting on the electron?

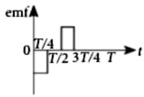
(a) $18e$ N along +ve z-axis
(b) $18e$ N along –ve z-axis
(c) $36e$ N along –ve z-axis
(d) $54e$ N along +ve z-axis

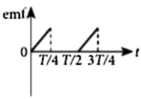
37. Two copper wires, one of length 1 m and the other of length 9 m have the same resistance. The diameters are in the ratio
(a) 3 : 1 (b) 1 : 3 (c) 9 : 1 (d) 1 : 9

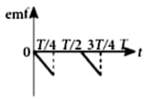
38. The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be



(a)


(b)


(c)


(d)


39. The rms speed of oxygen is v at a particular temperature. If the temperature is doubled and oxygen molecules dissociate into oxygen atoms, the rms speed becomes
(a) v (b) $\sqrt{2}v$ (c) $2v$ (d) $4v$

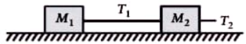
40. If the maximum kinetic energy of emitted photo electrons from a metal surface of work function 2.5 eV, is 1.7 eV. If wavelength of incident radiation is halved, then stopping potential will be
(a) 2.5 V (b) 6.7 V (c) 5 V (d) 1.1 V

41. A diatomic gas is heated at constant pressure. What fraction of the heat energy is used to increase the internal energy?
(a) $\frac{3}{5}$ (b) $\frac{3}{7}$ (c) $\frac{5}{7}$ (d) $\frac{5}{9}$

42. In an n-p-n transistor, the collector current is 24 mA. If 80% of electrons reach collector, its base current in mA is
(a) 36 (b) 26 (c) 16 (d) 6

43. The instantaneous voltage through a device of impedance 20 Ω is $e = 80 \sin 100\pi t$. The effective value of the current is
(a) 3 A (b) 2.828 A (c) 1.732 A (d) 4 A

44. Two masses M_1 and M_2 are accelerated uniformly on a frictionless surface as shown in figure. The ratio of the tensions $\frac{T_1}{T_2}$ is

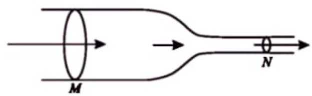


(a) $\frac{M_1}{M_2}$ (b) $\frac{M_2}{M_1}$
(c) $\frac{(M_1+M_2)}{M_2}$ (d) $\frac{M_1}{(M_1+M_2)}$

45. In YDSE if the screen is moved away from the plane of the slits, the fringe width of interference fringes will
(a) increase (b) decrease
(c) remain same (d) none of these

46. Two parallel wires in free space are 10 cm apart and each carries a current of 10 A in the same direction. The force exerted by one wire on the other, per metre length is
(a) 2×10^{-4} N, repulsive
(b) 2×10^{-7} N, repulsive
(c) 2×10^{-4} N, attractive
(d) 2×10^{-7} N, attractive.

47. Horizontal tube of non-uniform cross-section has radii of 0.1 m and 0.05 m respectively at M and N. For a streamline flow of liquid the rate of liquid flow is

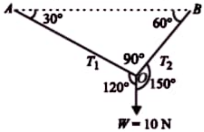


(a) continuously changes with time
(b) greater at M than at N
(c) greater at N than at M
(d) same at M and N

48. An object is placed 16 cm in front of a mirror. If the image is formed at 4 cm to the right of the mirror, calculate its focal length and radius of curvature of the mirror?
(a) 5.33 cm, 10.66 cm (b) 4.23 cm, 9.08 cm
(c) 5.67 cm, 10.02 cm (d) 10.02 cm, 9.06 cm

49. An electric dipole is placed at an angle of 30° with an electric field intensity 2×10^5 N C^{-1}. It experiences a torque equal to 4 N m. The charge on the dipole, if the dipole length is 2 cm, is
(a) 8 mC (b) 2 mC (c) 5 mC (d) 7 mC

50. A ball of mass 1 kg hangs in equilibrium from two strings OA and OB as shown in figure. What are the tensions in strings OA and OB? (Taking $g = 10\ m/s^2$)



(a) 5 N, zero (b) zero, $5\sqrt{3}$ N

(c) 5 N, $5\sqrt{3}$ N (d) $5\sqrt{3}$ N, 5 N

51. A galvanometer has a resistance of 25 Ω and a maximum of 0.01 A current can be passed through it. In order to change it into an ammeter of range 10 A, the shunt resistance required is

(a) $\frac{5}{999}\ \Omega$ (b) $\frac{10}{999}\ \Omega$ (c) $\frac{15}{999}\ \Omega$ (d) $\frac{25}{999}\ \Omega$

52. We are able to obtain fairly large currents in a conductor because

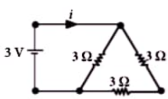
(a) the electron drift speed is usually very large

(b) the number density of free electrons is very high and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge

(c) the number density of free electrons as well as the electron drift speeds are very large and these compensate for the very small magnitude of the electron charge

(d) the very small magnitude of the electron charge has to be divided by the still smaller product of the number density and drift speed to get the electric current.

53. A 3 V battery with negligible internal resistance is connected in a circuit as shown in the figure. The current I, in the circuit will be



(a) 1 A (b) 1.5 A (c) 2 A (d) (1/3) A

54. A particle moves in the x-y plane with velocity $v_x = 8t - 2$ and $v_y = 2$. If it passes through the point $x = 14$ and $y = 4$ at $t = 2$ s, then the equation of the path is

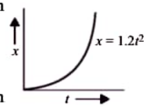
(a) $x = y^3 - y^2 + 2$ (b) $x = y^2 - y + 2$

(c) $x = y^2 - 3y + 2$ (d) $x = y^3 - 2y^2 + 2$

55. A luminous object is placed 20 cm from the surface of a convex mirror. A plane mirror is set so that the virtual images formed in the two mirrors coincide. If the plane mirror is at a distance of 12 cm from the object, then the focal length of the convex mirror is

(a) 10 cm (b) 5 cm (c) 20 cm (d) 40 cm

56. Given figure shows the distance-time graph of the motion of a car. It follows from the graph that the car is



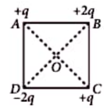
(a) at rest

(b) in uniform motion

(c) in non-uniform acceleration

(d) uniformly accelerated.

57. Four charges are arranged at the corners of a square $ABCD$ as shown in the figure. The force on the positive charge kept at the centre O is



(a) zero

(b) along the diagonal AC

(c) along the diagonal BD

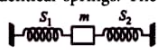
(d) perpendicular to side AB

58. A stress of 1 kg/mm^2 is applied on a wire. If the modulus of elasticity of the wire is 10^{10} dyne/cm^2, then the percentage increase in the length of the wire will be

(a) 0.0098% (b) 0.98%

(c) 9.8% (d) 98%

59. In the figure S_1 and S_2 are identical springs. The oscillation frequency of the mass m is f. If one spring is removed, the frequency will become



(a) f (b) $f/\sqrt{2}$ (c) $f \times 2$ (d) $f \times \sqrt{2}$

60. Two turning forks of frequencies n_1 and n_2 produces n beats per second. If n_2 and n are known, n_1 may be given by

(a) $\frac{n_2}{n} + n_2$ (b) $n_2 n$

(c) $n_2 \pm n$ (d) $\frac{n_2}{n} - n_2$

SOLUTIONS

1. **(b):** Distance of closest approach $d = \frac{1}{4\pi\varepsilon_0}\frac{zeZe}{K}$

where, Z = atomic number of target nucleus

z = atomic number of incident beam

K = kinetic energy of incident beam

e = electronic charge

Given : $z = 4$; $Z = 79$; $K = 5.3$ MeV and $e = 1.6 \times 10^{-19}$ C

$$d = \frac{9\times10^9 \times 4\times1.6\times10^{-19}\times79\times1.6\times10^{-19}}{5.3\times1.6\times10^{-19}\times10^6}$$

$= 8.58 \times 10^{-14}$ m

2. (b): Heat lost by the water, $Q_1 = 200 \times s_w \times (80 - 60)$
Heat gained by the solid, $Q_2 = 200 \times s_s \times (60 - 20)$
According to the principle of calorimetry, $Q_1 = Q_2$

$\therefore\ 200 \times s_w \times (80 - 60) = 200 \times s_s \times (60 - 20)$

or $s_s = \frac{1}{2} s_w$

3. (c) : Speed of light in a medium, $v = \frac{c}{\mu}$
Thickness of the medium $= t$
Time taken by light to cross the medium

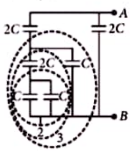
$$= \frac{\text{thickness}}{\text{speed}} = \frac{t}{c/\mu} = \frac{\mu t}{c}$$

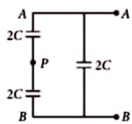
4. (b): Power of combination will decrease.

5. (b)

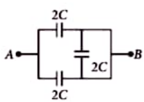
6. (c) : $F = IBl\sin\theta$
Since, PQ is parallel to the direction of magnetic field,
$\therefore\ \theta = 0°$; $F_{PQ} = BIl \sin 0° = 0$
Since, QR is perpendicular to the direction of magnetic field,
$\therefore\ \theta = 90°$; $F_{QR} = BIl\sin 90° = BIl$

7. (a) :





C (Loop 1) $= 2C$, C(Loop 2)
$= 1C$, ($2C$ in series with $2C$)
C (Loop 3) $= 2C$
$\Rightarrow\ C_{AB} = 1C + 2C = 3C.$



8. (a): The susceptibility of given material is 400 which is a very large value. So the class of the given material will be ferromagnetic.

9. (c) : As $\varepsilon = \frac{1}{2} B\omega r^2$

or $\varepsilon = \frac{1}{2}\times0.1\times2\pi\times10\times(0.1)^2$ $\quad [\because \omega = 2\pi f]$

or $\varepsilon = \pi \times 10^{-2}$ V

10. (c) : As $F = ma$ $\quad\therefore\ \mu mg = ma$ or $\mu = \frac{a}{g}$

Now, $v = u + at$ or $0 = 6 + 10a$ or $a = \frac{(0-6)}{10} = -0.6$
(Negative sign shows retardation)

$\therefore\ \mu = \frac{0.6}{10} = 0.06$

11. (a)

12. (a) : Diffusion current in a p-n junction is greater than the drift current in magnitude if the junction is forward-baised.

13. (a) : $v_{\text{average}} = \frac{x_{(t=2)} - x_{(t=1)}}{2-1}$

$$= \frac{[4(2)+5(2)^3]-[4+5]}{1} = \frac{8+40-9}{1} = 39 \text{ m s}^{-1}$$

Instantaneous velocity at ($t = 1$ s)
$v_{ins} = 4 + 15 \times 1 = 19$ m s^{-1}
The difference between the average velocity and the instantaneous velocity is $= 39 - 19 = 20$ m s^{-1}.

14. (c) : Let the length of the wire be l. Then, the resistance of the wire is

$R = \rho\frac{l}{\pi r^2}$ (where r is the radius of the wire)

According to Ohm's law, the potential difference across the ends is $V_e \propto R\sqrt{P}$

$$\therefore\ l = \frac{\pi r^2 V}{I\rho} = \frac{(3.14)(2\times10^{-3}\text{ m})^2(1\text{ V})}{(5\text{ A})(2.8\times10^{-8}\,\Omega\text{ m})} = 89.7\text{ m} \approx 90\text{ m}$$

15. (c) : Let R_1 and R_2 be the initial and final resistances of wire before and after stretching respectively.

$$\text{Now, } \frac{R_1}{R_2} = \frac{L_1}{L_2}\times\frac{A_2}{A_1} = \frac{L_1}{L_2}\times\frac{\frac{\pi d_2^2}{4}}{\frac{\pi d_1^2}{4}} \Rightarrow \frac{R_1}{R_2} = \frac{L_1 d_2^2}{L_2 d_1^2}$$

16. (d): The nuclear force is of short range.
The range of nuclear force is of the order of 1.4×10^{-15} m.

17. (d)

18. (b): Here the voltage across the capacitor,

$V = V_{max} = V_{rms} \times \sqrt{2} = 220\sqrt{2}$ V

19. (a): $x_n = \frac{n\lambda D}{2d}$ or $\frac{x_n}{D} = \frac{n\lambda}{2d}$

$\therefore\ \sin\theta = \frac{n\lambda}{2d} = \frac{3\times589\times10^{-9}}{0.589}$ $\quad \theta = \sin^{-1}(3 \times 10^{-6})$

20. (a) : $V_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G\cdot\frac{4}{3}\pi R^3\rho}{R}}$

$= \sqrt{\frac{8}{3}G\pi\rho R^2} = 2R\sqrt{\frac{2}{3}G\pi\rho}$ Thus, $V_e \propto R\sqrt{P}$

21. (b)

22. (c) : Given, $y = 0.4\left(\cos^2\frac{\pi t}{2} - \sin^2\frac{\pi t}{2}\right)$

$y = 0.4\ (\cos \pi t)$

$y = 0.4\ (\sin(\pi - \pi t)) \Rightarrow y = 0.4 \sin \pi\ (1 - t)$

We know the equation of SHM is $y = A \sin \omega t$

$\therefore$ It is SHM with amplitude, $A = 0.4$

23. (d) : Arsenic is pentavalent and is a donor impurity and supplies extra electrons, so electrons become majority charge carriers and the material becomes n-type whereas indium is trivalent and is an acceptor impurity and supplies holes, which become majority charge carriers and the material behaves as p-type semiconductors.

As X is n-type and Y is p-type and negative of battery is connected to p-type and positive of battery is connected to n-type so the junction is reverse biased.

24. (c) : Energy of single fission is 200 MeV.

Number of atoms in 235 g = 6.023×10^{23}

$\therefore$ Number of atoms in 1 kg of uranium 235

$= \frac{1000}{235} \times 6.023 \times 10^{23}$

$\therefore$ Energy released in fission of 1 kg of U^{235}

$= \frac{200\times10^6\times1000\times6.023\times10^{23}\times1.6\times10^{-19}}{235}$ J

$= 8.2 \times 10^{13}$ J

25. (b): $P = \frac{a - t^2}{bx}$

Dimensions of $a = [T^2]$, as t^2 is subtracted from a.

From $P = \frac{a - t^2}{bx} = \frac{t^2}{bx}$

$\therefore\ [b] = \frac{[t^2]}{[Px]} = \frac{[T^2]}{[ML^{-1}T^{-2}][L]} = [M^{-1}L^0T^4]$

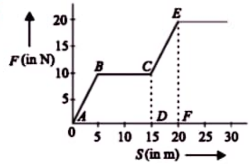
$\therefore\ \left[\frac{a}{b}\right] = \frac{[T^2]}{[M^{-1}L^0T^4]} = [ML^0T^{-2}]$

26. (a): When the point is on the diameter and away from the centre of hemisphere which is charged uniformly and positively, the component of electric field intensity parallel to the diameter cancel out. So the electric field is perpendicular to the diameter.

