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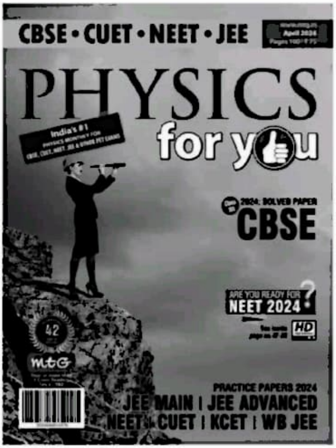

PHYSICS for you

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PRACTICE PAPER

JEE Main

2024

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

SECTION-A (MULTIPLE CHOICE QUESTIONS)

1. Choose the incorrect statement.
   (A) The electric lines of force entering into a Gaussian surface provide negative flux.
   (B) A charge 'q' is placed at the centre of a cube. The flux through all the faces will be the same.
   (C) In a uniform electric field net flux through a closed Gaussian surface containing no net charge, is zero.
   (D) When electric field is parallel to a Gaussian surface, it provides a finite non-zero flux.
   Choose the most appropriate answer from the options given below.
   (a) (B) and (D) only (b) (C) and (D) only
   (c) (A) and (C) only (d) (D) only

2. A particle of mass m moving with velocity v collides with a stationary particle of mass 2 m. After collision, they stick together and continue to move together with velocity
   (a) v (b) $v/4$ (c) $v/3$ (d) $v/2$

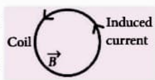
3. A solenoid of 1200 turns is wound uniformly in a single layer on a glass tube 2 m long and 0.2 m in diameter. The magnetic intensity at the center of the solenoid when a current of 2 A flows through it is
   (a) 2.4×10^3 A m^{-1} (b) 1.2×10^3 A m^{-1}
   (c) 1.2×10^{-3} A m^{-1} (d) 2.4×10^{-3} A m^{-1}

4. The specific heat of water = 4200 J kg^{-1} K^{-1} and the latent heat of ice = 3.4×10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams)
   (a) 64.6 (b) 69.3 (c) 61.7 (d) 63.8

5. A plano convex lens of refractive index 1.5 and radius of curvature 30 cm is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance from this lens an object be placed in order to have a real image of the size of the object?
   (a) 20 cm (b) 30 cm (c) 60 cm (d) 80 cm

6. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.
   Assertion A : Two identical balls A and B thrown with same velocity 'u' at two different angles with horizontal attained the same range R. If A and B reached the maximum height h_1 and h_2 respectively, then $R = 4\sqrt{h_1 h_2}$
   Reason R : Product of said heights
   $$h_1 h_2 = \left(\frac{u^2 \sin^2\theta}{2g}\right)\cdot\left(\frac{u^2 \cos^2\theta}{2g}\right)$$
   Choose the correct answer :
   (a) Both A and R are true and R is the correct explanation of A.
   (b) Both A and R are true but R is NOT the correct explanation of A.
   (c) A is true but R is false.
   (d) A is false but R is true.

7. A coil is placed in a magnetic field $\vec{B}$ as shown below. A current is induced in the coil because $\vec{B}$ is



   (a) parallel to the plane of coil and increasing with time.
   (b) outward and increasing with time.
   (c) outward and decreasing with time.
   (d) parallel to the plane of coil and decreasing with time.

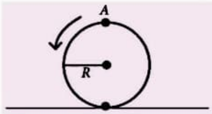
8. A disc is rolling without slipping on a surface. The radius of the disc is R. At $t = 0$, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is

(a) $R\sqrt{(\pi^2+1)}$

(b) $2R$

(c) $R\sqrt{(\pi^2+4)}$

(d) $2R\sqrt{(1+4\pi^2)}$



9. Match List I with List II :

	List I		List II
(A)	3 Translational degrees of freedom	(I)	Monoatomic gases
(B)	3 Translational, 2 rotational degrees of freedoms	(II)	Polyatomic gases
(C)	3 Translational, 2 rotational and 1 vibrational degrees of freedom	(III)	Rigid diatomic gases
(D)	3 Translational, 3 rotational and more than one vibrational degrees of freedom	(IV)	Non rigid diatomic gases

Choose the correct answer from the options given below :

(a) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)
(b) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)
(c) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(d) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)

10. Two cells of same emf but different internal resistances r_1 and r_2 are connected in series with a resistance R. The value of resistance R, for which the potential difference across second cell is zero is

(a) $r_2 - r_1$ (b) $r_1 - r_2$ (c) r_1 (d) r_2

11. Consider the efficiency of carnot's engine is given by $\eta = \frac{\alpha\beta}{\sin\theta}\log_e\frac{\beta x}{kT}$, where α and β are constants. If T is temperature, k is Boltzmann constant, θ is angular displacement and x has the dimensions of length. Then, choose the incorrect option.

(a) Dimensions of β is same as that of force.
(b) Dimensions of $\alpha^{-1}x$ is same as that of energy.
(c) Dimensions of $\eta \sin\theta$ is same that of $\alpha\beta$.
(d) Dimensions of α is same as that of β.

12. The ratio of wavelengths of proton and deuteron accelerated by potential V_p and V_d is $1:\sqrt{2}$. Then, the ratio of V_p to V_d will be

(a) 1 : 1 (b) $\sqrt{2}:1$ (c) 2 : 1 (d) 4 : 1

13. n moles of an ideal gas with constant volume heat capacity C_V undergo an isobaric expansion by certain volume. The ratio of the work done in the process, to the heat supplied is

(a) $\frac{nR}{C_V - nR}$ (b) $\frac{4nR}{C_V - nR}$

(c) $\frac{nR}{C_V + nR}$ (d) $\frac{4nR}{C_V + nR}$

14. The total charge on the system of capacitance $C_1 = 1\ \mu F$, $C_2 = 2\ \mu F$, $C_3 = 4\ \mu F$ and $C_4 = 3\ \mu F$ connected in parallel is (Assume a battery of 20 V is connected to the combination)

(a) 200 μC (b) 200 C (c) 10 μC (d) 10 C

15. $^{238}_{92}A \rightarrow ^{234}_{90}B + ^{4}_{2}D + Q$

In the given nuclear reaction, the approximate amount of energy released will be

[Given, mass of $^{238}_{92}A = 238.05079 \times 931.5\ MeV/c^2$, mass of $^{234}_{90}B = 234.04363 \times 931.5\ MeV/c^2$, mass of $^{4}_{2}D = 4.00260 \times 931.5\ MeV/c^2$]

(a) 2.12 MeV (b) 5.9 MeV
(c) 3.82 MeV (d) 4.25 MeV

16. Given below are two statements :

Statement I : For a planet, if the ratio of mass of the planet to its radius increases, the escape velocity from the planet also increases.

Statement II : Escape velocity is independent of the radius of the planet.

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

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

17. The electric field in an electromagnetic wave is given by $E = 56.5 \sin\omega(t - x/c)\ N\ C^{-1}$. Find the

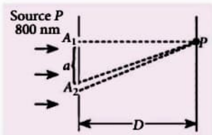
intensity of the wave if it is propagating along x-axis in the free space.
(Given $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$)

(a) $5.65\ W\ m^{-2}$ (b) $4.24\ W\ m^{-2}$
(c) $1.9 \times 10^{-7}\ W\ m^{-2}$ (d) $56.5\ W\ m^{-2}$

18. In the wave equation $y = 0.5\sin\frac{2\pi}{\lambda}(400t - x)$ m, the velocity of the wave will be

(a) 200 m/s (b) $200\sqrt{2}$ m/s
(c) 400 m/s (d) $400\sqrt{2}$ m/s

19. In a Young's double slit experiment, two slits are illuminated with a light of wavelength 800 nm. The line joining A_1P is perpendicular to A_1A_2 as shown in the figure. If the first minimum is detected at P, the value of slits separation 'a' will be (The distance of screen from slits D = 5 cm.)



(a) 0.4 mm (b) 0.2 mm
(c) 0.5 mm (d) 0.1 mm

20. Which of the following statements are correct?

(A) Electric monopoles do not exist whereas magnetic monopoles exist.
(B) Magnetic field lines due to a solenoid at its ends and outside cannot be completely straight and confined.
(C) Magnetic field lines are completely confined within a toroid.
(D) Magnetic field lines inside a bar magnet are not parallel.
(E) $\chi = -1$ is the condition for a perfect diamagnetic material, where χ is its magnetic susceptibility.

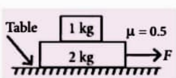
Choose the correct answer from the options given below

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

SECTION-B (NUMERICAL TYPE QUESTIONS)

Attempt any 5 questions out of 10.

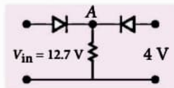
21. The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is ______ N.



22. In a metre bridge experiment the balance point is obtained if the gaps are closed by 2 Ω and 3 Ω. A shunt of X Ω is added to 3 Ω resistor to shift the balancing point by 22.5 cm. The value of X is ______.

23. The amplitude of a particle executing SHM is 3 cm. The displacement at which its kinetic energy will be 25% more than the potential energy is ______ cm.

24. Both the diodes used in the circuit shown are assumed to be ideal and have negligible resistance when these are forward biased. Built in potential in each diode is 0.7 V. For the input voltages shown in the figure, the voltage (in volts) at point A is ________ .



25. Glycerin of density $1.25 \times 10^3\ kg\ m^{-3}$ is flowing through the conical section of pipe. The area of cross-section of the pipe at its ends are 10 cm^2 and 5 cm^2 and pressure drop across its length is 3 Nm^{-2}. The rate of flow of glycerin through the pipe is $x \times 10^{-5}\ m^3\ s^{-1}$. The value of x is ______.

26. A solid sphere and a solid cylinder of same mass and radius are rolling on a horizontal surface without slipping. The ratio of their radius of gyrations respectively ($k_{sph} : k_{cyl}$) is $2 : \sqrt{x}$. The value of x is ________.

27. An inductor of 10 mH is connected to a 20 V battery through a resistor of 10 kΩ and a switch. After a long time, when maximum current is set up in the circuit, the current is switched off. The current in the circuit after 1 μs is $\frac{x}{100}$ mA. Then x is equal to _____. (Take $e^{-1} = 0.37$)

28. In an ac generator, a rectangular coil of 100 turns each having area $14 \times 10^{-2}\ m^2$ is rotated at 360 rev/min about an axis perpendicular to a uniform magnetic field of magnitude 3.0 T. The maximum value of the emf produced will be ______ V.

$\left(\text{Take } \pi = \frac{22}{7}\right)$

29. In a screw gauge, there are 100 divisions on the circular scale and the main scale moves by 0.5 mm on a complete rotation of the circular

scale. The zero of circular scale lies 6 divisions below the line of graduation when two studs are brought in contact with each other. When a wire is placed between the studs, 4 linear scale divisions are clearly visible while 46^{th} division of the circular scale coincide with the reference line. The diameter of the wire is ______ $\times 10^{-2}$ mm.

30. Two transparent media having refractive indices 1.0 and 1.5 are separated by a spherical refracting surface of radius of curvature 30 cm. The centre of curvature of surface is towards denser medium and a point object is placed on the principle axis in rarer medium at a distance of 15 cm from the pole of the surface. The distance of image from the pole of the surface is ____ cm.

SOLUTIONS

1. **(d) :** $\phi = \vec{E}\cdot\vec{A} = EA\cos\theta$; When $\theta = 90°, \phi = 0$

So, when the electric field is parallel to a Gaussian surface, it gives zero flux.

2. **(c) :** 

After collision, let them move with combined velocity v'.

Using conservation of momentum, $\vec{P}_i = \vec{P}_f$

$$mv + 2m \times 0 = (m + 2m)v' \Rightarrow mv = 3mv' \text{ or } v' = \frac{v}{3}$$

3. **(b):** $N = 1200$, length, $l = 2$ m, diameter, $d = 0.2$ m current, $I = 2$ A

Magnetic field at the centre of solenoid

$$B = \mu_0 nI = \mu_0 \frac{NI}{l},\ H = \frac{B}{\mu_0} \Rightarrow \frac{\mu_0}{\mu_0}\times\frac{NI}{l}$$

$$H = \frac{NI}{l} = \frac{1200\times 2}{2} \Rightarrow H = 1.2\times 10^3 \text{ A/m}$$

4. **(c) :** Given, specific heat of water, $S_w = 4200$ J kg^{-1} K^{-1}

Latent heat of fusion, $L_f = 3.4\times 10^5$ J kg^{-1}

Also, $m_i = 100$ g $= 0.1$ kg, $T_i = 0°$C, $m_w = 200$ g $= 0.2$ kg and $T_w = 25°$C

Now, heat lost by water $= m_w S_w \Delta\theta$

$= 0.2 \times 4200 \times 25 = 21000$ J

Heat required to melt ice $= m_x \times 3.4 \times 10^5$

where m_x is the mass of ice that will melt as the temperature of water reaches 0°C.

Now, heat lost = heat gained

$$\therefore\quad m_x = \frac{21000}{3.4\times 10^5} = 0.0617 \text{ kg} = 61.7 \text{ g}$$

5. **(a) :** A plano-convex lens behaves like a concave mirror when its curved surface is silvered.

Focal length of concave mirror so formed

$$= \frac{R}{2\mu} = \frac{30}{2\times 1.5} = 10 \text{ cm}$$

To form an image of object size, the object should be placed at (2*F*) of the concave mirror.

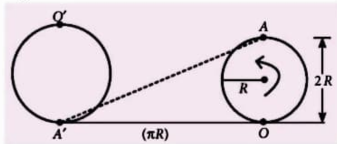
$\therefore$ Distance of object from lens $= 2\times F$

$= 2 \times 10 = 20$ cm

6. **(a)**

7. **(c) :** As the induced current is anticlockwise, so induced magnetic field is outwards to the plane and thus, by Lenz's law, the direction of $\vec{B}$ is outwards and decreasing with time.

8. **(c) :** Consider motion of the rolling disc as shown in the figure.



During half of the rotation the new locations of *O* and *A* will *O′* and *A′* as shown.

Thus, displacement of point *A* is given by

$$AA' = \sqrt{(OA')^2 + (OA)^2} = \sqrt{(\pi R)^2 + (2R)^2}$$

$$= R\sqrt{(\pi^2 + 4)}$$

9. **(d):** For monoatomic gas: Translational degree of freedom is 3 and rotational degree of freedom is 0.

For Rigid diatomic gas: Translational degree of freedom is 3 and rotational degree of freedom is 2.

For non rigid diatomic gas: Translational degree of freedom is 3, rotational degree of freedom is 2 and vibrational degree of freedom is 1.

For Polyatomic gas: Translational degree of freedom is 3, rotational degree of freedom is 3 and vibrational degree of freedom is more than 1.

$\therefore$ (A)–(I), (B)–(III), (C)–(IV), (D)–(II)

10. **(a)**

11. **(d):** Efficiency, $\eta = \frac{\alpha\beta}{\sin\theta}\log_e\frac{\beta x}{kT}$

Dimension of $\left[\frac{\beta x}{kT}\right] = [M^0L^0T^0]$

$$\beta = \frac{CkT}{x} = \frac{[ML^2T^{-2}]}{[L]} = [MLT^{-2}] \text{(where } C \text{ is constant)}$$

So, β has dimension of force.

$$[\eta] = \left[\frac{\alpha\beta}{\sin\theta}\right]; \ [\alpha] = \left[\frac{1}{\beta}\right] = [M^{-1}L^{-1}T^2]$$

$$\left[\frac{x}{\alpha}\right] = [x\beta] = [ML^2T^{-2}]$$

So, $\alpha^{-1}x$ has dimension of energy.

$[\eta\sin\theta] = [\alpha\beta]$

So, dimensions of $\eta \sin\theta$ is same as that of $\alpha\beta$.

12. (d)

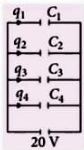
13. (c) : Work done, $dW = PdV = nRdT$

Heat supplied, $dQ = dU + dW = C_V dT + nRdT$

$= (C_V + nR)dT$

Required ratio, $\frac{dW}{dQ} = \frac{nRdT}{(C_V + nR)dT} = \frac{nR}{(C_V + nR)}$

14. (a) : The capacitances are connected in parallel combination across a battery of 20 V, the equivalent circuit diagram is as shown in figure



Total charge, $Q = q_1 + q_2 + q_3 + q_4$

or $Q = C_1V + C_2V + C_3V + C_4V$

or $Q = 1 \times 20 + 2 \times 20 + 4 \times 20 + 3 \times 20$

$\therefore \ Q = 200\ \mu C$

15. (d): The energy released will be

$\Delta Q = \Delta mc^2 = (m_A - m_B - m_D) \times 931.5$ MeV

$= (238.05079 - 234.04363 - 4.00260) \times 931.5$

$= 4.25$ MeV

16. (b): As, the escape velocity is given by, $v_e = \sqrt{\frac{2GM}{R}}$

If ratio of mass to radius of planet $\left(\frac{M}{R}\right)$ increases, the escape velocity also increases.

Escape velocity is inversely proportional to square root of radius of planet.

$$v_e \propto \frac{1}{\sqrt{R}}$$

So, statement I is correct but statement II is incorrect.

17. (b): Here, $E = 56.5\sin(\omega)\left(t - \frac{x}{c}\right)$

Intensity, $I = \frac{1}{2}\varepsilon_0 E_0^2 c$

$$I = \frac{1}{2} \times 8.85 \times 10^{-12} \times (56.5)^2 \times 3 \times 10^8$$

$$I = \frac{1}{2} \times 8.85 \times 3 \times 10^{-4} \times 56.5 \times 56.5 \Rightarrow I = 4.24\ \text{W/m}^2$$

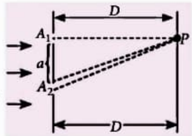
18. (c) : $y = 0.5 \sin\frac{2\pi}{\lambda}(400t - x)$

By comparing $y = A \sin[(\omega t - x)]$

$\omega = 400 \times \frac{2\pi}{\lambda}; k = 2\pi/\lambda$

$$v = \frac{\omega}{k} = \frac{400 \times 2\pi}{\lambda \times \frac{2\pi}{\lambda}} = 400 \text{ m/s}$$

19. (b): In a Youngs double slit experiment ;



Wavelength of light $(\lambda) = 800$ nm.

Distance of screen from slit $(D) = 5$ cm $= 5 \times 10^{-2}$ m

Here, $\sqrt{D^2 + a^2} - D = \frac{\lambda}{2} \ \Rightarrow \sqrt{D^2 + a^2} = \frac{\lambda}{2} + D$

$$\Rightarrow \left(D^2 + a^2\right) = \left(\frac{\lambda}{2} + D\right)^2$$

$$\Rightarrow D^2 + a^2 = \frac{\lambda^2}{4} + D^2 + \frac{2\lambda}{2} \times D$$

$$\Rightarrow a^2 = \frac{\lambda^2}{4} + D\lambda \qquad \left\{\because \frac{\lambda^2}{4} << D\lambda\right\}$$

So, $a^2 = D\lambda \Rightarrow 5 \times 10^{-2} \times 800 \times 10^{-9}$

$a^2 = 4000 \times 10^{-11}$ m^2; $a = 2 \times 10^{-4}$ m or $a = 0.2$ mm

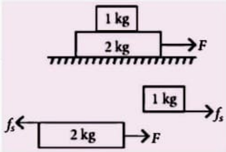
20. (d)

21. (15) : $\mu_s = 0.5$

Apply the force F

Let a is acceleration

Now, use Newton's second law.



$F - f_s = 2a$ ... (i)

$f_s = 1 \times a$ ... (ii)

$f_s = m \times 1 \times g;\ f_s = \mu Mg$

$\mu \times 1 \times g = 1a$

$0.5 \times 10 = a \Rightarrow a = 5\ \text{m/s}^2$

$\therefore\ F - 5 = 2 \times 5 = 15\ \text{N}$ ($\because$ using (ii))

22. (2) : In a metre bridge experiment, $\frac{R}{S} = \frac{l}{100 - l}$

Without shunt $\frac{2}{3} = \frac{l}{(100 - l)}$

$200 - 2l = 3l$ or $l = 40$ cm

After adding ($X\Omega$) shunt

$$\frac{2(3+X)}{3X} = \frac{40 + 22.5}{(100 - 62.5)} \Rightarrow \frac{6 + 2X}{3X} = \frac{62.5}{37.5} \Rightarrow X = 2\Omega$$

23. (2) : Amplitude, $A = 3$ cm, displacement $= x$

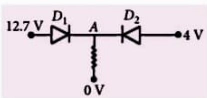
$$\text{KE} = \text{PE} + \frac{25}{100}\text{PE} \Rightarrow \frac{1}{2}m\omega^2(A^2 - x^2) = \frac{5}{4} \times \frac{1}{2}m\omega^2 x^2$$

$\Rightarrow 4A^2 - 4x^2 = 5x^2$

$\Rightarrow \frac{9x^2}{4} = A^2;\ x = \frac{2}{3}A = \frac{2}{3} \times 3 = 2\ \text{cm}$

24. (12) : Here D_1 is forward biased and D_2 is reverse biased.

$V_A = 12.7 - 0.7 = 12$ V



25. (4) : Given : $\rho = 1.25 \times 10^3\ \text{kg m}^{-3}$

Area at the ends, $A_1 = 10\ \text{cm}^2$; $A_2 = 5\ \text{cm}^2$

$\Delta P = 3\text{N m}^{-2}$; $A_1 v_1 = A_2 v_2$; $v_1 = \frac{A_2 v_2}{A_1}$

Using Bernoulli's equation,

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2;\ P_1 - P_2 = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right)$$

$$\Delta P = \frac{1}{2}\rho\left[v_2^2 - \left(\frac{A_2}{A_1}\right)^2 v_2^2\right];\ \Delta P = \frac{1}{2}\rho v_2^2\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]$$

$$3 = \frac{1}{2} \times 1.25 \times 10^3 \times v_2^2\left[1 - \left(\frac{5}{10}\right)^2\right]$$

$$v_2^2 = \frac{600}{125} \times 10^{-3}\left(\frac{4}{3}\right);\ v_2 = \sqrt{64 \times 10^{-4}} = 8 \times 10^{-2}\ \text{m/s}$$

Discharge rate $= A_2 v_2 = 5 \times 8 \times 10^{-2} \times 10^{-4}$

$= 4 \times 10^{-5}\ \text{m}^3\ \text{s}^{-1}$

$\therefore$ The value of $x = 4$

26. (5) : $I_{\text{solid sphere}} = \frac{2}{5}MR^2,\ k_s = \sqrt{\frac{2}{5}}R$

$I_{\text{solid cylinder}} = \frac{1}{2}MR^2,\ k_c = \sqrt{\frac{1}{2}}R$

$\frac{k_S}{k_C} = \sqrt{\frac{2 \times 2}{5 \times 1}} = \frac{2}{\sqrt{5}} \Rightarrow 2 : \sqrt{x} = 2 : \sqrt{5}$; So, $x = 5$

27. (74) : Inductance, $L = 10$ mH

Voltage, $V = 20$ V, $e^{-1} = 0.37$

Resistance, $R = 10\ \text{k}\Omega$, Time $t = 1\ \mu\text{s}$

The maximum current is,

$I_{\max} = \frac{V}{R} = \frac{20}{10 \times 10^3} = 2 \times 10^{-3}$ A

For $L - R$ decay circuit, $I = I_{\max} e^{-R\frac{t}{L}}$

$I = 2 \times 10^{-3} e^{\frac{-10 \times 10^3 \times 10^{-6}}{10 \times 10^{-3}}}$

$I = 2 \times 10^{-3} e^{-1} = 2 \times 10^{-3} \times 0.37;\ I = \frac{74}{100}$ mA

28. (1583) : $N = 100$ turns, $A = 14 \times 10^{-2}\ \text{m}^2$

$\omega = \frac{360 \times 2\pi}{60};\ B = 3.0$ T

As emf, $e = NAB\omega$

$e = 100 \times 14 \times 10^{-2} \times 3.0 \times \frac{360 \times 2\pi}{60}$ or $e = 1583$ V

29. (220) : LC of screw gauge $= \frac{0.5}{100} = \frac{1}{200}$ mm

Zero error $= \frac{+6}{200}$ mm $= 0.03$ mm

Main scale reading $= 4 \times 0.5$

Therefore, width of wire $= 4 \times 0.5 + \frac{46}{200} = 2.23$

Corrected width of wire $= 2.23 - 0.03 = 2.20$ mm

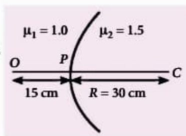
$= 220 \times 10^{-2}$ mm

30. (30) : Given, $\mu_1 = 1.0$; $\mu_2 = 1.5$

$u = -15$ cm,

$R = 30$ cm

From refraction formula,



$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\Rightarrow \frac{1.5}{v} - \frac{1}{(-15)} = \frac{1.5 - 1}{30}$

$\Rightarrow \frac{1.5}{v} + \frac{1}{15} = \frac{0.5}{30} \Rightarrow \frac{1.5}{v} = \frac{1}{60} - \frac{1}{15}$

$\Rightarrow \frac{1.5}{v} = \frac{1 - 4}{60} = \frac{-3}{60}\ \therefore\ v = \frac{-1.5 \times 60}{3} = -30$ cm

Practice Paper NEET 2024

Exam on 5th May

SECTION - A

1. A current of 1 A through a coil of inductance of 200 mH is increasing at a rate of 0.5 A s^{-1}. The energy stored in the inductor per second is
(a) 0.5 J s^{-1} (b) 5.0 J s^{-1}
(c) 0.1 J s^{-1} (d) 2.0 J s^{-1}

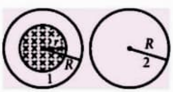
2. Which of the following has maximum Young's modulus?
(a) Steel (b) Copper
(c) Brass (d) Aluminium

3. Monochromatic light incident on a metal surface emits electrons with kinetic energies from zero to 2.6 eV. What is the least energy of the incident photon, if the tightly bound electron needs 4.2 eV to remove?
(a) 1.6 eV (b) From 1.6 eV to 6.8 eV
(c) 6.8 eV (d) More than 6.8 eV

4. A cycle wheel of radius 0.5 m is rotated with constant angular velocity of 10 rad/s in a region of magnetic field of 0.1 T which is perpendicular to the plane of the wheel. The emf generated between its centre and the rim is,
(a) 0.25 V (b) 0.125 V (c) 0.5 V (d) zero

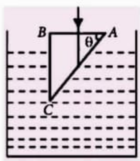
5. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the sun and the earth in terms of the new unit if light takes 8 min and 20 s to cover this distance?
(a) 300 (b) 400 (c) 500 (d) 600

6. A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{d\vec{B}}{dt}$.



Loop 1 of radius $R > r$ encloses the region r and loop 2 of radius R is outside the region of magnetic field as shown in the figure. Then the emf generated is
(a) zero in loop 1 and zero in loop 2
(b) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 2
(c) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2
(d) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and zero in loop 2

7. A glass prism of refractive index 1.5 is immersed in water $\left(\mu = \frac{4}{3}\right)$. Refer figure. A light beam incident normally on the face AB is totally reflected to reach the face BC if

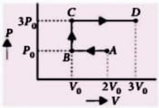


(a) $\sin\theta \leq \frac{2}{3}$ (b) $\cos\theta \geq \frac{8}{9}$
(c) $\sin\theta > \frac{8}{9}$ (d) $\cos\theta \leq \frac{8}{9}$

8. An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be
(a) $\frac{24hR}{25m}$ (b) $\frac{25hR}{24m}$ (c) $\frac{25m}{24hR}$ (d) $\frac{24m}{25hR}$

9. A thin rod of length $2m$ and mass 5 kg is bent at its midpoint into two halves so that the angle between them is 90°. The moment of inertia of the bent rod about an axis passing through the bending point and perpendicular to the plane defined by the two halves of the rod in units of kg–m^2 is
(a) 7/5 (b) 3/2 (c) 3/5 (d) 5/3

10. P–V diagram of an ideal gas is as shown in figure. Work done by the gas in the process $ABCD$ is



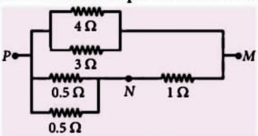
(a) $4P_0V_0$ (b) $2P_0V_0$
(c) $3P_0V_0$ (d) P_0V_0

11. A particle of mass 'm' is projected with a velocity $v = kv_e$ $(k < 1)$ from the surface of the earth. The maximum height above the surface reached by the particle is
(v_e = escape velocity)

(a) $\frac{Rk^2}{1-k^2}$ (b) $R\left(\frac{k}{1-k}\right)^2$

(c) $R\left(\frac{k}{1+k}\right)^2$ (d) $\frac{R^2k}{1+k}$

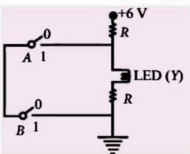
12. In the circuit shown, the current through the 4 Ω resistor is 1 amp when the points P and M are connected to a d.c. voltage source. The potential difference between the points M and N is



(a) 0.5 volt (b) 3.2 volt
(c) 1.5 volt (d) 1.0 volt

13. A small signal voltage $V(t) = V_0 \sin\omega t$ is applied across an ideal capacitor C
(a) Current $I(t)$ is in phase with voltage $V(t)$.
(b) Current $I(t)$ leads voltage $V(t)$ by 180°.
(c) Current $I(t)$, lags voltage $V(t)$ by 90°.
(d) Over a full cycle the capacitor C does not consume any energy from the voltage source.

14.

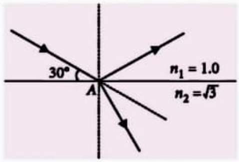


The correct Boolean operation represented by the circuit diagram drawn is
(a) NOR (b) AND (c) OR (d) NAND

15. A man throws balls with the same speed vertically upwards one after the other at an interval of 2s. What should be the speed of the throw so that more than two balls are in the sky at any time?
(Given g = 9.8 m s^{-2})
(a) Any speed less than 19.6 m s^{-1}
(b) Only with speed 19.6 m s^{-1}
(c) More than 19.6 m s^{-1}
(d) At least 9.8 m s^{-1}

16. The frequency (in Hz) of electromagnetic wave, which is best suited to observe a particle of radius 3×10^{-4} cm is of the order of
(a) 10^{15} (b) 10^{14} (c) 10^{13} (d) 10^{12}

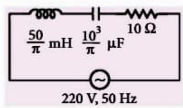
17. A beam of monochromatic light reflects and refracts at point A, as shown in the diagram. Find the angle of refraction at point A.



(a) 60° (b) 45°
(c) 30° (d) None of the above

18. **Assertion :** In the absence of an externally applied electric field, the displacement per unit volume of a polar dielectric material is always zero.
Reason : In polar dielectrics, each molecule has a permanent dipole moment but these are randomly oriented in the absence of an externally applied electric field.
(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.

19. The net impedance of circuit (as shown in figure) will be



(a) $5\sqrt{5}$ Ω
(b) 25 Ω
(c) $10\sqrt{2}$ Ω
(d) 15 Ω

20. If a star converts all helium in its core to oxygen then energy released per oxygen nucleus is
(Mass of He = 4.0026 u, Mass of O = 15.9994 u)
(a) 10.24 MeV (b) 5 MeV
(c) 7.56 MeV (d) 23.9 MeV

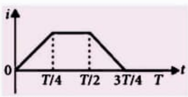
21. Energy released in nuclear fission is due to
(a) some mass converted into energy.
(b) total binding energy of fragments is more than the binding energy of parental element.
(c) total binding energy of fragments is less than the binding energy of parental element.
(d) total binding energy of fragments is equal to the binding energy of parental element.

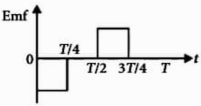
22. A galvanometer having a resistance of 9 ohm is shunted by a wire of resistance 2 ohm. If the total current is 1 amp, the part of it passing through the shunt will be
(a) 0.2 amp (b) 0.8 amp
(c) 0.25 amp (d) 0.5 amp

23. A block of mass 2 kg is initially at rest on a horizontal frictionless surface. A horizontal force $\vec{F}=(9-x^2)\hat{i}$ N acts on it, when the block is at $x=0$. The maximum kinetic energy of the block between $x=0$ and $x=3$ m in joule is
(a) 24 (b) 20 (c) 18 (d) 15

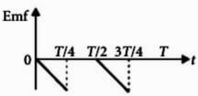
24. If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct?
(a) Raindrops will fall faster.
(b) Walking on the ground would become more difficult.
(c) Time period of a simple pendulum on the Earth would decrease.
(d) g on the Earth will not change.

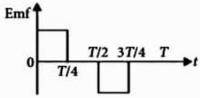
25. The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be



(a)


(b)


(c)


(d)


26. A mass M is suspended from a light spring. An additional mass m added displaces the spring further by a distance X. Now the combined mass will oscillate on the spring with period
(a) $T=2\pi\sqrt{\dfrac{mg}{X(M+m)}}$ (b) $T=2\pi\sqrt{\dfrac{(M+m)X}{mg}}$
(c) $T=\dfrac{\pi}{2}\sqrt{\dfrac{mg}{X(M+m)}}$ (d) $T=2\pi\sqrt{\dfrac{(M+m)}{mg}}$

27. Given below are two statements :
Statement-I : Susceptibilities of paramagnetic and ferromagnetic substances increase with decrease in temperature.
Statement-II : Diamagnetism is a result of orbital motions of electrons developing magnetic moments opposite to the applied magnetic field.
Choose the correct answer from the options given below
(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.

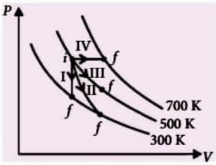
28. A solid sphere of mass M, radius R and having moment of inertia about an axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plane remains I. Then, radius of the disc will be
(a) $\dfrac{2R}{\sqrt{15}}$ (b) $R\sqrt{\dfrac{2}{15}}$ (c) $\dfrac{4R}{\sqrt{15}}$ (d) $\dfrac{R}{4}$

29. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of the input energy. How much power is generated by the turbine?
($g=10\ \text{m/s}^2$)
(a) 7.0 kW (b) 10.2 kW
(c) 8.1 kW (d) 12.3 kW

30. The displacement of a particle in a periodic motion is given by $y=4\cos^2\left(\dfrac{t}{2}\right)\sin(1000t)$.
This displacement may be considered as the result of superposition of n independent harmonic oscillations. Here n is
(a) 1 (b) 2 (c) 3 (d) 4

31. The flux of the electric field $\vec{E} = 24\hat{i} + 30\hat{j} + 28\hat{k}$ N C^{-1} through an area of 20 m^2 on the *yz* plane is
(a) 480 N m^2 C^{-1} (b) 600 N m^2 C^{-1}
(c) 560 N m^2 C^{-1} (d) 1640 N m^2 C^{-1}

32. Thermodynamic processes are indicated in the following diagram.



Match the following

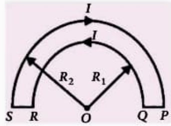
	Column-1		Column-2
P.	Process I	A.	Adiabatic
Q.	Process II	B.	Isobaric
R.	Process III	C.	Isochoric
S.	Process IV	D.	Isothermal

(a) P → C, Q → A, R → D, S → B
(b) P → C, Q → D, R → B, S → A
(c) P → D, Q → B, R → A, S → C
(d) P → A, Q → C, R → D, S → B

33. For Young's double slit experiment, two statements are given below :
Statement I : If screen moved away from the plane of slits, angular separation of the fringes remains constant.
Statement II : If the monochromatic source is replaced by another monochromatic source of larger wavelength, the angular separation of fringes decreases.
In the light of the above statements, choose the correct answer from the options given below
(a) Statement I is true but Statement II is false.
(b) Statement I is false but Statement II is true.
(c) Both Statement I and Statement II are true.
(d) Both Statement I and Statement II are false.

34. If $\vec{E}_{ax}$ and $\vec{E}_{eq}$ represents electric field at a point on the axial and equatorial line of a dipole. If points are at a distance *r* from the centre of the dipole, for $r >> a$
(a) $\vec{E}_{ax} = \vec{E}_{eq}$ (b) $\vec{E}_{ax} = -\vec{E}_{eq}$
(c) $\vec{E}_{ax} = -2\vec{E}_{eq}$ (d) $\vec{E}_{eq} = 2\vec{E}_{ax}$

35. A wire loop *PQRSP* is constructed by joining two semi-circular coils of radii R_1 and R_2 respectively as shown in the figure. If the current flowing in the loop is *I*, then the magnetic induction at the point *O* is

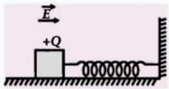


(a) $\frac{\mu_0 I}{4}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$
(b) $\frac{\mu_0 I}{4}\left[\frac{1}{R_1} + \frac{1}{R_2}\right]$
(c) $\frac{\mu_0 I}{2}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ (d) $\frac{\mu_0 I}{2}\left[\frac{1}{R_1} + \frac{1}{R_2}\right]$

SECTION - B

Attempt any 10 questions out of 15.

36. A wooden block performs SHM on a frictionless surface with frequency, υ. The block carries a charge +*Q* on its surface. If now a uniform electric field $\vec{E}$ is switched on as shown, then the SHM of the block will be



(a) of the same frequency and with shifted mean position.
(b) of the same frequency and with the same mean position.
(c) of changed frequency and with shifted mean position.
(d) of changed frequency and with the same mean position.

37. The main scale of a vernier callipers has *n* divisions per cm. *n* divisions of the vernier scale coincide with $(n - 1)$ divisions of main scale. The least count of the vernier callipers is,
(a) $\frac{1}{(n+1)(n-1)}$ cm (b) $\frac{1}{n}$ cm
(c) $\frac{1}{n^2}$ cm (d) $\frac{1}{n(n+1)}$ cm

38. The potential energy of gravitational interaction of a point mass *m* and a thin uniform rod of mass *M* and length *l*, if they are located along a straight line at distance *a* from each other is
(a) $U = \frac{GMm}{l}\ln\left(\frac{a+l}{a}\right)$
(b) $U = GMm\left(\frac{1}{a} - \frac{1}{a+l}\right)$

(c) $U = -\frac{GMm}{l}\ln\left(\frac{a+l}{a}\right)$

(d) $U = -\frac{GMm}{a}$

39. **Assertion :** An electrical bulb starts glowing instantly as it is switched on.

Reason : Drift speed of electrons in a metallic wire is very large.

(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.

40. The magnetic needle has magnetic moment 8.7×10^{-2} A m^2 and moment of inertia 11.5×10^{-6} kg m^2. It performs 10 complete oscillations in 6.70 s, what is the magnitude of the magnetic field?

(a) 0.012 T (b) 0.120 T
(c) 1.200 T (d) 2.10 T

41. A beaker contains water up to a height h_1 and kerosene of height h_2 above water so that the total height of (water + kerosene) is $(h_1 + h_2)$. Refractive index of water is μ_1 and that of kerosene is μ_2. The apparent shift in the position of the bottom of the beaker when viewed from above is

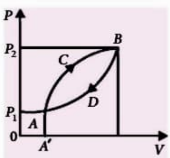
(a) $\left(1-\frac{1}{\mu_1}\right)h_2+\left(1-\frac{1}{\mu_2}\right)h_1$

(b) $\left(1+\frac{1}{\mu_1}\right)h_1-\left(1+\frac{1}{\mu_2}\right)h_2$

(c) $\left(1-\frac{1}{\mu_1}\right)h_1+\left(1-\frac{1}{\mu_2}\right)h_2$

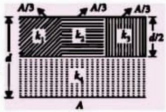
(d) $\left(1+\frac{1}{\mu_1}\right)h_2-\left(1+\frac{1}{\mu_2}\right)h_1$

42. A thermodynamic system is taken from state A to B along ACB and is brought back to A along BDA as shown in the PV diagram. The net work done during the complete cycle is given by the area



(a) $P_1ACBP_2P_1$ (b) $ACBB'A'A$
(c) $ACBDA$ (d) $ADBB'A'A$

43. A parallel-plate capacitor of area A, plate separation d and capacitance C is filled with four dielectric materials having dielectric constants k_1, k_2, k_3 and k_4 as shown in the figure. If a single dielectric material is to be used to have the same capacitance C in this capacitor, then its dielectric constant k is given by



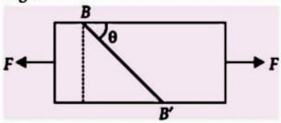
(a) $k = k_1 + k_2 + k_3 + 3k_4$

(b) $k = \frac{2}{3}(k_1 + k_2 + k_3) + 2k_4$

(c) $\frac{2}{k} = \frac{3}{k_1+k_2+k_3} + \frac{1}{k_4}$

(d) $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} + \frac{3}{2k_4}$

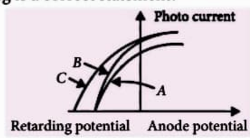
44. A bar of cross-section area A is subjected two equal and opposite tensile forces at its ends as shown in figure. Consider a plane BB' making an angle θ with the length.



The ratio of tensile stress to the shearing stress on the plane BB' is

(a) $\tan\theta$ (b) $\sec\theta$ (c) $\cot\theta$ (d) $\cos\theta$

45. The figure shows a plot of photo current versus anode potential for a photo sensitive surface for three different radiations. Which one of the following is a correct statement?

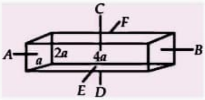


(a) Curves (A) and (B) represent incident radiations of same frequency but of different intensities.
(b) Curves (B) and (C) represent incident radiations of different frequencies and different intensities.
(c) Curves (B) and (C) represent incident radiations of same frequency having same intensity.
(d) Curves (A) and (B) represent incident radiations of different frequencies and different intensities

46. A liquid drop having surface energy E is spread into 512 droplets of same size. The final surface energy of the droplets is

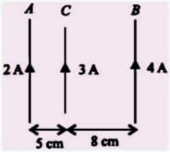
(a) $2E$ (b) $4E$ (c) $8E$ (d) $12E$

47. A conductor with rectangular cross-section has dimensions ($a \times 2a \times 4a$) as shown in figure. Resistance across AB is R_1, across CD is R_2 and across EF is R_3. Then



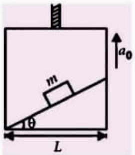
(a) $R_1 = R_2 = R_3$
(b) $R_1 > R_2 > R_3$
(c) $R_2 > R_3 > R_1$
(d) $R_1 > R_3 > R_2$

48. A and B are two infinitely long straight parallel conductors. C is another straight conductor of length 1 m kept parallel to A and B as shown in the figure. Then the force experienced by C is



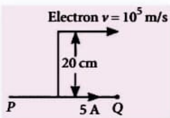
(a) towards A equal to 0.6×10^{-5} N
(b) towards B equal to 5.4×10^{-5} N
(c) towards A equal to 5.4×10^{-5} N
(d) towards B equal to 0.6×10^{-5} N

49. A block of mass m starting from rest slides down a smooth inclined plane of inclination θ, fixed in a lift moving upwards with an acceleration a_0 as shown in figure. If the base of the inclined plane has length L, the time taken by the block to slide from top to bottom of the inclined plane, will be



(a) $\dfrac{L}{(g+a_0)\sin 2\theta}$
(b) $\left[\dfrac{4L}{(g+a_0)\sin 2\theta}\right]^{1/2}$
(c) $\dfrac{(g+a_0)\sin 2\theta}{2L}$
(d) $\left[\dfrac{2L}{(g+a_0)\sin\theta}\right]^{2}$

50. An infinitely long straight conductor carries a current of 5 A as shown. An electron is moving with a speed of 10^5 m/s parallel to the conductor.



The perpendicular distance between the electron and the conductor is 20 cm at an instant. Calculate the magnitude of the force experienced by the electron at that instant.

(a) 8×10^{-20} N
(b) 4×10^{-20} N
(c) $8\pi \times 10^{-20}$ N
(d) $4\pi \times 10^{-20}$ N

SOLUTIONS

1. **(c) :** The energy stored in the inductor is, $U = \frac{1}{2}LI^2$

The energy stored in the inductor per second is

$$\frac{dU}{dt} = LI\frac{dI}{dt} = (200\times10^{-3}\text{H})(1\text{ A})(0.5\text{ As}^{-1}) = 0.1\text{ J s}^{-1}$$

2. **(a)**

3. **(c) :** Maximum KE = 2.6 eV,

Work function, $\phi_0 = 4.2$ eV

Energy of incident photon = Maximum KE + ϕ_0
= 2.6 + 4.2 = 6.8 eV

4. **(b) :** Here, given, $B = 0.1$ T, $r = 0.5$ m, $\omega = 10$ rad/s

So, the emf generated between its centre and rim is,

$$\varepsilon = \frac{1}{2}B\omega r^2 = \frac{1}{2}\times0.1\times10\times(0.5)^2 = 0.125\text{ V}$$

5. **(c) :** Here, Speed of light in vacuum,

c = 1 new unit of length s^{-1}

Time taken by light of sun to reach the earth

t = 8 min and 20 seconds = (8 × 60 + 20) s = 500 s

∴ Distance between the sun and the earth

$S = ct$ = 1 new unit of length s^{-1} × 500 s
= 500 new unit of length

6. **(d)**

7. **(c) :** Here, ${}^a\mu_g = 1.5 = \frac{3}{2}, {}^a\mu_w = \frac{4}{3}$

$${}^a\mu_w \times {}^w\mu_g = {}^a\mu_g \quad \therefore \quad {}^w\mu_g = \frac{{}^a\mu_g}{{}^a\mu_w} = \frac{3/2}{4/3} = \frac{9}{8}$$

$$\text{As } \sin C = \frac{1}{{}^w\mu_g} = \frac{1}{9/8} = \frac{8}{9}\text{ ; } C = \sin^{-1}\left(\frac{8}{9}\right)$$

For total internal reflection, $\theta > C$

$$\theta > \sin^{-1}\left(\frac{8}{9}\right) \text{ or } \sin\theta > \frac{8}{9}$$

8. **(a) :** According to Rydberg formula,

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

Here, $n_f = 1$, $n_i = 5$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{5^2}\right] = R\left[\frac{1}{1} - \frac{1}{25}\right] = \frac{24}{25}R$$

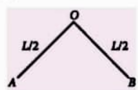
According to conservation of linear momentum, we get

Momentum of photon = Momentum of atom

$$\frac{h}{\lambda} = mv \text{ or } v = \frac{h}{m\lambda} = \frac{h}{m}\left(\frac{24R}{25}\right) = \frac{24hR}{25m}$$

9. **(d) :** Total mass = M,

total length = L



Moment of inertia of OA about O
= Moment of inertia of OB about O

$$\Rightarrow \text{M.I.}_{\text{total}} = 2\times\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2\cdot\frac{1}{3} = \frac{ML^2}{12}$$

$$= \frac{5(2)^2}{12} = \frac{5}{3}\text{kg m}^2$$

10. (c) : $W_{AB} = -P_0V_0$, $W_{BC} = 0$; $W_{CD} = 4P_0V_0$

$W_{ABCD} = W_{AB} + W_{BC} + W_{CD} = -P_0V_0 + 0 + 4P_0V_0 = 3P_0V_0$

11. (a) : The particle is fired vertically upwards from the Earth's surface with a velocity v and reaches a height h.

Energy of the particle at the surface of the Earth is

$$E_i = \frac{1}{2}mv^2 - \frac{GM_Em}{R_E}$$

Energy of the particle at a height h

$$E_f = -\frac{GM_Em}{R_E+h}$$

($\because$ At height h velocity of the particle is zero.)

According to law of conservation of energy, $E_i = E_f$

$$\frac{1}{2}mv^2 - \frac{GM_Em}{R_E} = -\frac{GM_Em}{R_E+h}$$

$$\frac{1}{2}mv^2 = GM_Em\left[\frac{1}{R_E} - \frac{1}{R_E+h}\right] = \frac{GM_Emh}{(R_E)(R_E+h)}$$

$$\frac{1}{2}mv^2 = \frac{mghR_E}{R_E+h} \quad ...(i) \quad \left(\because g = \frac{GM_E}{R_E^2}\right)$$

As per question,

$$v = kv_e = k\sqrt{2gR_E} \quad ...(ii)$$

Using (i) and (ii), we get $h = \frac{R_Ek^2}{1-k^2}$

If $R_E = R$, then $h = \frac{Rk^2}{1-k^2}$

12. (b) : As the P.D. across 4 Ω and 3 Ω (in parallel), are the same, $V = 4\times1 = 4$ V

$\therefore$ P.D. across points P and M = 4 V

$$\text{Current in } MNP = \frac{4}{1.25} = \frac{4\times4}{5} = \frac{16}{5}\text{A}$$

($\because$ R_{eq} across MNP = 1.25 Ω)

$$\therefore \text{ P.D. across } 1\,\Omega = \frac{16}{5}\text{A}\times1\,\Omega = \frac{16}{5}\text{ volt} = 3.2 \text{ volt}$$

13. (d)

14. (d) : LED bulb will light up if switch(s) A or B or both A and B is/are open. Hence, it represents a NAND gate.

15. (c) : Let time taken by ball to reach maximum height be T.

Also, $v = u - gT$

At maximum height, final speed is zero *i.e*, $v = 0$

So, $u = gT$ (Using (i))

In 2 s, $u = 2\times9.8 = 19.6$ m s^{-1}

Hence, the speed should be more than 19.6 m s^{-1}.

16. (d) : The wavelength of radiation used should be less than the size of the particle.

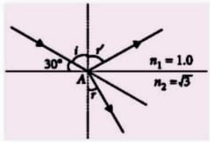
$$\text{Size of particle} = \lambda = \frac{c}{\upsilon}$$

$$3\times10^{-4} = \frac{3\times10^8}{\upsilon} \text{ or } \upsilon = 10^{12} \text{ hertz}$$

However, when frequency is higher than this, wavelength is still smaller. Resolution becomes better.

17. (c) : Angle of incidence,

$i = 90° - 30° = 60°$



As angle of reflection = angle of incidence

$\therefore$ $r' = i = 60°$

Applying the Snell's law at point A on the interface,

$n_1 \sin i = n_2 \sin r$

$$\sin r = \frac{n_1}{n_2}\sin i = \frac{1}{\sqrt{3}}\sin 60° = \frac{1}{\sqrt{3}}\frac{\sqrt{3}}{2} = \frac{1}{2}$$

$$r = \sin^{-1}\left(\frac{1}{2}\right) = 30°$$

18. (a)

19. (a) : Given, $L = \frac{50}{\pi}\text{mH} = \frac{50}{\pi}\times10^{-3}$ H

$f = 50$ Hz

Then, $X_L = 2\pi fL$

$$= 2\pi\times50\times\frac{50}{\pi}\times10^{-3} = 5\,\Omega \quad ...(i)$$

Similarly, $X_C = \frac{1}{2\pi fC}$

Here, $C = \frac{10^3}{\pi}\mu\text{F} = \frac{10^3}{\pi}\times10^{-6}$ F

$$\text{Then, } X_C = \frac{1}{2\pi\times50\times\frac{10^3}{\pi}\times10^{-6}} = 10\,\Omega \text{ and } R = 10\,\Omega$$

Therefore, net impedance $Z = \sqrt{R^2 + (X_L - X_L)^2}$

$$= \sqrt{10^2 + (10-5)^2} = 5\sqrt{5}\,\Omega$$

Hence, option (a) is correct.

20. (a) : When four He nuclei are fused together, one oxygen nucleus is formed. The reaction is $4\,{}^4_2\text{He} \rightarrow {}^{16}_8\text{O}$

Mass defect, $\Delta m = 4m_{\text{He}} - m_{\text{O}}$

$\therefore\ \Delta m = 4 \times 4.0026\text{ u} - 15.9994\text{ u} = 0.011\text{ u}$

Equivalent energy,

$E = \Delta mc^2 = 0.011 \times 931\text{ MeV} = 10.24\text{ MeV}$

21. (a)

22. (b) : The shunt and galvanometer are in parallel.

Therefore, $\frac{1}{R_{eq}} = \frac{1}{9} + \frac{1}{2}$ or $R_{eq} = \frac{18}{11}\ \Omega$

Using Ohm's law, $V = IR_{eq} = 1 \times \frac{18}{11} = \frac{18}{11}$ V.

$\therefore$ Current through shunt $= \frac{V}{R_s} = \frac{18/11}{2} = \frac{9}{11} \simeq 0.8$ amp

23. (c) : From work-energy theorem kinetic energy of the block at x is

$$K = \int_0^x (9 - x^2)dx = \left[9x - \frac{x^3}{3}\right]$$

For K to be maximum, $\frac{dK}{dx} = 0$

or $9 - x^2 = 0$ or $x = \pm 3$ m

At $x = +3$ m $\frac{d^2K}{dx^2}$ is negative

i.e., Kinetic energy K is maximum.

$\therefore\ K_{\max} = 9(3) - \frac{(3)^3}{3} = 18$ J

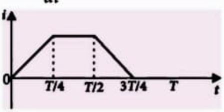
24. (d) : If universal gravitational constant becomes ten times, then $G' = 10\,G$.

So, acceleration due to gravity increases. *i.e*, (d) is the wrong option.

25. (a) : Induced emf, $e = -L\frac{di}{dt}$

For $0 \le t \le \frac{T}{4}$,

i-*t* graph is a straight line with positive constant slope.

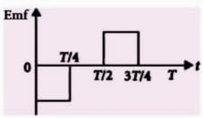


$\therefore\ \frac{di}{dt} = \text{constant} \Rightarrow e = -\text{ve and constant}$

For $\frac{T}{4} \le t \le \frac{T}{2}$

i is constant $\therefore\ \frac{di}{dt} = 0$

$\Rightarrow e = 0$



For $\frac{T}{2} \le t \le \frac{3T}{4}$

i-*t* graph is a straight line with negative constant slope.

$\therefore\ \frac{di}{dt} = \text{constant} \Rightarrow e = +\text{ve and constant}$

For $\frac{3T}{4} \le t \le T$; i is zero $\therefore\ \frac{di}{dt} = 0 \Rightarrow e = 0$

From this analysis, the variation of induced emf with time is as shown in the figure.

26. (b)

27. (a) : Both statement I and statement II are true.

28. (a) : Moment of inertia of solid sphere of mass M and radius R about an axis passing through the centre of mass is $I = \frac{2}{5}MR^2$.

Let the radius of the disc be r.

Moment of inertia of circular disc of radius r and mass M about an axis passing through the centre of mass and perpendicular to its plane $= \frac{1}{2}Mr^2$.

Using theorem of parallel axes, moment of inertia of disc about its edge is

$I' = \frac{1}{2}Mr^2 + Mr^2 = \frac{3}{2}Mr^2$ Given, $I = I'$

$\therefore\ \frac{2}{5}MR^2 = \frac{3}{2}Mr^2$ or $r^2 = \frac{4}{15}R^2$ or $r = \frac{2R}{\sqrt{15}}$

29. (c) : Given, $h = 60$ m

Now, water falls at the rate of 15 kg/s

i.e., $\frac{m}{t} = 15$ kg/s $g = 10\text{ m/s}^2$

As loss due to friction is 10%, therefore, only 90% of input energy is used to generate power.

TRIO

The same THREE LETTERS will complete these five words.

Can you find the three-letter sequence?

D I S P L A C E – – – T

L U – – –

– – – I S C U S

F I L A – – – T

M O – – – T U M

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names will be published in next issue.

$\therefore \quad P = gh\dfrac{m}{t} \times \dfrac{90}{100}$

$P = 10 \times 60 \times 15 \times \dfrac{90}{100} = 8100\text{ W} \Rightarrow \quad P = 8.1\text{ kW}$

30. (c) : $y = 4\cos^2\left(\dfrac{t}{2}\right)\sin(1000t)$

$y = 2(1 + \cos t)\sin(1000t)$ ($\because 2\cos^2\theta = 1 + \cos 2\theta$)

$= 2\sin(1000t) + 2\sin(1000t)\cos t$

$= 2\sin(1000t) + \sin(1001t) + \sin(999t)$

($\because$ $2\sin A\cos B = \sin(A + B) + \sin(A - B)$)

So, the given expression is the resultant of three independent harmonic oscillations.

31. (a) : Here, $\vec{E} = 24\hat{i} + 30\hat{j} + 28\hat{k}\text{ N C}^{-1}$; $\vec{S} = 20\hat{i}\text{ m}^2$

Electric flux, $\phi = \vec{E}\cdot\vec{S}$

$= (24\hat{i} + 30\hat{j} + 28\hat{k}\text{ N C}^{-1})\cdot(20\hat{i}\text{ m}^2) = 480\text{ N m}^2\text{ C}^{-1}$

32. (a) : In process I, volume is constant

$\therefore$ Process I → Isochoric; P → C

As slope of curve II is more than the slope of curve III.

Process II → Adiabatic and Process III → Isothermal

$\therefore$ Q → A, R → D

In process IV, pressure is constant

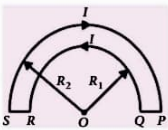
Process IV → Isobaric; S → B

33. (a)

34. (c) : $\vec{E}_{ax} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{2\vec{p}}{r^3}$; $\vec{E}_{eq} = -\dfrac{1}{4\pi\varepsilon_0}\dfrac{\vec{p}}{r^3} = -\dfrac{\vec{E}_{ax}}{2}$

$\therefore \quad \vec{E}_{ax} = -2\vec{E}_{eq}$

35. (a) : Magnetic induction at O due to semicircular arc QR of radius R_1 is



$B_{QR} = \dfrac{\mu_0 I\pi}{4\pi R_1} = \dfrac{\mu_0 I}{4R_1}\odot$

Magnetic induction at O due to straight portions PQ and RS is zero.

$\therefore \quad B_{PQ} = B_{RS} = 0$

(Since point O lying on the axis of the PQ and RS)

Magnetic induction at O due to semicircular arc SP of radius R_2 is

$B_{SP} = \dfrac{\mu_0 I\pi}{4\pi R_2} = \dfrac{\mu_0 I}{4R_2}\otimes$

Net magnetic field at O is

$B = B_{PQ} + B_{QR} + B_{RS} + B_{SP}$

$= 0 + \dfrac{\mu_0 I}{4R_1} + 0 - \dfrac{\mu_0 I}{4R_2} = \dfrac{\mu_0 I}{4}\left[\dfrac{1}{R_1} - \dfrac{1}{R_2}\right]$

36. (a) : As frequency of oscillation of wooden block, $\upsilon = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$, does not depend on constant external force due to electric field, hence the frequency of oscillation will be the same. But due to constant external force, the mean position of the wooden block gets shifted. Hence, option (a) is correct.

37. (c) : If n^{th} division of vernier scale coincides with $(n - 1)$ divisions of main scale.

Therefore, n VSD = $(n - 1)$ MSD

$\Rightarrow$ 1 VSD = $\dfrac{(n-1)}{n}$ MSD

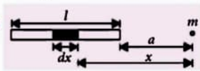
$\therefore$ Least count = 1 MSD – 1 VSD

$= 1\text{ MSD} - \dfrac{(n-1)}{n}\text{MSD}$

$= 1\text{ MSD} - 1\text{ MSD} + \dfrac{1}{n}\text{MSD} = \dfrac{1}{n}\text{MSD}$

$= \dfrac{1}{n} \times \dfrac{1}{n} = \dfrac{1}{n^2}\text{ cm} \qquad \left[\because 1\text{ MSD} = \dfrac{1}{n}\text{cm}\right]$

38. (c) :



Mass per unit length of rod $= \dfrac{M}{l}$

Mass of element of length dx, $dm = \dfrac{M}{l}dx$

The gravitational potential energy between this element and point mass is

$$dU = -\frac{Gmdm}{x} = -\frac{Gm\left(\frac{M}{l}dx\right)}{x}$$

EXAM ALERT 2024

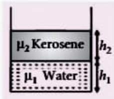
Exam	Date
JEE Main Session 2	Between 4th April and 15th April
KARNATAKA CET MATHS/BIOLOGY	18th April
KARNATAKA CET PHYSICS/CHEMISTRY	19th April
WB JEE	28th April
NEET	5th May
COMEDK (Engg.)	12th May
CUET	Between 15th May and 31st May
JEE Advanced	26th May
BITSAT Session 1	Between 19th May to 24th May
BITSAT Session 2	Between 22nd June to 26th June

$$\therefore \quad U = -\frac{GmM}{l}\int_a^{a+l}\frac{dx}{x} \text{ or } U = -\frac{GmM}{l}\ln\left(\frac{a+l}{a}\right)$$

39. (c) : As the conductor is full of electrons, with slight drift anywhere the queue starts moving. As a result bulb starts glowing instantly. Drift velocity of electrons in a good conductor is very low.

40. (a)

41. (c) : Apparent shift of bottom position of beaker in water is



$$x_1 = h_1 - \frac{h_1}{\mu_1} = h_1\left(1 - \frac{1}{\mu_1}\right)$$

Apparent shift of bottom position in kerosene is

$$x_2 = h_2 - \frac{h_2}{\mu_2} = h_2\left(1 - \frac{1}{\mu_2}\right)$$

$$\text{Total shift} = x_1 + x_2 = h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right)$$

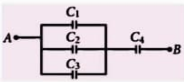
42. (c) : Work done = Area under curve *ACBDA*

43. (c) : Here, $C_1 = \frac{2\varepsilon_0 k_1 A}{3d}$, $C_2 = \frac{2\varepsilon_0 k_2 A}{3d}$,

$C_3 = \frac{2\varepsilon_0 k_3 A}{3d}$, $C_4 = \frac{2\varepsilon_0 k_4 A}{d}$

Given system of C_1, C_2, C_3 and C_4 can be simplified as

$$\therefore \quad \frac{1}{C_{AB}} = \frac{1}{C_1 + C_2 + C_3} + \frac{1}{C_4}$$



Suppose, $C_{AB} = \frac{k\varepsilon_0 A}{d}$

$$\frac{1}{k\left(\frac{\varepsilon_0 A}{d}\right)} = \frac{1}{\frac{2}{3}\frac{\varepsilon_0 A}{d}(k_1 + k_2 + k_3)} + \frac{1}{\frac{2\varepsilon_0 A}{d}k_4}$$

$$\Rightarrow \frac{1}{k} = \frac{3}{2(k_1 + k_2 + k_3)} + \frac{1}{2k_4} \quad \therefore \quad \frac{2}{k} = \frac{3}{k_1 + k_2 + k_3} + \frac{1}{k_4}$$

44. (a) : Consider the equilibrium of the plane BB′. A force F must be acting on this plane making an angle (90° – θ) with the normal *ON*. Resolving *F* into two components, along the plane and normal to the plane.

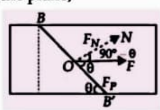
Component of force *F* along the plane,

$\therefore \quad F_P = F\cos\theta$

Component of force *F* normal to the plane,

$F_N = F\cos(90° - \theta) = F\sin\theta$

Let the area of the face *BB′* be *A′*. Then



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

$$\therefore \quad A' = \frac{A}{\sin\theta}$$

$$\therefore \quad \text{Tensile stress} = \frac{F\sin\theta}{A'} = \frac{F}{A}\sin^2\theta$$

$$\text{Shearing stress} = \frac{F\cos\theta}{A'}$$

$$= \frac{F}{A}\cos\theta\sin\theta = \frac{F\sin 2\theta}{2A}$$

Their corresponding ratio is

$$\frac{\text{Tensile stress}}{\text{Shearing stress}} = \frac{F}{A}\sin^2\theta \times \frac{A}{F\sin\theta\cos\theta} = \tan\theta$$

45. (a)

46. (c) : Let *R* and *r* be the radius of big drop and each smaller droplet respectively.

$$\therefore \quad \frac{4\pi R^3}{3} = 512 \times \frac{4\pi}{3}r^3 \Rightarrow R = 8r$$

Now, surface energy of big drop is

$E = 4\pi R^2 T$

Total surface energy of small droplets is

$$E_1 = 512 \times 4\pi r^2 T = 512 \times 4\pi\left(\frac{R}{8}\right)^2 T = 8 \times 4\pi R^2 T = 8E$$

47. (b) : $R = \frac{\rho l}{A}$

where the symbols have their usual meanings.

$$\therefore \quad R_1 = \frac{\rho(4a)}{(2a)(a)} = \frac{2\rho}{a}$$

$$R_3 = \frac{\rho(a)}{(4a)(2a)} = \frac{\rho}{8a} \text{ and } R_2 = \frac{\rho(2a)}{(4a)(a)} = \frac{\rho}{2a}$$

$\therefore \quad R_1 > R_2 > R_3$

48. (d) : Conductor A attracts conductor C towards A.

$\therefore$ Force towards A

$$= \frac{\mu_0}{2\pi}\frac{I_1 I_2 l}{r} = \frac{\mu_0}{2\pi}\frac{2\times 3\times 1}{0.05} = 240\times 10^{-7}\ \text{N}$$

Again, force towards B

$$= \frac{\mu_0}{2\pi}\times\frac{3\times 4\times 1}{0.08} = \frac{3\mu_0}{\pi}\times 25 = 300\times 10^{-7}\ \text{N}$$

Resultant force towards $B = (300 - 240)10^{-7}$ N

$= 0.6\times 10^{-5}$ N

49. (b) : Acceleration along the inclined plane,

$a = (g + a_0)\sin\theta$

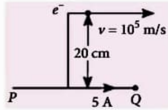
Slope length $= \dfrac{L}{\cos\theta}$

Using $S = ut + \frac{1}{2}at^2$, we get

$$\frac{L}{\cos\theta} = 0\times t + \frac{1}{2}(g + a_0)\sin\theta\, t^2$$

or $\quad t = \sqrt{\dfrac{2L}{(g+a_0)\sin\theta\cos\theta}}$ or $\quad t = \sqrt{\dfrac{4L}{(g+a_0)\sin 2\theta}}$

50. (a) : The magnetic field due to a straight wire at the location of electron is



$$B = \frac{\mu_0}{4\pi}\cdot\frac{2I}{r}$$

$$B = 10^{-7}\times\frac{2\times 5}{0.2}$$

$$= 50\times 10^{-7}\ \text{T}\,(\hat{k})$$

The direction is given by right hand thumb rule.

The force on charged particle moving in magnetic field is

$$\vec{F} = q(\vec{v}\times\vec{B})$$

$$\vec{F} = -1.6\times 10^{-19}\times(10^5\hat{i}\times 50\times 10^{-7}\hat{k})$$

$$\vec{F} = 8\times 10^{-20}\ \text{N}\,\hat{j}$$

JEE 2024 PRACTICE PAPER ADVANCED

Exam on 26th May

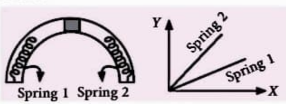
PAPER - I

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. In the figure, a block rests on the top of a smooth fixed hemispherical tube of radius R in which it can just fit. Two springs are connected to the base as shown. The block is given a small jerk so that it can slide on the hemisphere. The F-X (F is magnitude of force and X is compression) graph for the springs is given below. Which of the following may be possible?



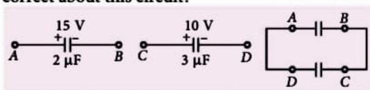
(a) The block will compress both springs by same amount.

(b) The block will compress the springs during its to and fro motion about its original position by different amounts.

(c) The block will perform to and fro motion along the hemispherical surface about the original position.

(d) The block can never come to the original position.

2. In the figure initial status of capacitance and their connection is shown. Which of the following is/are correct about this circuit?