27. (a) : $L = f_0 + f_e = 105$ cm and $M = \frac{f_0}{f_e} = 20$

$\Rightarrow f_0 = 100$ cm and $f_e = 5$ cm

28. (b):



Work done W = area under F-S graph

= area of trapezium $ABCD$ + area of trapezium $CEFD$

$= \frac{1}{2}\times(10+15)\times10 + \frac{1}{2}\times(10+20)\times5 = 125 + 75 = 200$ J

29. (b): $g_\phi = g - R\omega^2$; $Y = -mx + c$.

It is a straight line with negative slope

30. (a) : In a transformer (No energy loss)

$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}\ \therefore\ \frac{I_P}{I_S} = \frac{N_S}{N_P} = \frac{4}{5}$

31. (c) : Given, $\vec{A} = 3\hat{i} + \hat{j} + 3\hat{k}$; $\vec{B} = 3\hat{i} + 5\hat{j} - 2\hat{k}$

$\vec{A} + 3\vec{B} - \vec{C} = 0$; $(3\hat{i} + \hat{j} + 3\hat{k}) + 3(3\hat{i} + 5\hat{j} - 2\hat{k}) - \vec{C} = 0$

$3\hat{i} + \hat{j} + 3\hat{k} + 9\hat{i} + 15\hat{j} - 6\hat{k} - \vec{C} = 0$

$12\hat{i} + 16\hat{j} - 3\hat{k} - \vec{C} = 0$; $\vec{C} = 12\hat{i} + 16\hat{j} - 3\hat{k}$

32. (b): $3.8 \times 10^{-6} + 4.2 \times 10^{-5} = 3.8 \times 10^{-6} + 42 \times 10^{-6}$
$= 45.8 \times 10^{-6} = 4.58 \times 10^{-5} = 4.6 \times 10^{-5}$

(Round off to first decimal place)

33. (d) **34. (b)**

35. (d): Before contact, $Q_1 = \sigma\cdot4\pi R^2$ and $Q_2 = \sigma\cdot4\pi(2R)^2$

As, surface charge density, $\sigma = \frac{\text{Net charge } (Q)}{\text{Surface area } (A)}$

Now, after contact, $Q_1' + Q_2' = Q_1 + Q_2 = 5(\sigma\cdot4\pi R^2)$ ...(i)

They will be at equal potentials, so,

$\frac{Q_1'}{R} = \frac{Q_2'}{2R} \Rightarrow Q_2' = 2Q_1'$

$\therefore\ 3Q_1' = 5(\sigma\cdot4\pi R^2)$ (From equation (i))

and $Q_2' = \frac{10}{3}(\sigma\cdot4\pi R^2)$

$\therefore\ \sigma_1 = \frac{5}{3}\sigma$ and $\sigma_2 = \frac{5}{6}\sigma$.

36. (a): Given : $\vec{v} = 3\hat{i} + 5\hat{j}$, $\vec{B} = 6\hat{i} + 4\hat{j}$

Force on a particle of charge q, moving with velocity $\vec{v}$ is placed in a magnetic field $\vec{B}$ is given by $\vec{F} = q(\vec{v} \times \vec{B})$

$$\vec{v}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 5 & 0 \\ 6 & 4 & 0 \end{vmatrix}$$

$= \hat{i}[0-0] - \hat{j}[0-0] + \hat{k}[12-30] = -18\hat{k}$

For an electron $q = (-e)$

$\therefore \quad \vec{F} = (-e)[-18\hat{k}] = 18e\hat{k}$ along + ve z axis $|\vec{F}| = 18e$ N

37. (b): Resistance of a wire, $R = \rho \frac{l}{A}$

where ρ is the resistivity, l is the length and A area of cross-section.

Since both wires are made up of same material, therefore their resistivity is same.

As $R_1 = R_2$ (Given)

$\therefore \quad \rho \frac{l_1}{A_1} = \rho \frac{l_2}{A_2}$ or $\frac{A_1}{A_2} = \frac{l_1}{l_2}$

As $A = \frac{\pi D^2}{4}$ (where D is the diameter of the wire)

$\therefore \quad \frac{D_1^2}{D_2^2} = \frac{l_1}{l_2} \quad \frac{D_1}{D_2} = \sqrt{\frac{l_1}{l_2}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$

38. (b): emf, $\varepsilon \propto -\frac{di}{dt}$.

39. (c) : As, $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

For oxygen molecules at temperature T,

$$v_{\text{rms}} = v = \sqrt{\frac{3RT}{M}} \quad \text{...(i)}$$

Now, temperature is doubled and oxygen molecules dissociate into oxygen atom (molar mass becomes $M/2$) then rms speed will be

$$v'_{\text{rms}} = \sqrt{\frac{3R(2T)}{(M/2)}} = 2\sqrt{\frac{3RT}{M}} = 2v \quad \text{(Using (i))}$$

40. (b): Energy of incident photons,

$h\upsilon = \phi_0 + K_{\text{max}} = 2.5 + 1.7 = 4.2$ eV

$\upsilon\lambda = c$ and $\upsilon' \frac{\lambda}{2} = c \Rightarrow \upsilon' = 2\upsilon$

According to Einstein's photoelectric equation,

$eV_0 = h\upsilon' - \phi_0 = h(2\upsilon) - \phi_0 = 2 \times 4.2 - 1.7 = 6.7$ eV

$\Rightarrow \quad V_0 = 6.7$ V

41. (c) : At constant pressure,

$\Delta Q = nC_P\Delta T$ and $\Delta U = nC_V\Delta T$

$$\therefore \quad \frac{\Delta U}{\Delta Q} = \frac{nC_V\Delta T}{nC_P\Delta T} = \frac{C_V}{C_P} = \frac{1}{\gamma} \quad \left(\because \gamma = \frac{C_P}{C_V}\right)$$

For a diatomic gas, $\gamma = \frac{7}{5}$. Thus, $\frac{\Delta U}{\Delta Q} = \frac{1}{7/5} = \frac{5}{7}$

42. (d): Here, $\frac{80}{100} I_E = 24$ mA or $I_E = \frac{24 \times 100}{80}$ mA

$$I_B = \frac{20}{100} I_E = \frac{20}{100} \times \frac{24 \times 100}{80} \text{ mA} = 6 \text{ mA}.$$

43. (b): Given equation, $e = 80 \sin 100\pi t$ ...(i)

Instantaneous voltage is given by

$e = e_m \sin\omega t$ ...(ii)

Compare (i) and (ii), we get $e_m = 80$ V

where e_m is the voltage amplitude.

Current amplitude $I_m = \frac{e_m}{Z}$ where, Z = impedance

$I_m = \frac{80}{20} = 4$ A

Effective current or root mean square current,

$$I_{\text{rms}} = \frac{4}{\sqrt{2}} = \frac{4\sqrt{2}}{2} = 2\sqrt{2} = 2.828 \text{ A}.$$

44. (d): Let a be the common acceleration of the system. The equations of motion of masses M_1 and M_2 are

$T_1 = M_1 a$ ...(i)

$T_2 - T_1 = M_2 a$ ...(ii)

Adding (i) and (ii), we get $T_2 = (M_1 + M_2)a$

$\therefore \quad \frac{T_1}{T_2} = \frac{M_1}{M_1 + M_2}$

45. (a) : We know $\beta = \frac{\lambda D}{d}$

If D is increased $\Rightarrow \beta$ increases.

so the width of interference fringes increases

46. (c) : Distance between two arallel wires $(x) = 10$ cm $= 0.1$ m; current in each wire $= I_1 = I_2 = 10$ A and length of wire $(l) = 1$ m.

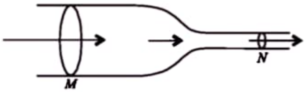
$\therefore \quad$ Force on the wire $(F) = \frac{\mu_0 I_1 \cdot I_2 \times l}{2\pi x}$

$$= \frac{(4\pi \times 10^{-7}) \times 10 \times 10 \times 1}{2\pi \times 0.1} = 2 \times 10^{-4} \text{ N}$$

COMIC CAPSULE

Since the current is flowing in the same direction, therefore the force will be attractive.

47. (d):



According to principle of continuity, for a streamline flow of fluid through a tube of non-uniform cross-section the rate of flow of fluid is same at every point in the tube.

i.e., Av = constant or $A_1v_1 = A_2v_2$

Therefore, the rate of flow of fluid is same at M and N.

48. (a): Here, $u = -16$ cm, $v = 4$ cm, $f = ?$

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}=\frac{1}{4}-\frac{1}{16}=\frac{4-1}{16}=\frac{3}{16} \Rightarrow f=\frac{16}{3}=5.33\text{ cm}$$

Focal length is positive, so the mirror must be convex and image is virtual, erect and diminished.

$R = 2f = 2 \times 5.33 = 10.66$ cm

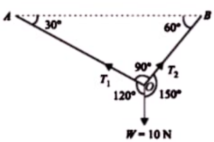
49. (b): Here, $\theta = 30°$, $E = 2 \times 10^5$ N C^{-1}

$\tau = 4$ N m, $l = 2$ cm $= 0.02$ m; $\tau = pE\sin\theta = (ql)E\sin\theta$

$$\therefore\ q=\frac{\tau}{El\sin\theta}=\frac{4}{2\times10^5\times0.02\times\frac{1}{2}}=2\text{ mC}$$

50. (c): Various forces acting on the ball are shown in figure. Applying Lami's theorem,

$$\frac{T_1}{\sin150°}=\frac{T_2}{\sin120°}=\frac{10}{\sin90°}\text{ or }\frac{T_1}{\sin30°}=\frac{T_2}{\sin60°}=\frac{10}{1}$$



$\therefore\ T_1 = 10\sin30° = 10 \times 0.5 = 5$ N and $T_2 = 10\sin60$

$$=10\times\frac{\sqrt{3}}{2}=5\sqrt{3}\text{ N}$$

51. (d): $$S=\frac{I_gG}{I-I_g}=\frac{0.01\times25}{10-0.01}=\frac{25}{999}\ \Omega.$$

52. (b): $i = neAv_d$

v_d is of order of few m s^{-1}, $e = 1.6 \times 10^{-19}$ C,

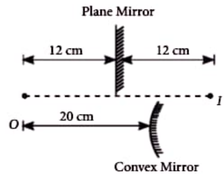
A is of the order of mm^2, so a large I is due to a large value of n in conductors.

53. (b): Equivalent resistance $$=\frac{(3+3)\times3}{(3+3)+3}=\frac{18}{9}=2\ \Omega$$

$$\therefore\ \text{Current } i=\frac{V}{R}=\frac{3}{2}=1.5\text{ A}.$$

54. (b)

55. (b) : The image by the plane mirror is formed 12 cm behind it. Since the two images coincide, it means image is formed 4 cm behind the convex mirror.



For the convex mirror, $u = -20$ cm, $v = +4$ cm

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{4}+\frac{1}{-20}=\frac{1}{f} \Rightarrow f=+5\text{ cm}.$$

56. (d): Since $x = 1.2t^2$ which is in form $x=\frac{1}{2}at^2$.

Thus, the motion is uniformly accelerated.

57. (c): Magnitude as well as polarities of charges at points A and C are same. Therefore, forces at O, due to these charges cancel each other. Moreover, polarities of the charges at B and D are opposite; therefore force on charge kept at the centre is along the diagonal BD.

58. (b)

59. (b): In case of spring, frequency $=\frac{1}{2\pi}\sqrt{\frac{K}{m}}$

As per question, the two springs are in parallel in horizontal position, effective force constant $= 2K$,

$$f=\frac{1}{2\pi}\sqrt{\frac{2K}{m}}\ ;\quad f'=\frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

when one spring is removed, $f'=\frac{f}{\sqrt{2}}$.

60. (c)

Exam on 28th April 2024

WB JEE PRACTICE PAPER 2024

Category-I (Q.1 to 30)

(Carry 1 mark each. Only one option is correct. Negative marks –¼)

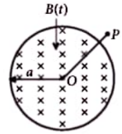
1. The quantity $\left(\frac{nh}{2\pi qB}\right)^{1/2}$, where n is a positive integer, h is Planck's constant, q is charge and B is magnetic field, has the dimensions of
   (a) area (b) speed
   (c) length (d) acceleration

2. An object moving with a speed of 6.25 m s^{-1}, is decelerated at a rate given by $\frac{dv}{dt} = -2.5\sqrt{v}$, where v is the instantaneous speed. The time taken by the object to come to rest, would be
   (a) 2 s (b) 4 s (c) 8 s (d) 1 s

3. A block released from rest from the top of a smooth inclined plane of angle θ_1 reaches the bottom in t_1. The same block released from rest from the top of another smooth inclined plane of angle θ_2, reaches the bottom in time t_2. If the two inclined planes have the same height, the relation between t_1 and t_2 is
   (a) $\frac{t_2}{t_1} = \left(\frac{\sin\theta_1}{\sin\theta_2}\right)^{1/2}$ (b) $\frac{t_2}{t_1} = 1$
   (c) $\frac{t_2}{t_1} = \frac{\sin\theta_1}{\sin\theta_2}$ (d) $\frac{t_2}{t_1} = \frac{\sin^2\theta_1}{\sin^2\theta_2}$

4. A satellite is orbiting around the earth with total energy E. What will happen if the satellite's kinetic energy is made $2E$?
   (a) Radius of the orbit is doubled
   (b) Radius of the orbit is halved
   (c) Period of revolution is doubled
   (d) Satellite escapes away

5. A uniform but time-varying magnetic field $B(t)$ exists in a circular region of radius a and is directed into the plane of the paper, as shown in the figure. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region



   (a) is zero (b) decreases as $\frac{1}{r}$
   (c) increases as r (d) decreases as $\frac{1}{r^2}$.