(a) final charge on each capacitor will be zero

(b) final total electrical energy of the capacitors will be zero

(c) total charge flown from A to D is 30 μC

(d) total charge flown from A to D is – 30 μC

3. An electron of charge e and mass m is moving in a circular path of radius r with a uniform angular speed ω. Then which of the following statements are correct?

(a) The equivalent current flowing in the circular path is proportional to r^2.

(b) The magnetic moment due to circular current loop is independent of m.

(c) The magnetic moment due to circular current loop is equal to $2e/m$ times the angular momentum of the electron.

(d) The angular momentum of the particle is proportional to the areal velocity of electron.

SECTION 2 (MAXIMUM MARKS : 12)

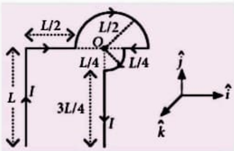
- *This section contains FOUR (04) questions.*
- *Each question has FOUR options (a), (b), (c) and (d). Only one of these four options is the correct answer.*
- *For each question, choose the option corresponding to the correct answer.*
- *Answer to each question will be evaluated according to the following 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. A copper wire of diameter 1 cm has a resistance of 0.25 Ω. It is drawn under pressure so that its diameter is reduced to 50%. The new resistance of the wire will be
(a) 2 Ω (b) 4 Ω (c) 6 Ω (d) 8 Ω

5. Which one of the following options represents the magnetic field $\vec{B}$ at O due to the current flowing in the given wire segments lying on the xy plane?



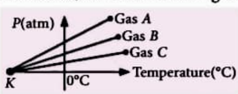
(a) $\vec{B}=\frac{-\mu_0 I}{L}\left(\frac{3}{2}+\frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

(b) $\vec{B}=\frac{-\mu_0 I}{L}\left(\frac{3}{2}+\frac{1}{2\sqrt{2}\pi}\right)\hat{k}$

(c) $\vec{B}=\frac{-\mu_0 I}{L}\left(1+\frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

(d) $\vec{B}=\frac{-\mu_0 I}{L}\left(1+\frac{1}{4\pi}\right)\hat{k}$

6. For three low density gases A, B, C pressure versus temperature graphs are plotted while keeping them at constant volume, as shown in the figure.



The temperature corresponding to the point K is
(a) –373°C (b) –40°C (c) –100°C (d) –273°C

7. If R_E is the radius of Earth, then the ratio between the acceleration due to gravity at a depth r below and a height r above the earth's surface is
(Given : $r < R_E$)

(a) $1+\frac{r}{R_E}-\frac{r^2}{R_E^2}-\frac{r^3}{R_E^3}$ (b) $1+\frac{r}{R_E}+\frac{r^2}{R_E^2}+\frac{r^3}{R_E^3}$

(c) $1-\frac{r}{R_E}-\frac{r^2}{R_E^2}-\frac{r^3}{R_E^3}$ (d) $1+\frac{r}{R_E}-\frac{r^2}{R_E^2}+\frac{r^3}{R_E^3}$

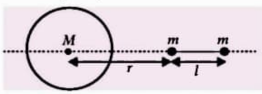
SECTION 3 (MAXIMUM MARKS : 24)

- *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. A body of mass 1 kg collides head on elastically with a stationary body of mass 3 kg. After collision, the smaller body reverses its direction of motion and moves with a speed of 2 m/s. The initial speed of the smaller body before collision is ______ m s^{-1}.

9. Consider an LC circuit, with inductance L = 0.1 H and capacitance $C = 10^{-3}$ F, kept on a plane. The area of the circuit is 1 m^2. It is placed in a constant magnetic field of strength B_0 which is perpendicular to the plane of the circuit. At time t = 0, the magnetic field strength starts increasing linearly as $B = B_0 + \beta t$ with β = 0.04 T s^{-1}. The maximum magnitude of the current in the circuit is ________ mA.

10. A large spherical mass M is fixed at one position and two identical point masses m are kept on a line passing through the centre of M (see figure). The point masses are connected by a rigid massless rod of length l and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass nearer to M is at a distance $r = 3l$ from M, the tension in the rod is zero for $m=k\left(\frac{M}{288}\right)$. The value of k is ________.



11. The pressure P_1 and density d_1 of diatomic gas $\left(\gamma=\frac{7}{5}\right)$ changes suddenly to $P_2(> P_1)$ and d_2 respectively during an adiabatic process. The temperature of the gas increases and becomes ________ times of its initial temperature. $\left(\text{given } \frac{d_2}{d_1}=32\right)$

12. In hydrogen-like atom (Z = 11), n^{th} line of Lyman series has wavelength λ. The de-Broglie's wavelength of electron in the level from which it originated is also λ. Find the value of n.

13. A square shaped coil of area 70 cm^2 having 600 turns rotates in a magnetic field of 0.4 Wb m^{-2}, about an axis which is parallel to one of the side of the coil and perpendicular to the direction of field. If the coil completes 500 revolutions in a minute, the instantaneous emf when the plane of the coil is inclined at 60° with the field, will be ______ V. $\left(\text{Take } \pi = \frac{22}{7}\right)$

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.

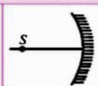
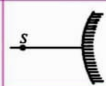
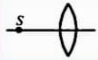
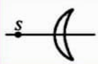
14. List I describes thermodynamic processes in four different systems. List II gives the magnitudes (either exactly or as a close approximation) of possible changes in the internal energy of the system due to the process.

List-I		List-II	
(P)	10^{-3} kg of water at 100°C is converted to steam at the same temperature, at a pressure of 10^5 Pa. The volume of the system changes from 10^{-6} m^3 to 10^{-3} m^3 in the process. Latent heat of water = 2250 kJ kg^{-1}.	(1)	2 kJ
(Q)	0.2 moles of a rigid diatomic ideal gas with volume V at temperature 500 K undergoes an isobaric expansion to volume 3 V. Assume R = 8.0 J mol^{-1} K^{-1}.	(2)	7 kJ
(R)	One mole of a monatomic ideal gas is compressed adiabatically from volume $V = \frac{1}{3} m^3$ and pressure 2 kPa to volume $V/8$.	(3)	4 kJ
(S)	Three moles of a diatomic ideal gas whose molecules can vibrate, is given 9 kJ of heat and undergoes isobaric expansion.	(4)	5 kJ
		(5)	3 kJ

Which one of the following options is correct?

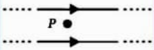
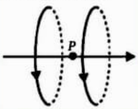
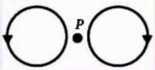
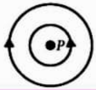
(a) (P) → (5), (Q) → (3), (R) → (4), (S) → (2)
(b) (P) → (4), (Q) → (1), (R) → (5), (S) → (1)
(c) (P) → (1), (Q) → (3), (R) → (5), (S) → (2)
(d) (P) → (2), (Q) → (3), (R) → (4), (S) → (5)

15. An optical component and an object S placed along its optic axis are given in Column I. The distance between the object and the component can be varied. The properties of images are given in Column II. Match all the properties of images from Column II with the appropriate components given in Column I.

Column I		Column II	
(P)		(1)	Real image
(Q)		(2)	Virtual image
(R)		(3)	Magnified image
(S)		(4)	Image at infinity
		(5)	Erect

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

16. Two wires each carrying a steady current I are shown in four configurations in column I. Some of the resulting effects are described in column II. Match the statements in column I with the statements in column II.

	Column I		Column II
(P)	Point P is situated midway between the wires. 	(1)	The magnetic fields (B) at P due to the currents in the wires are in the same direction.
(Q)	Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii. 	(2)	The magnetic fields (B) at P due to the currents in the wires are in opposite directions.
(R)	Point P is situated at the mid-point of the coils. 	(3)	There is no magnetic field at P.
(S)	Point P is situated at the common center of the wires. 	(4)	The wires repel each other
		(5)	There is non-zero magnetic field at P

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

17. A planet of mass M, has two natural satellites with masses m_1 and m_2. The radii of their circular orbits are R_1 and R_2 respectively. Ignore the gravitational force between the satellites. Define v_1, L_1, K_1 and T_1 to be, respectively, the orbital speed, angular momentum, kinetic energy and time period of revolution of satellite 1; and v_2, L_2, K_2 and T_2 to be the corresponding quantities of satellite 2. Given $m_1/m_2 = 2$ and $R_1/R_2 = 1/4$, match the ratios in List-I to the numbers in List-II.

	List-I		List-II
(P)	v_1/v_2	(1)	1/8
(Q)	L_1/L_2	(2)	1
(R)	K_1/K_2	(3)	1/2
(S)	T_1/T_2	(4)	8
		(5)	2

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

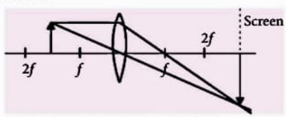
PAPER - II

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. Formation of real image using a biconvex lens is shown here.



If the whole set up is immersed in water without disturbing the object and the screen positions, what will one observe on the screen?

(a) Image disappears (b) Magnified image
(c) Erect real image (d) No change

2. An ice cube of dimensions 60 cm × 50 cm × 20 cm is placed in an insulation box of wall thickness 1 cm. The box keeping the ice cube at 0°C of temperature is brought to a room of temperature 40°C. The rate of melting of ice is approximately (Latent heat of fusion of ice is 3.4×10^5 J kg^{-1} and thermal conductivity of insulated wall is 0.05 W m^{-1}°C^{-1})
(a) 61×10^{-3} kg s^{-1} (b) 61×10^{-5} kg s^{-1}
(c) 208 kg s^{-1} (d) 30×10^{-5} kg s^{-1}

3. Choose the correct relationship between Poisson's ratio (σ), bulk modulus (K) and modulus of rigidity (η) of a given solid object.
(a) $\sigma = \frac{3K+2\eta}{6K+2\eta}$ (b) $\sigma = \frac{6K-2\eta}{3K-2\eta}$
(c) $\sigma = \frac{3K-2\eta}{6K+2\eta}$ (d) $\sigma = \frac{6K+2\eta}{3K-2\eta}$

4. A parallel beam of monochromatic light of wavelength 400 nm passes through a slit 0.4 mm wide and forms a diffraction pattern on a screen 1 m away from the slit and parallel to it. The width of central bright band is
(a) 0.24 cm (b) 0.20 cm
(c) 0.30 cm (d) 0.40 cm

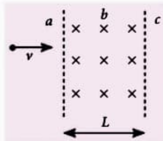
SECTION 2 (MAXIMUM MARKS : 12)

- ***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 rod of mass m and length L, pivoted at one of its ends, is hanging vertically. A bullet of the same mass moving at speed v strikes the rod horizontally at a distance x from its pivoted end and gets embedded in it. The combined system now rotates with angular speed ω about the pivot. The maximum angular speed ω_M is achieved for $x = x_M$. Then
(a) $\omega = \frac{3vx}{L^2+3x^2}$ (b) $\omega = \frac{12vx}{L^2+12x^2}$
(c) $x_M = \frac{L}{\sqrt{3}}$ (d) $\omega_M = \frac{v}{2L}\sqrt{3}$

6. A particle of mass m and charge q moving with velocity v enters region-b from region-a along the normal to the boundary as shown in the figure. Region-b has a uniform magnetic field B perpendicular to the plane of the paper. Also, region-b has length L. Choose the correct statements.



(a) The particle enters region-c only if $v > \frac{qLB}{m}$.
(b) The particle enters region-c only if $v < \frac{qLB}{m}$.
(c) Path of the particle is a circle in region-b.
(d) Time spent in region-b is independent of velocity v.

7. Consider a thin square plate floating on a viscous liquid in a large tank. The height h of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true?
(a) The resistive force of liquid on the plate is inversely proportional to h.
(b) The resistive force of liquid on the plate is independent of the area of the plate.
(c) The tangential (shear) stress on the floor of the tank increases with u_0.
(d) The tangential (shear) stress on the plate varies linearly with the viscosity η of the liquid.

SECTION 3 (MAXIMUM MARKS : 24)

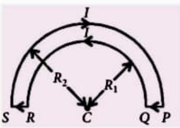
- ***This section contains SIX (06) questions.***
- ***The answer to each question is a NON-NEGATIVE INTEGER.***
- ***For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtua numeric keypad in the place designated to enter the answer.***

- ***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.***

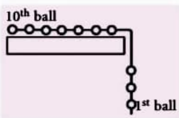
8. The electric field intensity produced by the radiation coming from a 100 W bulb at a distance of 3 m is E. The electric field intensity produced by the radiation coming from 60 W at the same distance is $\sqrt{\frac{x}{5}}E$, where the value of x is ______.

9. A projectile is fired from horizontal ground with speed v and projection angle θ. When the acceleration due to gravity is g, the range of the projectile is d. If at the highest point in its trajectory, the projectile enters a different region where the effective acceleration due to gravity is $g' = \frac{g}{0.81}$, then the new range is $d' = nd$. The value of n is ________.

10. The wire loop $PQRSP$ formed by joining two semicircular wires of radii R_1 and R_2 carries a current I as shown in the figure. The magnitude of the magnetic induction at the centre C is $\frac{\mu_0 I}{x}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ where the value of x is ______.

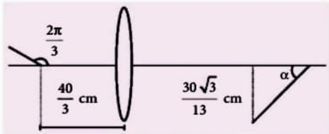


11. A system of 10 balls each of mass 2 kg are connected via massless and unstretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is ________ N.



12. Two concentric circular coils, C_1 and C_2, are placed in the XY plane. C_1 has 500 turns and a radius of 1 cm. C_2 has 200 turns and radius of 20 cm. C_2 carries a time dependent current $I(t) = (5t^2 - 2t + 3)$ A where t is in s. The emf induced in C_1 (in mV), at the instant $t = 1$ s is $\frac{4}{x}$. The value of x is ______.

13. A rod of length 2 cm makes an angle $\frac{2\pi}{3}$ rad with the principal axis of a thin convex lens. The lens has a focal length of 10 cm and is placed at a distance of $\frac{40}{3}$ cm from the object as shown in the figure. The height of the image is $\frac{30\sqrt{3}}{13}$ cm and the angle made by it with respect to the principal axis is α rad. The value of α is $\frac{\pi}{n}$ rad, where n is ______.



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

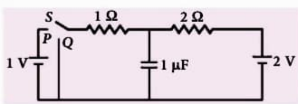
Consider a wave propagating in the negative x-direction whose frequency is 100 Hz. At $t = 5$ sec, the displacement associated with wave is given by $y = 0.5 \cos(0.1x)$, where x and y are in centimetres.

14. The wave velocity is $n\pi$ cm/s where the value of n is ______.

15. The displacement (as a function of x) at $t = 10$ sec is $y = n\cos(0.1x)$ where the value of n is ______.

Paragraph II

In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor becomes q_1 μC. Then S is switched to position Q. After a long time, the charge on the capacitor is q_2 μC.

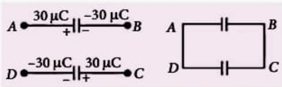


16. The magnitude of q_1 is ______ μC.
17. The magnitude of q_2 is ______ μC.

PAPER-I

1. (b, c) : The two springs have different spring constants. Also energy remains conserved during the motion as no friction is present.

2. (a, b, c) : $V = \dfrac{Q_1 + Q_2}{C_1 + C_2} = 0$



Final potential difference = zero
Final charge = zero
Charge flow is 30 μC from A to D.

3. (b, d) : An electron moving in a circular orbit acts like a current loop.

∴ The current flowing in the loop is $I = \dfrac{e}{T} = \dfrac{e\omega}{2\pi}$

Hence, statement (a) is incorrect.
Area of the loop, $A = \pi r^2$

Magnetic moment of the loop, $M = IA = \dfrac{e\omega}{2\pi}(\pi r^2) = \dfrac{er^2\omega}{2}$
Hence, statement (b) is correct.

As $M = \dfrac{e}{2m}L$ where L is the angular momentum of the electron.
Hence, statement (c) is incorrect.

Angular momentum $= 2m\dfrac{dA}{dt}$ where $\dfrac{dA}{dt}$ is the areal velocity.
Hence, statement (d) is correct.

4. (b)

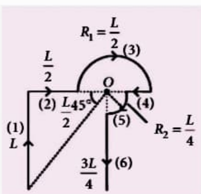
5. (c) : $B_1 = \dfrac{\mu_0 I}{4\pi L}(\sin 0° + \sin 45°)$

$\vec{B}_1 = \dfrac{\mu_0 I}{4\sqrt{2}\pi L}(-\hat{k})$

$\vec{B}_2 = 0$

$\vec{B}_3 = \dfrac{\mu_0 I}{4\left(\dfrac{L}{2}\right)}(-\hat{k}) = \dfrac{\mu_0 I}{2L}(-\hat{k})$

$\vec{B}_4 = 0$

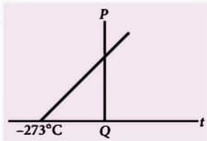


$\vec{B}_5 = \dfrac{\mu_0 I}{8\left(\dfrac{L}{4}\right)}(-\hat{k}) = \dfrac{\mu_0 I}{2L}(-\hat{k})$; $\vec{B}_6 = 0$

$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4 + \vec{B}_5 + \vec{B}_6$

$\vec{B}_{net} = \dfrac{\mu_0 I}{L}\left(1 + \dfrac{1}{4\sqrt{2}\pi}\right)(-\hat{k})$

6. (d) :



For isobaric process, $\dfrac{P}{T} = n\dfrac{R}{V}$ = constant

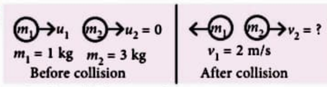
where T is temperature in Celsius.

or $P = \dfrac{nR}{V}(t + 273)$

where $t + 273$ represents temperature in Kelvin.
If $P = 0$, then $t + 273 = 0$
∴ $t = -273°C$

7. (a)

8. (4) :



Given, for elastic collision, $e = 1$
Using conservation of momentum
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \Rightarrow 1u_1 + 0 = -1 \times 2 + 3v_2$
$u_1 = 3v_2 - 2$ ...(i)

$e = 1 = \dfrac{v_2 - (-2)}{u_1}$; $u_1 = v_2 + 2$ ...(ii)

From (i) and (ii); $3v_2 - 2 = v_2 + 2$
$v_2 = 2$ m/s and from (ii); $u_1 = 2 + 2 = 4$ m/s

9. (4) : Given, $L = 0.1$ H, $C = 10^{-3}$ F, Area, $A = 1\ m^2$
$B = B_0 + \beta t$, $\beta = 0.04\ T\ s^{-1}$

For maximum energy, $\dfrac{q_0^2}{2C} = \dfrac{1}{2}L I_0^2$

∴ $I_0 = \dfrac{q_0}{\sqrt{LC}} = \dfrac{CV}{\sqrt{LC}} = V \times \sqrt{\dfrac{C}{L}}$ ...(i)

The induced emf is given by

$V = \left|\dfrac{d\phi}{dt}\right| = A\dfrac{dB}{dt} = A \times \dfrac{d}{dt}(B_0 + \beta t)$

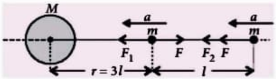
$V = A \times \beta$ ...(ii)

From eqn. (i) and (ii), $I_0 = \sqrt{\dfrac{10^{-3}}{0.1}}(1 \times 0.04)$; $I_0 = 4$ mA

10. (7) : Both the point masses are connected by a light rod so they have same acceleration.
Suppose each point mass is moving with acceleration a towards larger mass M.
Using Newton's 2nd law of motion for point mass nearer to larger mass,

$F_1 - F = ma$

$$\frac{GMm}{(3l)^2} - \frac{Gm^2}{l^2} = ma \quad \text{...(i)}$$



Again using 2nd law of motion for another mass

$F_2 + F = ma$

$$\frac{GMm}{(4l)^2} + \frac{Gm^2}{l^2} = ma \quad \text{...(ii)}$$

From eqn. (i) and (ii), we get

$$\frac{GM}{9l^2} - \frac{Gm}{l^2} = \frac{GM}{16l^2} + \frac{Gm}{l^2}$$

$$\frac{M}{9} - \frac{M}{16} = m + m \Rightarrow \frac{7M}{144} = 2m$$

$$m = \frac{7M}{288} = k\left(\frac{M}{288}\right) \quad \therefore k = 7$$

11. (4) : For adiabatic process, $PV^\gamma = K$

$P_1V_1^\gamma = P_2V_2^\gamma$; V is constant

$$P_1\left(\frac{m}{d_1}\right)^\gamma = P_2\left(\frac{m}{d_2}\right)^\gamma ; \frac{P_1}{P_2} = \left(\frac{d_1}{d_2}\right)^\gamma ;$$

$$\frac{P_1}{P_2} = \left(\frac{1}{32}\right)^{7/5} ; \frac{P_1}{P_2} = \frac{1}{128}$$

As $PV = nRT$

$$\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2} ; \frac{1}{128} \times \frac{d_2}{d_1} = \frac{T_1}{T_2} ; \frac{1}{128} \times 32 = \frac{T_1}{T_2} ; T_2 = 4T_1$$

12. (25)

13. (44) : $A = 70$ cm^2, $N = 600$, $B = 0.4$ T
Number of revolutions $n = 500$; time, $t = 1$ min,

$\theta = 30°$ and $\pi = \dfrac{22}{7}$

As, $\omega = \dfrac{n}{t} = \dfrac{500 \times 2\pi}{60} = \dfrac{50 \times 2\pi}{6}$ rad/s

Here, emf, $\varepsilon = NBA\omega \sin \omega t$

$$= 600 \times 0.4 \times 70 \times 10^{-4} \times 50 \times \frac{2\pi}{6} \times \sin 30°$$

$$\therefore \varepsilon = 600 \times 0.4 \times 70 \times 10^{-4} \times \frac{100 \times 22}{7 \times 6} \times \frac{1}{2} = 44 \text{ V}$$

14. (c)

15. (a) : (P) As per the sign convention f is to be taken as negative and u is also negative.

$$v = \frac{uf}{u-f} = \frac{f}{1-f/u} = \frac{u}{u/f - 1} \text{ and } m = -\frac{v}{u}$$

Values of v may be positive, negative or infinity, also it can have values less than or greater than u.

(P) → (1), (2), (3), (4), (5)

(Q) Focal length f is positive. So v will be positive and less than u.

(Q) → (2), (5)

(R) $v = \dfrac{f}{1 + f/u} = \dfrac{u}{u/f + 1}$.

Here $u < 0$, and $f > 0$

v may be positive, negative or infinity. v may be greater than or less than u.

(R) → (1), (2), (3), (4), (5)

(S) The lens is a concavo-convex lens, a converging lens, with positive focal length.
This case is same as in case (R) for the nature of image.
So (S) → (1), (2), (3), (4), (5)

16. (c)

17. (b) : Orbital speed, $v = \sqrt{\dfrac{GM}{R}} \Rightarrow v \propto \dfrac{1}{\sqrt{R}}$

$$\therefore \frac{v_1}{v_2} = \sqrt{\frac{R_2}{R_1}} = \sqrt{4} = 2$$

Angular momentum, $L = mvR$

$$\therefore \frac{L_1}{L_2} = \frac{m_1}{m_2} \times \frac{v_1}{v_2} \times \frac{R_1}{R_2} = \frac{2}{1} \times \frac{2}{1} \times \frac{1}{4} = 1$$

K.E. of satellite, $K = \dfrac{GMm}{2R}$

$$\therefore \frac{K_1}{K_2} = \frac{m_1}{m_2} \times \frac{R_2}{R_1} = 2 \times 4 = 8$$

From Kepler's second law, $T^2 \propto R^3$

$\Rightarrow T \propto R^{3/2}$

$$\therefore \frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{3/2} = \left(\frac{1}{4}\right)^{3/2} = \frac{1}{8}$$

So, (P) → (5), (Q) → (2), (R) → (4), (S) → (1)

PAPER-II

1. (a) : The focal length of the lens is given as

$$\frac{1}{f}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

If the setup is immersed in water, the focal length of the lens increases. Hence the image shifts further away from the lens while the position of screen has been kept unchanged. So, the image will not be observed on the screen.

2. (b)

3. (c) : The relation between Y, K, η and σ is given in the following equations. $Y = 2\eta(1+\sigma)$ ...(i)

$Y = 3K(1-2\sigma)$ ...(ii)

On subtracting equation (ii) from (i), we get

$0 = 2\eta + 2\eta\sigma - 3K + 6K\sigma$

$$\Rightarrow -\sigma(6K+2\eta) = 2\eta - 3K \Rightarrow \sigma=\frac{3K-2\eta}{6K+2\eta}$$

4. (b) : Here, $\lambda = 400\text{ nm} = 400\times10^{-9}\text{ m}$

$d = 0.4\text{ mm} = 0.4\times10^{-3}\text{ m}$, $D = 1\text{ m}$

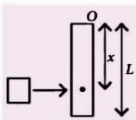
The width of the central bright band $=\dfrac{2\lambda D}{d}$

$$=\frac{2\times400\times10^{-9}\times1}{0.4\times10^{-3}}=2\times10^{-3}\text{ m}$$

$= 0.2\times10^{-2}\text{ m} = 0.20\text{ cm}$

5. (a, c, d) : Given that bullet is getting embedded at a distance x from O.

Then from angular momentum conservation



$$Mvx=\left(\frac{ML^2}{3}+Mx^2\right)\omega$$

or $$\omega=\frac{vx}{\left(\frac{L^2}{3}+x^2\right)}=\frac{3vx}{L^2+3x^2}$$

For maximum angular velocity, $\dfrac{d\omega}{dx}=0$

$$\frac{d\omega}{dx}=\frac{3v(L^2+3x^2)-3vx(6x)}{(L^2+3x^2)^2}=0$$

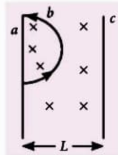
or $L^2+3x^2-6x^2=0$ or $3x^2=L^2$

$$\Rightarrow x=x_M=\frac{L}{\sqrt{3}}$$

$$\therefore \omega_{max}=\omega_M=\frac{3vx_M}{L^2+3x_M^2}=\frac{3v}{2\sqrt{3}L}=\frac{\sqrt{3}v}{2L}$$

6. (a,c,d) : As magnetic field is perpendicular to the motion of the particle, so its path is circular.

Radius of the circular path,



$$r=\frac{mv}{qB}$$

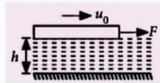
Particle will enter region 'c' if r is greater than L

i.e. $\dfrac{mv}{qB}>L$ or $v>\dfrac{qBL}{m}$.

Time spent in region b, $T=\dfrac{\pi}{\omega}=\dfrac{\pi m}{qb}$

$\therefore$ Option (d) is also correct.

7. (a,c,d) : Viscous force on the square plate moving on viscous liquid is



$$F=-\eta A\frac{dv}{dy}$$

According to the question,

$dv = u_0$ and $dy = h$

$$\therefore F=-\eta A\frac{u_0}{h} \text{ or } F\propto\frac{1}{h} \text{ and } F\propto A$$

Tangential stress $(S)=\dfrac{F}{A}=-\eta\dfrac{u_0}{h}$ $\therefore$ $S\propto\eta$ and $S\propto u_0$

8. (3) : Given : $P = 100$ W, $r = 3$ m

We know that, intensity, $I=\dfrac{1}{2}C\varepsilon_0E^2$ or $E^2\propto I$

Intensity, $I=\dfrac{P}{4\pi r^2}$; So, $E^2\propto\dfrac{P}{4\pi r^2}$

In first case, $E^2\propto\dfrac{100}{4\pi r^2}$ ...(i)

In second case, $\left(\sqrt{\dfrac{x}{5}}E\right)^2\propto\dfrac{60}{4\pi r^2}$ ...(ii)

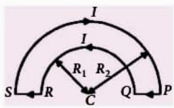
Dividing equation (ii) by (i), we get

$$\left(\sqrt{\frac{x}{5}}\right)^2=\frac{60}{100}=\frac{6}{10} \text{ or } \frac{x}{5}=\frac{6}{10} \text{ or } x=3$$

9. (0.95)

10. (4) : At C, magnetic field due to currents in PQ and RS will be zero.

Due to current in QR,



$$B_1=\frac{1}{2}\left(\frac{\mu_0 I}{2R_1}\right)$$

or $B_1=\dfrac{\mu_0 I}{4R_1}$, perpendicular to paper, outwards.

Due to current in SP,

$$B_2 = \frac{1}{2}\left(\frac{\mu_0 I}{2R_2}\right) = \frac{\mu_0 I}{4R_2}$$, perpendicular to paper, inwards.

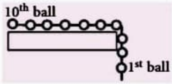
$\therefore$ Net magnetic field, $B = (B_1 - B_2)$

$\therefore$ $B = \frac{\mu_0 I}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, perpendicular to paper, outwards.

11. (36) : Number of balls, $n = 10$, Mass of balls $m = 2$ kg
When 6^{th} ball just leave the table, $6mg = 10ma$
Tension on the string between the

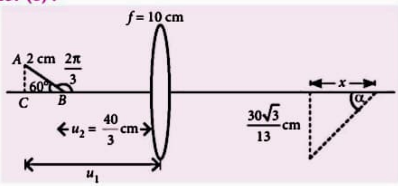
7^{th} and 8^{th}; $T = ma = 3m \times \frac{6g}{10}$

$$T = \frac{18 \times 2 \times 10}{10} = 36 \text{ N}$$



12. (5)

13. (6) :



$AB = 2$ cm (given), $u_1 = -\left(\frac{40}{3} + 1\right) = -\frac{43}{3}$ cm

$AC = 2 \sin 60° = \sqrt{3}$ cm , $BC = 2 \cos 60° = 1$ cm

$$\frac{h_i}{h_o} = \frac{v_1}{u_1} \Rightarrow \frac{-30\sqrt{3}}{13 \times \sqrt{3}} = \frac{v_1 \times 3}{-43}\ ;\ v_1 = \frac{30 \times 43}{13 \times 3} = \frac{430}{13} \text{cm}$$

$$\text{So, } \frac{1}{v_2} + \frac{3}{40} = \frac{1}{10} \Rightarrow \frac{1}{v_2} = \frac{1}{10} - \frac{3}{40} = \frac{1}{40}\ ;\ v_2 = 40 \text{ cm}$$

$$\therefore\ x = v_2 - v_1 = 40 - \frac{430}{13} = \frac{90}{13} \text{cm}$$

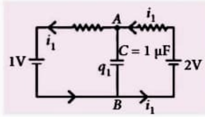
$$\text{So, } \tan\alpha = \frac{30\sqrt{3} \times 13}{13 \times 90} = \frac{1}{\sqrt{3}} \text{ or } \alpha = \frac{\pi}{6}\ \therefore\ n = 6$$

14. (2000) : A wave travelling in –ve x direction is
$y(x, t) = A \cos(kx + \omega t + \phi)$
At $t = 5$ sec; $y(x, t = 5) = A \cos(kx + 5\omega + \phi)$
Comparing with given equation.
$A = 0.5$ cm, $k = 0.1$ cm^{-1}
$5\omega + \phi = 0$ ...(i)

$\omega = 2\pi f = 200\pi$; $v = \frac{\omega}{k} = 2000\pi$ cm/sec

15. (0.5) : From (i), $\phi = -5\omega$
at $t = 10$s, $y = 0.5 \cos(0.1x + 10\omega - 5\omega)$
$= 0.5 \cos(0.1x + 5\omega)$
Put $\omega = 200\pi$, $y = 0.5\cos(0.1x)$

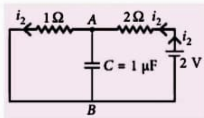
16. (1.33) : When the switch S is closed at P.
Let the current from dominant battery 2V be i_1.
Using KVL,



$V_A - 1 \times i_1 - 1 + 2 - 2i_1 = V_A - i_1 - 2i_1 = -1$
$i_1 = 1/3$ A
Now, $V_A - 1 \times i_1 - 1 = V_B$
$V_A - V_B = 1 + i_1 = 1 + 1/3 = 4/3$ V
So, potential difference across capacitor, $\Delta V = 4/3$ V

$$q_1 = C.\Delta V = 1 \times \frac{4}{3} = \frac{4}{3} \mu\text{C} = 1.33\ \mu\text{C}$$

17. (0.67) : When the switch closed at Q
Using KVL, $V_A - 1 \times i_2 + 2 - 2i_2 = V_A$
$3i_2 = 2 \Rightarrow i_2 = 2/3$A
And $V_A - i_2 \times 1 = V_B$



$$V_A - V_B = \frac{2}{3} \text{V}$$

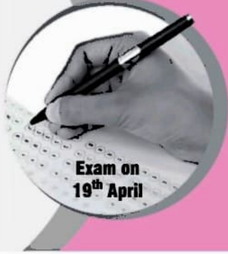
P.d. across capacitor,

$$\Delta V = \frac{2}{3} \text{V}$$

$$q_2 = C.\Delta V = 1 \times \frac{2}{3} = 0.67\ \mu\text{C}$$

PRACTICE PAPER 2024

Karnataka CET

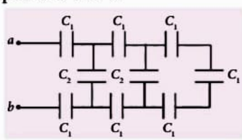


1. A man grows into a giant such that his linear dimensions increase by a factor of 9. Assuming that his density remains same, the stress in the leg will change by a factor of
(a) 9 (b) $\frac{1}{9}$ (c) 81 (d) $\frac{1}{81}$

2. Which of the following is another term for magnetization?
(a) Magnetic neutrality
(b) Magnetic polarization
(c) Magnetic power
(d) Magnetic moment

3. The acceleration due to gravity at the poles and the equator is g_p and g_e respectively. If the earth is a sphere of radius R_E and rotating about its axis with angular speed ω, then $g_p - g_e$ is given by
(a) $\frac{\omega^2}{R_E}$ (b) $\frac{\omega^2}{R_E^2}$ (c) $\omega^2 R_E^2$ (d) $\omega^2 R_E$

4. In the figure shown, each capacitor C_1 is 6.9 μF and C_2 is 4.6 μF. Calculate the equivalent capacitance between points '*a*' and '*b*'.