6. 5 mole of an ideal gas with $\gamma = 7/5$ initially at STP are compressed adiabatically so that its temperature becomes 400°C. The increase in the internal energy of gas in kJ is
   (a) 21.55 (b) 41.55 (c) 65.55 (d) 50.55

7. When a wire of length 10 m is subjected to a force of 100 N along its length, the lateral strain produced is 0.01×10^{-3}. The Poisson's ratio was found to be 0.4. If the area of cross-section of wire is 0.025 m^2, its Young's modulus is
   (a) 1.6×10^8 N m^{-2} (b) 2.5×10^{10} N m^{-2}
   (c) 1.25×10^{11} N m^{-2} (d) 16×10^9 N m^{-2}

8. An insulated container containing n moles of monoatomic gas of molar mass m is moving with a velocity v_0. If the container is suddenly stopped, find the change in temperature.
   (a) $\frac{mnv_0^2}{3R}$ (b) $\frac{mv_0^2}{3nR}$ (c) $\frac{mnv_0^2}{R}$ (d) $\frac{mv_0^2}{2R}$

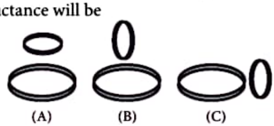
9. An object of mass 40 kg and having velocity 4 m s^{-1} collides with another object of mass 60 kg, having velocity 2 m s^{-1}. The loss of kinetic energy when the collision is perfectly inelastic is
   (a) 392 J (b) 440 J (c) 48 J (d) 110 J

10. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on
(a) ω and q (b) ω, q and m
(c) q and m (d) ω and m

11. The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$,
$$E_y = 2.5\frac{\text{N}}{\text{C}}\cos\left[\left(2\pi\times10^6\frac{\text{rad}}{\text{s}}\right)t-\left(\pi\times10^{-2}\frac{\text{rad}}{\text{m}}\right)x\right], E_z = 0.$$
The wave is
(a) moving along the + x direction with frequency 10^6 Hz and wavelength 100 m.
(b) moving along + x direction with frequency 10^6 Hz and wavelength 200 m.
(c) moving along – x direction with frequency 10^6 Hz and wavelength 200 m.
(d) moving along + y direction with frequency $2\pi\times10^6$ Hz and wavelength 200 m.

12. When 100 V dc is applied across a coil, a current of 1 A flows through it. When 100 V, 50 Hz ac is applied to the same coil, only 0.5 A flows. The inductance of the coil is
(a) 5.5 mH (b) 0.55 mH
(c) 55 mH (d) 0.55 H

13. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



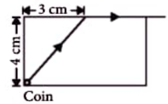
(a) maximum in situation (A)
(b) maximum in situation (B)
(c) maximum in situation (C)
(d) the same in all situation

14. A coil having 500 square loops each of side 10 cm is placed normal to a magnetic field which increased at a rate of 1.0 T/s. Find the induced e.m.f. (in volt).
(a) 5 (b) 10 (c) 15 (d) 20\

15. A 50 μF capacitor is connected to an ac source $V = 220 \sin 50t$ where V is in volt and t is in second. The rms current is
(a) 0.55 A (b) $\frac{0.55}{\sqrt{2}}$ A (c) $\frac{\sqrt{2}}{0.55}$ A (d) $\sqrt{2}$ A

16. In a Young's double slit experiment, $d = 0.5$ mm and $D = 100$ cm. It is found that 9^{th} bright fringe is at a distance of 7.5 mm from the second dark fringe of fringe pattern. The wavelength of light used is (in Å)
(a) $\frac{2500}{7}$ (b) 2500 (c) 5000 (d) $\frac{5000}{7}$

17. A small coin is resting on the bottom of a beaker filled with liquid. A ray of light from the coin travels upto the surface of the liquid and moves along its surface.



How fast is the light travelling in the liquid?
(a) 2.4×10^8 m s^{-1} (b) 3.0×10^8 m s^{-1}
(c) 1.2×10^8 m s^{-1} (d) 1.8×10^8 m s^{-1}

18. A 250 turn rectangular coil of length 2.1 cm and width 1.25 cm carries a current of 85 μA and subjected to a magnetic field of strength 0.85 T. Work done for rotating the coil by 180° against the torque is
(a) 4.55 μJ (b) 2.3 μJ (c) 1.15 μJ (d) 9.5 μJ

19. A shell of mass 100 g moving with speed of 50 m s^{-1} along a straight line inclined at an angle $\tan^{-1}\left(\frac{4}{3}\right)$ to the horizontal bursts into two pieces. The piece of mass 60 g starts moving horizontally with a speed of 50 m s^{-1}. The other piece moves with a speed of
(a) 50 m s^{-1} opposite to the first piece
(b) 100 m s^{-1} in vertically downward direction
(c) 50 m s^{-1} in the same direction as the first piece
(d) zero (remains at rest)

20. If K_1 and K_2 are maximum kinetic energies of photoelectrons emitted when lights of wavelength λ_1 and λ_2 respectively incident on a metallic surface. If $\lambda_1 = 3\lambda_2$, then
(a) $K_1 > (K_2/3)$ (b) $K_1 < (K_2/3)$
(c) $K_1 = 3K_2$ (d) $K_2 = 3K_1$

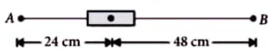
21. An electric dipole of dipole moment p is aligned parallel to a uniform electric field E. The energy required to rotate the dipole by 90° is
(a) p^2E (b) pE (c) infinity (d) pE^2

22. A system is taken from a given initial state to a given final state along various paths represented on a P-V diagram. The quantity that is independent of the path is
(a) amount of heat transferred Q
(b) amount of work done W
(c) Q but not W
(d) $(Q - W)$

23. The centre of mass of a system of three particles of masses 1 g, 2 g and 3 g is taken as the origin of a coordinate system. The position vector of a fourth particle of mass 4 g such that the centre of mass of the four particle system lies at the point (1, 2, 3) is $\alpha(\hat{i}+2\hat{j}+3\hat{k})$, where α is a constant. The value of α is
(a) $\frac{10}{3}$ (b) $\frac{5}{2}$ (c) $\frac{1}{2}$ (d) $\frac{2}{5}$

24. The rate of flow of glycerine of density 1.25×10^3 kg/m^3 through the conical section of a pipe, if the radii of its ends are 0.1 m and 0.04 m and the pressure drop across its length is 10 N/m^2 is
(a) 5.28×10^{-4} m^3/s (b) 6.28×10^{-4} m^3/s
(c) 7.28×10^{-4} m^3/s (d) 8.28×10^{-4} m^3/s

25. A bar magnet of length 3 cm has points A and B along its axis at distances of 24 cm and 48 cm on the opposite sides as shown in figure.



Ratio of magnetic fields at these points will be
(a) 8 (b) 1/2
(c) 3 (d) 4

26. An LCR circuit contains $R = 50\ \Omega$, $L = 1$ mH and $C = 0.1\ \mu$F. The impedance of the circuit will be minimum for a frequency of
(a) $\frac{10^5}{2\pi}$ Hz (b) $\frac{10^6}{2\pi}$ Hz
(c) $2\pi \times 10^5$ Hz (d) $2\pi \times 10^6$ Hz

27. The apparent depth of a needle lying in a water beaker is found to be 9 cm. If water is replaced by a liquid of refractive index 1.5, then the apparent depth of needle will be (μ of water is 4/3)
(a) 10 cm (b) 9 cm (c) 12 cm (d) 8 cm

28. Two astronauts have deserted their spaceships in a region of space far from the gravitational attraction of any other body. Each astronaut has a mass of 100 kg and they are 100 m apart. They are initially at rest relative to one another. How long will it be before the gravitational attraction brings them 1 cm closer together?
(a) 2.52 days (b) 1.41 days
(c) 0.70 day (d) 0.41 day

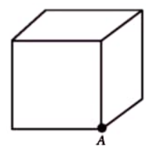
29. A proton of velocity $(3\hat{i}+2\hat{j})$ m s^{-1} enters a field of magnetic induction $(2\hat{j}+3\hat{k})$ tesla. The acceleration produced in the proton in m s^{-2} is (specific charge of proton = 0.96×10^8 C kg^{-1})
(a) $2.8\times10^8\,(2\hat{i}-3\hat{j})$
(b) $2.88\times10^8\,(2\hat{i}-3\hat{j}+2\hat{k})$
(c) $2.8\times10^8\,(2\hat{i}+3\hat{k})$
(d) $2.88\times10^8\,(\hat{i}-3\hat{j}+2\hat{k})$

30. Calculate the neutron separation energy from the following data
$m\left({}^{40}_{20}\text{Ca}\right) = 39.962591$ u; $m\left({}^{41}_{20}\text{Ca}\right) = 40.962278$ u;
$m_n = 1.00865$, 1 u = 931.5 MeV/c^2
(a) 7.57 MeV (b) 8.35 MeV
(c) 9.12 MeV (d) 9.56 MeV

Category - II (Q.31 to 35)

(Carry 2 marks each. Only one option is correct. Negative marks –½)

31. The total flux through the faces of the cube with side of length 'a' if a charge q is placed at corner A of the cube is

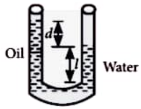


(a) $\frac{q}{8\varepsilon_0}$ (b) $\frac{q}{4\varepsilon_0}$
(c) $\frac{q}{2\varepsilon_0}$ (d) $\frac{q}{\varepsilon_0}$

32. A stone falls freely from rest and the total distance covered by it in the last second of its motion equals the distance covered by it in the first three seconds of its motion. The stone remains in the air for
(a) 6 s (b) 5 s
(c) 7 s (d) 4 s

33. A cup of coffee cools from 50°C to 45°C in 5 minutes and to 40°C in another 8 minutes. Find the temperature of the surroundings.
(a) 19° C (b) 28° C
(c) 34° C (d) 52° C

34. The U-tube contains two liquids as shown in static equilibrium. Water of density ρ_w (= 998 kg m^{-3}) is in the right arm and the oil of unknown density ρ_x is in the left. Measurement gives l = 135 mm and d = 12.3 mm. What is the density of the oil?



(a) 824 kg/m^3 (b) 1024 kg/m^3
(c) 1268 kg/m^3 (d) 915 kg/m^3

35. A parallel plate capacitor is charged and then isolated. The effect of increasing the plate separation on charge, potential and capacitance respectively are
(a) increases, decreases, decreases
(b) constant, increases, decreases
(c) constant, decreases, decreases
(d) constant, decreases, increases

Category-III (Q.36 to 40)

(Carry 2 marks each. One or more options are correct. No negative marks)

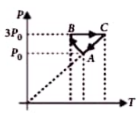
36. Two long, thin, parallel conductors are kept very close to each other, without touching. One carries a current I, and the other has charge λ per unit length. An electron moving parallel to the conductors is undeflected. Let c be the velocity of light and v be the velocity of electron, then

(a) $v = \frac{\lambda c^2}{I}$ (b) $v = \frac{I}{\lambda}$

(c) $c = \frac{I}{\lambda}$

(d) the electron may be at any distance from the conductor.

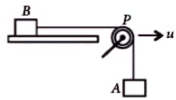
37. One mole of monoatomic gas is taken through cyclic process as shown in the diagram. T_A = 300 K. Process AB is defined as PT = constant.



Select the correct statements.
(a) Work done in process AB is – 400 R.
(b) Change in internal energy in process CA is 800 R.
(c) Heat transferred in the process BC is 2000 R.
(d) Change in internal energy in process CA is –900 R.

38. It is observed that only 0.39% of the original radioactive sample remains undecayed after eight hours. Select the correct options.
(a) The half-life of that substance is 1 hour.
(b) The mean life of the substance is $\frac{1}{\ln 2}$ hour.
(c) Decay constant of the substance is ln2 per hour.
(d) If the number of radioactive nuclei of this substance at a given instant is 10^8 then the number left after 30 min would be $\sqrt{2}\times 10^7$.

39. In the figure, the pulley P moves to the right with a constant speed u. The downward speed of A is v_A and the speed of B to the right is v_B. Then,



(a) $v_A = v_B$ (b) $v_B = u + v_A$
(c) $v_B + u = v_A$
(d) the two blocks have accelerations of the same magnitude.

40. Water is flowing smoothly through a closed pipe system. At one point A, the speed of the water is 3.0 m s^{-1} while at another point B, 1.0 m higher, the speed is 4.0 m s^{-1}. The pressure at A is 20 kPa when the water is flowing and 18 kPa when the water flow stops. Then
(a) the pressure at B when water is flowing is 6.7 kPa.
(b) the pressure at B when water is flowing is 8.2 kPa.
(c) the pressure at B when water stops flowing is 10.2 kPa.
(d) the pressure at B when water stops flowing is 8.2 kPa.

SOLUTIONS

1. (c) : Consider the expression for the energy of a photon $E = h\upsilon$ to get the dimensions of h as those of (energy × time). Again the expression for the force F acting on the charge q moving with velocity v in a magnetic field is $qvB\sin\theta$. This gives the dimensions of qB as those of (force/velocity).

$$\therefore \left(\frac{nh}{2\pi qB}\right)^{1/2} = \left(\frac{\text{Energy}\times\text{time}}{\text{Force / velocity}}\right)^{1/2} = \text{displacement,}$$

which is having the same dimensions as that of length.

2. (a) : Given: $\frac{dv}{dt} = -2.5\sqrt{v}$ or $\frac{dv}{\sqrt{v}} = -2.5\,dt$

Integrating both sides within the given conditions, we get

$$\therefore \int_{6.25}^{0} \frac{dv}{\sqrt{v}} = \int_{0}^{t} -2.5\, dt$$

$$2[\sqrt{v}]_{6.25}^{0} = -2.5t \text{ or } -2\sqrt{6.25} = -2.5t \text{ or } t = 2 \text{ s}$$

3. (c) : Lengths of the two inclined planes are

$$l_1 = \frac{h}{\sin\theta_1} \text{ and } l_2 = \frac{h}{\sin\theta_2}$$

Accelerations of the block down the two planes are $a_1 = g\sin\theta_1$ and $a_2 = g\sin\theta_2$

$$\text{As } l_1 = \frac{1}{2}a_1t_1^2 \text{ and } l_2 = \frac{1}{2}a_2t_2^2$$

$$\therefore \frac{l_1}{l_2} = \frac{a_1t_1^2}{a_2t_2^2} \text{ or } \frac{t_2^2}{t_1^2} = \frac{a_1l_2}{a_2l_1} = \frac{g\sin\theta_1}{g\sin\theta_2} \times \frac{\sin\theta_1}{\sin\theta_2}$$

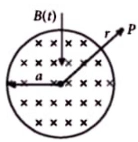
$$\therefore \frac{t_2}{t_1} = \frac{\sin\theta_1}{\sin\theta_2}$$

4. (d) : Kinetic energy of the satellite orbiting the earth is $E = \frac{1}{2}mv^2$, where v is the orbital velocity.

$$\therefore 2E = \frac{1}{2}m(\sqrt{2}v)^2$$

$\sqrt{2}v$ is the escape velocity of the satellite from the earth.
$\therefore$ When the kinetic energy of satellite is made $2E$, satellite escapes away.

5. (b) : Magnetic field $B(t)$ is directed into the plane of the paper. P lies outside the field.



$$\oint \vec{E} \cdot d\vec{l} = \frac{d\phi}{dt}$$

$$\text{or } E(2\pi r) = \frac{d}{dt}(\vec{B}\cdot\vec{A})$$

$$\text{or } 2\pi rE = \pi a^2\left(\frac{dB}{dt}\right)\cos 0° \text{ or } E = \frac{a^2}{2r}\frac{dB}{dt} \text{ or } E \propto \frac{1}{r}$$

6. (b) : Here, $n = 5$, $\gamma = 7/5$, $T_1 = 0°C$, $T_2 = 400°C$

$$dU = \frac{nR\,dT}{\gamma - 1}$$

$$= \frac{5 \times 8.31 \times (400 - 0)}{(7/5) - 1} = 41550 \text{ J} = 41.55 \text{ kJ}$$

7. (a) : Poisson's ratio $= \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$

$$\text{Longitudinal strain} = \frac{\text{Lateral strain}}{\text{Poisson's ratio}}$$

$$= \frac{0.01 \times 10^{-3}}{0.4} \quad \text{...(i)}$$

$$\text{Young's modulus, } Y = \frac{\text{Normal stress}}{\text{Longitudinal strain}}$$

$$Y = \frac{F}{A \times \left(\frac{0.01 \times 10^{-3}}{0.4}\right)} \quad \text{(Using (i))}$$

$$= \frac{100 \times 0.4}{0.025 \times 0.01 \times 10^{-3}} \text{ N m}^{-2} = 1.6 \times 10^8 \text{ N m}^{-2}$$

8. (a) : There is n moles of the monoatomic gas in the container.
molar mass of the gas $= m$,
Total mass of the gas in the container, $M = mn$
Change in KE of the gas when the container is suddenly stopped, *i.e.*,

$$\Delta K = (\text{KE})_{\text{initial}} - (\text{KE})_{\text{final}} = \frac{1}{2}Mv_0^2 - 0 = \frac{1}{2}Mv_0^2 = \frac{1}{2}mnv_0^2$$

This change in kinetic energy (ΔK) result in a change in internal energy (ΔU) of the gas.

$$\Delta U = nC_V\Delta T = n\left(\frac{3}{2}R\right)\Delta T$$

Here, ΔT is the change in temperature of the gas.

$$\text{As } \Delta U = \Delta K; n\left(\frac{3}{2}R\right)\Delta T = \frac{1}{2}mnv_0^2 \quad \therefore \Delta T = \frac{mnv_0^2}{3R}$$

9. (c) : Here, $m_1 = 40$ kg, $u_1 = 4$ m s^{-1}
$m_2 = 60$ kg, $u_2 = 2$ m s^{-1}
According to law of conservation of linear momentum, we get
$(m_1 + m_2)v = m_1u_1 + m_2u_2$

$$v = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} = \frac{40 \times 4 + 60 \times 2}{40 + 60} = 2.8 \text{ m s}^{-1}$$

$$\text{Loss in KE} = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

$$= \frac{1}{2}[40 \times 16 + 60 \times 4 - 100 \times 2.8^2] = 48 \text{ J}$$

10. (c) : Ratio of magnetic moment and angular momentum is given by $\frac{M}{L} = \frac{q}{2m}$

which is a function of q and m only. This can be derived as follows;

$$M = IA = (q\upsilon)(\pi r^2) = (q)\left(\frac{\omega}{2\pi}\right)(\pi r^2) = \frac{q\omega r^2}{2}$$

$$\text{and } L = I\omega = (mr^2\omega) \therefore \frac{M}{L} = \frac{q\omega r^2/2}{mr^2\omega} = \frac{q}{2m}$$

11. (b) : Given, $E_x = 0$,

$$E_y = 2.5\ \frac{N}{C}\ \cos\left[\left(2\pi\times10^6\ \frac{rad}{s}\right)t - \left(\pi\times10^{-2}\ \frac{rad}{m}\right)x\right],$$

$E_z = 0$.

This shows that the wave is propagating along $+x$ direction.

Comparing the given equation with

$E_y = E_0\cos(\omega t - kx)$, we get

$\omega = 2\pi\times10^6$ or $2\pi\upsilon = 2\pi\times10^6$ or $\upsilon = 10^6$ Hz

and $k = \pi\times10^{-2}$ or $k = \frac{2\pi}{\lambda} = \pi\times10^{-2}$

or $\lambda = \frac{2\pi}{\pi\times10^{-2}} = 200$ m

12. (d) : $R = \frac{V}{I} = \frac{100\ V}{1\ A} = 100\ \Omega$

$$Z = \frac{V_{rms}}{I_{rms}} = \frac{100\ V}{0.5\ A} = 200\ \Omega$$

As $R^2 + X_L^2 = Z^2$

$$X_L = \sqrt{Z^2 - R^2} = \sqrt{200^2 - 100^2} = 100\sqrt{3}\ \Omega$$

As $X_L = \omega L = 2\pi\upsilon L = 2\pi\times50\times L$

$$\therefore\ L = \frac{X_L}{100\pi} = \frac{100\sqrt{3}}{100\pi} = 0.55\ H$$

13. (a) : Magnetic field of one coil passing through other coil in case A is maximum so mutual induction is also maximum in case A.

14. (a) : $e = \left|-\frac{d\phi}{dt}\right| = Na^2\frac{dB}{dt} = 5$ volt

15. (b) : On comparing $V = 220\sin 50t$ with $V = V_0\sin\omega t$, we get

$V_0 = 220$ V and $\omega = 50$ rad s^{-1}

$\therefore$ The capacitive reactance is

$$X_C = \frac{1}{\omega C} = \frac{1}{(50\ rad\ s^{-1})(50\times10^{-6}\ C)} = \frac{10^4}{25}\Omega$$

$\therefore$ The rms current is

$$I_{rms} = \frac{V_{rms}}{X_C} = \frac{V_0/\sqrt{2}}{X_C}\quad \left(\because V_{rms} = \frac{V_0}{\sqrt{2}}\right)$$

$$= \frac{220/\sqrt{2}V}{10^4/25\Omega} = \frac{220\times25}{10^4\times\sqrt{2}}A = \frac{0.55}{\sqrt{2}}A$$

16. (c) : For bright fringes, $x = \frac{n\lambda D}{d}$

where $n = 0, 1, 2, 3, \ldots$

For dark fringes, $x = \frac{(2n-1)\lambda D}{2d}$

where $n = 1, 2, 3, \ldots$

As per question,

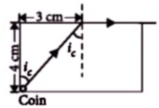
$$\frac{9\lambda D}{d} - \frac{3\lambda D}{2d} = 7.5\times10^{-3}\ m \text{ or } \frac{15\lambda D}{2d} = 7.5\times10^{-3}\ m$$

or $\lambda = \frac{2\times7.5\times10^{-3}\ m\times d}{15D}$

Substituting the given values, we get

$$\lambda = \frac{2\times7.5\times10^{-3}\ m\times0.5\times10^{-3}\ m}{15\times1\ m} = 5000\ Å$$

17. (d) : As $\sin i_c = \frac{3}{\sqrt{3^2+4^2}} = \frac{3}{5}$



$$\therefore\ \mu = \frac{1}{\sin i_c} = \frac{5}{3}$$

(as i_c is the angle which the ray from the coin makes with 4 cm side)

As, refractive index, $\mu = \frac{c}{v_l}$

$$\therefore\ v_l = \frac{c}{\mu} = \frac{3\times10^8\ m\ s^{-1}}{(5/3)} = 1.8\times10^8\ m\ s^{-1}$$

18. (d) : Work done in a coil, $W = mB(\cos\theta_1 - \cos\theta_2)$

When it is rotated by angle 180° then

$W = 2mB = 2(NIA)B$ ...(i)

Given: $N = 250$, $I = 85\ \mu A = 85\times10^{-6}$ A, $B = 0.85$ T

$A = 1.25\times2.1\times10^{-4}\ m^2 \approx 2.625\times10^{-4}\ m^2$

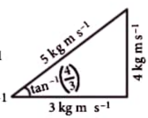
Putting these values in eqn. (i), we get

$W = 2\times250\times85\times10^{-6}\times2.625\times10^{-4}\times0.85$

$\approx 9.48\times10^{-6}\ J = 9.5\ \mu J$

19. (b) : Initial momentum

$$= \frac{100}{1000}\times50\ kg\ m\ s^{-1} = 5\ kg\ m\ s^{-1}$$



Horizontal momentum = 3 kg m s^{-1}

Vertical momentum = 4 kg m s^{-1}

The velocity of other piece of mass 40 g

$$= \frac{4\ kg\ m\ s^{-1}}{0.04\ kg} = 100\ m\ s^{-1}$$

To conserve momentum, it should be directed vertically downward.

20. (b)

21. (b) : Potential energy of dipole,

$U = -pE(\cos\theta_2 - \cos\theta_1)$

Here, $\theta_1 = 0°$, $\theta_2 = 90°$

$\therefore\ U = -pE(\cos90° - \cos0°) = -pE(0-1) = pE$

22. (d) : The only quantity $(Q - W)$ which itself is the internal energy of the system is independent of the path.

23. (b) : Let (x, y, z) coordinates of three particles of masses 1 g, 2 g and 3 g be (x_1, y_1, z_1), (x_2, y_2, z_2) and (x_3, y_3, z_3) respectively.

$\therefore$ The x-coordinate of the centre of mass is

$$X_{CM} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

or $0 = \frac{1x_1 + 2x_2 + 3x_3}{1+2+3}$ or $x_1 + 2x_2 + 3x_3 = 0$ ...(i)

Let the fourth particle of mass 4 g be placed at (x_4, y_4, z_4) so that the centre of mass of the four particles system lies at (1, 2, 3).

$$\therefore \quad 1 = \frac{x_1 + 2x_2 + 3x_4 + 4x_4}{1+2+3+4}$$

or $x_1 + 2x_2 + 3x_4 + 4x_4 = 10$ ...(ii)

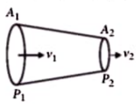
Subtract (i) from (ii), we get

$$4x_4 = 10 \text{ or } x_4 = \frac{10}{4} = \frac{5}{2}; \therefore \alpha = \frac{5}{2}$$

24. (b) : According to equation of continuity

$$\frac{v_2}{v_1} = \frac{A_1}{A_2} = \frac{\pi \times (0.1)^2}{\pi \times (0.04)^2} = \frac{25}{4} \quad ...(i)$$

According to Bernoulli's equation for horizontal tube,



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

or $v_2^2 - v_1^2 = \frac{2(P_1 - P_2)}{\rho}$

or $v_2^2 - v_1^2 = \frac{(2 \times 10)}{(1.25 \times 10^3)} = 16 \times 10^{-3}$ ...(ii)

Substituting the value of v_2 from equation (i) in (ii), we get

$(6.25v_1)^2 - v_1^2 = 16 \times 10^{-3}$ or $v_1 = 0.02$ m/s

So rate of flow through the tube

$= A_1v_1 = A_2v_2 = \pi \times (0.1)^2 \times 0.02 = 6.28 \times 10^{-4}$ m^3/s

25. (a) : When length $(2a)$ of the magnet is much shorter than the distance (r) of the point on the axial line where its magnetic field is to be found, $B \propto \frac{1}{r^3}$

$$\therefore \frac{B_A}{B_B} = \left(\frac{48 \text{ cm}}{24 \text{ cm}}\right)^3 = 8$$

26. (a) : The impedance of the LCR circuit will be minimum for a resonant frequency υ_r.

$$\upsilon_r = \frac{1}{2\pi\sqrt{LC}}$$

Here, $L = 1$ mH $= 1 \times 10^{-3}$ H, $C = 0.1$ μF $= 0.1 \times 10^{-6}$ F

$$\therefore \quad \upsilon_r = \frac{1}{2\pi\sqrt{(1 \times 10^{-3}\text{ H})(0.1 \times 10^{-6}\text{ F})}} = \frac{10^5}{2\pi}\text{ Hz}$$

27. (d) : Apparent depth $= \frac{\text{Real depth}}{\text{Refractive index}}$

$$\therefore \frac{\text{Apparent depth in water}}{\text{Apparent depth in liquid}} = \frac{\mu_{liq}}{\mu_{water}}$$

or $\frac{9}{\text{Apparent depth in liquid}} = \frac{1.5 \times 3}{4}$

$\therefore$ Apparent depth in liquid = 8 cm

28. (b) : Here, $m_1 = m_2 = 100$ kg, $r = 100$ m

Accelerations of first and second astronauts are

$$a_1 = \frac{Gm_1m_2}{r^2} \times \frac{1}{m_1} = \frac{Gm_2}{r^2} \text{ and } a_2 = \frac{Gm_1m_2}{r^2} \times \frac{1}{m_2} = \frac{Gm_1}{r^2}$$

Net acceleration of approach,

$$a = a_1 + a_2 = \frac{Gm_2}{r^2} + \frac{Gm_1}{r^2} = \frac{2Gm_1}{r^2} \quad (\because m_1 = m_2)$$

$$= \frac{2 \times (6.67 \times 10^{-11}) \times 100}{(100)^2} = 2 \times 6.67 \times 10^{-13} \text{ m s}^{-2}$$

$$\text{As, } s = \frac{1}{2}at^2 \Rightarrow t = \left(\frac{2s}{a}\right)^{1/2} = \left[\frac{2 \times (1/100)}{2 \times 6.67 \times 10^{-13}}\right]^{1/2} \text{ s}$$

$= 1.41$ days

29. (b) : Given :

$\vec{v} = (3\hat{i} + 2\hat{j})$ m s^{-1} and $\vec{B} = (2\hat{j} + 3\hat{k})$ tesla

Force experienced by the proton is

$$\vec{F} = q(\vec{v} \times \vec{B}) = q(3\hat{i} + 2\hat{j}) \times (2\hat{j} + 3\hat{k})$$

$$= q[6(\hat{i} \times \hat{j}) + 9(\hat{i} \times \hat{k}) + 4(\hat{j} \times \hat{j}) + 6(\hat{j} \times \hat{k})]$$

$$= 3q(2\hat{i} - 3\hat{j} + 2\hat{k}) \text{ newton}$$

$$\therefore \text{ Acceleration} = \frac{F}{m} = \frac{3q}{m}\,(2\hat{i} - 3\hat{j} + 2\hat{k})$$
$$= 3 \times (0.96 \times 10^8)(2\hat{i} - 3\hat{j} + 2\hat{k})\text{ m s}^{-2}$$
$$= 2.88 \times 10^8\,(2\hat{i} - 3\hat{j} + 2\hat{k})\text{ m s}^{-2}$$

30. (b) : When a neutron is separated from ${}^{41}_{20}\text{Ca}$, we are left ${}^{40}_{20}\text{C}$. So, ${}^{41}_{20}\text{Ca} \longrightarrow {}^{40}_{20}\text{Ca} + {}^{1}_{0}n$

Mass defect, $\Delta M = \left(m({}^{40}_{20}\text{Ca}) + m_n - m({}^{41}_{20}\text{Ca})\right)$

$= 39.962591 + 1.00865 - 40.962278 = 0.008963$ u

Neutron separation energy $= \Delta M c^2$

$= 0.008963 \times 931.5$ MeV $= 8.35$ MeV

31. (a)

32. (b) : Let the stone remain in air for t s.