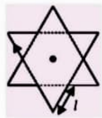


(a) 48.3 μF (b) 9.2 μF
(c) 11.5 μF (d) 2.3 μF

5. A mass M, attached to a horizontal spring, executes SHM with amplitude A_1. When the mass M passes through its mean position then a smaller mass m is placed over it and both of them move together with amplitude A_2. The ratio of $\left(\frac{A_1}{A_2}\right)$ is
(a) $\frac{M+m}{M}$ (b) $\left(\frac{M}{M+m}\right)^{1/2}$
(c) $\left(\frac{M+m}{M}\right)^{1/2}$ (d) $\frac{M}{M+m}$

6. The polariser and analyser are inclined to each other at 60°. The intensity of polarised light emerging from polariser is I. The intensity of the unpolarised light incident on the polariser is
(a) I (b) $8I$ (c) $4I$ (d) $2I$

7. A star shaped loop (with l = length of each section) carries current i. Magnetic field at the centroid of the loop is

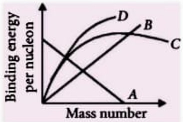


(a) $\frac{3\mu_0 i}{\pi l}$ (b) $\frac{3\mu_0 i}{2\pi l}$
(c) $(3-\sqrt{3})\frac{\mu_0 i}{\pi l}$ (d) $(3+\sqrt{3})\frac{\mu_0 i}{2\pi l}$

8. How much energy will be necessary for making a body of 500 kg to escape from the earth?
[$g = 10$ m s^{-2}, radius of earth = 6.4×10^6 m]
(a) 6.4×10^8 J (b) 3.2×10^{10} J
(c) 6.4×10^{12} J (d) 3.2×10^6 J

9. Needles N_1, N_2 and N_3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will
(a) attract all three of them
(b) attract N_1 strongly, N_2 weakly and repel N_3 weakly
(c) attract N_1 strongly but repel N_2 and N_3 weakly
(d) attract N_1 and N_2 strongly but repel N_3

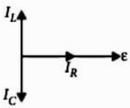
10. Binding energy per nucleon plot against the mass number for stable nuclei is shown in the figure. Which curve is correct?

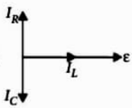


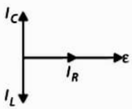
(a) A (b) B (c) C (d) D

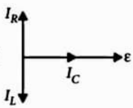
11. Which of the following quantities has the same dimensions as the gravitational constant?
(a) $(\text{velocity})^2$/mass per unit length
(b) force/mass
(c) $(\text{momentum})^2$/force
(d) work/time.

12. An alternating emf is applied across a parallel combination of a resistance R, capacitance C and an inductance L. If I_R, I_L and I_C are the currents through R, L and C respectively, then the diagram which correctly represents the phase relationship among I_R, I_L, I_C and source emf ε, is given by

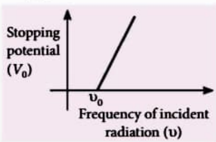
(a) 

(b) 

(c) 

(d) 

13. In an experiment to study photo-electric effect the observed variation of stopping potential with frequency of incident radiation is as shown in the figure. The slope and y-intercept are respectively



(a) $\frac{h}{e}, -\frac{h\upsilon_0}{e}$ (b) $\frac{h\upsilon}{e}, \upsilon_0$
(c) $\frac{h\upsilon}{e}, -\frac{h}{e}$ (d) $h\upsilon, -h\upsilon_0$

14. If two capillary tubes of radii r_1 and r_2 in the ratio 1 : 2 are dipped vertically in water, then the ratio of capillary rises in the respective tubes is
(a) 1 : 4 (b) 4 : 1
(c) 1 : 2 (d) 2 : 1

15. If a charged particle of charge 5 μC and mass 5 g is moving with constant speed 5 m/s in a uniform magnetic field B on a curve $x^2 + y^2 = 25$, where x and y are in metre. The value of magnetic field will be
(a) 1 kT along x-axis
(b) 1 kT along z-axis
(c) 5 kT along the x-axis
(d) 1 kT along any line in the x-y plane

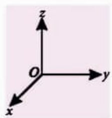
16. The first member of any series in hydrogen atom is (electron jumps from quantum number p to n)
(a) $p = n + 2$ (b) $p = n + 1$
(c) $p = n - 2$ (d) $p = n - 1$

17. An open organ pipe has fundamental frequency 100 Hz. What frequency will be produced if its one end is closed?
(a) 100, 200, 300 ....
(b) 50, 150, 250....
(c) 50, 100, 200, 300 ....
(d) 50, 100, 150, 200....

18. The kinetic energy of a revolving satellite (mass m) at a height equal to thrice the radius of the earth (R) is
(a) $\frac{mgR}{8}$ (b) $\frac{mgR}{16}$ (c) $\frac{mgR}{2}$ (d) $\frac{mgR}{4}$

19. Which of the following types of electromagnetic radiation travels at the greatest speed in vacuum?
(a) Radio waves
(b) Visible light
(c) X-rays
(d) All of these travel at the same speed

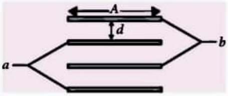
20. A force of $-F\hat{k}$ acts on O, the origin of the coordinate system. The torque about the point (1, –1) is



(a) $-F(\hat{i}+\hat{j})$
(b) $F(\hat{i}+\hat{j})$
(c) $-F(\hat{i}-\hat{j})$
(d) $F(\hat{i}-\hat{j})$

21. Stopping distance of a moving vehicle is directly proportional to
(a) square of the initial velocity
(b) square of the initial acceleration
(c) the initial velocity
(d) the initial acceleration

22. In figure, four parallel capacitors of equal area A and spacing d are arranged, then effective capacitance between points a and b is



(a) $\frac{\varepsilon_0 A}{d}$ (b) $\frac{2\varepsilon_0 A}{d}$ (c) $\frac{3\varepsilon_0 A}{d}$ (d) $\frac{4\varepsilon_0 A}{d}$

23. Which one of the following dimension is incorrect?
(a) Capacitance $C = [M^{-1}L^{-2}T^4A^2]$
(b) Magnetic field induction $B = [ML^0T^{-2}A^{-1}]$
(c) Coefficient of self-induction $L = [ML^2T^{-2}A^{-1}]$
(d) Specific resistance $\rho = [M L^3T^{-3}A^{-2}]$

24. A plane electromagnetic wave propagating in the x-direction has wavelength of 6.0 mm. The electric field is in the y-direction and its maximum magnitude is 33 V m^{-1}. The equation for the electric field as a function of x and t is

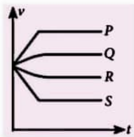
(a) $11 \sin [\pi(t - \frac{x}{c})]$

(b) $33 \sin [\pi \times 10^{11}(t - \frac{x}{c})]$

(c) $33 \sin [\pi(t - \frac{x}{c})]$

(d) $11 \sin [\pi \times 10^{11}(t - \frac{x}{c})]$

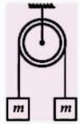
25. A solid sphere falls into a viscous liquid from a large height. Which of the graphs shown best represents the variation of velocity of sphere in liquid with time?



(a) P (b) Q (c) R (d) S

26. According to kinetic theory of gases, which one of the following statements is/are correct?
(a) Real gas behaves as ideal gas at high temperature and low pressure.
(b) Liquid state of ideal gas is impossible.
(c) There is an elastic collision between gas molecules and walls of the container.
(d) All of the above.

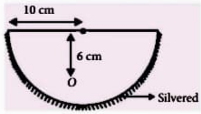
27. The radius of smooth light pulley is 0.2 m. The mass of each block is 10 kg. Find the normal force per unit length the string applies to the pulley.



(a) 500 N/m
(b) 100 N/m
(c) 200 N/m
(d) 250 N/m

28. Refractive index of a medium
(a) is dependent on temperature
(b) decreases as temperature increases
(c) increases as temperature decreases
(d) All of these

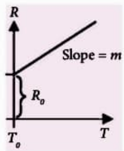
29. A hemispherical glass body of radius 10 cm and refractive index 1.5 is silvered on its curved surface. A small air bubble is 6 cm below the flat surface inside it along the axis. The position of the image of the air bubble made by the mirror is seen



(a) 14 cm below flat surface
(b) 20 cm below flat surface
(c) 16 cm below flat surface
(d) 30 cm below flat surface

30. Two satellites of Earth S_1 and S_2 are moving in the same orbit. The mass of S_1 is four times the mass of S_2. Which one of the following statements is true?
(a) The potential energies of satellite in the two cases are equal.
(b) S_1 and S_2 are moving with the same speed.
(c) The kinetic energies of the two satellites are equal.
(d) The time period of S_1 is four times that S_2.

31. Variation of resistance of the conductor with temperature is as shown. The temperature co-efficient (α) of the conductor is

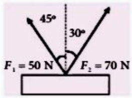


(a) $\frac{R_o}{m}$ (b) mR_o
(c) m^2R_o (d) $\frac{m}{R_o}$

32. Two small spherical shells A and B are given positive charge of 9 C and 4 C respectively and placed such that their centres are separated by 10 m. If P is a point in between them where the electric field intensity is zero, then the distance of the point P from the centre of A is

(a) 5 m (b) 6 m (c) 7 m (d) 8 m

33. Figure shows the top view of two horizontal forces pulling a box along the floor. The work done by each force to displace the box 70 cm along the broken line is

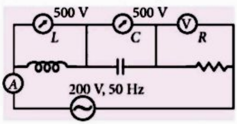


(a) 24.74 J, 42.4 J
(b) 42.4 J, 20.75 J
(c) 40 J, 24.74 J
(d) 42 J, 24 J.

34. Monochromatic light incident on a metal surface emits electrons with kinetic energies from zero to 1.8 eV. What is the least energy of the incident photon, if the tightly bound electron needs 3.6 eV to remove?
(a) 1.8 eV
(b) From 1.8 eV to 5.4 eV
(c) 5.4 eV
(d) More than 5.4 eV

35. Which of the following statements is incorrect?
(a) No work is done if the displacement is perpendicular to the direction of the applied force.
(b) If the angle between the force and displacement vectors is obtuse, then the work done is negative.
(c) Frictional force is a non-conservative.
(d) All the central forces are non-conservative.

36. In the series *LCR* circuit shown in figure the ammeter and voltmeter readings are

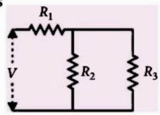


(a) 5 A, 1200 V
(b) 5 A, 200 V
(c) 3 A, 800 V
(d) 2 A, 600 V

37. A projectile is fired at an angle of 60° to the horizontal with a speed of 20 m s^{-1}. Take acceleration due to gravity as 10 m s^{-2}. The horizontal range of the projectile is
(a) $10\sqrt{3}$ m
(b) 20 m
(c) $20\sqrt{3}$ m
(d) $40\sqrt{3}$ m

38. A small flat circular coils of area 4 cm^2 with 20 closely wound turns is positioned normal to the field direction and then quickly snatched out of the field region. The total charge flowing in the coil (measured by a ballistic galvanometer connected to the coil) is 7.5 mC. The resistance of the coil and galvanometer is 0.8 Ω. The field strength of the magnet is
(a) 1.25 T (b) 0.50 T (c) 0.75 T (d) 2.10 T

39. For ensuring dissipation of same energy in all three resistors (R_1, R_2, R_3) connected as shown in figure, their values must be related as



(a) $R_1 = R_2 = R_3$
(b) $R_2 = R_3$ and $R_1 = 4R_2$
(c) $R_2 = R_3$ and $R_1 = \dfrac{R_2}{4}$
(d) $R_1 = R_2 + R_3$

40. Pick out the correct statements about optical fibres from the following.
S1 : Optical fibres are used for the transmission of optical signals only.
S2 : Optical fibres are used for transmitting and receiving electrical signals.
S3 : The intensity of light signals sent through optical fibres suffer very small loss.
S4 : Optical fibres effectively employ the principle of multiple total internal reflections.
S5 : Optical fibres are glass fibres coated with a thin layer of a material with lower refractive index.
(a) S1 and S2
(b) S2 and S3
(c) S3 and S4
(d) S2, S3, S4 and S5

41. The polarising angle for a medium is 60°. The critical angle for the medium is
(a) $\sin^{-1}\left(\frac{1}{2}\right)$
(b) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$
(c) $\cos^{-1}\left(\frac{1}{2}\right)$
(d) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

42. Two cars *A* and *B* moves along a concentric circular path of radius r_A and r_B with velocity v_A and v_B maintaining constant distance, then find v_A/v_B?
(a) r_B/r_A (b) $r_A \times r_B$ (c) r_A/r_B (d) $r_B \times r_A$

43. A ray of light strikes a silvered surface inclined to another one at an angle of 90°. Then the reflected ray will turn through
(a) 0° (b) 45° (c) 90° (d) 180°

44. A disc of moment of inertia I_1 is rotating with angular velocity ω_1 about an axis perpendicular to its plane and passing through its centre. If another disc of moment of inertia I_2 about the same axis is gently placed over it, then the new angular velocity of the combined disc will be
(a) $\dfrac{(I_1+I_2)\omega_1}{I_1}$
(b) $\dfrac{I_1\omega_1}{I_1+I_2}$
(c) ω_1
(d) $\dfrac{I_2\omega_2}{I_1+I_2}$

45. A light disc made of aluminium (a non-magnetic material) is kept horizontally and is free to rotate

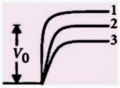
about its axis. A strong magnet is held vertically at a point above the disc away from its axis. On revolving the magnet about the axis of the disc, the disc will

(a) rotate in the direction opposite to the direction of magnet's motion
(b) rotate in the same direction as the direction of magnet's motion
(c) not rotate and its temperature will remain unchanged
(d) not rotate but its temperature will slowly rise.

46. Thermal capacity of 40 g of aluminum ($s = 0.2$ cal/g K) is

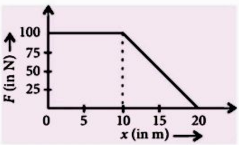
(a) 168 J/°C (b) 672 J/°C
(c) 840 J/°C (d) 33.6 J/°C

47. In figure, V_0 is the barrier potential across a p-n junction, when no battery is connected across the junction.



(a) 1 and 3 both correspond to forward bias of junction.
(b) 1 corresponds to reverse bias of junction and 3 corresponds to forward bias of junction.
(c) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.
(d) 1 and 3 both correspond to reverse bias of junction.

48. A force F acting on an object varies with distance x as shown in the figure. The work done by the force in moving the object from $x = 0$ to $x = 20$ m is

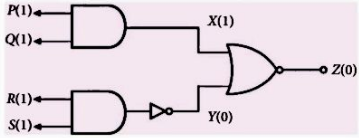


(a) 500 J (b) 1000 J (c) 1500 J (d) 2000 J

49. The radius of the hydrogen atom in its ground state is a_0. The radius of a muonic hydrogen atom in which the electron is replaced by an identically charged muon with mass 207 times that of an electron, is a_μ equal to

(a) $207a_0$ (b) $\frac{a_0}{207}$
(c) $\frac{a_0}{\sqrt{207}}$ (d) $a_0\sqrt{207}$

50. The circuit diagram shows a logical combination with the states of output X, Y and Z given for inputs P, Q, R and S all at state 1. When inputs P and R change to state 0 with inputs Q and S still at 1, the states of outputs X, Y and Z change to

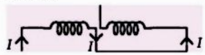


(a) 1, 0, 0 (b) 1, 1, 1
(c) 0, 1, 0 (d) 0, 1, 1

51. A force $\vec{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of α for which angular momentum about origin is conserved is

(a) zero (b) 1 (c) −1 (d) 2

52. Two coils of self inductance L_1 and L_2 are connected in series combination having mutual inductance of the coils as M. The equivalent self inductance of the combination will be



(a) $\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{M}$ (b) $L_1 + L_2 + M$
(c) $L_1 + L_2 + 2M$ (d) $L_1 + L_2 - 2M$

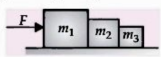
53. A parallel plate capacitor having area A and separated by distance d is filled by copper plate of thickness b. The new capacity is

(a) $\frac{\varepsilon_0 A}{d + \frac{b}{2}}$ (b) $\frac{\varepsilon_0 A}{2d}$ (c) $\frac{\varepsilon_0 A}{d - b}$ (d) $\frac{2\varepsilon_0 A}{d + \frac{b}{2}}$

54. A short bar magnet of magnetic moment 0.4 J T^{-1} is placed in a uniform magnetic field of 0.16 T. The magnet is in stable equilibrium when the potential energy is

(a) −0.064 J (b) zero
(c) −0.082 J (d) 0.064 J

55. Three blocks of masses m_1, m_2 and m_3 are placed in contact with each other on a frictionless table. A force F is applied on the heaviest mass m_1, the acceleration of m_3 will be



(a) $\frac{F}{m_1}$ (b) $\frac{F}{m_1 + m_2}$
(c) $\frac{F}{m_2 + m_3}$ (d) $\frac{F}{m_1 + m_2 + m_3}$

56. F_{pp}, F_{nn} and F_{np} are the nuclear forces between proton-proton, neutron-neutron and neutron-proton respectively. Then relation between them is

(a) $F_{pp} = F_{nn} \neq F_{np}$ (b) $F_{pp} \neq F_{nn} = F_{np}$
(c) $F_{pp} = F_{nn} = F_{np}$ (d) $F_{pp} \neq F_{nn} \neq F_{np}$

57. A charge of 0.8 coulomb is divided into two charges Q_1 and Q_2. These are kept at a separation of 30 cm. The force on Q_1 is maximum when

(a) $Q_1 = Q_2 = 0.4$ C
(b) $Q_1 \approx 0.8$ C, Q_2 negligible
(c) Q_1 negligible, $Q_2 \approx 0.8$ C
(d) $Q_1 = 0.2$ C, $Q_2 = 0.6$ C

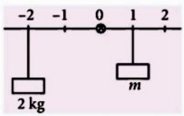
58. Two thin convex lenses of focal length 20 cm and 25 cm are placed at a finite distance apart. The power of the combination is 8 D. Distance between the lenses is

(a) 5 cm (b) 10 cm (c) 8 cm (d) 4 cm

59. A car of mass 2000 kg rounds a curve of radius 250 m at 90 km/hr. Compute its, (i) angular speed, (ii) centripetal acceleration, (iii) centripetal force.

	(i) [rad/s]	(ii) [m/s^2]	(iii) [N]
(a)	0.1	2.5	5000
(b)	0.2	5.0	4000
(c)	0.1	7.5	2500
(d)	0.2	10.0	500

60. A horizontal beam is pivoted at 0 as shown in the figure. Find the mass m to make the scale straight.



(a) 2 kg (b) 1 kg (c) 4 kg (d) 2.5 kg

SOLUTIONS

1. **(a) :** We know stress is given by

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{mg}{A} = \frac{\rho V g}{A} \quad \left(\because \rho = \frac{m}{V}\right)$$

i.e., stress $\propto \frac{L^3}{L^2}$ (L is the linear dimension.)

$\Rightarrow$ Stress $\propto L$

Since, linear dimension increases by a factor of 9, stress also increases by a factor of 9.

2. **(b) :** Magnetization is also termed as magnetic polarization. Magnetic polarization is basically a balance between the magnetic flux density in a space which is devoid of matter and the magnetic flux density in a space with matter, *i.e.*, in material.

3. **(d) :** Acceleration due to gravity at a place of latitude λ due to the rotation of earth is $g' = g - R_E\omega^2\cos^2\lambda$

At equator, $\lambda = 0°$, $\cos 0° = 1$ $\therefore$ $g' = g_e = g - R_E\omega^2$

At poles, $\lambda = 90°$, $\cos 90° = 0$

$\therefore$ $g' = g_p = g$

$\therefore$ $g_p - g_e = g - (g - R_E\omega^2) = R_E\omega^2$

4. **(d)**

5. **(c) :** When a mass M attached to a horizontal spring executes SHM, its frequency of oscillation is

$$\upsilon_1 = \frac{1}{2\pi}\sqrt{\frac{k}{M}} \quad ...(i)$$

When a smaller mass m is placed over mass M, the frequency of oscillation is

$$\upsilon_2 = \frac{1}{2\pi}\sqrt{\frac{k}{(M+m)}} \quad ...(ii)$$

According to law of conservation of linear momentum,

$Mv_1 = (M+m)v_2$ or $MA_1\omega_1 = (M+m)A_2\omega_2$

or $MA_1 2\pi\upsilon_1 = (M+m)A_2 2\pi\upsilon_2$

$$\therefore \frac{A_1}{A_2} = \frac{(M+m)}{M} \times \frac{\upsilon_2}{\upsilon_1} = \frac{(M+m)}{M} \times \sqrt{\frac{M}{M+m}}$$

(Using (i) and (ii))

$$= \sqrt{\frac{M+m}{M}}$$

6. **(b) :** $I = \frac{I_0}{2}\cos^2\theta = \frac{I_0}{2}\cos^2 60° = \frac{I_0}{2} \times \frac{1}{4}$

$\therefore$ $I_0 = 8I$

7. **(c) :** $r = \frac{\sqrt{3}l}{2}$; $B = 6\left[\frac{\mu_0}{4\pi}\frac{i}{r}(\sin 60° + \sin 60°)\right]$

$$-6\left[\frac{\mu_0}{4\pi}\frac{i}{r}(\sin 30° + \sin 30°)\right] = 6 \times \frac{\mu_0}{4\pi} \cdot \frac{i}{r}(\sqrt{3}-1)$$

$$\Rightarrow 6 \times \frac{\mu_0}{4\pi} \cdot \frac{i}{\left(\frac{\sqrt{3}l}{2}\right)}(\sqrt{3}-1) = \frac{\mu_0 i}{\pi l}(3-\sqrt{3})$$

8. **(b) :** P.E. of the body at the surface of the earth,

$$U = -\frac{GMm}{R_e}, \text{ but, } g = -\frac{GM}{R_e^2} \quad \therefore \frac{GM}{R_e} = gR_e$$

$\therefore$ $U = -gmR_e = -10 \times 500 \times 6.4 \times 10^6 = -3.2 \times 10^{10}$ J

Thus, an energy of 3.2×10^{10} J should be given to the body in the form of K.E., so that it will escape from the earth.

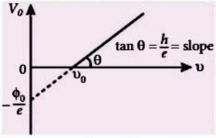
9. **(b) :** A ferromagnetic substance is strongly attracted, a paramagnetic substance is weakly attracted and a diamagnetic substance is weakly repelled by a magnet. Thus, a magnet when brought close to needles N_1, N_2 and N_3 will attract N_1 strongly, N_2 weakly and repel N_3 weakly.

10. (c)

11. (a) : $\frac{(\text{velocity})^2}{\text{mass/length}} = \frac{[LT^{-1}]^2}{[ML^{-1}]} = [M^{-1}L^3T^{-2}] = G.$

12. (c) : Current in inductance I_L lags behind the emf by a phase of $\pi/2$, current in resistance I_R is in phase with emf, while current in capacitance I_C leads by a phase of $\pi/2$.

13. (a) : Graph between frequency (υ) and stopping potential V_0 is shown in figure.



$eV_0 = h\upsilon - \phi_0$ or $V_0 = \frac{h}{e}\upsilon - \frac{\phi_0}{e} = \frac{h}{e}\upsilon - \frac{h\upsilon_0}{e}$

Therefore, slope of graph between the stopping potential and frequency is $\frac{h}{e}$ and y-intercept is $-\frac{h\upsilon_0}{e}$.

14. (d): Rise of liquid in a capillary tube,

$h = \frac{2S\cos\theta}{r\rho g}$ or $h \propto \frac{1}{r}$ $\quad\therefore\quad \frac{h_1}{h_2} = \frac{r_2}{r_1} = \frac{2}{1}$

15. (b): $x^2 + y^2 = 25 \quad \therefore\ r = 5$ m

$\because\ r = \frac{mv}{qB}$ or $5 = \frac{5\times10^{-3}\times5}{5\times10^{-6}\times B}$

or $B = \frac{5\times10^{-3}\times5}{5\times10^{-6}\times5} = 10^3\ \text{T} = 1\ \text{kT}$

The magnetic field will be 1 kT along z-axis.

16. (b)

17. (b): When one end is closed, $n_1 = \frac{100}{2} = 50$ Hz

For closed pipe only odd harmonics are produced which are 50, 150, 250,....

18. (a)

19. (d): All electromagnetic waves travel with the same speed $c\ (= 3\times10^8\ \text{m s}^{-1})$ in vacuum.

20. (b): Here, $\vec{F} = -F\hat{k}\,;\ \vec{r} = (\hat{i} - \hat{j})$

$\therefore\quad \vec{\tau} = \vec{r}\times\vec{F} = (\hat{i}-\hat{j})\times(-F\hat{k})$

$= -F(\hat{i}\times\hat{k} - \hat{j}\times\hat{k}) = -F(-\hat{j}-\hat{i})\ \vec{\tau} = F(\hat{i}+\hat{j})$

21. (a): Let d_s is the distance travelled by the vehicle before it stops.

Here, final velocity $v = 0$, initial velocity $= u$, $S = d_s$

Using equation of motion, $v^2 = u^2 + 2aS$

$\therefore\quad (0)^2 = u^2 + 2ad_s;\ d_s = -\frac{u^2}{2a}$ or $d_s \propto u^2$

22. (c)

23. (c) : $[C] = \frac{[q^2]}{[W]} = \frac{[AT]^2}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^4A^2]$

$[B] = \frac{[F]}{[I][l]} = \frac{[MLT^{-2}]}{[A][L]} = [ML^0T^{-2}A^{-1}]$

$[L] = \frac{\varepsilon}{\left(\frac{di}{dt}\right)} = \frac{\left[\frac{W}{q}\right][t]}{[i]} = \left[\frac{ML^2T^{-2}}{AT}\right]\frac{[T]}{[A]} = [ML^2T^{-2}A^{-2}]$

$[\rho] = \frac{[R][A]}{[L]} = \frac{[ML^2T^{-3}A^{-2}][L^2]}{[L]} = [ML^3T^{-3}A^{-2}]$

Choice (c) is dimensionally wrong.

24. (b): $\omega = 2\pi\upsilon = \frac{2\pi c}{\lambda} = \frac{2\pi\times3\times10^8}{6\times10^{-3}} = \pi\times10^{11}$ rad/s

The equation for the electric field, along y-axis in the electromagnetic wave is given by

$E_y = E_0\sin\omega\left(t - \frac{x}{c}\right) = 33\sin\left[\pi\times10^{11}\left(t - \frac{x}{c}\right)\right]$

25. (c) : The sphere, as it falls from a large height, has a large velocity when it enters the viscous liquid. So, it experiences a large viscous force upwards. The velocity, then keeps on decreasing. Thus, the viscous force and the magnitude of (negative) acceleration go on decreasing non-linearly. At a particular point of time, acceleration becomes zero and velocity remains constant. So, the best curve is R.

26. (c)

27. (a) : $r = 0.2$ m, $m = 10$ kg

$T = F = mg \Rightarrow 10\times10 = 100$ N

Normal force per unit length $= \frac{100\text{N}}{0.2\text{ m}} = 500$ N/m

28. (d)

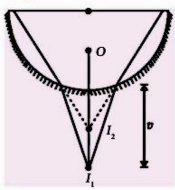
29. (b): Here, $R = -10$ cm

Object distance from mirror, $u = -(10-6) = -4$ cm

Focal length of mirror, $f = -\frac{R}{2} = -\frac{10}{2} = -5$ cm

Image distance $= v = ?$

Using mirror formula,



$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-4} = \frac{1}{-5}$

$\Rightarrow \frac{1}{v} = \frac{1}{4} - \frac{1}{5} = \frac{1}{20};\ v = 20$ cm

Now, I_1 acts as object for plane glass surface,

$\therefore$ Apparent depth $= \frac{R+v}{\mu} = \frac{30}{1.5} = 20$ cm

Hence, the position of the image of the air bubble made by the mirror is seen 20 cm below the flat surface.

30. (b)

31. (d): Equation of the line, $R = R_o + m(T - T_o)$ ...(i)
We know, $R = R_o[1 + \alpha(T - T_o)]$ ...(ii)

Comparing eqns. (i) and (ii), we get $R_o\alpha = m \therefore \alpha = \frac{m}{R_o}$

32. (b)

33. (a): Work done by force F_1, $W_1 = (F_1 \cos 45°)\, s_1$

$= 50 \cos 45° \times \frac{70}{100} = 24.74$ J

Work done by force F_2, $W_2 = (F_2 \cos 30°)\, s_2$

$= 70 \cos 30° \times \frac{70}{100} = 42.4$ J.

34. (c): Maximum KE = 1.8 eV,
Work function, $\phi_0 = 3.6$ eV
Energy of incident photon = Maximum KE + ϕ_0
= 1.8 + 3.6 = 5.4 eV

35. (d): All the central forces are conservative. All other statements are correct.

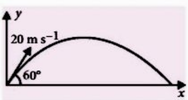
36. (b): $V = \sqrt{V_R^2 + (V_L - V_C)^2}$; Here $V_L = V_C = 500$ V

$V = 200$ V $\therefore$ $V = V_R = 200$ V,
Voltmeter reading across R is 200 V.

Current $I_V = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{200}{\sqrt{40^2 + 0^2}} = 5\,\text{A}$

$V_L = I_V X_L = 500$
$V_C = I_V X_C = 500$
$\therefore X_L = X_C$
Therefore, ammeter reading is 5A and voltmeter V reads = 200 V.
Choice (b) is correct.

37. (c): Given : $g = 10$ m s^{-2}
$u = 20$ m s^{-1}, $\theta = 60°$



As, $R = \frac{u^2 \sin 2\theta}{g}$

$= \frac{(20)^2 \sin 2(60°)}{10} = 20\sqrt{3}$ m

38. (c): Here, $A = 4$ cm^2 $= 4 \times 10^{-4}$ m^2, $N = 20$
Final flux, $\phi_f = 0$
(when the coil is removed from the field)
$q = 7.5$ mC $= 7.5 \times 10^{-3}$ C, $R = 0.8\ \Omega$

As $I = \frac{\varepsilon}{R} = \frac{-N(d\phi/dt)}{R}$; $I\,dt = -\frac{N}{R}d\phi$

Also charge,

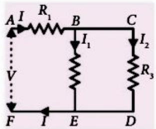
$$q = \int I\,dt = \int_{\phi_i}^{\phi_f} -\frac{N}{R}d\phi = -\frac{N}{R}(\phi_f - \phi_i) = \frac{N}{R}(\phi_i - \phi_f)$$

$$q = \frac{N}{R}\phi_i$$

Now, initial flux per turn when coil is normal to the field, $\phi_i = BA$

$$\therefore q = \frac{NBA}{R} \text{ or } B = \frac{qR}{NA} = \frac{7.5 \times 10^{-3} \times 0.8}{20 \times 4 \times 10^{-4}} = 0.75 \text{ T}$$

39. (c): As voltage across the resistors R_2 and R_3 is same and they show same dissipation of energy, so using the relation for energy, $H = \frac{V^2}{R}t$, we get $R_2 = R_3$.



Thus, the current in each resistor R_2 and R_3 will be $\frac{I}{2}$.

i.e., $I_1 = \frac{I}{2}$ and $I_2 = \frac{I}{2}$

Since, the energy dissipation is same in all the three resistors, so

$$I^2R_1t = I_{21}R_2t \text{ or } I^2R_1t = \left(\frac{I}{2}\right)^2 R_2t \text{ or } R_1 = \frac{R_2}{4}$$

40. (a)

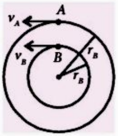
41. (d): Here, $i_p = 60°$
Refractive index of the medium,

$\mu = \tan i_p = \tan 60° = \sqrt{3}$

Now, critical angle of the medium, i_c

$= \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

42. (c) : For A and B, ω is the same.



As $v = r\omega$

$\therefore\ v_A = r_A\,\omega$

and $v_B = r_B\,\omega$

$\therefore\ v_A / v_B = r_A/r_B$

43. (d): For mirror M_1, $\angle i = 0°$

$\therefore\ \angle r = 0°$ *i.e.* the reflected ray would retrace its path turning through 180°. Mirror M_2 has no effect.

44. (b): According to conservation of angular momentum, $I_1\omega_1 = (I_1 + I_2)\omega_2$

$$\therefore\ \omega_2 = \frac{I_1\omega_1}{I_1 + I_2}$$

45. (b): Due to the motion of magnet, an induced e.m.f is produced on the disc, which according to the Lenz's law, opposes the motion of the magnet. Then, according to Newton's third law of motion, an equal and opposite force is applied on the disc by the magnet, which rotates the disc on the same direction as that of the magnet.

46. (d): Thermal capacity $= ms = 40 \times 0.2 = 8$ cal/°C
$= 4.2 \times 8 = 33.6$ J/°C

47. (b): When *p-n* junction is forward biased, applied voltage opposes the barrier potential resulting decrease in barrier potential. When *p-n* junction is reverse biased, applied voltage supports the barrier potential resulting increase in barrier potential. Thus, curve 1 corresponds to reverse bias and curve 3 corresponds to forward bias.

48. (c)

49. (b) : $a_0 = \dfrac{h^2\varepsilon_0}{\pi m e^2}$ ...(i)

$a_\mu = \dfrac{h^2\varepsilon_0}{\pi(207m)e^2}$ ...(ii)

Dividing (ii) by (i), we get, $\dfrac{a_\mu}{a_0} = \dfrac{1}{207}$ or $a_\mu = \dfrac{a_0}{207}$

50. (c) : In that states outputs X, Y and Z changes to 0, 1, 0

51. (c) : For the conservation of angular momentum about origin, the torque $\vec{\tau}$ acting on the particle will be zero. By definition, $\vec{\tau} = \vec{r} \times \vec{F}$

Here, $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$ and $\vec{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$

$$\therefore\ \vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -6 & -12 \\ \alpha & 3 & 6 \end{vmatrix}$$

$= \hat{i}(-36+36) - \hat{j}(12+12\alpha) + \hat{k}(6+6\alpha)$

$= -\hat{j}(12+12\alpha) + \hat{k}(6+6\alpha)$

But $\vec{\tau} = 0$; $\therefore\ 12 + 12\alpha = 0$ or $\alpha = -1$

and $6 + 6\alpha = 0$ or $\alpha = -1$

52. (d)

53. (c) : After inserting copper plate, $C = \dfrac{\varepsilon_o A}{d - b}$

54. (a) : Here, $M = 0.4$ J T^{-1}; $B = 0.16$ T

For stable equilibrium, the potential energy (U) of bar magnet in the magnetic field is

$U = -MB = -0.4 \times 0.16 = -0.064$ J

55. (d): When three blocks of masses m_1, m_2 and m_3 are placed in contact with each other on a frictionless table and a force F is applied to them as shown in figure which produces a common acceleration a in them. It is given by

$$a = \frac{F}{m_1 + m_2 + m_3}$$

$\therefore$ The acceleration of mass m_3 is a.

56. (c) : Nuclear force is charge independent.

$\therefore\ F_{pp} = F_{nn} = F_{np}$

57. (a)

58. (a) : Here, $f_1 = 20$ cm, $f_2 = 25$ cm, $P = 8$ D

Focal length of combination $= \dfrac{1}{8}$ m $= \dfrac{100}{8}$ cm

Now, using $\dfrac{1}{F} = \dfrac{1}{f_1} + \dfrac{1}{f_2} - \dfrac{d}{f_1 f_2}$,

(where d is the distance between lenses), we get

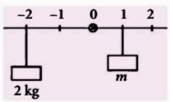
$$\frac{8}{100} = \frac{1}{20} + \frac{1}{25} - \frac{d}{20 \times 25}$$

$$\Rightarrow \frac{d}{500} = \frac{1}{20} + \frac{1}{25} - \frac{8}{100} = \frac{5+4-8}{100} = \frac{1}{100}$$

or $d = \dfrac{500}{100} = 5$ cm

59. (a)

60. (c) :



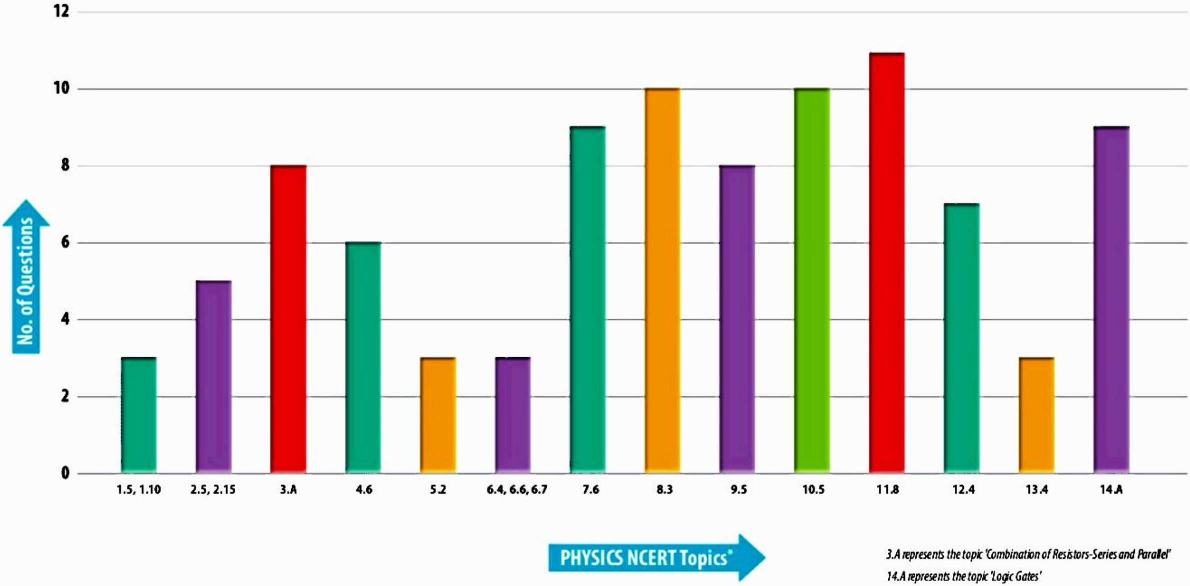
Taking the moments about 0, we get

$mg(1) = 2g(2)$ or $m = 4$ kg

Are You Ready for NEET 2024?

Class 12

Past 10 Years (2014-2023) Chapterwise Trend Analysis of NEET Questions



3.A represents the topic 'Combination of Resistors-Series and Parallel'

14.A represents the topic 'Logic Gates'

01 Electric Charges and Fields

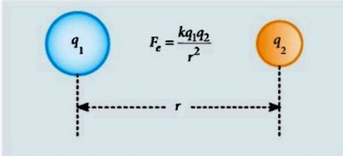
Coulomb's Law

- If two point charges q_1 and q_2 are separated by a distance r in vacuum, the magnitude of the force (F_e) between them is given by

$$F_e = k\frac{|q_1q_2|}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{|q_1q_2|}{r^2}$$

where ε_0 is called the permittivity of free space, $\varepsilon_0 = 8.854 \times 10^{-12}\ C^2 N^{-1} m^{-2}$

and $k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9 C^{-2} N m^2$

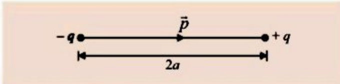


- In a dielectric medium of dielectric constant K, force decreases as,

$$F = \frac{F_e}{K} = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1q_2}{r^2}$$

Electric Dipole

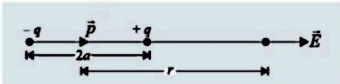
- An electric dipole is a system formed by two equal and opposite point-charges placed at a small distance apart.
  Dipole moment $\vec{p} = q(2\vec{a})$



- Electric field at a point on the axis of a dipole (end-on position)

$$\vec{E}_a = \frac{2\vec{p}r}{4\pi\varepsilon_0 (r^2 - a^2)^2}$$

  – At large distance ($r >> a$), $\vec{E}_a = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3}$

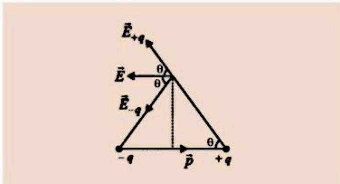


- Electric field at a point on the equatorial line of a dipole (Broadside-on position)

$$\vec{E}_e = \frac{1}{4\pi\varepsilon_0}\frac{-\vec{p}}{(r^2 + a^2)^{3/2}}$$

  – At large distance, $\vec{E}_e = \frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$

- At large distance from the dipole ($r >> a$), $E_a = 2E_e$

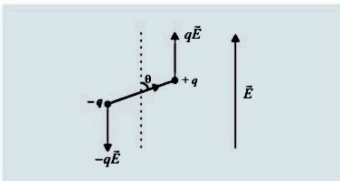


Dipole in a Uniform External Field

- When a dipole is placed in a uniform external electric field, then net force ($+ qE - qE$) on it is zero, but it experiences a torque.

  $\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\theta = 2qaE\sin\theta$

  – Minimum torque : $\tau_{min} = 0$
  Dipole is parallel or antiparallel to the electric field
  – Maximum torque : $\tau_{max} = pE$
  Dipole is perpendicular to the electric field



Equipotential Surfaces

An equipotential surface is a surface with a constant value of potential at all points on the surface. For a single point charge q, the potential is given by

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Relation between Electric Field and Electric Potential

$$E = -\frac{\partial V}{\partial r}$$

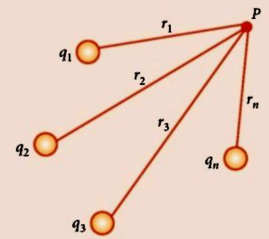
Electric field is in the direction in which the potential decreases steepest. Magnitude of electric field is given by the change in the magnitude of potential per unit displacement normal to the equipotential surface at the point.

Potential due to a System of Charges

- Net potential = Algebraic sum of the potentials due to the individual charges. So at point P,

$$V = V_1 + V_2 + V_3 + \ldots$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \ldots\right)$$

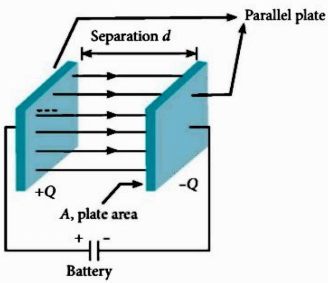


Capacitor and Energy Stored in it

- A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge.
- Charge and voltage are related to the capacitance C of a capacitor by $Q = CV$, and so the expression for E is algebraically manipulated into three equivalent expressions:

  $E = QV/2 = CV^2/2 = Q^2/2C$

  where Q is the charge and V the voltage on a capacitor C. The energy is in joules for a charge in coulombs, voltage in volts, and capacitance in farads.

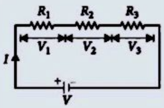


03 Current Electricity

Combination of Resistance

Series combination

Current is same across each resistance.



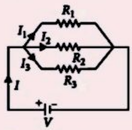
$V = V_1 + V_2 + V_3$

$IR_S = IR_1 + IR_2 + IR_3$

- $R_S = R_1 + R_2 + R_3$
- $R_S > \max(R_1 / R_2 / R_3)$

Parallel combination

Potential drop across all resistances is same.



$I = I_1 + I_2 + I_3$

$\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

- $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- $R_p < \min(R_1 / R_2 / R_3)$

Electric Power

- It is defined as the rate at which work is done by the source of emf in maintaining the current in the electric circuit.

$$\text{Electric power} = \frac{\text{Electric work done}}{\text{time taken}}$$

$$P = VI = I^2R = \frac{V^2}{R}.$$

- The SI unit of power is watt (W).

Electric Energy

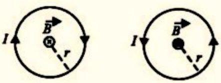
- It is defined as the total electric work done or energy supplied by the source of emf in maintaining the current in an electric circuit for a given time. Electric energy = Electric power × Time = $P \times t$.
- The SI unit of electrical energy is joule (J).

04 Moving Charges and Magnetism

Applications of Biot-Savart Law

- Magnetic field strength at any point at centre of circular loop carrying current I and radius r is

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

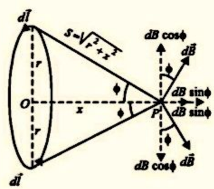


- Magnetic field strength at the centre O of circular arc of angle θ carrying current I is

$$B = \frac{\mu_0 I\theta}{4\pi r}$$

- Magnetic field on the axis of circular loop of radius r carrying current I at distance x is,

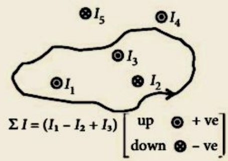
$$B = \frac{\mu_0 I r^2}{2(r^2 + x^2)^{3/2}}$$



Ampere's Circuital Law

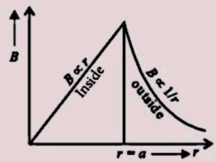
- It states that line integral of the magnetic field along any closed path in free space is equal to μ_0 times of net current, crossing through area bounded by the closed path. Mathematically,

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \Sigma I$$



Applications of Ampere's Circuital Law

- Magnetic field due to an infinitely long straight solid cylindrical wire of radius a, carrying current I
  - Magnetic field at a point outside the wire *i.e.*, ($r > a$) is $B = \frac{\mu_0 I}{2\pi r}$
  - Magnetic field at a point inside the wire *i.e.*, ($r < a$) is $B = \frac{\mu_0 I r}{2\pi a^2}$
  - Magnetic field at a point on the surface of a wire *i.e.*, ($r = a$) is $B = \frac{\mu_0 I}{2\pi a}$
  - The variation of magnetic field B and the distance r from axis is as shown in the figure.

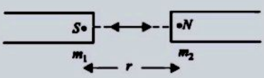


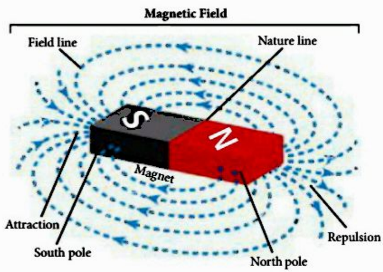
05 Magnetism and Matter

Bar Magnet

- When a bar magnet is freely suspended, it points in the north-south direction. The tip which points to the geographic north is called the north pole and the tip which points to the geographic south is called the south pole of the magnet.
- If two magnetic poles of strengths m_1 and m_2 are placed at a distance r apart, then force of attraction or repulsion between them is

$$F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2} \quad \text{where } \mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$





Magnetic Field at a Point due to a Bar Magnet

- The magnetic field due to a bar magnet of length $2l$ at any point (r) on the axial line (end on position) is given by

$$B_{axial} = \frac{\mu_0}{4\pi}\frac{2Mr}{(r^2 - l^2)^2}$$

  – For short magnet $l^2 << r^2$

$$B_{axial} = \frac{\mu_0 2M}{4\pi r^3}$$

- The magnetic field due to a bar magnet at any point on the equitorial line (board-side on position) of the bar magnet is given by

$$B_{equatorial} = \frac{\mu_0 M}{4\pi(r^2 + l^2)^{3/2}}$$

  – For short magnet $l^2 << r^2$

$$B_{equatorial} = \frac{\mu_0 M}{4\pi r^3}$$

09 Electromagnetic Induction

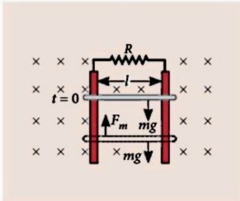
Faraday's Laws of Electromagnetic Induction

- **First law :** Whenever the amount of magnetic flux linked with a circuit changes, an emf is induced in the circuit. This induced emf persists as long as the change in magnetic flux continues.
- **Second law :** The magnitude of the induced emf is equal to the rate of change of magnetic flux.

$\varepsilon = -\frac{d\phi}{dt} = -\frac{\phi_2 - \phi_1}{t}$, where negative sign indicates the direction of ε.

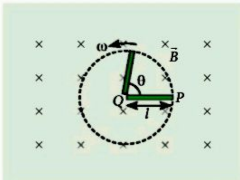
Applications of Motional Electromotive Force

- If conducting rod moves on two parallel conducting rails distance l apart,
  – Induced emf : $|\varepsilon| = \frac{d\phi}{dt} = Bvl$
  – Induced Current : $I = \frac{\varepsilon}{R} = \frac{Bvl}{R}$
  – Magnetic Force : $F_m = BIl = \frac{B^2vl^2}{R}$
  – Power dissipated in moving the conductor $= \frac{B^2v^2l^2}{R}$



- Motional emf due to rotational motion across the ends of the rod is,

$$\varepsilon = \frac{1}{2}Bl^2\omega = Bl^2\pi\upsilon = \frac{Bl^2\pi}{T}$$



Inductance

Inductance is the inertia offered by the coil due to change in magnetic flux. Emf induced in the coil/conductor,

- Self inductance, $L = \frac{N}{I}\phi_B = \frac{-\varepsilon}{dI/dt}$
  - Self inductance of a long solenoid,

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

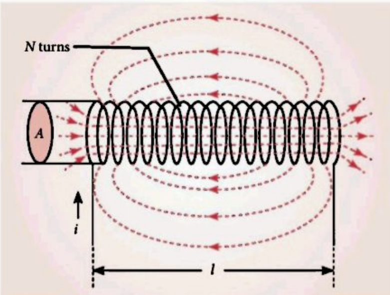
- Mutual inductance,

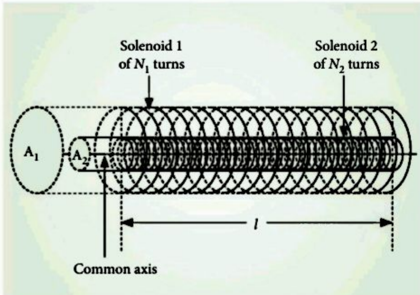
$$M = \frac{N_2\phi_2}{I_2} = \frac{-\varepsilon_2}{(dI_1/dt)} = \frac{-\varepsilon_1}{(dI_2/dt)}$$

  - Mutual inductance of two long coaxial solenoids,

$$M = \mu_0\mu_r \pi r_1^2 n_1 n_2 l = \frac{\mu_0\mu_r N_1 N_2 A_1}{l}$$

  - Coefficient of coupling, $k = \frac{M}{\sqrt{L_1 L_2}}$

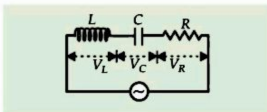




07 Alternating Current

Series *RLC* Circuit

An ac source is connected to resistor of resistance R, an inductor of inductance L and capacitor of capacitance C in series as shown in the figure.

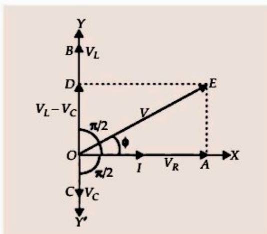


- Impedance of the circuit, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

- The voltage leads the current by a phase angle ϕ, where

$$\tan\phi = \frac{X_L - X_C}{R}$$



Admittance and Susceptance

- Admittance, $Y = \frac{1}{\text{Impedance}}$ or $Y = \frac{1}{Z}$
- Susceptance, $S = \frac{1}{\text{Reactance}}$

The unit of admittance and susceptance is $(\text{ohm})^{-1}$ or siemen.

– Inductive susceptance, $S_L = \frac{1}{X_L} = \frac{1}{\omega L}$

– Capacitive susceptance,

$$S_C = \frac{1}{X_C} = \frac{1}{1/\omega C} = \omega C$$

Resonant series *LCR* circuit

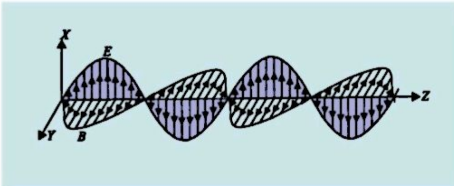
- For $X_L = X_C$, current in the circuit becomes maximum. Such a series *LCR* circuit is called resonant series *LCR* circuit. The resonant frequency is

$$\upsilon_r = \frac{1}{2\pi\sqrt{LC}} \text{ or } \omega_r = \frac{1}{\sqrt{LC}}$$

08 Electromagnetic Waves

Nature of Electromagnetic Waves

- If the electric field vector $\vec{E}$ is along *X*-axis and magnetic field vector $\vec{B}$ is along *Y*-axis, the direction of propagation is along $\vec{E} \times \vec{B}$. *i.e.* along the *Z*-axis.
- EM. wave is propagating in *Z* direction ;
  - The equation of an electric field along *X*-axis is given as $E_X = E_0 \sin(kz - \omega t)$
  - The equation of a magnetic field along *Y*-axis is given as $B_Y = B_0 \sin(kz - \omega t)$,



here, k is propagation constant and is equal to $\frac{2\pi}{\lambda}$ and ω is the angular frequency = $\frac{2\pi}{T}$

09 Ray Optics and Optical Instruments

Refraction at Spherical Surfaces and by Lenses

- When the object is situated in rarer medium, the relation between μ_1 (refractive index of rarer medium), μ_2 (refractive index of the denser medium) and R (radius of curvature) with the object and image distances is given by

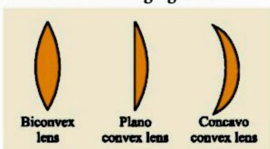
$$-\frac{\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

- When the object is situated in denser medium,

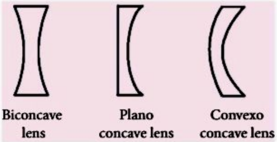
$$-\frac{\mu_1}{v} + \frac{\mu_2}{u} = \frac{\mu_2 - \mu_1}{R}$$

Lens

- Convex lens or converging lens : When a lens is thicker in the middle than at the edges it is known as convex lens or converging lens.



- Concave lens or diverging lens : When the lens is thicker at the edges than in the middle it is known as concave lens or diverging lens.



Lens Maker's Formula

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

where R_1 and R_2 are radii of curvature of the two surfaces of the lens and μ is refractive index of material of lens w.r.t. medium in which lens is placed.

Thin Lens Formula : $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

where, u = distance of the object from the optical centre of the lens, v = distance of the image from the optical centre of the lens and f = focal length of a lens

Linear Magnification : $m=\frac{\text{size of image }(I)}{\text{size of object }(O)}=\frac{v}{u}$

Power of a Lens : $P=\frac{1}{\text{focal length in metres}}$

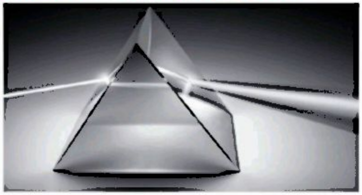
Combination of Thin Lenses in Contact

- The total magnification of the combination is given by, $m = m_1 \times m_2 \times m_3$ ....
- When two thin lenses of focal lengths f_1 and f_2 are placed coaxially and separated by a distance d, the focal length of a combination is given by

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}.$$

- Power, $P = P_1 + P_2 - dP_1P_2$.

Refraction Through a Prism



- The refractive index of the material of the prism is

$$\mu=\frac{\sin\left[\frac{(A+\delta_m)}{2}\right]}{\sin\left(\frac{A}{2}\right)}$$

where A is the angle of prism and δ_m is the angle of minimum deviation.

10 Wave Optics

Interference of Light

Intensity distribution

- If a, b are the amplitudes of interfering waves due to two coherent sources and ϕ is constant phase difference between the two waves at any point P, then the resultant amplitude at P will be

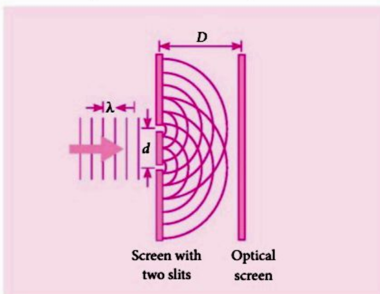
$$R=\sqrt{a^2+b^2+2ab\cos\phi}$$

If $a^2 = I_1$, $b^2 = I_2$ and $I_1 = I_2 = I_0$, then

$$I = 4I_0\cos^2\frac{\phi}{2}$$

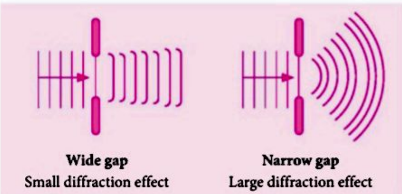
- If the sources are incoherent, $I = I_1 + I_2$

Young's Double Slit Experiment



- For constructive interference (*i.e.*, formation of bright fringes), $x_n = n\lambda\frac{D}{d}$ d = distance between two slits
  D = distance of slits from the screen
  x_n = distance of n^{th} bright fringe from the centre.
- For destructive interference (*i.e.*, formation of dark fringes).
  x_n = distance of n^{th} dark fringe from the centre
  $\therefore\ x_n = (2n-1)\frac{\lambda}{2}\frac{D}{d}$
- Fringe width, $\beta = \frac{\lambda D}{d}$
- Angular fringe width, $\theta = \frac{\beta}{D} = \frac{\lambda}{d}$
- Fringe visibility, $V = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$
- When entire apparatus of Young's double slit experiment is immersed in a medium of refractive index μ, then fringe width becomes, $\beta' = \frac{\beta}{\mu}$
- When a thin transparent plate of thickness t and refractive index μ is placed in the path of one of the interfering waves, fringe width remains unaffected but the entire pattern shifts by, $\Delta x = (\mu - 1)t\frac{\beta}{\lambda}$

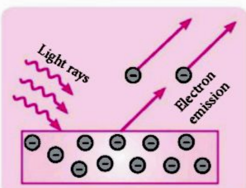
Diffraction due to a Single Slit



- Condition for n^{th} secondary maximum is
  Path difference $= a\sin\theta_n = (2n+1)\frac{\lambda}{2}$
  where n = 1, 2, 3,.......
- Condition for n^{th} secondary minimum is
  Path difference = $a\sin\theta_n = n\lambda$
  where n = 1, 2, 3,.......
- Width of secondary maxima or minima
  $\beta = \frac{\lambda D}{a} = \frac{\lambda f}{a}$
  where, a = width of slit ; D = distance of screen from the slit ; f = focal length of lens for diffracted light
  Width of central maximum $= \frac{2\lambda D}{a} = \frac{2f\lambda}{a}$
- Angular fringe width of central maximum $= \frac{2\lambda}{a}$.
- Angular fringe width of secondary maxima or minima $= \frac{\lambda}{a}$

11 Dual Nature of Radiation and Matter

Photoelectric Equation



- Einstein's photoelectric equation is, $E = W_0 + K_{\max}$
  where $K_{\max} = \frac{1}{2}mv^2_{\max}$ = maximum kinetic energy of emitted electrons and W_0 is work function where $W_0 = h\upsilon_0$
- For a given metal, there exists a certain minimum frequency of light radiation below which no photoelectric emission takes place. This minimum frequency of radiation is known as threshold frequency (υ_0).

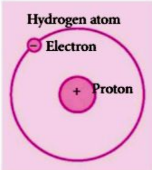
Wave Particle Duality

- A wavelength of the matter wave associated with a particle is given by $\lambda = \frac{h}{p} = \frac{h}{mv}$, where m is the mass and v is velocity of the particle.
- If an electron is accelerated through a potential difference of V volt, then, $\lambda = \frac{h}{\sqrt{2eVm_e}}$

12 Atoms

Bohr Model of Hydrogen and Hydrogen Like Atoms

Bohr postulates



- The angular momentum of the electron in the stationary orbits is quantised.

  $mvr = n\hbar$ where $\hbar = \frac{h}{2\pi}$ is h Planck's constant and n is called the quantum number;
- **Circular Orbits :** The necessary centripetal force for circular orbits is provided by the Coulomb attraction between the electron and nucleus.

  So, $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(e)}{r^2}$, where, m = mass of electron ; r = radius of circular orbit, v = speed of electron in circular orbit ; Ze = charge on nucleus ; Z = atomic number; e = charge on electron $= -1.6 \times 10^{-19}$ C
- **Radius of Orbit :** $r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2 Z} \Rightarrow r_n = (0.53)\frac{n^2}{Z}$

Velocity of Electron in nth Orbit

$$v = \left(\frac{e^2}{2h\varepsilon_0}\right)\frac{Z}{n} \Rightarrow v = \left(\frac{e^2}{2h\varepsilon_0 c}\right)\left(\frac{cZ}{n}\right)$$

Kinetic Energy (*K*) of Electron in nth Orbit

$$K = \frac{1}{2}mv^2 = \frac{Ze^2}{8\pi\varepsilon_0 r}$$

Potential Energy (*U*) of Electron in nth Orbit

$$U = -\frac{Ze^2}{4\pi\varepsilon_0 r}$$

Total Energy (*E*) of Electron in nth Orbit

Total energy = $K + U$, $E = -\frac{Ze^2}{8\pi\varepsilon_0 r}$

Frequency of Emitted Radiation

$$\upsilon = \frac{c}{\lambda} = Z^2 Rc\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

13 Nuclei

Mass Defect and Binding Energy

If m_n = mass of neutron and m_p = mass of proton

$M(Z, A)$ = mass of bound nucleus

Then, $\Delta m = Zm_p + (A - Z)m_n - M(Z, A)$

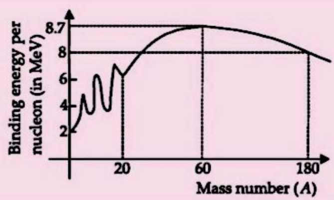
According to Einsteins, mass-energy relation

$\Rightarrow$ Binding energy = $\Delta m\, c^2$

- Where Δm is measured in amu (u) units.

  $\Rightarrow$ B.E. = Δm (931) MeV

B.E. per nucleon $= \frac{\Delta m(931)}{A}$ MeV.



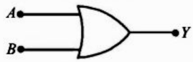
14 Semiconductor Electronics : Materials, Devices and Simple Circuits

Logic Gates

A digital circuit with one or more input signals but only one output signal is known as logic gate.

OR gate

- The logic symbol of OR gate is



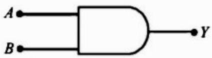
- The truth table for OR gate is

Input		Output
A	B	Y
0	0	0
0	1	1
1	1	1
1	0	1

- The Boolean expression for OR gate is
  $Y = A + B$

AND gate

- The logic symbol of AND gate is



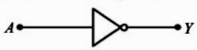
- The truth table for AND gate is

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

- The Boolean expression for AND gate is
  $Y = A \cdot B$

NOT gate

- The logic symbol of NOT gate is



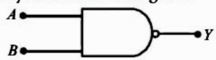
- The truth table for NOT gate is

Input	Output
A	Y
0	1
1	0

- The Boolean expression for NOT gate is $Y = \overline{A}$

NAND gate

- The logic symbol for NAND gate is



- The truth table for NAND gate is

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

- The Boolean expression for NAND gate is
  $Y = \overline{A \cdot B}$

NOR gate

- The logic symbol of NOR gate is

- The truth table for NOR gate is

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

- The Boolean expression for NOR gate is
  $Y = \overline{A + B}$

Exclusive OR gate or XOR gate

- The logic symbol and the truth table for XOR gate is as shown in the figure.

Input		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

- The Boolean expression for XOR gate is

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

CUET (UG)

Exam between 15^{th} to 31^{st} May 2024

PRACTICE PAPER 2024

In this practice paper, 40 questions to be attempted out of 50.

Time Allowed : 60 Minutes **Maximum Marks :** 200

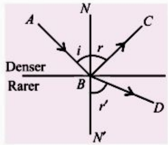
1. Which one of the following is not correct about Lorentz Force?
   (a) In presence of electric field $\vec{E}(r)$ and magnetic field $\vec{B}(r)$ the force on a moving electric charge is $\vec{F}=q[\vec{E}(r)+\vec{v}\times\vec{B}(r)]$.
   (b) The force due to magnetic field on a negative charge is opposite to that on a positive charge.
   (c) The force due to magnetic field becomes zero if velocity and magnetic field are parallel or anti-parallel.
   (d) For a static charge the magnetic force is maximum.

2. The ratio of number of turns in the primary and secondary coils of a transformer is 1 : 2, then the ratio of the currents in the primary and secondary coils respectively are
   (a) 1 : 2 (b) 2 : 1
   (c) 3 : 1 (d) 3 : 2

3. A capacitor of capacitance C, is connected across an ac source of voltage V, is given by $V = V_0\sin\omega t$. The displacement current between the plates of the capacitor, would be given by
   (a) $I_d = V_0\omega C\sin\omega t$ (b) $I_d = V_0\omega C\cos\omega t$
   (c) $I_d=\frac{V_0}{\omega C}\cos\omega t$ (d) $I_d=\frac{V_0}{\omega C}\sin\omega t$

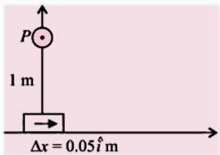
4. The net electric force on a charge of +3 μC at the mid-point on the line joining two charges of magnitude +2 μC and –2 μC separated by the distance of 6 mm, is
   (a) 6000 N (b) 500 N
   (c) 12000 N (d) zero

5. A ray of light from a denser medium strikes a rarer medium as shown in figure. The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are r and r'. The critical angle would be



   (a) $\sin^{-1}(\tan r)$
   (b) $\sin^{-1}(\sin r)$
   (c) $\cos^{-1}(\tan r)$
   (d) $\tan^{-1}(\sin r)$

6. An element of length $0.05\hat{i}$ m is placed at the origin as shown in figure which carries a large current of 10 A. The magnetic field at a distance of 1 m in perpendicular direction is



   (a) 4.5×10^{-8} T (b) 5.5×10^{-8} T
   (c) 5.0×10^{-8} T (d) 7.5×10^{-8} T

7. In a Young's double slit experiment if there is no initial phase difference between the light from the two slits, a point on the screen corresponding to the fifth minimum has path difference.
   (a) $5\frac{\lambda}{2}$ (b) $10\frac{\lambda}{2}$ (c) $9\frac{\lambda}{2}$ (d) $11\frac{\lambda}{2}$

8. What retarding potential is necessary to stop the emission of photoelectrons, if the work function of the target material is 1.24 eV and wavelength of incident light is 436 nm? (Take hc = 1240 eV nm)
   (a) 1.6 V (b) 1.2 V (c) 2.8 V (d) 13.2 V

9. Two thin wire rings each having a radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are $+q$ and $-q$. The potential difference between the centres of the two rings is

(a) $\frac{q}{4\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

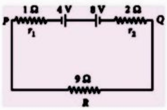
(b) zero

(c) $\frac{q}{2\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

(d) $\frac{qR}{4\pi\varepsilon_0 d^2}$

10. A linear object of height 10 cm is kept in front of a concave mirror of radius of curvature 15 cm, at a distance of 10 cm. The image formed is
(a) magnified and erect
(b) magnified and inverted
(c) diminished and erect
(d) diminished and inverted

11. Two batteries of emf 4 V and 8 V with internal resistance 1 Ω and 2 Ω are connected in a circuit with resistance of 9 Ω as shown in figure. The current and potential difference between the points P and Q are



(a) $\frac{1}{3}$ A and 3 V
(b) $\frac{1}{6}$ A and 4 V
(c) $\frac{1}{9}$ A and 9 V
(d) $\frac{1}{12}$ A and 12 V

12. An eye is placed at a depth h inside water of refractive index μ and viewed outside. The radius of circular path through which outer objects can be seen is

(a) $\frac{\sqrt{\mu^2-1}}{2h}$
(b) $\frac{2h}{\sqrt{\mu^2-1}}$
(c) $\frac{\sqrt{\mu^2-1}}{h}$
(d) $\frac{h}{\sqrt{\mu^2-1}}$

13. If radius of the 1st orbit of H-atom is 0.0529 nm then the radius of its 3rd orbit is
(a) 0.5328 nm
(b) 0.5121 nm
(c) 0.4761 nm
(d) 0.0587 nm

14. Pick out the statement which is incorrect.
(a) The electric field lines forms closed loop.
(b) Field lines never intersect.
(c) The tangent drawn to a line of force represents the direction of electric field.
(d) A negative test charge experiences a force opposite to the direction of the field.