From $s = ut + \frac{1}{2}gt^2$ Here, $u = 0$ $\therefore\ s = \frac{1}{2}gt^2$

Total distance travelled by the stone in last second is

$$D = s_t - s_{t-1} = \frac{1}{2}gt^2 - \frac{1}{2}g(t-1)^2 = \frac{g}{2}(2t-1) \quad \text{...(i)}$$

Distance travelled by the stone in first three seconds is

$$s_3 = \frac{1}{2} \times g \times 3^2 = \frac{9}{2}g$$

According to given problem, $D = S_3$

$$\therefore\ \frac{g}{2}(2t-1) = \frac{9}{2}g \text{ or } 2t - 1 = 9;\ t = 5\text{ s}$$

33. (c) : The mean temperature of coffee as it cools from 50°C to 45°C is $\left(\frac{50+45}{2}\right)$°C $= 47.5$°C.

The rate of decrease of temperature is

$$\frac{50°\text{C} - 45°\text{C}}{5\text{ min}} = \frac{1°\text{C}}{\text{min}}$$

Newton's law of cooling is

$$\frac{d\theta}{dt} = -K(\theta - \theta_0) \Rightarrow \frac{-1°\text{C}}{\text{min}} = K[47.5 - \theta_0] \quad \text{...(i)}$$

Since, the time taken for the temperature to become 40°C is 8 minutes,

During this period, $\frac{d\theta}{dt} = \left[\frac{45°\text{C} - 40°\text{C}}{8\text{ min}}\right] = \frac{5°\text{C}}{8\text{ min}}$

The mean temperature is $\left(\frac{45+40}{2}\right)$°C $= 42.5$°C

$$\text{Now, } \frac{-d\theta}{dt} = K(\theta - \theta_0) \Rightarrow \frac{-5°\text{C}}{8\text{ min}} = K[42.5 - \theta_0] \quad \text{...(i)}$$

From eqn. (i) ÷ (ii), we get

$$\frac{8}{5} = \frac{47.5 - \theta_0}{42.5 - \theta_0} \Rightarrow 8(42.5 - \theta_0) = 5(47.5 - \theta_0)$$

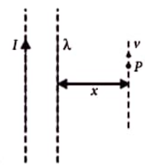
or $\theta_0 = 34.1$°C $\Rightarrow \theta_0 = 34$°C.

34. (d) : Pressure at the interface level due to the left arm and right arm can be equated.

$$(P_{\text{int}})_{\text{left}} = (P_{\text{int}})_{\text{Right}}$$
$$P_0 + \rho_x g(l + d) = P_0 + \rho_w lg$$
$$\Rightarrow \rho_x = \frac{\rho_w l}{(l+d)} = (998\text{ kg/m}^3)\cdot\frac{135\text{mm}}{(135+12.3)\text{mm}}$$
$$= 915\text{ kg/m}^3.$$

35. (b) : As the capacitor is isolated after charging, charge Q on it remains constant. Plate separation d increases, capacitance decreases as $C = \frac{\varepsilon_0 A}{d}$ and hence, potential increases as $V = \frac{Q}{C}$.

36. (a, d) : At P, electric field,



$E = \frac{\lambda}{2\pi\varepsilon_0 x}$ (to the right),

and magnetic field, $B = \frac{\mu_0 I}{2\pi x}$ (into the paper)

For no deflection, $E = vB$ or $v = \frac{E}{B}$

$$\text{or } v = \frac{\lambda}{2\pi\varepsilon_0 x} \times \frac{2\pi x}{\mu_0 I} = \frac{\lambda}{I}\frac{1}{\varepsilon_0\mu_0} = \frac{\lambda c^2}{I}.\ \left(\because c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}\right)$$

37. (a, c, d) : Process AB : PT = constant = k

$$\Rightarrow \frac{nRT^2}{V} = k \Rightarrow \frac{dV}{dT} = \frac{2nRT}{k}$$

$$W_{AB} = \int_A^B PdV = \int_A^B \frac{k}{T}dV$$

$$W_{AB} = \int_{T_A}^{T_B} \frac{k}{T}\cdot\frac{2nRT}{k}dT$$

$$\text{Now, } \frac{P_A}{P_B} = \frac{T_B}{T_A} \Rightarrow \frac{1}{3} = \frac{T_B}{T_A} \Rightarrow T_B = \frac{300}{3} = 100\text{ K}$$

$$\therefore\ W_{AB} = \int_{300}^{100} 2nR\,dT = 2nR(100 - 300)$$

$\Rightarrow W_{AB} = -400nR = -400R$ $(\because n = 1$ mole$)$

Process CA : P/T = constant

$\therefore\ T_A/T_C = P_A/P_C$; $T_A/T_C = P_A/P_B$

$\Rightarrow T_A/T_C = 1/3 \quad \Rightarrow T_C = 3T_A$

or $T_C = 900$ K, $\Delta U = nC_V\Delta T$

$$= (1)\frac{3}{2}R \times (T_A - T_C) = \frac{3}{2}R \times (300 - 900) = -900R$$

Process BC : Isobaric, $Q = nC_P\Delta T$

$$\therefore\ Q = (1)\frac{5}{2}R \times (T_C - T_B)$$

$$Q = \frac{5}{2}R \times (900 - 100) = \frac{5}{2}R \times 800 = 2000R$$

38. (a, b, c) : Here, $t = 8$ hours

As $N = N_0e^{-\lambda t}$ [Law of radioactive decay]

$$\Rightarrow\ \frac{N}{N_0} = e^{-\lambda t} \Rightarrow 0.0039 = e^{-\lambda 8}$$

$$\Rightarrow\ e^{8\lambda} = \frac{1}{0.0039} = 256 \text{ or } e^{8\lambda} = 2^8$$

Taking natural logarithm on both sides, we get

$8\lambda = 8\ln 2$

$\lambda = \ln 2$ per hour

Option (c) is correct.

Again, half life = $T_{1/2} = \frac{\ln 2}{\lambda} = 1$ hour

Option (a) is correct.

Mean time, $\tau = \frac{1}{\lambda} = \frac{1}{\ln 2}$ hour

Option (b) is correct.

$$\therefore\ N = (10)^8\left(\frac{1}{2}\right)^{(1/2)} = \frac{1}{\sqrt{2}} \times 10^8 \text{ or } N = 5\sqrt{2} \times 10^7$$

Option (d) is incorrect.

39. (b, d) : At any instant of time, let the length of the string $BP = l_1$ and the length $PA = l_2$. In a further time t, let B move to the right by x and A move down by y, while P moves to the right by ut. As the length of the string must remain constant,

$l_1 + l_2 = (l_1 - x + ut) + (l_2 + y)$

or $x = ut + y$ or $\frac{dx}{dt} = u + \frac{dy}{dt}$

$\frac{dx}{dt}$ = speed of B to the right = v_B,

$\frac{dy}{dt}$ = downward speed of $A = v_A$ $\therefore v_B = u + v_A$

Also $\frac{dv_B}{dt} = \frac{dv_A}{dt}$ or $a_B = a_A$.

40. (a, d) : Let P_1, h_1, v_1 and P_2, h_2, v_2 represent the pressures, heights and velocities of flow at the two points A and B respectively. According to the Bernoulli's principle

$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2 \quad \text{...(i)}$$

Putting $v_1 = 3.0$ m s^{-1}, $v_2 = 4.0$ m s^{-1}, $(h_2 - h_1) = 1$ m, $P_1 = 20$ kPa

we get, $P_2 = 20 + \left[10^3 \times 9.8\,(-1) + \frac{10^3}{2}[9 - 16]\right]$

$= 20 - 9.8 - 3.5 = 6.7$ kPa

Also when the flow stops, $v_1 = v_2 = 0$ and then from (i),

$P_2' = 18 - 9.8 = 8.2$ kPa

SOLUTIONS TO FEBRUARY 2024 QUIZ CLUB

1. Battery
2. Yes, the condition is that vector sum of all forces acting on the body must be zero.
3. No. This is because, push is an internal force which cannot produce motion.
4. The function of shockers is to increase the time of impact.
5. No, centre of mass of a ring lies outside.
6. The gramophone records get charged due to rubbing action of the needle and attract the dust particles.
7. Bird's body is at same potential. No charge flows and no shock is produced. The man touching the ground maintains a potential difference between different parts of his body, which causes electrolysis of blood and causes death.
8. Zero
9. Projectile
10. Zero
11. Water acts as a lubricant reducing friction between the road and our feet.
12. The value of '*g*' on moon is small, therefore, the weight of moon travellers will also be small.
13. 1 millibar = 100 pascal
14. The coefficient of viscosity of liquid decreases with rise in temperature.
15. The room may become hotter, because amount of heat removed would be less than the amount of heat released in the room.
16. Increase
17. This reduces the force of friction due to air.
18. This is because rolling friction is less than the sliding friction.
19. Due to conservation of angular momentum, the helicopter itself will turn in the opposite direction of the propeller.
20. No

Winners : Chandrashekhar (West Bengal), Suraj (Chennai)

UCD Unique Career in Demand

Explore the available Unique Career Options!

B.Tech. in Meteorology

Meteorology is the science of weather. It is essentially an inter-disciplinary science because the atmosphere, land and ocean constitute an integrated system. The three basic aspects of meteorology are observation, understanding and prediction of weather. In recent years, the interest in meteorology has grown exponentially, with more individuals seeking to explore the intricacies of weather phenomena and contribute to the global understanding of climate science. Within meteorology there are a number of speciality fields which include climatology, severe storms and tornadoes, tropical cyclones, hydrology, and agriculture.

Courses Offered

For those aspiring to dwell deeper into this captivating discipline, India offers a range of meteorology courses that cater to various academic and career interests. Candidates can also pursue diploma courses to gain skills in specific aspects of meteorology.

- B.Tech. Meteorology/Atmospheric Sciences
- M.Tech. Meteorology/Atmospheric Sciences
- Bachelors of Science in Meteorology
- Masters of Science in Meteorology
- Diploma in Meteorology
- PhD in Meteorology

Eligibility Criteria

Eligibility requirements for BSc in Meteorology vary from college to college, but typically include: 10+2 or equivalent examination with Physics, Chemistry, and Mathematics as compulsory subjects. Some colleges may also require students to have taken an entrance exam.

The criteria for pursuing M. Tech or M.SC in Meteorology is to be a science graduate from a recognized university with 50%-60 % marks in aggregate.

The eligibility criteria for applying for PhD course is a postgraduate degree in Meteorology with at least 55% marks in aggregate. Admission to the program is done based on an entrance test followed by an interview conducted by the concerned university.

Top Colleges

- **Indian Institute of Tropical Meteorology, Pune**
- Government Institute of Science, Maharashtra
- A.B.V. Government Degree College, Warangal, Andhra Pradesh
- Shivaji University, Kolhapur, Maharashtra
- Aryabhata Research Institute of Observational Sciences, Uttarakhand
- Cochin University of Science & Technology, Cochin, Kerala
- Department of Atmospheric and Space Sciences, Savitribai Phule Pune University

Job Prospects

Meteorologists are found in the public sector (military, federal and state government), private sector (media, commercial companies, etc.), and academia (post graduate research, professorships). People with jobs in meteorology study conditions of the atmosphere to make forecasts and recommendations. If you're curious about the world's complex weather patterns and want to make a difference, a career in or relating to meteorology may be a perfect fit. Listed below are few of the career options under the field of Meteorology:

- Scientist
- Industrial Meteorologist
- Broadcast meteorologist
- Subject Matter Specialist
- Physical Meteorologist
- Hydrologist
- Airline Forecasters
- Research Meteorologist
- Environmental scientist
- Military Forecasters
- GIS technician

Indian Institute of Tropical Meteorology, Pune

The Indian Institute of Tropical Meteorology (IITM) is a scientific institution based in Pune, Maharashtra, India for expanding research in the tropical Indian Ocean with special reference to monsoon meteorology, and air-sea interaction of South Asian climate. The need to study the fundamental atmospheric problems and understand the mechanism of monsoon, weather systems and climate related processes in the tropical region, particularly over the monsoon region, became acute for India in 1950's when the country's post-Independence economic development program was launched. Considering this urgent need the World Meteorological Organization (WMO), recommended the creation of meteorological research and training institutes in the tropical countries as a result of which Indian Institute of Tropical Meteorology was established in the year 1962.

The institution offers M.Sc., M.Tech. and Ph.D. courses jointly under the aegis of the Department of Atmospheric and Space Sciences, University of Pune. Apart from degree-courses, students can also apply for summer or master's thesis projects to individual scientists based on their research.

The main motive of the institution is to develop outstanding research talent capable of understanding and exploring enlightened and effective Atmospheric sciences and to further the advancement of Research in Ocean-Atmosphere by undertaking relevant scientific programmes.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I	Column II
1. EECOLTRSTITACS	(a) Colour with least wavelength.
2. IOTEVL	(b) Rate of change of angular momentum with time.
3. OLALSY	(c) Ferromagnets turn into this when heated beyond curie temperature.
4. QUEROT	(d) The process of heat transfer in which heat is transmitted from one point to another due to actual motion of heated particles in liquids and gases.
5. OONETICCVN	(e) Change in momentum.
6. ECMEDIARHS	(f) Branch of physics dealing with static charges.
7. IPUMELS	(g) A unit of temperature.
8. SUILECS	(h) A mixture of two or more metals in varied amounts.
9. TAAARNEMPGS	(i) Device used to measure pressure of liquids and gases.
10. AMTEENMOR	(j) The person who discovered the concept of buoyancy.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

GK CORNER

Enhance Your General Knowledge with Current Updates!

SPORTS

- Sumit Nagal won his fifth ATP challenger tour becoming the first Indian to enter the top-100 since Prajnesh Gunneswaran in 2019.
- The Saurashtra Cricket Association Stadium (SCA), a cricket stadium in Rajkot, renamed as Niranjan Shah Stadium. It was renamed after veteran cricket player and administrator Niranjan Shah. The inauguration of the stadium was done by BCCI secretary Jay Shah. The ceremony was attended by both the Indian and English cricket teams, as well as BCCI Apex Council members and state association office-bearers.
- The Khelo India Winter Games 2024, the fourth edition of the annual event in the Khelo India calendar, was hosted by the Union Territory of Ladakh this year alongside the UT of Jammu & Kashmir. Leh was the venue for the first part of the Games from February 2-6, whereas its second part is scheduled in Gulmarg.
- The mascot of the Khelo India Winter Games 2024 was a snow leopard named 'Sheen-e She' or Shan. The logo integrates the Indian tricolour and symbols of Ladakh.

- Malvika Bansod ends international golden drought with triumph against Tanya Hemnath, in Baku in the international badminton tournament organised by Badminton World Federation (BWF).
- The SAFF Women's U-19 Championships concluded with India and Bangladesh being declared joint winners. The tournament held in Dhaka, witnessed a series of unusual occurrences that led to this unprecedented decision.
- Union Sports Minister, Anurag Singh Thakur opened 1st BIMSTEC Aquatics Championships in New Delhi. Championships were held at Dr. Syama Prasad Mookerjee Swimming Pool Complex from 6th February to 9th February 2024.
- Australia won U-19 World Cup 2024 by beating India to 79 runs. Australia have secured its fourth World Cup title in U-19 cricket.
- Abhinav Bindra, India's first individual Olympic gold medallist, was selected as torchbearer for the 2024 Paris Olympics. The ancient tradition of the Olympic Torch Relay continues its journey towards Paris 2024, with the flame set to cross the Mediterranean and embark on a 68-day adventure across France.
- Shooter Divyansh Singh Panwar, participant of Tokyo Olympics, clinched gold with a world record in 10m Air Rifle Event at the ISSF World Cup in Cairo.
- For the first time in history, The Telangana Football Association (TFA) has gained approval to host the FIFA World Cup qualifiers for India vs. Kuwait which will be held on 6 June this year in Hyderabad.
- Indian Boxer Mandeep Jangra, secured intercontinental title in U.S. after defeating American Gerardo Esquivel at Toppenish City, Washington.

Test Yourself!

1. What is the importance of torch of Olympic or Olympic flame?
(a) It symbolizes peace and friendship
(b) It symbolizes tolerance and hope
(c) It symbolizes the light of spirit, knowledge and life
(d) All of these

2. In which event did Divyansh Singh Panwar clinch gold medal?
(a) 50m Air Rifle Event
(b) 10m Air Rifle Event
(c) Trap Skeet
(d) 25m Rapid Fire Pistol

3. Saurashtra Cricket Association (SCA) was renamed after which cricket administrator?
(a) Joseph Pamensky
(b) Rohit Pawar
(c) Amitabh Choudhary
(d) Niranjan Shah

4. Where will the FIFA World Cup qualifiers between India and Kuwait be hosted?
(a) Hyderabad (b) Kuwait
(c) New Delhi (d) Ahmadi

5. Where was the 1^{st} BIMSTEC Aquatics Championships organized?
(a) Yamuna Sports Complex
(b) Dr. S.P.M Swimming Pool Complex
(c) Basavanagudi Aquatic Centre
(d) Velachery Aquatic Complex

6. Indian boxer Mandeep Jangra secured a remarkable triumph at the _________.
(a) US-based National Boxing Association's (NBA)
(b) UK-based National Boxing Association's (NBA)
(c) Sweden-based National Boxing Association's (NBA)
(d) Germany-based National Boxing Association's (NBA)

7. In which stadium was the opening ceremony of Khelo India Winter Games 2024 organised?
(a) Guru Dronacharya Stadium
(b) Indoor Stadium
(c) Nawang Dorjay Stobdan Stadium
(d) Sports Council Stadium

8. Where was SAFF Women's U-19 Championships held?
(a) Dhaka (b) Ladakh
(c) New Delhi (d) Saurashtra

9. Who is the youngest person to reach 2700 in chess?
(a) Vidit Gujrathi
(b) Wei Yi
(c) Rameshbabu Praggnanandhaa
(d) Javokhir Sindarov

10. What is the highest governing body for badminton?
(a) International Badminton Federation
(b) World Badminton Association
(c) Olympic International Federation
(d) Badminton World Federation

Answer Key

1. (d) 2. (b) 3. (d) 4. (a) 5. (b)
6. (a) 7. (c) 8. (a) 9. (b) 10. (d)

TRIO

The same THREE LETTERS will complete these six words.
Can you find the three-letter sequence?

HE– – – NG
REL– – – VITY
POLARIS– – – ON
RADI– – – ON
MONOCHROM– – – C
ELECTROST– – – CS

Readers can send their responses at editor@mtg.in or post us with complete address by 10^{th} of every month. Winners' names will be published in next issue.

BRUSH UP for NEET/JEE

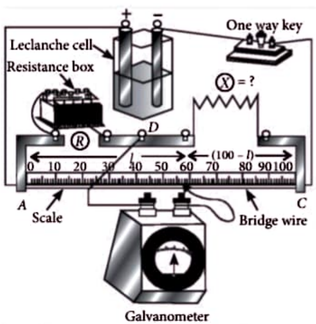
Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Experimental Skills

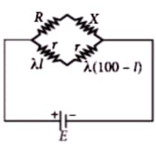
FIND RESISTIVITY OF THE MATERIAL OF A GIVEN WIRE USING METRE-BRIDGE

Theory

A metre bridge is a practical form of the wheatstone bridge. The circuit is connected as follows with the unknown resistance as one of the resistances.



The resistance R, the unknown resistance X, the wire of length l and the wire of length $(100 - l)$ act as the four arms of the wheatstone bridge.



If we take λ as the resistance per unit length, then λl and $\lambda(100 - l)$ will be the resistances of the wires, l and $(100 - l)$ respectively.

According to wheatstone bridge principle, at the null point.

$$\frac{R}{X} = \frac{\lambda \cdot l}{\lambda \cdot (100 - l)} \Rightarrow X = \frac{R}{l} \cdot (100 - l)$$

As resistivity $\rho = \frac{R \cdot A}{l}$ where A is the cross-section area of the resistance X and l is its length.

If D is the diameter of the wire X, then $A = \frac{\pi D^2}{4}$

$$\Rightarrow \rho = \frac{X \cdot \pi D^2}{4l}$$

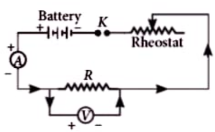
D is measured using a screw guage and thus specific resistance of X or its resistivity is determined.

FIND RESISTANCE OF A GIVEN WIRE USING OHM'S LAW.

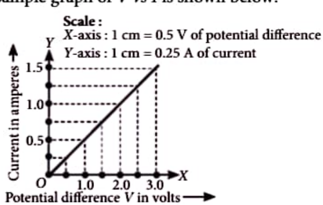
Construction

To use ohm's law, we require the following apparatus. A resistance wire, a voltmeter and an ammeter of appropriate range, a battery, a rheostat, a one way key and connecting wires.

Connect the elements as shown in the circuit diagram below.



The sample graph of V *vs* I is shown below:

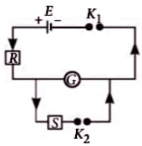


Resistance And Figure Of Merit Of A Galvanometer By Half-deflection Method.

A galvanometer is device (instrument) used for detecting feeble electric currents in circuits.

Resistance of Galvanometer

The connections for finding the resistance of a galvanometer by half deflection method are shown in figure. When key K_1 is closed and K_2 open, then current flowing through the galvanometer is given by



Resistance of galvanometer by half deflection method.

$$I = \frac{E}{R+G} = k\theta \quad \text{...(i)}$$

($\because$ current $\propto$ deflection in galvanometer)

where E is the E.M.F. of the cell, R is resistance from the resistance box, G is the galvanometer resistance and θ is the deflection in galvanometer for current I, k is proportionality constant (called figure of merit).

When key K_2 is also closed and the value of shunt resistance S is so adjusted that deflection in the galvanometer becomes $\frac{\theta}{2}$, then resistance of the parallel combination of G and S is $\frac{GS}{G+S}$ and current in the circuit is

$$I' = \frac{E}{R+\frac{GS}{G+S}} = \frac{E(G+S)}{R(G+S)+GS} \quad \text{...(ii)}$$

Of this current I', a fraction $\frac{S}{G+S}$ flows through the galvanometer given by

$$I_1' = \frac{I'S}{G+S} = \frac{ES}{R(G+S)+GS} = k\frac{\theta}{2}$$

$$\text{or } \frac{2ES}{R(G+S)+GS} = k\theta \quad \text{...(iii)}$$

Comparing Eqs. (i) and (iii),

$$\frac{E}{R+G} = \frac{2ES}{R(G+S)+GS} \quad \text{...(iv)}$$

By solving eq. (iv), we can find $G = \frac{RS}{R-S}$

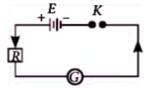
Figure of Merit of a Galvanometer

It is defined as the current required to produce a deflection of one division in the scale of galvanometer. Its symbol is k. (It is reciprocal of current sensitivity).

When current I produces a deflection θ in the galvanometer, then figure of merit is given by using Eq. (i),

$$k = \frac{I}{\theta} = \frac{E}{(R+G)\theta} \text{ or } k = \frac{E}{(R+G)\theta}$$

If n is the number of divisions in the galvanometer scale, then current required to produce full scale deflection is given by $I_g = nk$.



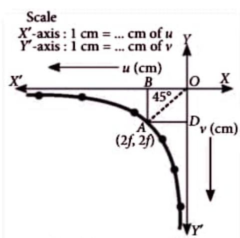
Focal Length of (i) Concave Mirror (ii) Convex Mirror (iii) Convex Lens, Using The Parallax Method.

(i) To find the value of v for different values of u in case of a concave mirror and to find its focal length by plotting graphs between u and v.

To perform the experiment, we require an optical bench with three uprights (zero end upright fixed, two outer uprights with lateral movement), concave mirror, a mirror holder, two optical needles (one thin, one thick), a knitting needle and a half metre scale.

Calculations of Focal Length Using Graph

***u-v* Graph** : Select a suitable but the same scale to represent u along X'-axis and v along Y'-axis. According to sign conventions, in this case u and v both are negative. Plot the various points for different sets of values of u and v from the observation table. The graph comes out to be a rectangular hyperbola as shown in figure.



Graph between u and v

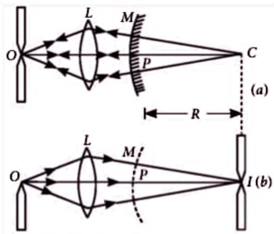
Draw a line OA making an angle of 45° with either axis (*i.e.*, bisecting $\angle Y'OX'$) and meeting the curve at point A. Draw AB and AD perpendicular on X' and Y'-axis respectively. The values of u and v will be same for point A. So the coordinates of point A must be $(2f, 2f)$ because for a concave mirror u and v are equal only when the object is placed at the centre of curvature.

Hence, $u = v = R = 2f$

(ii) To find the focal length of a convex mirror using a convex lens.

To perform the experiment, we require an optical bench with four uprights (two fixed uprights in middle, two outer uprights with lateral movement), convex lens (20 cm focal length), convex mirror, a lens holder, a mirror holder, two optical needles, (one thin, one thick) a knitting needle, and a half metre scale.

The following Ray-diagram explains the essence of this experiment.



Focal length of convex mirror

As a convex mirror always forms a virtual image, its focal length can not be found directly as for a concave mirror. For this purpose, indirect method is used, as described below.

An auxiliary convex lens L is introduced between the convex mirror M and object needle O as shown in Figure (a). Keeping the object needle at distance about 1.5 times rough focal length of convex lens, the position of convex mirror behind convex lens is so adjusted that a real and inverted image of object needle O, is formed at O itself. Under such condition, the light rays are incident normally over the convex mirror to retrace their path. In the absence of convex mirror, these rays would have met at centre of curvature C of the convex mirror. The distance PC gives the radius of curvature R of the mirror.

To locate the position of C, convex mirror is removed (without disturbing the object needle O and convex lens L). An image needle I is put behind the convex lens and moved to a position at which there is no parallax between tip of inverted image of O needle and tip of I needle. Position of image needle I gives position of centre of curvature C of mirror M. (See figure).

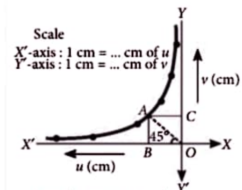
Then, $PC = PI = R$ and $f = \frac{R}{2} = \frac{PI}{2}$

(iii) To find the focal length of a convex lens by plotting graphs between u and v, or between $\frac{1}{u}$ and $\frac{1}{v}$.

To perform the experiment, we require an optical bench with three uprights (central upright fixed, two outer uprights with lateral movement), a convex lens with lens holder, two optical needles, (one thin, one thick) a knitting needle and a half metre scale.

Calculation of Focal Length by Using Graphs

***u*-*v* Graph :** Select a suitable but the same scale to represent u along X'-axis and v along Y-axis. According to sign conventions, in this case, u is negative and v is positive. Plot the various points for different sets of values of u and v from observation table. The graph comes out to be a rectangular hyperbola as shown in figure next.



Graph between u and v

Draw a line OA making an angle of 45° with either axis (*i.e.*, bisecting $\angle YOX'$) and meeting the curve at point A. Draw AB and AC perpendicular on X'-and Y-axes, respectively.

The values of u and v will be same for point A. So the coordinates of point A must be $(2f, 2f)$, because for a convex lens, when $u = 2f$, $v = 2f$.

Hence, $AB = AC = 2f$ or $OC = OB = 2f$

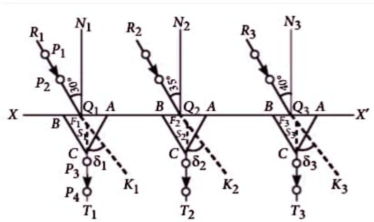
$\therefore \ f = \frac{OB}{2}$ and also $f = \frac{OC}{2}$

$\therefore$ Mean value of f = ____cm

The Plot of Angle of The Deviation vs Angle of Incidence for a Triangular Prism

The apparatus required is a drawing board, white sheets of paper, prism, drawing pins, pencil, scale of office pins, graph paper and protractor.

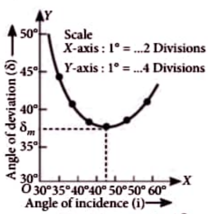
The white paper is pinned to the drawing board and the prism is fixed at a place. The outline of the prism is marked on the paper. Then an incident ray say (at 30°) is drawn on one of the faces of the prism and two pins are inserted at P_1 and P_2 on the ray as shown below.



When viewed from the other face the pins are along a particular line. We place pins P_3 and P_4 in line with the images of P_1 and P_2 as seen in the prism. Thereafter line P_3P_4 is drawn which represents the emergent ray.

Lift the prism and make the dotted lines and discover the angle of deviation δ_1 here. This angle can be measured by a protractor.

Several such observations for angle of incidence ranging from 30° to 60° can be made and the corresponding angle of deviation can be measured. Plot a graph between δ *vs* i. A sample graph is drawn below:



Graph between i and δ

From the graph the minimum value of deviation can be obtained.

To get refractive index of the material of the prism, prism formula is used as follows:

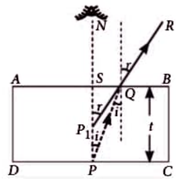
$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Refractive Index Of a Glass Slab Using A Travelling Microscope

Real and Apparent Thickness of a Glass Slab

Diagram shows a section *ABCD* of a glass slab taken by a horizontal plane. The slab has thickness t.