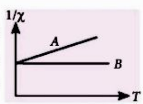
15. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf $V = 10 \sin 340t$. The power loss in A.C. circuit is
(a) 0.76 W
(b) 0.89 W
(c) 0.46 W
(d) 0.67 W

16. An astronomical refractive telescope has an objective of focal length 20 m and an eyepiece of focal length 2 cm. Then,
(a) the length of the telescope tube is 20.02 m.
(b) the magnification is 1800.
(c) the image formed is real.
(d) an objective of a larger aperture will increase the brightness and reduce chromatic aberration of the image.

17. A charged particle having drift velocity of 7.5×10^{-4} m s^{-1} in an electric field of 3×10^{-10} V m^{-1}, has a mobility in m^2 V^{-1} s^{-1} of
(a) 2.25×10^{15}
(b) 2.5×10^{6}
(c) 2.5×10^{-6}
(d) 2.25×10^{-15}

18. Unpolarised light is incident from air on a plane surface of a material of refractive index μ. At a particular angle of incidence i, it is found that the reflected and refracted rays are perpendicular to each other. Which of the following options is correct for this situation?
(a) Reflected light is polarised with its electric vector parallel to the plane of incidence.
(b) Reflected light is polarised with its electric vector perpendicular to the plane of incidence.
(c) $i = \sin^{-1}\left(\frac{1}{\mu}\right)$
(d) $i = \tan^{-1}\left(\frac{1}{\mu}\right)$

19. For two types of magnetic materials A and B, variation of $1/\chi$ (χ : susceptibility) *vs* temperature T is shown in the figure. Then



(a) A is diamagnetic and B is paramagnetic
(b) A is ferromagnetic and B is diamagnetic
(c) A is paramagnetic and B is ferromagnetic
(d) A is paramagnetic and B is diamagnetic.

20. A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is 1.813×10^{-4}. The mass of the particle is
(Mass of electron = 9.1×10^{-31} kg)
(a) 1.67×10^{-27} kg (b) 1.67×10^{-31} kg
(c) 1.67×10^{-30} kg (d) 1.67×10^{-32} kg

21. 4×10^{10} electrons are removed from a neutral metal sphere of diameter 20 cm placed in air. The magnitude of the electric field (in N C^{-1}) at a distance of 20 cm from its centre is
(a) Zero (b) 5760 (c) 640 (d) 1440

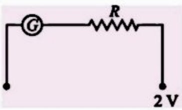
22. Match the Column-I with Column-II.

Column-I		Column-II	
(A)	Ultraviolet	(P)	To destroy living tissue
(B)	Infrared	(Q)	Radar system
(C)	X-rays	(R)	Eye surgery
(D)	Microwaves	(S)	Heating the body muscles

(a) A - P; B - S; C - R; D - Q
(b) A - P; B - Q; C - S; D - R
(c) A - Q; B - P; C - R; D - S
(d) A - S; B - P; C - Q; D - R

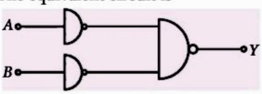
23. The radius of a spherical nucleus as measured by electron scattering is 3.6 fm. What is the likely mass number of the nucleus?
(a) 27 (b) 40 (c) 56 (d) 120

24. A voltmeter which can measure 2 V is constructed by using a galvanometer of resistance 12 Ω and that produces maximum deflection for the current of 2 mA, then the resistance R is



(a) 888 Ω (b) 988 Ω (c) 898 Ω (d) 999 Ω

25. The combination of NAND gates is shown in figure. The equivalent circuit is

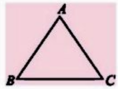


(a) AND gate (b) NOR gate
(c) OR gate (d) NOT gate

26. An electron of energy 1800 eV describes a circular path in magnetic field of flux density 0.4 T. The radius of path is
($q = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg)
(a) 2.58×10^{-4} m (b) 3.58×10^{-4} m
(c) 2.58×10^{-3} m (d) 3.58×10^{-3} m

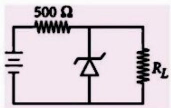
27. An eye specialist prescribes spectacles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination, in dioptre, is
(a) + 1.5 (b) – 1.5 (c) + 6.67 (d) – 6.67

28. Three identical charges each of 2 μC are placed at the vertices of a triangle ABC as shown in the figure. If $AB + AC = 12$ cm and $AB \cdot AC = 32$ cm^2, the potential energy of the charge at A is
(a) 1.53 J
(b) 5.31 J
(c) 3.15 J
(d) 1.35 J



29. If voltage across a bulb rated 220 volt-100 watt drops by 2.5% of its rated value, the percentage of the rated value by which the power would decrease is
(a) 20% (b) 2.5% (c) 5% (d) 10%

30. In the circuit shown in figure if the current through the 500 Ω resistor is 25 mA and that through the load R_L is 5 mA, then the maximum current through the Zener diode is



(a) 5 mA (b) 20 mA (c) 30 mA (d) 125 mA

31. A bar magnet has a magnetic moment of 200 A m^2. The magnet is suspended in a magnetic field of 0.30 N A^{-1} m^{-1}. The torque required to rotate the magnet from its equilibrium position through an angle of 30°, will be
(a) 30 N m (b) $30\sqrt{3}$ N m
(c) 60 N m (d) $60\sqrt{3}$ N m

32. At two different places the angles of dip are respectively 30° and 45°. At these two places the ratio of horizontal component of earth's magnetic field is
(a) $\sqrt{3} : \sqrt{2}$ (b) $1 : \sqrt{2}$
(c) $1 : 2$ (d) $1 : \sqrt{3}$

33. A circular coil of radius 0.1 m has 80 turns of wire. If the magnetic field through the coil increases from 0 to 2 tesla in 0.4 s and the coil is connected to a 11 Ω resistor, what is the current flow through the resistor during the 0.4 s?

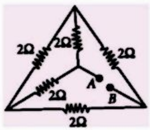
(a) $\left(\frac{8}{7}\right)$A (b) $\left(\frac{7}{8}\right)$A (c) 8 A (d) 7 A

34. Match the column I with column II.

Column-I		Column-II	
(A)	$m = -2$	(P)	convex mirror
(B)	$m = -\frac{1}{2}$	(Q)	concave mirror
(C)	$m = +2$	(R)	Real image
(D)	$m = +\frac{1}{2}$	(S)	virtual image

(a) A - P, R; B - P, S ; C - P, Q ; D - R, S
(b) A - P, S ; B - Q, R ; C - Q, S ; D - Q, R
(c) A - R, S ; B - Q, S ; C - Q, R ; D - P, S
(d) A - Q, R ; B - Q, R ; C - Q, S ; D - P, S

35. In the network shown in the figure, each of the resistance is equal to 2 Ω. The resistance between the points A and B is



(a) 3 Ω
(b) 4 Ω
(c) 1 Ω
(d) 2 Ω

36. The ratio of resolving powers of an optical microscope for two wavelengths λ_1 = 4000 Å and λ_2 = 6000 Å is

(a) 9 : 4 (b) 3 : 2
(c) 16 : 81 (d) 8 : 27

37. The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time $t_2 (t_2 > t_1)$. If its mean life is T, then

(a) $A_1 t_1 = A_2 t_2$ (b) $A_1 - A_2 = t_2 - t_1$
(c) $A_2 = A_1 e^{(t_1 - t_2)/T}$ (d) $A_2 = A_1 e^{(t_1/t_2)T}$

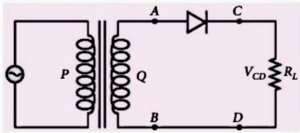
38. A 90 cm long solenoid has six layers of windings of 450 turns each. If the diameter of solenoid is 2.2 cm and current carried is 6 A, then the magnitude of field inside the solenoid, near its centre is

(a) 50π G (b) 60π G
(c) 72π G (d) 80π G

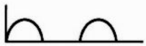
39. Pick out the false statement from the following.

(a) The direction of eddy current is given by Fleming's right hand rule.
(b) A choke coil is a pure inductor used for controlling current in an a.c circuit.
(c) The energy stored in a conductor of capacitance C having a charge q is $\frac{1}{2}Cq^2$.
(d) The magnetic energy stored in a coil of self inductance L carrying current is $\frac{1}{2}LI^2$.

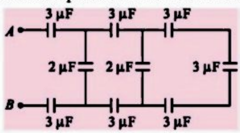
40. In the half-wave rectifier circuit shown,



which one of the following wave form is true for V_{CD}, the output across C and D?

(a)  (b) 
(c)  (d) 

41. The resultant capacitance between A and B is



(a) 1 μF (b) 3 μF
(c) 2 μF (d) 1.5 μF

42. The T.V. signals have a bandwidth of 3.7 MHz. The number of T.V. channels that can be accommodated with a band of 3700 GHz is

(a) 10^4 (b) 10^5
(c) 10^6 (d) 10^7

43. The binding energy per nucleon of Li and He nuclei are 5.60 MeV and 7.06 MeV respectively. In the nuclear reaction

$${}^7_3\text{Li} + {}^1_1\text{H} \rightarrow {}^4_2\text{He} + {}^4_2\text{He} + Q$$

the value of energy Q released is

(a) 19.6 MeV (b) −2.4 MeV
(c) 8.4 MeV (d) 17.3 MeV

44. A student measures the terminal potential difference (V) of a cell (of emf ε and internal resistance r) as a function of the current (I) flowing through it. The slope, and intercept, of the graph between V and I, then, respectively, equal

(a) $-r$ and ε (b) r and $-\varepsilon$
(c) $-\varepsilon$ and r (d) ε and $-r$

45. A potentiometer wire has length 4 m and resistance 8 Ω. The resistance that must be connected in series with the wire and an accumulator of e.m.f. 2 V, so as to get a potential gradient 1 mV per cm on the wire is

(a) 44 Ω (b) 48 Ω (c) 32 Ω (d) 40 Ω

46. There is a uniform magnetic field directed perpendicular and into the plane of the paper. An irregular shaped conducting loop is slowly changing into a circular loop in the plane of the paper. Then

(a) current is induced in the loop in the anti-clockwise direction.
(b) current is induced in the loop in the clockwise direction.
(c) AC is induced in the loop.
(d) no current is induced in the loop.

47. A coil of inductance 8 μH is connected to a capacitor of capacitance 0.02 μF. To what wavelength is this circuit tuned ?

(a) 7.54×10^3 m (b) 15.90×10^2 m
(c) 15.90×10^3 m (d) 7.54×10^2 m

48. The refracting angle of a glass prism is 30°. A ray is incident on one of the faces perpendicular to it. The angle of deviation δ between the incident ray and that leaves the prism is
(Refractive index of glass = 1.5) (sin 30° = 0.5, sin(48.6)° = 0.75)

(a) 17° (b) (18.6)° (c) (12.6)° (d) 16°

49. When an electron jumps from the orbit $n = 2$ to $n = 4$, then wavelength of the radiations absorbed will be (R is Rydberg's constant)

(a) $\frac{16}{3R}$ (b) $\frac{16}{5R}$ (c) $\frac{5R}{16}$ (d) $\frac{3R}{16}$

50. A plane square sheet of charge of side 0.5 m has uniform surface charge density. An electron at 1 cm from the centre of the sheet experiences a force of 1.6×10^{-12} N directed away from the sheet. The total charge on the plane square sheet is ($\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 m^{-2} N^{-1})

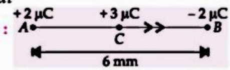
(a) 16.25 μC (b) – 22.15 μC
(c) – 44.27 μC (d) 144.27 μC

SOLUTIONS

1. **(d)** : If charge is not moving then the magnetic force is zero. Since $\vec{F}_m = q(\vec{v} \times \vec{B})$
As, $\vec{v} = 0$, for stationary charge $\therefore \vec{F}_m = 0$

2. **(b)** : Using, $\frac{I_p}{I_s} = \frac{n_s}{n_p}$
Given, $\frac{n_p}{n_s} = \frac{1}{2}$ $\therefore$ $\frac{I_p}{I_s} = \frac{2}{1}$

3. **(b)** : The instantaneous voltage, $V = V_0 \sin\omega t$
Displacement current is given by, $i_d = \frac{CdV}{dt}$
$i_d = C\frac{d}{dt}(V_0 \sin \omega t) \Rightarrow i_d = CV_0\omega \cos\omega t$

4. **(c)** : 

Net force on point charge at point C, $F_C = F_{AC} + F_{CB}$
$$= \frac{1}{4\pi\varepsilon_0}\frac{2\times3\times10^{-12}}{(3\times10^{-3})^2} + \frac{2\times3\times10^{-12}}{4\pi\varepsilon_0(3\times10^{-3})^2} = 12000 \text{ N}$$

5. **(a)**

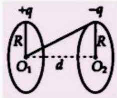
6. **(c)** : $dB = \frac{\mu_o}{4\pi}\frac{Idl\sin\theta}{r^2}$
Here, $dl = \Delta x = 0.05$ m, $I = 10$ A, $r = 1$ m
$\sin\theta = \sin 90° = 1$,
$\therefore dB = 10^{-7} \times \frac{10\times0.05\times1}{(1)^2} = 0.50\times10^{-7} = 5.0\times10^{-8}$ T

7. **(c)** : Given, there is no initial phase difference.
$\therefore$ Initial phase = $\delta = 0$
Again, phase difference $= \frac{2\pi}{\lambda} \times$ path difference
$\Rightarrow \delta' = \frac{2\pi}{\lambda}\times\Delta x \Rightarrow \Delta x = \frac{\lambda}{2\pi}\times\delta'$
Now, for the fifth minima we will consider n = 4 as initial phase difference is zero.
$\therefore$ For fifth minimum, $\delta' = (8 + 1)\pi = 9\pi$
$\therefore$ Path difference, $\Delta x = \frac{\lambda}{2\pi}\times 9\pi = \frac{9\lambda}{2}$

8. **(a)** : Energy of photon, $E = h\upsilon = \frac{hc}{\lambda}$
or $E = \frac{1240 \text{ eV nm}}{436 \text{ nm}} = 2.84$ eV
According to Einstein equation for photoelectric effect
$K_{max} = h\upsilon - \phi_0 = 2.84 - 1.24 = 1.6$ eV
In terms of stopping potential,
$K_{max} = eV_S$
$\Rightarrow 1.6 \text{ eV} = eV_s$ or $V_s = 1.6$ V

9. (c) : $V_1 = \frac{q}{4\pi\varepsilon_0 R} - \frac{q}{4\pi\varepsilon_0\sqrt{R^2+d^2}}$

$V_2 = -\frac{q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0\sqrt{R^2+d^2}}$



$V_1 - V_2 = \frac{2q}{4\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

$V_1 - V_2 = \frac{q}{2\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

10. (b): Object distance, $u = -10$ cm,

focal length, $f = \frac{R}{2} = \frac{-15}{2} = -7.5\text{ cm}$

By mirror formula, $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-7.5)} - \frac{1}{(-10)}$

$\frac{1}{v} = \frac{-25}{750} \Rightarrow v = -30\text{ cm}$

Magnification, $m = \frac{-v}{u} = -\frac{-30}{-10} = -3$

$\therefore$ The image formed is real, magnified and inverted.

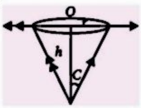
11. (a): $I = \frac{8-4}{1+2+9} = \frac{4}{12} = \frac{1}{3}\text{A}$

$V_P - V_Q = 4 - \frac{1}{3}\times 3 = 3\text{ volt}$

12. (d): $\mu = \frac{1}{\sin C} = \text{cosec}\, C$

$\Rightarrow \text{cosec}^2 C = \mu^2 \Rightarrow 1 + \cot^2 C = \mu^2$

$\Rightarrow 1 + \frac{h^2}{r^2} = \mu^2 \Rightarrow \frac{h^2}{r^2} = \mu^2 - 1$



$r = \frac{h}{\sqrt{\mu^2 - 1}}$

13. (c) : Radius of n^{th} orbit,

$r_n = \frac{n^2h^2\varepsilon_0}{\pi c^2 m}$; $r_n \propto n^2$ $\therefore$ $\frac{r_3}{r_1} = \frac{(3)^2}{(1)^2} = 9$

$r_3 = 9r_1 \Rightarrow r_3 = 0.0529 \times 9 \Rightarrow 0.4761$ nm

14. (a) : The electric field lines do not form closed loop. All other statements are correct.

15. (c)

16. (a) : Given, $f_o = 20$ m, $f_e = 2$ cm $= 0.02$ m

Length of telescope tube, $L = f_o + f_e$

$L = 20 + 0.02 = 20.02$ m

Magnification $= \frac{f_o}{f_e} = \frac{20}{0.02} = 1000$

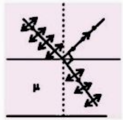
Image formed is virtual.

Larger aperture of objective is used to gather more light.

17. (b): Here, $v_d = 7.5 \times 10^{-4}$ m/s, $E = 3 \times 10^{-10}$ V/m

Mobility, $\mu = \frac{v_d}{E} = \frac{7.5\times10^{-4}}{3\times10^{-10}} \Rightarrow \mu = 2.5 \times 10^6$

18. (b): When reflected light and refracted light are perpendicular, reflected light is polarised with electric field vector perpendicular to the plane of incidence.



Also, $\tan i = \mu$ (Brewster angle)

19. (d): For diamagnetic material, $\chi \propto T$

For paramagnetic material, $1/\chi \propto T$

A is paramagnetic and B is diamagnetic material.

20. (a): de Broglie wavelength of a moving particle, having mass m and velocity v is given by

$\lambda = \frac{h}{p} = \frac{h}{mv}$ or $m = \frac{h}{\lambda v}$

For an electron, $\lambda_e = \frac{h}{m_e v_e}$ or $m_e = \frac{h}{\lambda_e v_e}$

Given : $\frac{v}{v_e} = 3$, $\frac{\lambda}{\lambda_e} = 1.813\times10^{-4}$

Mass of the particle, $m = m_e\left(\frac{v_e}{v}\right)\left(\frac{\lambda_e}{\lambda}\right)$

Substituting the values, we get

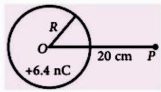
$m = (9.1\times10^{-31}\text{ kg})\times\left(\frac{1}{3}\right)\times\left(\frac{1}{1.813\times10^{-4}}\right)$

$m = 1.67 \times 10^{-27}$ kg

21. (d): Number of electrons removed $= 4 \times 10^{10}$

Charge on this sphere $= 4 \times 10^{10} \times 1.6 \times 10^{-19} C$

$= 6.4 \times 10^{-9} C = 6.4\ nC$



Diameter of sphere,

$D = 20$ cm $= 0.2$ m

Distance from the centre,

$d = 20$ cm $= 0.2$ m; $E_P = \frac{q}{4\pi\varepsilon_0 d^2}$

$= \left(\frac{9\times10^9\times6.4\times10^{-9}}{(0.2)^2}\right)\text{N C}^{-1} = 1440\text{ N C}^{-1}$

22. (a)

23. (a) : Nuclear radius $R = R_0(A)^{1/3}$

where A is the mass number of a nucleus.

Given : $R = 3.6$ fm

$\therefore$ 3.6 fm $= (1.2\text{ fm})(A^{1/3})$ $[\because R_0 = 1.2\text{ fm}]$

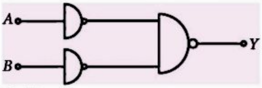
or $A = (3)^3 = 27$

24. (b): $R = \frac{V}{I_g} - G$

Putting $V = 2$ V, $I_g = 2$ mA $= 2 \times 10^{-3}$ A, $G = 12\ \Omega$,

$\therefore$ $R = \frac{2}{2\times10^{-3}} - 12 = 1000 - 12 = 988\ \Omega$

25. (c) : Boolean expression from figure,



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

This combination of gates represent OR gate.

26. (b): $E = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2E}{m}}$

$r = \frac{mv}{Be} = \frac{m}{Be}\sqrt{\frac{2E}{m}} = \frac{\sqrt{2mE}}{Be}$

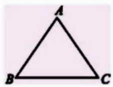
$r = \frac{\sqrt{2\times1800\times1.6\times10^{-19}\times9.1\times10^{-31}}}{1.6\times10^{-19}\times0.4} = 3.58\times10^{-4}\,\text{m}$

27. (b): For convex lens, power $P_1 = \frac{100}{40} = 2.5\,\text{D}$

For concave lens, power $P_2 = \frac{100}{-25} = -4.0\,\text{D}$

$\therefore$ Power of combination $= P_1 + P_2 = 2.5 - 4.0 = -1.5\,\text{D}$.

28. (d): Given each charge, $q = 2\,\mu\text{C}$



or $q = 2\times10^{-6}\,\text{C}$

$AB + AC = 12\,\text{cm}$ ...(i)

$AB \cdot AC = 32\,\text{cm}^2$ ...(ii)

From equation (i), $AB = 12 - AC$

Put the value of AB in equation (ii)

$(12 - AC)\,AC = 32$ or $AC^2 - 12\,AC + 32 = 0$

On solving, we get $AC = 8$ or 4

$\therefore$ If $AC = 8$ cm, $AB = 4$ cm or $AB = 0.04$ m, $AC = 0.08$ m

The P. E of the charge at A is $U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{AB} + \frac{q^2}{AC}\right]$

$= 9\times10^9\left[\frac{4\times10^{-12}}{0.04} + \frac{4\times10^{-12}}{0.08}\right] = 1.35\,\text{J}$

29. (c) : Power, $P = \frac{V^2}{R}$

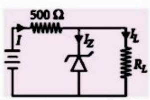
As the resistance of the bulb is constant

$\therefore \frac{\Delta P}{P} = \frac{2\Delta V}{V}$

% decrease in power $= \frac{\Delta P}{P}\times100 = \frac{2\Delta V}{V}\times100$

$= 2\times2.5\% = 5\%$

30. (b): The current distribution is shown in figure.



As $I = I_Z + I_L \quad \therefore I_Z = I - I_L$

$= 25\,\text{mA} - 5\,\text{mA} = 20\,\text{mA}$

31. (a) : Torque experienced by a magnet suspended in a uniform magnetic field B is given by

$\tau = MB\sin\theta$

Here, $M = 200\,\text{A m}^2$, $B = 0.30\,\text{N A}^{-1}\text{m}^{-1}$ and $\theta = 30°$

$\therefore \tau = 200\times0.30\times\sin30° \Rightarrow \tau = 30\,\text{N m}$

32. (a) : Horizontal component, $B_H = B_e\cos\theta$

$\therefore B_{H_1} = B_e\cos30°$ and $B_{H_2} = B_e\cos45°$

Thus, $\frac{B_{H_1}}{B_{H_2}} = \frac{\cos30°}{\cos45°} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{3}}{\sqrt{2}}$

33. (a) : $|\varepsilon| = N\frac{d\phi}{dt} = NA\frac{dB}{dt} = 80\times\frac{22}{7}\times(0.1)^2\left(\frac{2.0}{0.4}\right)$

$I = \frac{|\varepsilon|}{R} = 80\times\frac{22}{7}\times\frac{(0.1)^2\times5}{11} = \frac{8}{7}\,\text{A}$

34. (d): Magnification in the mirror, $m = -\frac{v}{u}$

$m = -2 \Rightarrow v = 2u$

As v and u have same signs so the mirror is concave and image formed is real.

$m = -\frac{1}{2} \Rightarrow v = \frac{u}{2} \Rightarrow$ Concave mirror and real image.

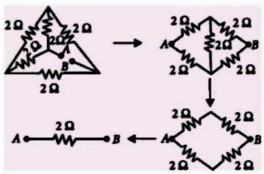
$m = +2 \Rightarrow v = -2u$

As v and u have different signs but magnification is 2, so, the mirror is concave and image formed is virtual.

$m = +\frac{1}{2} \Rightarrow v = -\frac{u}{2}$

As v and u have different signs with magnification $\left(\frac{1}{2}\right)$, so, the mirror is convex and image formed is virtual.

35. (d): The circuit is equivalent to a balanced Wheatstone bridge. Therefore, resistance between A and B is 2 Ω.



36. (b)

37. (c) : $A_1 = \left(\frac{dN}{dt}\right)_1 = \lambda N_1 = \lambda N_0 e^{-\lambda t_1}$

$A_2 = \left(\frac{dN}{dt}\right)_2 = \lambda N_2 = \lambda N_0 e^{-\lambda t_2}$

$\therefore \frac{A_2}{A_1} = \frac{e^{-\lambda t_2}}{e^{-\lambda t_1}} = e^{(t_1 - t_2)\lambda}$

$\frac{A_2}{A_1} = e^{(t_1 - t_2)/T}$ or $A_2 = A_1 e^{(t_1 - t_2)/T}$

38. (c) : For six layers of windings the total number of turns = 6 × 450 = 2700

Now number of turns per unit length

$$n = \frac{N}{l} = \frac{2700}{90 \times 10^{-2}} = 3000$$

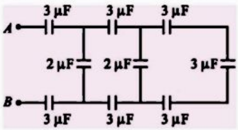
Then the field inside the solenoid near the centre

$B = \mu_0 n I = 4\pi \times 10^{-7} \times 3000 \times 6 = 72\pi \times 10^{-4}$ T $= 72\pi$ G

39. (c) : The energy stored in a conductor of capacitance C having a charge q is $U = \frac{1}{2}\frac{q^2}{C}$

40. (b): When p-n junction is forward biased it conducts, and if reverse biased it does not conduct.

41. (a) : Starting from right end of figure,



$$\frac{1}{C_S} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1 \text{ or } C_S = 1\,\mu\text{F}$$

$C_P = 1 + 2 = 3$ μF and so on.

Finally, the equivalent resistance between A and B is $C_{AB} = 1$ μF

42. (c) : Here,

Bandwidth of each channel = 3.7 MHz = 3.7×10^6 Hz

Total bandwidth = 3700 GHz = 3700×10^9 Hz

Number of T.V. channels accomodated

$$= \frac{\text{Total bandwidth}}{\text{Bandwidth per channel}} = \frac{3700 \times 10^9}{3.7 \times 10^6} = 10^6$$

43. (d): Binding energy of $^7_3$Li nucleus

= 7 × 5.60 MeV = 39.2 MeV

Binding energy of $^4_2$He nucleus

= 4 × 7.06 MeV = 28.24 MeV

The reaction is $^7_3\text{Li} + ^1_1\text{H} \rightarrow 2(^4_2\text{He}) + Q$

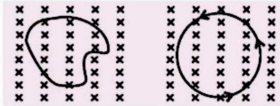
$\therefore\ Q = 2(\text{BE of } ^4_2\text{He}) - (\text{BE of } ^7_3\text{Li})$

= 2 × 28.24 MeV − 39.2 MeV

= 17.28 MeV ≈ 17.3 MeV

44. (a) **45. (c)**

46. (a) : Due to change in the shape of the loop, the magnetic flux linked with the loop increases. Hence, current is induced in the loop in such a direction that it opposes the increases in flux. Therefore, induced current flows in the anticlockwise direction.



47. (d): Here, $L = 8\ \mu\text{H} = 8 \times 10^{-6}$ H

$C = 0.02\ \mu\text{F} = 0.02 \times 10^{-6}$ F

∴ Resonant frequency,

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{8 \times 10^{-6} \times 0.02 \times 10^{-6}}}$$

$= 3.98 \times 10^5$ Hz

If $c\ (= 3 \times 10^8\ \text{m s}^{-1})$ is the velocity of the electromagnetic wave then,

$$\text{Wavelength, } \lambda = \frac{c}{f} = \frac{3 \times 10^8}{3.98 \times 10^5} = 7.54 \times 10^2\ \text{m}$$

48. (b): Given, $A = 30°$, $\mu = 1.5$; $i_1 = 0°$

In a prism, $r_1 + r_2 = A$ ∴ $r_2 = A = 30°$

From snells law, $\mu = \frac{\sin i_2}{\sin r_2}$

$$\Rightarrow 1.5 = \frac{\sin i_2}{\sin 30°} \Rightarrow \sin i_2 = 1.5 \sin 30° = 1.5 \times \frac{1}{2} = 0.75$$

$i_2 = \sin^{-1}(0.75) = 48.6°$

Deviation, $\delta = (i_1 + i_2) - A = (0 + 48.6°) - 30° = 18.6°$

49. (a) : According to Rydberg formula,

$$\frac{1}{\lambda} = R\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$$

Therefore, the wavelength corresponds to transition from $n_i = 2$ to $n_f = 4$ is

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{4} - \frac{1}{16}\right] = R\left[\frac{4-1}{16}\right]$$

$$\frac{1}{\lambda} = \frac{3R}{16} \Rightarrow \lambda = \frac{16}{3R}$$

50. (c) : Let σ be uniform surface density of the sheet.

Electric field due to the sheet is $E = \frac{\sigma}{2\varepsilon_0}$

Force experienced by the electron is

$$F = eE = \frac{e\sigma}{2\varepsilon_0} \text{ or } \sigma = \frac{2F\varepsilon_0}{e}$$

$$\sigma = \frac{2 \times 1.6 \times 10^{-12} \times 8.854 \times 10^{-12}}{1.6 \times 10^{-19}}$$

$= 177.08 \times 10^{-6}\ \text{C m}^{-2} = 177.08\ \mu\text{C m}^{-2}$

Area of the sheet, $A = (0.5\ \text{m})^2 = 0.25\ \text{m}^2$

Total charge on the sheet is

$Q = \sigma A = (177.08\ \mu\text{C m}^{-2})(0.25\ \text{m}^2) = 44.27\ \mu\text{C}$

It should be negative because force is repulsive.

∴ $Q = -44.27\ \mu\text{C}$

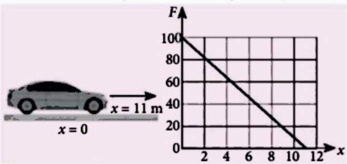
Exam on 28th April 2024

WB JEE
PRACTICE PAPER 2024

Category - I (Q.1 to 30)

(Carry 1 mark each. Only one option is correct. Negative marks –¼)

1. A toy car of mass 5 kg moves up a ramp under the influence of force F plotted against displacement x. The maximum height attained is given by



(a) 20 m (b) 15 m (c) 11 m (d) 5 m

2. A car travels 100 km east and then 100 km south. Finally, it comes back to the starting point by the shortest route. Throughout the journey, the speed is constant at 60 km/h. The average velocity for the whole of the journey is
(a) 60 km/h (b) 90 km/h
(c) 0 km/h (d) 180 km/h

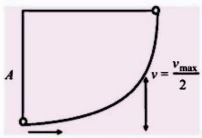
3. If the gap between the plates of a parallel plate capacitor is filled with medium of dielectric constant $k = 2$, then the field between them
(a) Increases by a factor 2
(b) Increases by a factor $\sqrt{2}$
(c) Decreased by a factor $\sqrt{2}$
(d) Decreased by a factor 2

4. The acceleration due to gravity g and mean density of the earth ρ are related by which of the following relations? (where G is the gravitational constant and R is the radius of the earth.)
(a) $\rho = \frac{3g}{4\pi GR}$ (b) $\rho = \frac{3g}{4\pi GR^3}$
(c) $\rho = \frac{4\pi gR^2}{3G}$ (d) $\rho = \frac{4\pi gR^3}{3G}$

5. Heat is produced at a rate given by H in a resistor when it is connected across a supply of voltage V. If now the resistance of the resistor is doubled and the supply voltage is made $V/3$ then the rate of production of heat in the resistor will be
(a) $H/18$ (b) $H/9$ (c) $6H$ (d) $18H$

6. A man is walking on a road with a velocity 3 km/h. Suddenly rain starts falling. The velocity of rain is 10 km/h in vertically downward direction. The relative velocity of rain is
(a) $\sqrt{13}$ km/h (b) $\sqrt{109}$ km/h
(c) $\sqrt{7}$ km/h (d) 13 km/h

7. A particle starts with S.H.M. from the mean position as shown in the figure. Its amplitude is A and its time period is T. At any instant, its speed is half that of the maximum speed. What is the displacement of the particle at the that point?



(a) $\frac{2A}{\sqrt{3}}$ (b) $\frac{3A}{\sqrt{2}}$ (c) $\frac{\sqrt{2}A}{3}$ (d) $\frac{\sqrt{3}A}{2}$

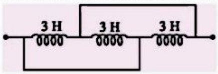
8. If λ_v, λ_x and λ_m represent the wavelengths of visible light, X-rays and microwaves respectively, then
(a) $\lambda_m > \lambda_x > \lambda_v$ (b) $\lambda_m > \lambda_v > \lambda_x$
(c) $\lambda_v > \lambda_x > \lambda_m$ (d) $\lambda_v > \lambda_m > \lambda_x$.

9. The velocity v of a particle at time t is given by $v = at + \frac{b}{t+c}$, where a, b and c are constants. The dimensions of a, b and c are

(a) [L], [LT] and [LT^{-2}] (b) [LT^{-2}], [L] and [T]
(c) [L^2], [T] and [LT^2] (d) [LT^2], [LT] and [L].