Description: P is a point marked at the bottom of the slab. A ray of light PQ from P is incident at the top at the point Q at an angle of incidence i and refracts along QR at an angle r. It appears to come from P_1.

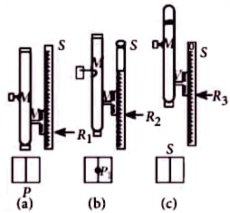


P_1 is the virtual image of real object P formed on normal *PSN*.

PS is the real thickness of the slab.

P_1S is the apparent thickness of the slab.

To determine refractive index of a glass slab, using a travelling microscope, the required apparatus is three glass slabs of different thickness but same material, a travelling microscope, lycopodium powder.



We mark a cross (P) on a board and measure its distance as shown in fig. (a) with the travelling microscope.

Then the glass-slab is placed over the cross. Now, the cross appears at (P_1) and its distance is measured using the travelling microscope.

Finally, we put some lycopodium powder (S) on top of the slab and measure its distance using the travelling microscope.

PS = Real Thickness of slab and

P_1S = Apparent thickness of slab

Thus refractive index can be found as

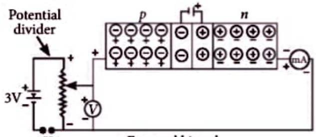
$$\mu = \frac{\text{Real thickness of slab}}{\text{Apparent thickness of slab}} = \frac{PS}{P_1S}.$$

Draw The Characteristic Curve Of A *p-n* Junction Diode in Forward and Reverse Bias

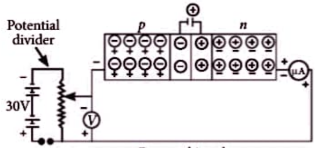
Apparatus Required

A *p-n* junction (semi-conductor) diode, a 30 volt and a 3 volt battery, a high resistance rheostat, one 0-3 volt voltmeter, one 0-30 volt voltmeter, one 0-100 mA ammeter, one 0-100 μA ammeter, one way key, connecting wires and pieces of sand paper.

Circuit Diagram



Forward biased



Reverse biased

Theory

Forward-bias on junction : It produces forward current. With increase in bias voltage, the forward current increases slowly in the beginning and then rapidly. At about 2.4 V, the current increases suddenly. The bias is at once made zero to avoid damage to the diode.

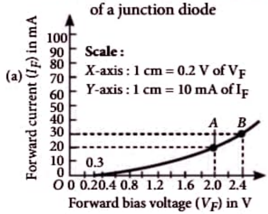
Reverse-bias on junction : In the beginning no appreciable reverse current flows. At about 5 V, a feeble current starts flowing. With increase in bias voltage, the current slowly increases. At about 25 V, the reverse current increase suddenly. Again the bias is made zero to avoid damage.

Calculations

For forward-bias : Plot a graph between forward-bias voltage V_F and forward current I_F taking V_F along X-axis and I_F along Y-axis. A sample graph is shown below.

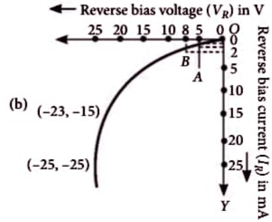
This graph is called forward bias characteristic curve of a junction diode.

Forward bias characteristic curve of a junction diode



For reverse-bias : Plot a graph between reverse-bias voltage V_R and reverse current I_R taking V_R along X-axis and I_R along Y-axis. A sample graph is shown below.

This graph is called reverse-bias characteristic curve of a junction diode.



In figure (a), For change from point A to B

$\Delta V_F = 2.4 - 2.0 = 0.4$ V, $\Delta I_F = 30 - 20 = 10$ mA

Hence junction resistance for forward-bias,

$$r = \frac{\Delta V_F}{\Delta I_F} = \frac{0.4 \text{ V}}{10 \text{ mA}} = 40 \text{ ohm}$$

In figure (b), for change from point A to B

$\Delta V_R = 8.0 - 5.0 = 3$V, $\Delta I_R = 2 - 1 = 1$ mA

Hence, junction resistance for reverse-bias, $r = \frac{\Delta V_F}{\Delta I_F}$

$$= \frac{3 \text{ V}}{1 \text{ mA}} = 3 \times 10^3 \text{ ohm.}$$

Draw The Characteristic Curves of A Zener Diode and Finding Reverse Breakdown Voltage

Zener Diode

Principle

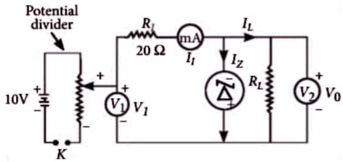
It works on phenomenon of Zener breakdown at reverse voltage, for which large changes in diode current produce only a small change in diode voltage.

Construction

It is specially made to work only in breakdown region. The Zener voltage is kept to a desired value by changing level of doping. More density of dopant atoms keeps Zener voltage low. For same density of impurity (dopant) atoms, Zener voltage is higher for silicon than that for germanium. Zener diodes for voltage range 40 V to 50.0 V are commonly available.

Apparatus

A Zener diode (with reverse breakdown voltage of about 6 volts), [*i.e.*, V_Z = 6 V], a 10 volt battery, a high resistance rheostat, two 0-10 V voltmeters, one 0-100 mA ammeter, one 20 ohm resistance, one way key, connecting wires.



Circuit Parameters

V_I = Input (reverse bias) voltage

V_0 = Output voltage (R_L/I_L)

R_I = Input resistance

R_L = Load resistance

I_I = Input current (reverse current)

I_Z = Zener diode current

I_L = Load current

Relations

$I_L = I_I - I_Z$ ...(i)

$V_0 = V_I - R_I I_I$ ...(ii)

$V_0 = R_L I_L$ ...(iii)

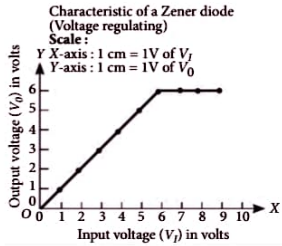
This constant value of V_0 which is the reverse breakdown voltage, is called Zener voltage.

Calculations

Plot a graph between input voltage V_I and output voltage V_0, taking V_I along X-axis and V_0 along Y-axis. The graph comes as shown in figure next.

Since V_0 becomes constant at 6 volt the reverse breakdown voltage (Zener voltage) of Zener diode is 6 volt.

Note. A graph between V_I and I_I will give reverse bias characteristic of the Zener diode.



Identification of Diode, LED Resistor, A Capacitor from A Mixed Collection of Such Items.

- If the item has two terminals, it may be diode, a LED, a resistor or a capacitor.

  Make a series circuit with battery eliminator, reversing key, the item and the multimeter with range set in milliamperes. Switch on the battery eliminator and watch the movement of the multimeter pointer.
- If pointer moves when voltage is applied in one way and does not move when reversed and there is no light emission, the item is a diode.
- If pointer moves when voltage is applied in one way and does not move when reversed and there is light emission, the item is a LED.
- If pointer moves when voltage is applied in one way and also when reversed, the item is a resistor.
- If pointer does not move when voltage is applied in one way and also when reversed, the item is a capacitor.

WRAP it up!

1. In a meter bridge experiment, the corresponding observation table are shown in figure.

S. No.	R (Ω)	l (cm)
1.	1000	60
2.	100	13
3.	10	1.5
4.	1	1.0

Which of the readings is inconsistent ?

(a) 99 (b) 109 (c) 70 (d) 98

2. In a simple metre-bridge circuit, the gaps are bridged by coils P and Q having the smaller resistance. A balance is obtained when the jockey key makes contact at a point of the bridge wire 40 cm from the P end. On shunting the coil Q with a resistance of 50 Ω, the balance point is moved through 10 cm. The resistance P and Q are:

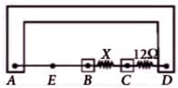
(a) $\frac{25}{3}$ Ω, $\frac{25}{2}$ Ω respectively

(b) $\frac{50}{3}\Omega, \frac{50}{2}\Omega$ respectively

(c) $\frac{75}{3}\Omega, \frac{75}{2}\Omega$ respectively

(d) $\frac{100}{3}\Omega, \frac{100}{2}\Omega$ respectively

3. A thin uniform wire AB of length 1 m, an unknown resistance X and a resistance of 12 Ω are connected by thick conducting strips as shown in figure. A battery and a galvanometer (with a sliding jockey connected to it) are also available. Connections are to be made to measure the unknown resistance X using the principle of wheatstone bridge. The appropriate connections are:



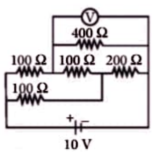
(E is the balance point for Wheatstone bridge)

(a) battery across EB and galvanometer across BC.
(b) battery across BC and galvanometer across CD
(c) battery across EC and galvanometer across BD
(d) battery across BD and galvanometer across EC.

4. In the above question, after appropriate connections are made, it is found that no deflection takes place in the galvanometer when the sliding jockey touches the wire at a distance of 60 cm from A. The value of the resistance X is

(a) 4 Ω (b) 8 Ω (c) 16 Ω (d) 18 Ω

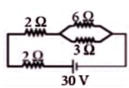
5. For the electrical circuit shown in the figure, the potential difference across the resistor of 400 Ω as will be measured by the voltmeter V of resistance 400 Ω is



(a) 5V (b) $\frac{10}{3}$ V

(c) 4V (d) $\frac{20}{3}$ V

6. The current taken from the 30 V supply and the current through the 6 Ω resistor are respectively.



(a) 5 A, $\frac{5}{6}$ A (b) 5 A, $\frac{5}{3}$ A

(c) 6 A, $\frac{5}{6}$ A (d) 6 A, 2 A

7. If a copper wire is stretched to make it η = 0.1% longer, then the percentage change in its resistance is

(a) 0.1 % (b) 0.2 % (c) 0.3 % (d) 0.4 %

8. The temperature coefficient of resistance of a wire is 1.25×10^{-3}/°C. At 300 K, its resistance is 1 Ω. The temperature at which its resistance becomes 2 Ω is

(a) 800°C (b) 827°C
(c) 1100°C (d) 1127°C

9. The scale of a galvanometer of resistance 100 Ω contains 25 divisions. It gives a deflection of 1 division on passing a current of 4×10^{-4} A. The resistance in ohm to be added to it, so that it may become a voltmeter of range 2.5 V is

(a) 100 (b) 150 (c) 250 (d) 300

10. A galvanometer, having a resistance of 50 Ω, gives a full scale deflection for a current of 0.05 A. The length in metre of a resistance wire of area of cross-section 2.97×10^2 cm^2 that can be used to convert the galvanometer into an ammeter which can read a maximum of 5 A current is (specific resistance of wire = 5×10^{-7} Ω m)

(a) 8 (b) 6 (c) 3 (d) 1.5

11. A microammeter has a resistance of 100 Ω and a full scale range of 50 μA. It can be used as a voltmeter or as a higher range ammeter provided a resistance is added to it. Pick the correct range and resistance combination(s).

(a) 50 V range with 10 kΩ resistance in series
(b) 10 V range with 200 mΩ resistance in series
(c) 5 A range with 1 Ω resistance in parallel
(d) 10 mA range with 1 Ω resistance in parallel

12. To find the focal length of a convex mirror, a student records the following data.

Object Pin	Convex Lens	Convex Mirror	Image Pin
22.2 cm	32.2 cm	45.8 cm	71.2 cm

The focal length of the convex lens is f_1 and that of mirror is f_2. Then taking index correction to be negligibly small, f_1 and f_2 are close to

(a) f_1 = 7.8 cm f_2 = 12.7 cm
(b) f_1 = 12.7 cm f_2 = 7.8 cm
(c) f_1 = 15.6 cm f_2 = 25.4 cm
(d) f_1 = 7.8 cm f_2 = 25.4 cm

13. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two

axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be

(a) $(2f, 2f)$ (b) $(f/2, f/2)$
(c) (f, f) (d) $(4f, 4f)$

14. A concave lens of focal length f forms an image which is n times the size of the object. The distance of the object from the lens is

(a) $(1 - n)f$ (b) $(1 + n)f$
(c) $\left(\frac{1+n}{n}\right)f$ (d) $\left(\frac{1-n}{n}\right)f$

15. A convex lens of focal length f produces a real image x times the size of an object, then the distance of the object from the lens is

(a) $(x - 1)f$ (b) $(x + 1)f$
(c) $\{(x + 1)/x\}f$ (d) $\{(x - 1)/x\}f$

16. In an experiment for determination of refractive index of glass of a prism by $i - \delta$ plot, it was found that a ray incident at angle 35°, suffers a deviation of 40° and that it emerges at angle 79°. In that case which of the following is closest to the maximum possible value of the refractive index?

(a) 1.5 (b) 1.6 (c) 1.7 (d) 1.8

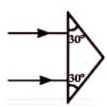
17. There is a prism with refractive index equal to $\sqrt{2}$ and the refracting angle equal to 30°. One of the refracting surfaces of the prism is polished. A beam of monochromatic light will retrace its path if its angle of incidence over the refracting surface of the prism is

(a) 0° (b) 30° (c) 45° (d) 60°

18. The minimum deviation produced by a glass prism of angle 60° is 30°. If the velocity of light in vacuum is 3×10^8 m/s, then the velocity of light in glass in m/s is

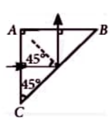
(a) 2.9×10^8 (b) 3.1×10^8
(c) 2.121×10^8 (d) 2.72×10^8

19. Two parallel light rays are incident on a surface of a prism of refractive index 1.5 as shown in figure. What is the angle between the rays as they emerge?



(a) 30° (b) 37° (c) 45° (d) 49°

20. A light ray is incident perpendicular to one face of 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index



(a) $n < \frac{1}{\sqrt{2}}$ (b) $n > \sqrt{2}$ (c) $n > \frac{1}{\sqrt{2}}$ (d) $n < \sqrt{2}$

21. An equilateral prism deviates a ray through 45° for two angles of incidence differing by 20°. μ of the prism is

(a) 1.567 (b) 1.467 (c) 1.5 (d) 1.65

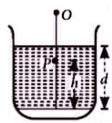
22. A bird in air looks at a fish vertically below it and inside water; h_1 is the height of the bird above the surface of water and h_2, the depth of the fish below the surface of water. If refractive index of water with respect to air be μ, then the distance of the fish observed by the bird is

(a) $h_1 + h_2$ (b) $h_1 + h_2/\mu$
(c) $\mu h_1 + h_2$ (d) $\mu h_1 + \mu h_2$

23. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by

(a) a screw gauge provided on the microscope
(b) a vernier scale provided on the microscope
(c) a standard laboratory scale
(d) a meter scale provided on the microscope.