10. A cylinder of radius R and length L is placed in a uniform electric field E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by
(a) $2\pi R^2 E$ (b) $\pi R^2/E$
(c) $\frac{\pi R^2 + \pi R^2}{E}$ (d) zero

11. Pure inductances of 3.0 H are connected as shown in figure. The equivalent inductance of the circuit is



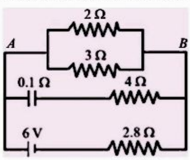
(a) 9 H (b) 3 H (c) 1 H (d) 1/3 H

12. The frequency of the first overtone of a closed pipe of length l_1 is equal to that of the first overtone of an open pipe of length l_2. The ratio of their lengths ($l_1 : l_2$) is
(a) 2 : 3 (b) 4 : 5 (c) 3 : 5 (d) 3 : 4.

13. An iron bar of length L, cross-section area A and Young's modulus Y is pulled by a force F from both ends so as to produce an elongation l. Which of the following statements is correct ?
(a) $l \propto Y$ (b) $l \propto \frac{1}{A}$ (c) $l \propto A$ (d) $l \propto \frac{1}{L}$

14. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Two objects each of mass m are attached gently to the opposite ends of a diameter of the ring. The ring will now rotate with an angular velocity
(a) $\frac{\omega(M+2m)}{M}$ (b) $\frac{\omega M}{M+2m}$
(c) $\frac{\omega(M-2M)}{M+2m}$ (d) $\frac{\omega M}{M+m}$

15. The steady state current in a 2 Ω resistor when the internal resistance of the battery is negligible and the capacitance of the condenser is 0.1 μF is



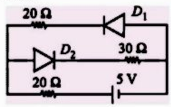
(a) 0.6 A (b) 0.9 A (c) 1.5 A (d) 0.3 A

16. Identify the correct statement from the following.
(a) Cyclotron frequency is independent of charge of the particle.
(b) Kinetic energy of chargced particle in cyclotron does not depend on its mass.
(c) Cyclotron frequency does not depend on speed of charged particle.
(d) Kinetic energy of charged particle in cyclotron is independent of its charge.

17. 300 gm of water at 25 °C is added to 100 gm of ice at 0°C. The final temperature of the mixture is
(a) 12.5 °C (b) 0°C (c) 25°C (d) 50°C

18. A dust particle of mass 2 mg is carried with a velocity of 100 cm/s. What is the de Broglie wavelength associated with the dust particle? ($h = 6.64 \times 10^{-34}$ J-s)
(a) 3.32×10^{-31} m (b) 6.64×10^{-30} m
(c) 3.32×10^{-34} m (d) 3.32×10^{-28} m

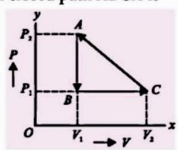
19. The current in the circuit will be
(a) 5/40 A
(b) 5/50 A
(c) 5/10 A
(d) 5/20. A



20. Two soap bubbles of radii x and y coalesce to constitute a bubble of radius z. Then z is equal to
(a) $\sqrt{x^2+y^2}$ (b) $\sqrt{x+y}$
(c) $x+y$ (d) $\frac{x+y}{2}$

21. The current in self inductance L = 40 mH is to be increased uniformly from 1 amp to 11 amp in 4 milliseconds. The e.m.f. induced in inductor during process is
(a) 100 volt (b) 0.4 volt (c) 4.0 volt (d) 440 volt

22. Work done by the system in closed path $ABCA$ is
(a) zero
(b) $(V_1 - V_2)(P_1 - P_2)$
(c) $\frac{(P_2 - P_1)(V_2 - V_1)}{2}$
(d) $\frac{(P_2 + P_1)(V_2 - V_1)}{2}$

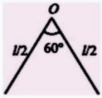


23. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal lengths is 2/3. Their equivalent focal length is 30 cm. What are their individual focal lengths?
(a) – 15, 10 (b) – 10, 15 (c) 75, 50 (d) – 75, 50

24. A 5 MeV of a particle is approaching a gold nucleus. What is its impact parameter if it is scattered through 90°? [For gold Z = 79]

(a) 1.5×10^{-14} m (b) 2.27×10^{-14} m
(c) 3×10^{-14} m (d) 3.37×10^{-17} m

25. A thin rod of length l and mass m is turned at mid-point O at angle of 60°. The moment of inertia of the rod about an axis passing through O and perpendicular to the plane of the rod will be

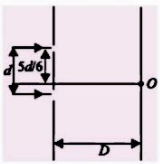


(a) $ml^2/3$ (b) $\frac{ml^2}{6}$ (c) $\frac{ml^2}{8}$ (d) $\frac{ml^2}{12}$

26. Which of the following statements is correct ?

(a) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.
(b) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.
(c) In nuclear fission, energy is released by fusion of two nuclei of medium mass (approximately 100 amu)
(d) In nuclear fission, energy is released by fragmentation of a very low nucleus.

27. In the figure, if a parallel beam of white light is incident on the plane of the slits, then the distance of the white spot on the screen from O is [assume $d << D, \lambda << d$]



(a) 0
(b) $d/2$
(c) $d/3$
(d) $d/6$

28. Five particles have speeds 1, 2, 3, 4, 5 m/s. The average velocity of the particles is (in m/s)

(a) 3 (b) 0
(c) 2.5 (d) data insufficient

29. A thin magnetic wire of length l and moment M is bent at its midpoint at an angle of 60°. The new magnetic moment after bending will be

(a) $\frac{M}{2}$ (b) $\frac{M}{4}$ (c) $\sqrt{2}M$ (d) $2M$

30. Two layers of cloth of equal thickness provide warmer covering than a single layer of cloth of double the thickness, because they

(a) behave like a thermos.
(b) have lesser thickness.
(c) allow heat of atmosphere to come to body.
(d) enclose between them a layer of air.

Category - II (Q.31 to 35)

(Carry 2 marks each. Only one option is correct. Negative marks -½)

31. An alternating current of rms value 10 A is passed through a 12 Ω resistor. The maximum potential difference across the resistor is

(a) 20 V (b) 90 V
(c) 169.68 V (d) none of these.

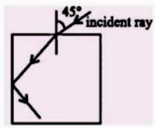
32. The phase difference between two waves, represented by

$y_1 = 10^{-6} \sin[100t + (x/50) + 0.5]$ m
$y_2 = 10^{-6} \cos[100t + (x/50)]$ m,

where x is expressed in metres and t is expressed in seconds, is approximately.

(a) 1.07 radians (b) 2.07 radians
(c) 0.5 radians (d) 1.5 radians

33. For the given incident ray as shown in figure, the condition of total internal refraction of this ray the required refractive index of prism will be



(a) $\frac{\sqrt{3}+1}{2}$ (b) $\frac{\sqrt{2}+1}{2}$ (c) $\sqrt{\frac{3}{2}}$ (d) $\sqrt{\frac{7}{6}}$

34. A particle with charge Q coulomb, tied at the end of an inextensible string of length R meter, revolves in a vertical plane. At the centre of the circular trajectory there is a fixed charge of magnitude Q coulomb. The mass of the moving charge M is such that $Mg = \frac{Q^2}{4\pi\varepsilon_0 R^2}$. If at the highest position of the particle, the tension of the string just vanishes, the horizontal velocity at the lowest point has to be

(a) 0 (b) $2\sqrt{gR}$ (c) $\sqrt{2gR}$ (d) $\sqrt{5gR}$

35. A bullet is fired from a gun. The force on the bullet is given by $F = 600 - 2 \times 10^5 t$ where, F is in newton and t in seconds. The force on the bullet becomes zero as soon as it leaves the barrel. What is the average impulse imparted to the bullet?

(a) 9 N-s (b) zero (c) 1.8 N-s (d) 0.9 N-s

Category - III (Q.36 to 40)

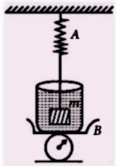
(Carry 2 marks each. One or more options are correct. No negative marks)

36. Hydrogen $({}_1^1\text{H})$, deuterium $({}_1^2\text{H})$, singly ionised helium $({}_2^4\text{He})^+$ and doubly ionised lithium $({}_3^6\text{Li})^+$ all have one electron around the nucleus. Consider an electron transition from $n = 2$ to $n = 1$. If the wavelengths of emitted radiation are λ_1, λ_2, λ_3 and λ_4 respectively then approximately which one of the following is correct?

(a) $\lambda = \frac{1}{RZ^2}\left(\frac{n_1^2 n_2^2}{n_2^2 - n_1^2}\right)$ (b) $\lambda = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

(c) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$ (d) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

37. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure. In this situation



(a) the balance A will read more than 2 kg
(b) the balance B will read more than 5 kg
(c) the balance A will read less than 2 kg and B will read more than 5 kg
(d) the balance A and B will read 2 kg and 5 kg respectively.

38. In the Young's double slit experiment using a monochromatic light of wavelength λ, the path difference (in terms of an integer n) corresponding to any point having half the peak intensity is

(a) $(2n+1)\frac{\lambda}{2}$ (b) $(2n+1)\frac{\lambda}{4}$

(c) $(2n+1)\frac{\lambda}{8}$ (d) $(2n+1)\frac{\lambda}{16}$

39. A rod OA of length l is rotating (about end O) over a conducting ring in crossed magnetic field B with constant angular velocity ω as shown in figure.

(a) Current flowing through the rod is $\frac{3B\omega l^2}{4R}$

(b) Magnetic force acting on the rod is $\frac{3B^2\omega l^3}{4R}$

(c) Torque due to magnetic force acting on the rod is $\frac{3B^2\omega l^4}{8R}$

(d) Magnitude of external force that acts perpendicularly at the end of the rod of maintain the constant angular speed is $\frac{3B^2\omega l^3}{8R}$.

40. Consider two satellites A and B of equal mass m, moving in the same circular orbit about the earth, but in opposite sense as shown in figure. The orbital radius is R. The satellite undergo a collision which is perfectly inelastic. For this situation, mark out the correct statements. [Take mass of earth as M]

(a) The total energy of the satellite plus earth's system before collision is $-(GMm)/r$.
(b) The total energy of the two satellites plus earth's system just after collision is $-(2GMm)/r$.
(c) The total energy of the two satellites plus earth's system just after collision is $-(GMm)/2r$.
(d) The combined mass (two satellites) will fall towards the earth just after collision.

SOLUTIONS

1. (c) : Work done = Gain in potential energy

Area under curve = mgh

$\Rightarrow \frac{1}{2}\times 11\times 100 = 5\times 10\times h \Rightarrow h = 11$ m

2. (c)

3. (d) : Between the plates of a capacitor, intensity of field = E

$$E = \frac{\sigma}{\varepsilon_0 K} = \frac{q}{\varepsilon_0 KA}\ ;\ \frac{E_{air}}{E} = K \Rightarrow E = \frac{E_{air}}{K} = \frac{E_{air}}{2}$$

$\Rightarrow$ Electric field decreases by a factor of 2.

4. (a) : Acceleration due to gravity $(g) = G\times\frac{M}{R^2}$

$$G\frac{(4/3)\pi R^3\times\rho}{R^2} = G\times\frac{4}{3}\pi R\times\rho \text{ or } \rho = \frac{3g}{4\pi GR}$$

5. (a) : $H = \frac{V^2}{R}$ ...(i)

When R is doubled and V becomes $V/3$, then

$$H' = \frac{(V/3)^2}{2R} = \frac{1}{18}\frac{V^2}{R} = \frac{H}{18} \quad \text{(Using (i))}$$

6. (b) : Relative velocity of rain with respect to man

$= \sqrt{3^2 + 10^2} = \sqrt{109}$ km/h.

7. **(d)** : Maximum velocity, $v_{max} = A\omega$

According to question, $\frac{v_{max}}{2} = \frac{A\omega}{2} = \omega\sqrt{A^2 - y^2}$

$\frac{A^2}{4} = A^2 - y^2 \Rightarrow y^2 = A^2 - \frac{A^2}{4} \Rightarrow y = \frac{\sqrt{3}A}{2}$

8. **(b)** : $\lambda_m > \lambda_v > \lambda_x$.

In electromagnetic spectrum X-rays has minimum wavelength and microwave has maximum wavelength.

9. **(b)** : $v = at + \frac{b}{t+c}$

As c is added to t, $\therefore\ c = [\text{T}]$

$at = \text{LT}^{-1}$ or, $[a] = \frac{[\text{LT}^{-1}]}{\text{T}} = [\text{LT}^{-2}]$; $\frac{[b]}{[\text{T}]} = [\text{LT}^{-1}]$

$\therefore\ [b] = [\text{L}]$.

10. **(d)** : $-\pi R^2E + \pi R^2E = 0$

11. **(c)** : The three identical inductances are in parallel.

$\therefore\ L_P = \frac{L}{3} = \frac{3}{3} = 1\text{ H}$

12. **(d)** : The frequency of the first overtone of a closed pipe of length l_1 is

$\upsilon_C = \frac{3v}{4l_1}$

where v is the velocity of sound in air.

The frequency of the first overtone of an open pipe of length l_2 is

$\upsilon_O = \frac{2v}{2l_2} = \frac{v}{l_2}$

As per question, $\upsilon_C = \upsilon_O$

$\therefore\ \frac{3}{4}\frac{v}{l_1} = \frac{v}{l_2}$ or $\frac{l_1}{l_2} = \frac{3}{4}$

13. **(b)** : $Y = \frac{F}{A} \times \frac{L}{l}$ or $l = \frac{FL}{AY}$ or $l \propto \frac{1}{A}$.

14. **(b)** : $L = I\omega$ = constant (No external torque is acting)

$(M + 2m)r^2\omega' = Mr^2\omega$

$\omega' = \frac{Mr^2\omega}{(M+2m)r^2} = \frac{\omega M}{M+2m}$.

15. **(b)** : Capacitor will work as open key. Therefore, no current flows through resistance 4 Ω.

The total resistance of circuit,

$= 2.8 + \frac{2\times3}{2+3} = 2.8 + 1.2 = 4\ \Omega$

$\therefore$ Main current, $I = \frac{6}{4} = \frac{3}{2}$ A

So, potential difference across A and $B = \frac{3}{2} \times 1.2 = 1.8$ V

$\therefore$ Current through 2 Ω resistor = 1.8 / 2 = 0.9 A.

16. **(c)** : As, frequency of cyclotron is, $\upsilon = \frac{qB}{2\pi m}$, which is independent of speed of the charged particle.

17. **(b)** : Mass of water, m = 300 gm, T_1 = 25°C.

Mass of ice, m' = 100 gm, T_2 = 0°C

Amount of heat required to melt ice,

$\Delta Q_1 = mL_{fusion}$ = 100 gm × 80 cal gm^{-1} = 8000 cal

Heat released by water,

$\Delta Q_2 = ms\Delta T$ $\quad\therefore\ \Delta Q_2$ = 300 × 1 × 25 = 7500 cal

($\because$ Specific heat of water, s = 1 cal gm^{-1} °C^{-1})

As $\Delta Q_2 < \Delta Q_1$

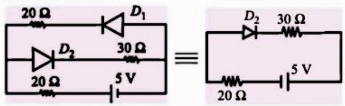
$\therefore$ The mixture remains at 0°C, hence final temperature will be 0°C.

18. **(d)** : $\lambda = \frac{h}{mv} = \frac{6.64\times10^{-34}}{2\times10^{-3}\times10^{-3}\times100\times10^{-2}}$

$= 3.32 \times 10^{-28}$ m

19. **(b)** : $D_1 \rightarrow$ reverse biased and $D_2 \rightarrow$ forward biased.

Equivalent circuit is



Therefore, current through the circuit will be,

$I = \frac{5\text{ V}}{(30+20)\Omega} = \frac{5}{50}$ A.

20. **(a)** : Volume of soap bubble of radius x is $V_x = \frac{4}{3}\pi x^3$

Volume of soap bubble of radius y is $V_y = \frac{4}{3}\pi y^3$

Let T be the surface tension of soap bubble. Let P_x and

SOLUTIONS TO MARCH 2024 QUIZ CLUB

1. Longitudinal
2. Steradian
3. Inertial
4. Parabola
5. Circular
6. 746
7. directly
8. semi major axis
9. Cantilever
10. decreases
11. Zero
12. Vibrational
13. Equipotential
14. Dynamo
15. Diamagnetics
16. False
17. Isothermal
18. Thermoionic
19. Fe^{56}
20. more

Winner : Olshee Basu, Kolkata (West Bengal)

P_y be the excess pressure inside these two soap bubbles, then $P_x = \frac{4T}{x}$ and $P_y = \frac{4T}{y}$

These two soap bubbles coalesce to form a new soap bubble of radius z under isothermal conditions. Let V_z and P_z be the volume and excess pressure inside this new soap bubble, then $V_z = \frac{4}{3}\pi z^3$, $P_z = \frac{4T}{z}$

Assuming the external pressure is negligible as compared to internal pressure and the new bubble is formed under isothermal conditions, so Boyle's law holds good.

$\therefore\ P_xV_x + P_yV_y = P_zV_z$

$$\frac{4T}{x}\times\frac{4}{3}\pi x^3 + \frac{4T}{y}\times\frac{4}{3}\pi y^3 = \frac{4T}{z}\times\frac{4}{3}\pi z^3$$

$x^2 + y^2 = z^2$ or $z = \sqrt{x^2+y^2}$

21. (a) : Magnitude of induced e.m.f, $|\varepsilon| = L\frac{di}{dt}$

Given that, $L = 40 \times 10^{-3}$ H,

$di = 11\text{ A} - 1\text{ A} = 10$ A and $dt = 4 \times 10^{-3}$ s

$\therefore\ |\varepsilon| = 40\times10^{-3}\cdot\left(\frac{10}{4\times10^{-3}}\right) = 100$ V

22. (c) : Work done by the system in the closed path $ABCA$ = Area of ΔABC

$= \frac{AB\times BC}{2} = \frac{(P_2-P_1)(V_2-V_1)}{2}$.

23. (a) : Let focal length of convex lens be $f_1 = f$.

f_2 = focal length of concave lens = $\frac{-3f}{2}$

Equivalent focal length = 30 cm

$\therefore\ \frac{1}{30} = \frac{1}{f} - \frac{2}{3f}$ $\left(\because\ \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}\right)$ or $\frac{1}{30} = \frac{1}{3f}$

or $f = 10$ cm = Focal length of convex lens.

$\therefore$ Focal length of concave lens $= -\frac{3}{2}\times10 = -15$ cm

$\therefore$ Focal lengths are –15 cm (concave lens) and 10 cm (convex lens).

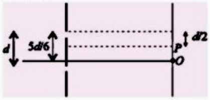
24. (b)

25. (d) : M.I. of a uniform rod about one end $= \frac{ml^2}{3}$

M.I. of the system $= 2\times\left(\frac{m}{2}\right)\frac{(l/2)^2}{3} = \frac{ml^2}{12}$

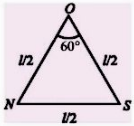
26. (a)

27. (c) : White spot will be central maxima, where path difference is zero



$\therefore\ y = \frac{5d}{6} - \frac{d}{2} = \frac{d}{3}$

28. (d) : Since, velocity is not given so average velocity cannot be calculated.



29. (a) : $M = ml$

$M' = \frac{m\times l}{2} = \frac{M}{2}$

$\therefore\ M' = M/2$

Here $NO = OS = NS = l/2$

An equilateral triangle is formed as NOS.

30. (d) : Air enclosed between two layers of cloth is a bad conductor of heat.

31. (c) : Here $I_{rms} = 10$ A, $R = 12\ \Omega$

The maximum current is

$I_m = \sqrt{2}I_{rms} = \sqrt{2}(10) = 10\sqrt{2}$ A

Maximum potential difference is $V_m = I_mR$

$= 10\sqrt{2}\times12 = 169.68$ V.

32. (a) : $y_1 = 10^{-6}\sin[100t + (x/50) + 0.5]$

and $y_2 = 10^{-6}\cos[100t + (x/50)]$

$= 10^{-6}\sin[100t + (x/50) + \pi/2]$

$= 10^{-6}\sin[100t + (x/50) + 1.57]$

[Using $\cos x = \sin(x + \pi/2)$]

The phase difference = 1.57 – 0.5 = 1.07 radians

[Also using $\sin x = \cos(\pi/2 - x)$, we can get the same result].

33. (c) : Applying Snell's law of refraction at A, we get

$\mu = \frac{\sin i}{\sin r} = \frac{\sin 45°}{\sin r}$

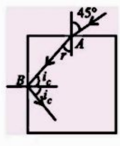
$\therefore\ \sin r = 1/\sqrt{2}\mu\quad \therefore\ r = \sin^{-1}\left(\frac{1}{\sqrt{2}\mu}\right)$ ... (i)

Applying the condition of total internal reflection at B, we get

$i_c = \sin^{-1}(1/\mu)$ ...(ii)

where i_c is the critical angle.

Now, $r + i_c = 90° = \pi/2$.



$\Rightarrow\ r = \frac{\pi}{2} - i_c$

$\therefore\ \sin^{-1}\frac{1}{\sqrt{2}\mu} = \frac{\pi}{2} - \sin^{-1}\frac{1}{\mu}$

or, $\sin^{-1}\frac{1}{\sqrt{2}\mu} = \cos^{-1}\frac{1}{\mu}$

$\sin^{-1}x = \cos^{-1}\sqrt{1-x^2}$; $x = \frac{1}{\sqrt{2}\mu}$ and $\sqrt{1-x^2} = \frac{1}{\mu}$

Solving, $\mu^2 = \frac{3}{2}$ $\quad \therefore \; \mu = \sqrt{3/2}$.

34. (b)

35. (d) : When $F = 0$,

$$600 - 2\times 10^5 t = 0 \Rightarrow t = \frac{600}{2\times 10^5} = 3\times 10^{-3}\,\text{s}$$

Now, impulse, $I = \int_0^t F dt = \int_0^t (600 - 2\times 10^5 t)dt$

$$I = 600t - 2\times 10^5\left(\frac{t^2}{2}\right) = 600\times 3\times 10^{-3} - 10^5\times(3\times 10^{-3})^2$$

or, $I = 0.9$ N-s.

36. (a, c) : The wave number of a spectral line is given by, $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For the transition $n = 2$ to $n = 1$,

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4}RZ^2 \quad \therefore \lambda = \frac{4}{3RZ^2}$$

For H_2, $Z = 1$, $\therefore \; \lambda_1 = \frac{4}{3R}$ ... (i)

For deuterium, $Z = 1$, $\therefore \; \lambda_2 = \frac{4}{3R}$ ... (ii)

For singly ionized helium, $Z = 2$

$\therefore \; \lambda_3 = \frac{4}{3R(4)} = \frac{4}{12R}$. $\therefore \; 4\lambda_3 = \frac{4}{3R}$ ... (iii)

and for lithium, $Z = 3$ and $\lambda_4 = \frac{4}{3R(9)} = \frac{4}{27R}$

$\therefore \; 9\lambda_4 = \frac{4}{3R}$ ... (iv)

Thus, from (i), (ii), (iii) and (iv), we get

$\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

37. (b, c) : When the hanging mass is inside the liquid, the liquid will apply an upthrust on the mass. Hence, the balance A will read less than 2 kg. Infact m loses weight when dipped in a liquid.

An upthrust acts on block m.

By reaction, an equal force will be exerted on the liquid contained in beaker in the downward direction.

Hence B will read more than 5 kg.

Hence (b) and (c) both are correct.

38. (b) : As $I = I_{max}\cos^2\left(\frac{\phi}{2}\right)$

Here, $I = \frac{I_{max}}{2}$

$$\therefore \; \frac{I_{max}}{2} = I_{max}\cos^2\left(\frac{\phi}{2}\right) \Rightarrow \frac{1}{2} = \cos^2\frac{\phi}{2}$$

$$\Rightarrow \cos\phi = 0 \Rightarrow \phi = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \ldots \text{ or } \quad \phi = (2n+1)\frac{\pi}{2}$$

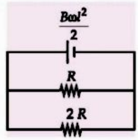
where $n = 0, 1, 2, \ldots$

Since phase difference $= \frac{2\pi}{\lambda} \times$ Path difference

$\therefore$ Path difference $= \frac{\lambda}{2\pi} \times$ Phase difference

$$= \frac{\lambda}{2\pi}\times(2n+1)\frac{\pi}{2} = (2n+1)\frac{\lambda}{4}$$

39. (a, b, c, d) : $I = \dfrac{\varepsilon}{\frac{2R}{3}} = \dfrac{3\varepsilon}{2R} = \dfrac{3}{2R}\times\dfrac{1}{2}B\omega l^2 = \dfrac{3B\omega l^2}{4R}$



Magnetic force,

$$F = \frac{3B\omega l^2}{4R}\times l\times B = \frac{3B^2\omega l^3}{4R}$$

Torque, $\tau = \frac{3B^2\omega l^3}{4R}\times\frac{l}{2} = \frac{3B^2\omega l^4}{8R}$

$\therefore$ Force to be applied at the end $= \frac{3B^2\omega l^3}{8R}$

40. (a, b, d) : Just before collision, the total energy of satellites is

$$E = -\frac{GMm}{2r} - \frac{GMm}{2r} = -\frac{GMm}{r}.$$

Let the orbital velocity be v_1. Then from momentum conservation,

$mv - mv = 2mv_1 \quad \Rightarrow \quad v_1 = 0$

As velocity of combined mass just after collision is zero, the combined mass will fall towards the earth. At this instant, the total energy of the system only consists of the gravitational potential energy given by

$$U = \frac{GM\times 2m}{2r} = \frac{GMm}{r}.$$

TRIO

ANSWERS MARCH 2024

The three letter sequence is **A T I**.

HEATING

RELATIVITY

POLARISATION

RADIATION

MONOCHROMATIC

ELECTROSTATICS

Winner : Aayush Kumar (Noida)

Quiz CLUB

Unlock Your Knowledge!

1. Radar is used for _________.
2. Newton's First law of motion is called _________.
3. SI unit of temperature is _________.
4. A magnifying glass comprises of a simple _________.
5. What is the relation between joule and calorie?
6. Name the device which is used to measure current?
7. Rainbow is formed due to a phenomena called _________.
8. The proper name for Far-sightedness is _________.
9. A process in which no heat is transferred is known as _________.
10. In electromagnetic spectrum, which type of radiation has the shortest wavelength?
11. A force that resists the movement of one surface against another is _________.
12. Which type of energy is associated with motion of particles and is responsible for the sensation of warmth or heat?
13. The smallest particle of an element is _________.
14. Name the phenomena that is involved in the absorption of ink by blotting paper. _________.
15. Sources that produce waves with a constant phase relation are said to be _________.
16. A process of removing the excess charge from an object is known as _________.
17. Which type of charge exist on electron, proton and neutron respectively?
18. What will be the work done in moving a charge on an equipotential surface?
19. Which type of lens is used in flashlights.
20. Which law is used to describe rotation in sprinkler system?

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.

Contributed by : *Seethiraju Nagesh*

SOLUTIONS TO MARCH 2024 WORD GRID

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. Zero
2. Momentum
3. Newton
4. Isochoric
5. mho

Down
1. Drift
2. Galvanometer
3. Gauss
4. Energy
5. Convex

Unique Career in Demand

Explore the available Unique Career Options!

B.Tech. in Robotics

The world is rapidly moving towards human independent systems and processes in almost all aspects of life. In today's era, a robot can do what a human mind can imagine. With advancement in Artificial Intelligence, robots assist human in every domain of services and development. Robotics is the primary driver behind these advancements. This is achieved through synergistic integration of various streams, namely, Mechanics and Mechanical Engineering, Electronics, and Computer Technology that enables to produce and enhance robotic systems. Robotics engineers design, build, maintain as well as develop software and algorithms for controlling these systems. They may also work on integrating robots into various applications, such as manufacturing, healthcare, and space exploration.

Courses Offered

For those who are interested in technology, engineering, and problem-solving, India offers a range of courses in Robotics

- B.Tech. in Robotics and Artificial Intelligence
- B.Tech. in Mechanical Engineering (Robotics)
- B. Tech. in Computer Science and Engineering (Artificial Intelligence and Robotics)
- B.E. in Robotics and Automation
- M.Tech. in Intelligent System and Robotics
- Diploma in Automation and Robotics Engineering
- Ph.D. in Robotics Engineering

Eligibility Criteria

- The eligibility requirement for B. Tech/B.E. in Robotics entails candidates to have cleared 10+2 level from any recognised board with Physics, Chemistry and Maths as compulsory subjects. Many of the nation's top colleges require prospective engineering students to pass a national or state-level entrance exam. For private universities, students need to earn good ranks in university-level entrance tests.
- For admission in M. Tech. in Robotics, candidate must have completed (or appearing final semester) B. Tech. or equivalent degree from a recognised university with 50-60% marks in aggregate and valid GATE/Entrance exam score.
- The eligibility criteria for admission to Ph.D. course is a postgraduation degree. The students are also required to qualify GATE/National exam followed by an interview by the concerned universities.

Job Prospects

Robotics offers a plethora of exciting opportunities for individuals seeking a dynamic and impactful career. After completion of B.Tech. in Robotics Engineering, the candidates can either seek jobs or can pursue higher studies. Mining, telecommunications, forestry, the food industry, industrial engineering, space exploration, healthcare, and transportation are just a few of the industries that will need robotics graduates. Space research and microchip manufacturing industries abound opportunities for qualified professionals. Listed below are few recruiting companies for Robotics and Automation Engineering Graduates

- TATA
- DRDO
- ISRO
- BHEL
- NASA
- Precision Automation Robotics India Ltd.
- Defacto Robotics and Automation
- Kuka Robotics
- Tech Mahindra Ltd.

Best Colleges offering B.Tech. in Robotics

S.No.	Name of the University/ College	City/State
I.	**Madras Institute of Technology**	**Chennai**
II.	Vellore Institute of Technology, Amaravati	Chennai
III.	J. C. Bose University of Science and Technology	Faridabad
IV.	Khwaja Moinuddin Chishti Language University	Lucknow
V.	Central Institute of Tool Design	Hyderabad

College Info

Madras Institute of Technology, Chennai

Madras Institute of Technology is an engineering institute founded by Chinnaswami Ranjam located in Chennai, India. It is one of the four autonomous constituent colleges of Anna University. After independence the need to propel industrial developement in the country led to the establishment of this institution.

The Department of Production Technology was started by MIT, Anna University in year 1977. A new Undergraduate programme B.E. (Robotics and Automation) was introduced in 2022-23, in lieu of B.E. (Mechanical Engineering) based on recent development in Industrial Automation. For undergraduate programmes, the admission is conducted through Graduate Aptitude Test in Engineering (GATE). It is a highly specialised and job-oriented programme providing wide scope of placement and entrepreneurial opportunities globally. Institute provides placements in major organisations.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I	Column II
1. NEARETGOR	(a) A part of standing wave which does not move.
2. MTOSERHTAT	(b) An electrically neutral sub atomic particle.
3. ASRNO	(c) The process of converting AC to DC usually through the use of a diode.
4. LARLAXAP	(d) A technique involving the use of propagation of sound for navigation.
5. EDON	(e) A device for converting mechanical energy into electrical energy by electromagnetic induction.
6. LAKBCLOHE	(f) The difference in the apparent position of an object viewed through two different lines of sight.
7. RINOTENU	(g) A region of space-time where gravity prevents anything, including light, from escaping.
8. RACELEDIONET	(h) A device that maintains a system at a constant temperature.
9. ECFICIAIONTRT	(i) Ability of metals to be pulled into wires.
10. TUCIDEL	(j) The rate of change in velocity when velocity is decreasing.

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!

INTERNATIONAL RELATIONS

- China and Maldives signed a Defence Cooperation Agreement to foster stronger bilateral ties. The agreement comes as the Maldives set a deadline for Indian military personnel withdrawal.
- Three years after objecting to a Chinese energy project in northern Sri Lanka, Indian company U-Solar Clean Energy Solutions and Sri Lanka Sustainable Energy Authority have signed a contract for building "Hybrid Renewable Energy Systems" in Delft or Neduntheevu, Nainativu and Analaitivu islands off the Jaffna peninsula in Sri Lanka with a \$11-million grant.
- The Raisina Dialogue's 9th edition began in New Delhi from 23rd February 2024, with more than 2,500 participants from approximately 115 countries. Greece's Prime Minister Kyriakos Mitsotakis joined the inauguration session as the chief guest. This conference was focused on geopolitics and geo-economics, committed to addressing the most challenging issues being faced by the international community.
- Recently, the Indian Ministry of Defense (MoD) and the United States Department of Defense (DoD) participated in the second India-U.S. Defense Acceleration Ecosystem (INDUS-X) Summit in New Delhi, India. The summit was jointly organised by Innovations for Defence Excellence (iDEX), MoD, and the DoD. It was coordinated by the U.S.-India Business Council (USIBC) and Society of India Defense Manufacturers (SIDM).
- Chinese nationals have started occupying several of their model "Xiaokang" border defence villages across India's north-eastern borders which the country has been building along the Line of Actual Control (LAC) since 2019.
- India and the United Arab Emirates (UAE) signed eight pacts to bolster cooperation in key areas such as investments, electricity trade and digital payment platforms, as Prime Minister Narendra Modi and UAE President Mohamed bin Zayed Al Nahyan discussed new fields of collaboration.
- Recently, the first trial movement of vessels carrying stone aggregates from Maia Port in India, to the Sultanganj Port in Bangladesh (Maia-Aricha route) successfully took place. The Bangladesh flag vessel M V Desh Bangla carrying stone aggregates was flagged-off by Minister of State for Ports, Shipping and Waterways Shri Shantanu Thakur from Maia Inland Customs Port in West Bengal. The trial shipment of cargo marks a new beginning for improved connectivity and cooperation between India and Bangladesh.
- Jennifer Larson, Consul General, U.S. Consulate General, Hyderabad, said that the U.S. and India are aiming to launch the joint NISAR satellite from Andhra Pradesh. She further stated that there will be Tiger Triumph exercise off the Andhra Pradesh coast in less than a month. NISAR is a low Earth orbit observatory jointly developed by NASA and ISRO to measure changes in our planet's surface.