24. A plane mirror is placed at the bottom of a tank containing a liquid of refractive index μ. P is a small object at a height h above the mirror. An observer O, vertically above P, outside the liquid sees P and its image in the mirror. The apparent distance between these two will be



(a) $2\mu/h$ (b) $2h/\mu$
(c) $2h/(\mu - 1)$ (d) $h[1 + (1/\mu)]$

25. Monochromatic light of wavelength λ_1 travelling in a medium of refractive index n_1 enters a denser medium of refractive index n_2. The wavelength in the second medium is

(a) $\lambda_1\left(\frac{n_1}{n_2}\right)$ (b) $\lambda_1\left(\frac{n_2}{n_1}\right)$
(c) $\frac{\lambda_1(n_2 - n_1)}{n_2}$ (d) $\frac{\lambda_1(n_2 - n_1)}{n_1}$

26. When a P-N junction diode is reverse biased

(a) electrons and holes are attracted towards each other and move towards the depletion region.
(b) electrons and holes move away from the junction depletion region
(c) height of the potential barriers decreases
(d) no change in the current takes place.

27. When *P-N* junction diode is forward biased, then
(a) the depletion region is reduced and barrier height is increased
(b) the depletion region is widened and barrier height is reduced
(c) both the depletion region and barrier height are reduced
(d) both the depletion region and barrier height are increased.

28. An experiment is performed to determine the *I-V* characteristics of a Zener diode, which has a protective resistance of $R = 100\ \Omega$, and a maximum power of dissipation rating of 1 W. The minimum voltage range of the DC source in the circuit is
(a) 0 – 5 V (b) 0 – 24 V
(c) 0 – 12 V (d) 0 – 8 V

29. Zener diode is a heavily doped P-N junction and operated in
(a) reverse bias (b) forward bias
(c) Both (a) and (b) (d) None of these

30. For the same density of impurity atoms, Zener voltage is
(a) higher for silicon than for germanium
(b) higher for Ge than for Si
(c) same for both Ge and Si
(d) none of the above

SOLUTIONS

1. **(a) :** $\because \frac{R}{X} = \frac{l}{(100-l)}$. So, $X = \frac{R(100-l)}{l}$

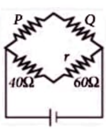
So, $X_1 = \frac{1000\times(100-60)}{60} = \frac{1000\times 40}{60} = 666.66\ \Omega$

$X_2 = \frac{100\times(100-13)}{13} = \frac{100\times 87}{13} = 669.23\ \Omega$

$X_3 = \frac{10\times(100-1.5)}{1.5} = \frac{10\times 98.5}{1.5} = 656.66\ \Omega$

$X_4 = \frac{1\times(100-1)}{1} = 99\ \Omega$

2. **(b) :**



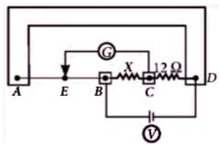
$\frac{P}{40} = \frac{Q}{60}$ ...(i)

On shunting Q with 50 Ω, the resistance of the arm containing Q comes down, so length also must shorten to keep the ratio same.

$\Rightarrow \frac{P}{(40+10)} = \frac{\left(\frac{50Q}{50+Q}\right)}{(60-10)} \Rightarrow P = \frac{50Q}{50+Q}$ ...(ii)

Solving (i) and (ii) we get, $P = \frac{50}{3}\ \Omega$ and $Q = \frac{50}{2}\ \Omega$

3. **(d) :** The appropriate connections for wheatstone bridge are as shown below:

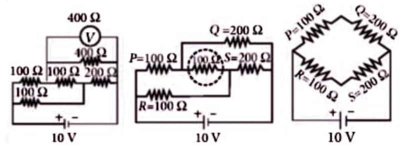


4. **(b) :** No deflection in the galvanometer means wheatstone bridge is balanced. So, $\frac{X}{12} = \frac{R_{BJ}}{R_{AJ}}$

$\frac{X}{12} = \frac{40}{60}$ (As resistance is proportional to the length of the wires)

$\Rightarrow X = \frac{12\times 4}{6} = 8\ \Omega.$

5. **(d) :** The given circuit actually forms a balanced wheatstone bridge (including the voltmeter) as shown below.



$\Rightarrow$ Voltmeter measures voltage across Q as $\frac{200}{300}(10\text{ V}) = \frac{20}{3}$

6. **(b) :** 6 Ω and 3 Ω in parallel make $\left(\frac{6\times 3}{6+3}\right)\Omega = 2\ \Omega$

The net resistance of the circuit is $(2 + 2 + 2)\Omega = 6\ \Omega$

$\Rightarrow I_{\text{Battery}} = \frac{30\text{ V}}{6\ \Omega} = 5\text{ A}.$

The 5 A current in the main circuit will divide in the inverse ratio of resistances, while splitting in the 6 Ω and 3 Ω parallel combination.

$\Rightarrow I_{6\Omega} = 5\text{A}\times\left(\frac{3\Omega}{3\Omega+6\Omega}\right) = 5\text{A}\times\frac{1}{3} = \frac{5}{3}\text{A}$

7. **(b) :** $R = \frac{\rho \cdot l}{A}$

$\ln R = \ln \rho + \ln l - \ln A$

$$\frac{dR}{R} = 0 + \frac{dl}{l} - \frac{dA}{A} \quad \ldots\text{(i)}$$

Now, $V = l \cdot A$ and volume is constant

$\ln V = \ln l + \ln A$

$$\frac{dV}{V} = \frac{dl}{l} + \frac{dA}{A} \Rightarrow 0 = \frac{dl}{l} + \frac{dA}{A} \quad \ldots\text{(ii)}$$

Adding (i) and (ii), we get

$$\frac{dR}{R} = \frac{2dl}{l} \text{ (As } \eta = 0.1\ \%,\ dl = 0.1\ \%)$$

$$\Rightarrow \frac{dR}{R} = 2 \times 0.1\% = 0.2\ \%$$

8. **(b) :** $R = R_0(1 + \alpha\Delta T)$

$2\ \Omega = 1\ \Omega(1 + (1.25 \times 10^{-3})\Delta T)$

$\Rightarrow 2 = 1 + (1.25 \times 10^{-3})\Delta T$

$$\Delta T = \left(\frac{1}{1.25 \times 10^{-3}}\right)°\text{C} = 800°\text{C}$$

Now, $T_f = T_0 + \Delta T.$

Here $T_0 = 300\text{ K} = 27°\text{C} \Rightarrow T_f = 27°\text{C} + 800°\text{C} = 827°\text{C}$

9. **(b) :** For full scale deflection, $I_g = nk$

$\therefore \quad I_g = 25 \times (4 \times 10^{-4}) = 10^{-2}\text{ A}$

Now $R = \frac{V}{I_g} - G = \frac{2.5}{10^{-2}} - 100 = 250 - 100 = 150\ \Omega$

10. **(c) :** We know that $(I - I_g)S = I_gG$

$$\therefore I = \frac{(G+S)}{S} I_g$$

Therefore, $5 = \frac{50+R}{R} \times 0.05$ or $R = \frac{2.5}{4.95}\ \Omega$

Further $R = \rho\left(\frac{l}{A}\right)$ or $l = \frac{AR}{\rho}$

or $l = \frac{(2.97 \times 10^{-6}) \times (2.5)}{(5 \times 10^{-7}) \times 4.95} = 3\text{ m}$

11. **(c) :** We know that $I_g = V/(R + G)$

For a, $50 \times 10^{-6} = 50/(R + 100)$

$\therefore \quad R = (10^6 - 100)\Omega$

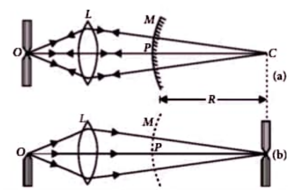
For b, $50 \times 10^{-6} = 10/(R + 100)$, $\therefore R = 200 \times 10^3\ \Omega$

Further $I_g = \{S/(S + G)\}I$

For c, $50 \times 10^{-6} = \{S/(S + 100)\}\ 5 \times 10^{-3}$

Solving, We get $S = 100/99 \approx 1\ \Omega$.

12. **(a) :** The given figures shows the experimental set up to find the focal length of convex mirror using convex lens.



$\therefore \quad$ For lens, $u_1 = -(32.2 - 22.2)\text{ cm} = -10\text{ cm}$

$v_1 = (71.2 - 32.2)\text{ cm} = 39\text{ cm}$

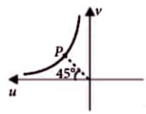
$$\therefore \frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{39} + \frac{1}{10} = \frac{49}{390} \text{ or } f_1 = \frac{390}{49}\text{ cm} \approx 7.8\text{ cm}$$

$\therefore \quad$ For mirror, $R = (71.2 - 45.8)\text{ cm} = 25.4\text{ cm}$

or $f_2 = \frac{25.4}{2}\text{ cm} = 12.7\text{ cm}$

13. **(a) :** According to New Cartesian coordinate system for a convex lens, as u is negative, the lens equation is

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}.$



One has to take that u is negative again for calculation, it effectively comes to

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

If u = radius of curvature, $2f$, $v = 2f$ *i.e.*, $\frac{1}{2f} + \frac{1}{2f} = \frac{1}{f}.$

v and u are have the same value when the object is at the centre of curvature. The solution is (a).

According the real and virtual system, u is +ve and v is also +ve as both are real. If $u = v$, $u = 2f$ = radius of curvature.

$$\therefore \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{2f} + \frac{1}{2f} = \frac{1}{f}$$

The answer is the same (a).

(The figure given is according to New Cartesian system).

UNSCRAMBLED WORDS

FEBRUARY 2024

1-h-MAGNIFICATION	2-g-INVERTER
3-e-CIRCULAR	4-f-SUSCEPTIBILITY
5-d-METACENTRE	6-a-CANDELA
7-j-RESISTIVITY	8-b-COLLISION
9-c-SATELLITE	10-i-FISSION

Winner : Srijita Ghosh

14. (d) : For concave lens

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \text{ or } \frac{u}{v}-1=\frac{u}{f} \text{ or } \left(\frac{1}{n}-1\right)=\frac{u}{f}$$

$$\therefore \quad u=\left(\frac{1-n}{n}\right)f$$

15. (c) : $x = (v/u)$ and $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

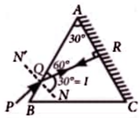
$$\therefore \quad v=f\left(1-\frac{v}{u}\right)=f(1-x)$$

since the image is real, hence it is inverted and so x is negative.

$\therefore \quad u = f\{1 + x\}/x$

16. (a)

17. (c) : See figure below. It is clear from the figure that the ray will retrace the path when the refracted ray QR is incident normally on the polished surface AC. Thus angle of refraction $r = 30°$.



We know that $\mu=\frac{\sin i}{\sin r}$

$\therefore \sin i = \mu \times \sin r$

$\sin i=\sqrt{2}\times \sin 30° = \sqrt{2}\times\frac{1}{2}=\frac{1}{\sqrt{2}}$

$\Rightarrow i=\sin^{-1}\frac{1}{\sqrt{2}}=45°.$

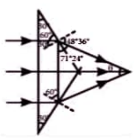
18. (c) : $$\mu=\frac{\sin\frac{(A+\delta_m)}{2}}{\sin\frac{A}{2}}=\frac{\sin\left(\frac{60+30}{2}\right)}{\sin\left(\frac{60}{2}\right)}$$

$$=\frac{\sin 45°}{\sin 30°}=\frac{0.7070}{0.5000}=1.414$$

Now velocity of light in glass $=\frac{C_{air}}{\mu}$

$$\Rightarrow \quad c_g=\frac{3\times10^8 \text{ m/s}}{1.414}=2.121\times10^8 \text{ m/s}$$

19. (b) : See figure.



$$\frac{\sin 30°}{\sin r}=\frac{1}{\mu}=\frac{1}{1.5}$$

$\sin r = 1.5 \times (1/2) = 0.75$

$r = 48° 36'$

$\therefore \quad \theta = 180° - 2(71° 24') \approx 37°$

20. (b) : For total internal reflection at glass-air interface critical angle C must be less than 45°.

Now $n=\frac{1}{\sin C}$ or $C=\sin^{-1}\left(\frac{1}{n}\right)<45°$

or $\frac{1}{n}<\sin 45°$ or $n > 1/\sin 45° \quad \therefore n>\sqrt{2}$.

21. (a) : We know that $\delta = i_1 + i_2 - A$

$45° = i_1 + i_2 - 60°$ or $i_1 + i_2 = 105°$ ...(i)

Given that $i_1 - i_2 = 20°$ ...(ii)

Solving eqs. (i) and (ii), we get

$i_1 = 62° 30'$ and $i_2 = 42° 30'$

Now, $\mu=\frac{\sin i_1}{\sin r_1}=\frac{\sin i_2}{\sin(60°-r_1)}$

or $\sin i_1 (\sin 60° \cos r_1 - \cos 60° \sin r_1) = \sin r_1 \sin i_2$

$0.8870 (0.866 \cos r_1 - 0.5 \sin r_1) = 0.6756 \sin r_1$

Solving, we get $\tan r_1=\frac{0.8870\times0.866}{1.1191}\Rightarrow r_1=34°28'$

$$\mu=\frac{\sin i_1}{\sin r_1}=\frac{0.8870}{0.5659}=1.567$$

22. (b) : Apparent position of fish as seen by bird is $=h_1+\left(\frac{h_2}{\mu}\right)$.

23. (b) : A travelling microscope moves horizontally on a main scale provided with a vernier scale, provided with the microscope.

24. (b) : The image of P will be formed at a distance h below the mirror. Apparent depth of $P=x_1=\frac{(d-h)}{\mu}$

Apparent depth of the image of $P=x_2=\frac{(d+h)}{\mu}$

Apparent distance between P and its image $=x_2-x_1=\frac{2h}{\mu}$.

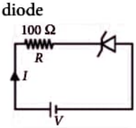
25. (a) : $\lambda_a=\frac{c}{\upsilon}$ or $\lambda_m=\frac{v}{\upsilon}=\frac{c}{\mu_m\upsilon}$

$\therefore \quad \lambda_1=\frac{c}{n_1\upsilon}$ and $\lambda_2=\frac{c}{n_2\upsilon}$

or $\lambda_1 n_1=\lambda_2 n_2$ and $\lambda_2=\lambda_1\left(\frac{n_1}{n_2}\right)$

26. (b) **27. (c)**

28. (b) : Potential drop across zener diode



$V_Z = V - IR = V - 100\, I$

$\therefore$ Power, $P = V_Z I_Z = (V - 100\, I)\, I$

But $P = 1$ W (given)

$\therefore \quad (V - 100\, I)\, I = 1$

or $\quad 100\, I^2 - VI + 1 = 0$

For I to be real, $V^2 - 4 \times 100 \times 1 \geq 0$ or $V \geq 20$ V

29. (a)

30. (a) : The value of zener voltage is higher for silicon (Si) than germanium (Ge) for same density of impurity atoms because reverse voltage for Si is higher than for Ge.

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