- The WTO's 13th Ministerial Conference (MC13) took place from 26 February to 2 March 2024 in Abu Dhabi, United Arab Emirates. Ministers from across the world attended the conference to review the functioning of the multilateral trading system. The Conference was chaired by H.E. Dr Thani bin Ahmed Al Zeyoudi, UAE's Minister of State for Foreign Trade.
- India recently planned to review the Free Movement Regime (FMR) agreement with Myanmar and fence the India-Myanmar border, especially in the north-eastern states. The decision aims to address a complex intersection of historical, cultural, and security considerations.

Test Yourself!

1. In which edition, did the Greece's Prime Minister join The Raisina Dialogue as the chief guest?
   (a) 7th (b) 8th
   (c) 9th (d) 10th
2. What is the Line of Actual Control between India and China?
   (a) A notional demarcation line that joins Indian and Chinese controlled territory in the north eastern region in western border.
   (b) India's controlled construction areas.
   (c) China's controlled construction areas in its northern borders.
   (d) A notional demarcation line that separates Indian and Chinese controlled territory in the Sino-Indian border dispute.
3. Who is the current Minister of State for Ministry of Ports, Shipping and Waterways of India?
   (a) Dinesh Menon (b) Rocktim Saikia
   (c) Shantanu Thakur (d) Sarbananda Sonowal
4. What is the full form of NISAR?
   (a) NASA-ISRO Synthetic Aperture Radar
   (b) NASA-ISRO Space Automation Radar
   (c) NASA-ISRO Synthetic Automation Rover
   (d) NASA International Space Aperture Rover
5. Which of the following countries have recently signed Defence Cooperation Agreement?
   (a) China and Pakistan
   (b) China and Maldives
   (c) Maldives and Pakistan
   (d) Pakistan and Sri Lanka
6. Who chaired WTO's 13th Ministerial Conference (MC13)?
   (a) Hadja Lahbib
   (b) Ahasanul Islam
   (c) Anupriya Patel
   (d) H.E. Dr Thani bin Ahmed Al Zeyoudi
7. India recently planned to review which agreement with Myanmar?
   (a) Freely Move Regime
   (b) Free Movement Regime
   (c) Free Motions Regime
   (d) Freely Motions Regime
8. With which country did the PM, Narendra Modi sign eight pacts to bolster cooperation in key areas such as investments, electricity trade and digital payment platforms?
   (a) UAE (b) Australia
   (c) Qatar (d) Hungary
9. Where was the 2nd India-U.S. Defense Acceleration Ecosystem (INDUS-X) Summit held?
   (a) New Delhi (b) Washington, D.C.
   (c) Bengaluru (d) Mexico
10. For which project did the Sri Lanka recently sign an agreement with India?
    (a) Hybrid Renewable Energy System
    (b) High Renewable Energy Source
    (c) Hybrid Resource Energy Sources
    (d) High Resource Energy System

Answer Key

1. (c) 2. (d) 3. (c) 4. (a) 5. (b)
6. (d) 7. (b) 8. (a) 9. (a) 10. (a)

UNSCRAMBLED WORDS

MARCH 2024

1-f-ELECTROSATICS	2-a-VIOLET
3-h-ALLOYS	4-b-TORQUE
5-d-CONVECTION	6-j-ARCHIMEDES
7-e-IMPULSE	8-g-CELSIUS
9-c-PARAMAGNETS	10-i-MANOMETER

Winners : Arnab Sur (Kolkata), Aayush Kumar (Noida), Adrija Maity (Kolkata)

Class 12

CBSE

SOLVED PAPER 2024

Held on 4^{th} March

Hurray!! We are happy to inform our readers that in CBSE 2024 Physics question papers more than 70% questions were either exactly same or of similar type from **MTG Books**.

The references of few questions of paper having code - 55/2/1 are given here :

Paper Q. No.	P. No.	Q. No.	MTG Book
7	215	44	CBSE Champion
17	70	32	CBSE Champion
18 (a)	278	27	CBSE Champion
18 (b)	279	39 (b)	CBSE Champion
19	235	21, 22	CBSE Champion
20	365-366	13	CBSE Champion
21	384	12	CBSE Champion
22	73	71	CBSE Champion
23 (b)	214	22	CBSE Champion
23 (c)	214	22	CBSE Champion
24	264	22	100 percent
25 (a)	103	55	CBSE Champion
25 (b)	201	24	100 percent
26	343	16	CBSE Champion

Paper Q. No.	P. No.	Q. No.	MTG Book
28	386	42 (i), (ii)	CBSE Champion
29 (ii)	72	61	CBSE Champion
29 (iv)	141	9	100 percent
30 (ii)	233	11	CBSE Champion
30 (iii)- b	234	13	CBSE Champion
31 (b)- i	11	64	CBSE Champion
32 (a)	100	17	CBSE Champion
32 (b)- i	106	82 (b)- i	CBSE Champion
32 (b)- ii	105	69	CBSE Champion
33 (a)- i	28	65 (a)	CBSE Champion
33 (a)- ii	279	38	CBSE Champion
33 (a)- iii	279	40 (b)	CBSE Champion
33 (b)- i	240	74	CBSE Champion
33 (b)- ii	241	86 (a):ii- II	CBSE Champion

and many more ......

General Instructions : Read the following instructions very carefully and follow them :

Time Allowed : 3 hours
Maximum Marks : 70

(1) This question paper contains 33 questions. **All questions are compulsory**.
(2) Question paper is divided into **FIVE** section – **Section A, B, C, D** and **E**.
(3) **Section A –** Question number **1 to 16** are Multiple Choice (MCQ) type questions. Each question carries **1** mark.
(4) **Section B –** Question number **17** to **21** are Very Short Answer type questions. Each question carries 2 mark.
(5) **Section C –** Question number **22** to **28** are Short Answer type questions. Each question carries 3 mark.
(6) **Section D –** Question number **29** and **30** are Case-Based questions. Each question carries 4 mark.
(7) **Section E –** Question number **31** to **33** are Long Answer type questions. Each question carries 5 mark.
(8) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section–A.
(9) Kindly note that there is a separate question paper for Visually Impaired candidates.
(10) Use of calculators is **NOT** allowed.

You may use the following values of physical constants wherever necessary :

(i) $c = 3 \times 10^8$ m/s
(ii) $h = 6.63 \times 10^{-34}$ Js
(iii) $e = 1.6 \times 10^{-19}$C
(iv) $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
(v) $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
(vi) $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}
(vii) Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg
(viii) Mass of neutron $= 1.675 \times 10^{-27}$ kg
(ix) Mass of proton $= 1.673 \times 10^{-27}$ kg
(x) Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
(xi) Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

SECTION-A

1. Two charged particles P and Q, having the same charge but different masses m_P and m_Q, start from rest and travel equal distances in a uniform electric field $\vec{E}$ in time t_P and t_Q respectively. Neglecting the effect of gravity, the ratio $\left(\frac{t_P}{t_Q}\right)$ is

(a) $\frac{m_P}{m_Q}$ (b) $\frac{m_Q}{m_P}$ (c) $\sqrt{\frac{m_P}{m_Q}}$ (d) $\sqrt{\frac{m_Q}{m_P}}$

2. Electrons drift with speed v_d in a conductor with potential difference V across its ends. If V is reduced to $\left(\frac{V}{2}\right)$, their drift speed will become

(a) $\frac{v_d}{2}$ (b) v_d (c) $2\,v_d$ (d) $4\,v_d$

3. A wire of length 4.4 m is bent round in the shape of a circular loop and carries a current of 1.0 A. The magnetic moment of the loop will be

(a) 0.7 Am^2 (b) 1.54 Am^2
(c) 2.10 Am^2 (d) 3.5 Am^2

4. A circular coil of radius 10 cm is placed in a magnetic field $\vec{B}=(1.0\hat{i}+0.5\hat{j})$ mT such that the outward unit vector normal to the surface of the coil is $(0.6\hat{i}+0.8\hat{j})$. The magnetic flux linked with the coil is

(a) 0.314 μWb (b) 3.14 μWb
(c) 31.4 μWb (d) 1.256 μWb

5. Which of the following quantity/quantities remains same in primary and secondary coils of an ideal transformer?

Current, Voltage, Power, Magnetic flux

(a) Current only
(b) Voltage only
(c) Power only
(d) Magnetic flux and Power both

6. A resistor and an ideal inductor are connected in series to a $100\sqrt{2}$ V, 50 Hz ac source. When a voltmeter is connected across the resistor or the inductor, it shows the same reading. The reading of the voltmeter is

(a) $100\sqrt{2}$ V (b) 100 V
(c) $50\sqrt{2}$ V (d) 50 V

7. Electromagnetic waves with wavelength 10 nm are called

(a) Infrared waves (b) Ultraviolet rays
(c) Gamma rays (d) X-rays

8. The work function for a photosensitive surface is 3.315 eV. The cut-off wavelength for photoemission of electron from this surface is

(a) 150 nm (b) 200 nm
(c) 375 nm (d) 500 nm

9. Energy levels A, B and C of an atom correspond to increasing values of energy *i.e.*, $E_A < E_B < E_C$. Let λ_1, λ_2 and λ_3 be the wavelengths of radiation corresponding to the transitions C to B, B to A and C to A, respectively. The correct relation between λ_1, λ_2 and λ_3 is

(a) $\lambda_1^2+\lambda_2^2=\lambda_3^2$ (b) $\frac{1}{\lambda_1}+\frac{1}{\lambda_2}=\frac{1}{\lambda_3}$
(c) $\lambda_1+\lambda_2+\lambda_3=0$ (d) $\lambda_1+\lambda_2=\lambda_3$

10. An alpha particle approaches a gold nucleus in Geiger-Marsden experiment with kinetic energy K. It momentarily stops at a distance d from the nucleus and reverses its direction. Then d is proportional to

(a) $\frac{1}{\sqrt{K}}$ (b) $\sqrt{K}$ (c) $\frac{1}{K}$ (d) K

11. An n-type semiconducting Si is obtained by doping intrinsic Si with

(a) Al (b) B (c) P (d) In

12. When a p-n junction diode is subjected to reverse biasing

(a) the barrier height decreases and the depletion region widens.
(b) the barrier height increases and the depletion region widens.
(c) the barrier height decreases and the depletion region shrinks.
(d) the barrier height increases and the depletion region shrinks.

For Questions number 13 to 16, two statements are given –one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).
(c) If Assertion (A) is true and Reason (R) is false.
(d) If both Assertion (A) and Reason (R) are false.

13. **Assertion (A)** : Photoelectric current increases with an increase in intensity of incident radiation,

for a given frequency of incident radiation and the accelerating potential.

Reason (R) : Increase in the intensity of incident radiation results in an increase in the number of photoelectrons emitted per second and hence an increase in the photocurrent.

14. **Assertion (A) :** Lenz's law is a consequence of the law of conservation of energy.

Reason (R) : There is no power loss in an ideal inductor.

15. **Assertion (A) :** An electron and a proton enter with the same momentum $\vec{p}$ in a magnetic field $\vec{B}$ such that $\vec{p} \perp \vec{B}$. Then both describe a circular path of the same radius.

Reason (R) : The radius of the circular path described by the charged particle (charge q, mass m) moving in the magnetic field $\vec{B}$ is given by $r = \frac{mv}{qB}$.

16. **Assertion (A) :** The magnifying power of a compound microscope is negative.

Reason (R) : The final image formed is erect with respect to the object.

SECTION-B

17. Define resistivity of a conductor. How does the resistivity of a conductor depend upon the following :

(a) Number density of free electrons in the conductor (n)

(b) Their relaxation time (τ)

18. (a) Two waves, each of amplitude 'a' and frequency 'ω' emanating from two coherent sources of light superpose at a point. If the phase difference between the two waves is ϕ, obtain an expression for the resultant intensity at that point.

OR

(b) What is the effect on the interference pattern in Young's double-slit experiment when (i) the source slit is moved closer to the plane of the slits, and (ii) the separation between the two slits is increased? Justify your answers.

19. A convex lens (n = 1.52) has a focal length of 15.0 cm in air. Find its focal length when it is immersed in liquid of refractive index 1.65. What will be the nature of the lens?

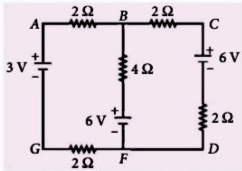
20. The carbon isotope $^{12}_{6}C$ has a nuclear mass of 12.000000 u. Calculate the binding energy of its nuclues.

Given m_p = 1.007825 u ; m_n = 1.008665 u.

21. How does the energy gap of an intrinsic semiconductor effectively change when doped with a (a) trivalent impurity, and (b) pentavalent impurity? Justify your answer in each case.

SECTION - C

22. The figure shows a circuit with three ideal batteries. Find the magnitude and direction of currents in the branches *AG*, *BF* and *CD*.



23. (a) On what factors does the speed of an electromagnetic wave in a medium depend?

(b) How is an electromagnetic wave produced?

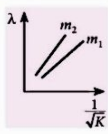
(c) Sketch a schematic diagram depicting the electric and magnetic fields for an electromagnetic wave propagating along z-axis.

24. A 100-turn coil of radius 1.6 cm and resistance 5.0 Ω is co-axial with a solenoid of 250 turns/cm and radius 1.8 cm. The solenoid current drops from 1.5 A to zero in 25 ms. Calculate the current induced in the coil in this duration. (Take π^2 = 10)

25. (a) Two long, straight, parallel conductors carry steady currents in opposite directions. Explain the nature of the force of interaction between them. Obtain an expression for the magnitude of the force between the two conductors. Hence define one ampere.

OR

(b) Obtain an expression for the torque $\vec{\tau}$ acting on a current carrying loop in a uniform magnetic field $\vec{B}$. Draw the necessary diagram.



26. Using Bohr's postulates, derive the expression for the radius of the n^{th} orbit of an electron in a hydrogen atom. Also, find the numerical value of Bohr's radius a_0.

27. de Broglie wavelength λ as a function of $\frac{1}{\sqrt{K}}$, for two particles of masses m_1 and m_2 are shown in the figure. Here, K is the energy of the moving particles.
(a) What does the slope of a line represent?
(b) Which of the two particles is heavier?
(c) Is this graph also valid for a photon?
Justify your answer in each case.

28. With the help of a circuit diagram, explain the working on a p-n junction diode as a full wave rectifier. Draw its input and output waveforms.

SECTION - D

Case Study Based Questions

Question no. 29 to 30 are Case Study based questions. Read the following paragraph and answer the questions that follow.

29. When the terminals of a cell are connected to a conductor of resistance R, an electric current flows through the circuit. The electrolyte of the cell also offers some resistance in the path of the current, like the conductor. This resistance offered by the electrolyte is called internal resistance of the cell (r). It depends upon the nature of the electrolyte, the area of the electrodes immersed in the electrolyte and the temperature. Due to internal resistance, a part of the energy supplied by the cell is wasted in the form of heat.

When no current is drawn from the cell, the potential difference between the two electrodes is known as emf of the cell (ε). With a current drawn from the cell, the potential difference between the two electrodes is termed as terminal potential difference (V).

(i) Choose the incorrect statement :
(a) The potential difference (V) between the two terminals of a cell in a closed circuit is always less than its emf (ε), during discharge of the cell.
(b) The internal resistance of a cell decreases with the decrease in temperature of the electrolyte.
(c) When current is drawn from the cell then $V = \varepsilon - Ir$.
(d) The graph between potential difference between the two terminals of the cell (V) and the current (I) through it is a straight line with a negative slope.

(ii) Two cells of emfs 2.0 V and 6.0 V and internal resistances 0.1 Ω and 0.4 Ω respectively, are connected in parallel. The equivalent emf of the combination will be
(a) 2.0 V (b) 2.8 V
(c) 6.0 V (d) 8.0 V

(iii) Dipped in the solution, the electrode exchanges charges with the electrolyte. The positive electrode develops a potential V_+ ($V_+ > 0$), and the negative electrode develops a potential $-(V_-)$ ($V_- \geq 0$), relative to the electrolyte adjacent to it. When no current is drawn from the cell then
(a) $\varepsilon = V_+ + V_- > 0$ (b) $\varepsilon = V_+ - V_- > 0$
(c) $\varepsilon = V_+ + V_- < 0$ (d) $\varepsilon = V_+ + V_- = 0$

(iv) (a) Five identical cells, each of emf 2 V and internal resistance 0.1 Ω are connected in parallel. This combination in turn is connected to an external resistor of 9.98 Ω. The current flowing through the resistor is
(a) 0.05 A (b) 0.1 A
(c) 0.15 A (d) 0.2 A

OR

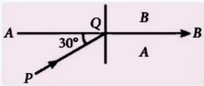
(b) Potential difference across a cell in the open circuit is 6 V. It becomes 4 V when a current of 2 A is drawn from it. The internal resistance of the cells is :
(a) 1.0 Ω (b) 1.5 Ω
(c) 2.0 Ω (d) 2.5 Ω

30. When a ray of light propagates from a denser medium to a rarer medium, it bends away from the normal. When the incident angle is increased, the refracted ray deviates more from the normal. For a particular angle of incidence in the denser medium, the refracted ray just grazes the interface of the two surfaces. This angle of incidence is called the critical angle for the pair of media involved.

(i) For a ray incident at the critical angle, the angle of reflection is
(a) 0° (b) < 90° (c) > 90° (d) 90°

(ii) A ray of light of wavelength 600 nm is incident in water $\left(n = \frac{4}{3}\right)$ on the water-air interface at an angle less than the critical angle. The wavelength associated with the refracted ray is
(a) 400 nm (b) 450 nm
(c) 600 nm (d) 800 nm

(iii) **(a)** The interface AB between the two media A and B is shown in the figure. In the denser medium A, the incident ray PQ makes an angle of 30° with the horizontal. The refracted ray is parallel to the interface. The refractive index of medium B w.r.t. medium A is



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

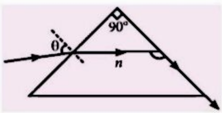
OR

(b) Two media A and B are separated by a plane boundary. The speed of light in medium A and B is 2×10^8 ms^{-1} and 2.5×10^8 ms^{-1} respectively. The critical angle for a ray of light going from medium A to medium B is

(a) $\sin^{-1}\frac{1}{2}$ (b) $\sin^{-1}\frac{4}{5}$

(c) $\sin^{-1}\frac{3}{5}$ (d) $\sin^{-1}\frac{2}{5}$

(iv) The figure shows the path of a light ray through a triangular prism. In this phenomenon, the angle θ is given by



(a) $\sin^{-1}\sqrt{n^2-1}$ (b) $\sin^{-1}(n^2-1)$

(c) $\sin^{-1}\left[\frac{1}{\sqrt{n^2-1}}\right]$ (d) $\sin^{-1}\left[\frac{1}{(n^2-1)}\right]$

SECTION - E

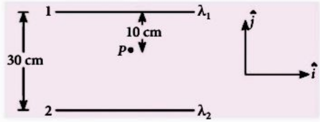
31. **(a)** (i) Obtain an expression for the electric potential due to a small dipole of dipole moment $\vec{p}$, at a point $\vec{r}$ from its centre, for much larger distances compared to the size of the dipole.

(ii) Three point charges q, $2q$ and nq are placed at the vertices of an equilateral triangle. If the potential energy of the system is zero, find the value of n.

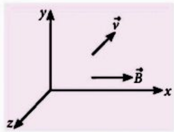
OR

(b) (i) State Gauss's Law in electrostatics. Apply this to obtain the electric field $\vec{E}$ at a point near a uniformly charged infinite plane sheet.

(ii) Two long straight wires 1 and 2 are kept as shown in the figure. The linear charge density of the two wires are $\lambda_1 = 10\ \mu C/m$ and $\lambda_2 = -20\ \mu C/m$. Find the net force $\vec{F}$ experienced by an electron held at point P.



32. **(a)** (i) A particle of mass m and charge q is moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ as shown in the figure. Show that it follows a helical path. Hence, obtain its frequency of revolution.



(ii) In a hydrogen atom, the electron moves in an orbit of radius 2 Å making 8×10^{14} revolutions per second. Find the magnetic moment associated with the orbital motion of the electron.

OR

(b) (i) What is current sensitivity of a galvanometer? Show how the current sensitivity of a galvanometer may be increased. "Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Explain.

(ii) A moving coil galvanometer has a resistance 15 Ω and takes 20 mA to produce full scale deflection. How can this galvanometer be converted into a voltmeter of range 0 to 100 V?

33. **(a)** (i) Give any two differences between the interference pattern obtained in Young's double-slit experiment and a diffraction pattern due to a single slit.

(ii) Draw an intensity distribution graph in case of a double-slit interference pattern.

(iii) In Young's double-slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen, where path difference is λ, is K units. Find the intensity of light at a point on the screen where the path difference is $\frac{\lambda}{6}$.

OR

(b) (i) Draw a labelled ray diagram of a compound microscope showing image formation at least distance of distinct vision. Derive an expression for its magnifying power.

(ii) A telescope consists of two lenses of focal length 100 cm and 5 cm. Find the magnifying power when the final image is formed at infinity.

SOLUTIONS

1. (c) : Given, two charged particles P and Q, having same charge but different masses.
Both starts from rest,
Let charge on both particles = q
Now, force on particle P, $F_P = qE = m_P a_P$
and force on particle Q, $F_Q = qE = m_Q a_Q$

So, acceleration of particle P, $a_P = \frac{qE}{m_P}$ ...(i)

and acceleration of particle Q, $a_Q = \frac{qE}{m_Q}$ ...(ii)

∴ Both particles travel equal distance, let distance travelled by both particles = S

For particle P, $S = ut + \frac{1}{2}at_1^2$

$S = \frac{1}{2} \times a_P t_P^2$ $(\because u = 0)$

$t_P^2 = \frac{2S}{a_P}$; $t_P^2 = \frac{2S}{qE}(m_P)$ (using (i))

$t_P = \sqrt{\frac{2Sm_P}{qE}}$ ...(iii)

For particle Q,

$S = ut + \frac{1}{2}a_Q t_Q^2$; $S = \frac{1}{2}a_Q t_Q^2$

$t_Q^2 = \frac{2S}{a_Q} = \frac{2S(m_Q)}{qE}$ (using (ii))

$t_Q = \sqrt{\frac{2Sm_Q}{qE}}$ ...(iv)

Dividing equation (iii) by (iv);

$$\frac{t_P}{t_Q} = \frac{\sqrt{\frac{2S\,m_P}{qE}}}{\sqrt{\frac{2S\,m_Q}{qE}}} ; \frac{t_P}{t_Q} = \sqrt{\frac{m_P}{m_Q}}$$

Hence, correct option is (c).

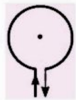
2. (a) : Current, $I = neAv_d$

$v_d = \frac{V}{ne\rho l}$ $\left(\text{using } A = \frac{\rho l}{R} \text{ and } IR = V\right)$

So, $v_d \propto V$

Therefore, drift speed will become $\frac{v_d}{2}$.

3. (b) : The length of wire, $l = 4.4$ m



The loop carries a current, $I = 1.0$ A
for radius of loop, r = ?
$2\pi r = 4.4$

$r = \frac{4.4 \times 7}{2 \times 22} = \frac{7}{10}$ or $r = 0.7$ m

So, Area of loop, $A = \pi r^2 = 3.14 \times (0.7)^2 = 1.54\ m^2$
Magnetic moment of loop, $M = NIA$
$M = 1 \times 1.54\ Am^2A$; $M = 1.54\ Am^2$

4. (c) : Given, radius of circular coil $r = 10$ cm or 0.1 m
Magnetic field, $B = \left(1.0\hat{i} + 0.5\hat{j}\right)10^{-3}T$
Vector normal to surface, $\hat{n} = (0.6\hat{i} + 0.8\hat{j})$
Area of coil, $A = \pi r^2 = 3.14 \times 10^{-2} m^2$
Flux, $\phi = \vec{B}.\vec{A} = B A\hat{n}$
$\phi = (3.14 \times 10^{-2}\ (1.0\hat{i} + 0.5\hat{j}))(10^{-3}(0.6\hat{i} + 0.8\hat{j})\ \text{Wb})$
$\phi = 3.14 \times 10^{-5}\ (0.6 + 0.4)$ Wb
$\phi = 3.14 \times 10^{-5}$ Wb ; $\phi = 31.4\ \mu$Wb

5. (d) : Magnetic flux and power remains same in primary and secondary coil for an ideal transformer.

6. (b) : Given, source voltage, $V_0 = 100\sqrt{2}V$
Given, potential across resistor = Potential across inductor.
Let $V_R = V_L = V$

$\because \sqrt{V_R^2 + V_L^2} = \sqrt{V_0^2}$

or $100\sqrt{2} = \sqrt{V^2 + V^2}$ or $\sqrt{2}\,V = 100\sqrt{2}$; $V = 100$ V

7. (d) : Electromagnetic waves with wavelength 10 nm are called X-rays.

8. (c) : The work function for a photosensitive surface, $\phi = 3.315$ eV
Cutoff wavelength for surface, λ = ?

$\because E = \frac{hc}{\lambda} = \phi$

$$\lambda = \frac{hc}{\phi} = \frac{6.63\times10^{-34}\times3\times10^{8}}{3.315\times1.6\times10^{-19}} = 3.75\times10^{-7}$$

or $\lambda = 375$ nm

Therefore, required wavelength = 375 nm.

9. (b) : Energy levels of atoms *A*, *B*, and *C* is,

$E_A < E_B < E_C$

Now, $E_C - E_A = (E_C - E_B) + (E_B - E_A)$

(on the basis of energy of emitted photon).

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

10. (c) : The distance from the nucleus, where all kinetic energy of α-particles is completely converted into potential energy is known as the distance of closest approach.

$$d = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2Ze^2}{K} \text{ or } d \propto \frac{1}{K}$$

11. (c) : An *n*-type semiconducting Si is obtained by doping intrinsic Si with pentavalent atom like Phosphorus.

12. (b) : When a *p*-*n* junction diode is subjected to reverse biasing, the barrier height increases and depletion regions widens and resistance of *p*-*n* junction is high to the flow of current.

13. (a) : Photoelectric current increases with an increase in intensity of incident radiation, for a given frequency. Here number of incident photoelectrons increase per second. Hence, an increase in the photocurrent occurs.

14. (b) : According to Lenz law, the induced emf opposes the change that has produced it. It is the opposition against which we perform mechanical work, that causes the change in magnetic flux. So, it is the mechanical energy which is converted into electrical energy. Thus, it is a consequence of conservation of energy.

An ideal inductor has zero resistance so it has no power loss.

15. (a) : Radius described by the charge, $\because r = \frac{mv}{qB}$

$\because$ Electron and proton has same momentum $\vec{p}$, therefore both have same radius and follow the above equation.

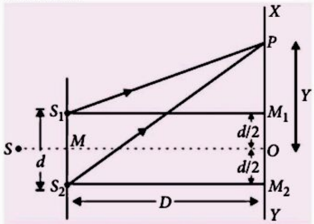
16. (c) : The magnifying power of a compound microscope is negative, so the final image formed is inverted with respect to the object.

17. Resistivity is defined as the measure of resistance offered by a conductor of unit length across unit area of cross section.

The resistivity ρ is given by, $\rho = \frac{m}{ne^2\tau}$

where *m* is mass of charge, *n* is the number density and τ is relaxation time.

18. (a) Light waves each of amplitude *a* and frequency ω, emanating from two coherent light sources superpose at a point. The displacements due to these waves is given by $y_1 = a\cos\omega t$ and $y_2 = a\cos(\omega t + \phi)$ where ϕ is the phase difference between the two.



Resultant displacement at point *P* will be,

$$y = y_1 + y_2 = a\cos\omega t + a\cos(\omega t + \phi)$$

$$= a[\cos\omega t + \cos(\omega t + \phi)]$$

$$= a\left[2\cos\frac{(\omega t + \omega t + \phi)}{2}\cos\frac{(\omega t - \omega t - \phi)}{2}\right]$$

$$y = 2a\cos\left(\omega t + \frac{\phi}{2}\right)\cos\left(\frac{\phi}{2}\right) \quad \text{...(i)}$$

Let $2a\cos\left(\frac{\phi}{2}\right) = A$, the equation (i) becomes

$$y = A\cos\left(\omega t + \frac{\phi}{2}\right)$$

where *A* is amplitude of resultant wave,

Now, $A = 2a\cos\left(\frac{\phi}{2}\right)$

On squaring, $A^2 = 4a^2\cos^2\left(\frac{\phi}{2}\right)$

Hence, resultant intensity, $I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

OR

(b) (i) In Young's double-slit experiment when source slit is moved closer to the plane of the slits, then, fringes will disappears because for fringes condition $\frac{s}{S} < \frac{\lambda}{d}$ should be satisfied. Here, *s* is size of source and *S* is distance of source from plane of two slits. Thus, *S* decreases (source slit is moved closer) then *s*/*S* increases. So, here the above condition is not satisfied.

(ii) If separation between two slits is increased then $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \frac{1}{d}$, so fringe width will decrease.

19. Refractive index of convex lens, $n = 1.52$

Focal length of lens, $f = 15.0$ cm.

According to Lens Makers formula,

$$\frac{1}{f} = ({}^{a}\mu_g - 1).\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{15} = (1.52 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \text{...(i)}$$

After dipping in liquid of refractive index, $n = 1.65$

$$\frac{1}{f_w} = \left(\frac{{}^{a}\mu_g}{{}^{a}\mu_w} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_w} = \left(\frac{1.52}{1.65} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_w} = \left(\frac{1.52 - 1.65}{1.65}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{...(ii)}$$

Dividing equation (i) by (ii)

$$\frac{\frac{1}{15}}{\frac{1}{f_w}} = \frac{(0.52)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}{\left(\frac{-0.13}{1.65}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}; \quad \frac{1}{15} \times \frac{f_w}{1} = \frac{-0.52 \times 1.65}{0.13}$$

$$f_w = \frac{-0.52 \times 1.65 \times 15}{0.13} = -99 \text{ cm}$$

So, after dipping in liquid, the convex lens behaves like a concave lens.

20. Carbon isotope ${}^{12}_{6}C$ has a nuclear mass = 12.000000 u

$\because$ mass of proton, $m_p = 1.007825$ u

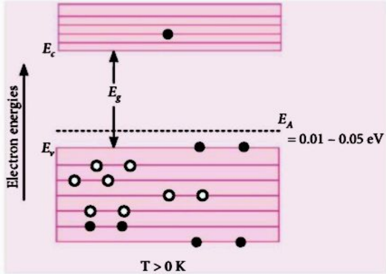
mass of neutron, $m_n = 1.008665$ u

Binding energy, $\Delta B = ((6m_p + 6m_n) - 12.000000)\, c^2$

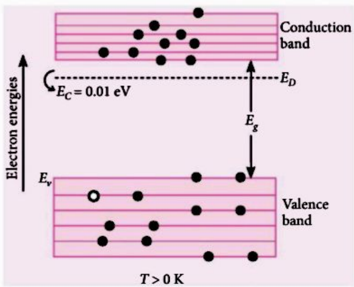
$= (6 \times (1.007825 + 1.008665) - 12.000000)$ amu c^2

$= (0.09894) \times 931.5$ MeV $= 92.16$ MeV

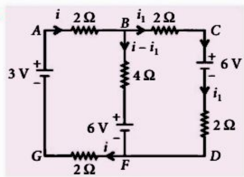
21. (a) The intrinsic semiconductors in which trivalent impurity is added, are called *p*-type semiconductors. Due to the trivalent impurity, holes are created which can be filled by an electron of Si – Si covalent bond, *i.e.*, very small energy ranging from 0.01 eV - 0.05 eV is required by an electron of the valence band to move into this hole. Therefore, the acceptor energy level E_A lies slightly above the top of the valence band. At room temperature, the electrons in the valence band get excited to acceptor energy levels, creating equal number of holes in the valence band.



(b) The intrinsic semiconductors in which pentavalent impurity is added are called *n*-type semiconductor. Due to the pentavalent impurity, a number of losely bonded electron are available in the lattice structure and as the voltage applied, then these electron break the covalent bonds and they are ready to conduct. These electrons occupy the lowest possible energy level in the conduction band. When a certain amount of voltage is applied, these electrons gain energy to cross the forbidden gap and leave the valence band and enter into the conduction band. A very less number of holes are formed in the valence band as the electron leaves valence band to enter conduction band. Moreover, the fermi level is near to the conduction band as more number of electrons enter the conduction band.



22.



Using Kirchoff's voltage rule,

(i) In loop $ABFGA$,

$2i + 4(i - i_1) + 6 + 2i - 3 = 0$

$8i - 4i_1 + 3 = 0$ ...(i)

(ii) In loop $BCDFB$,

$2i_1 + 6 + 2i_1 - 6 - 4(i - i_1) = 0$

$8i_1 - 4i = 0$ ...(ii)

Solving equation (i) and (ii),

$i = -0.5$ A

$i_1 = -0.25$ A

Current in branch AG = 0.5 A, from A to G.

Current in branch BF = 0.25 A, from F to B.

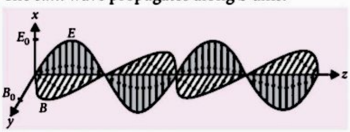
Current in branch CD = 0.25 A, from D to C.

23. (a) Speed (v) of electromagnetic wave for a medium of electric permeability 'ε' and magnetic permeability 'μ' is given as, $v = \dfrac{1}{\sqrt{\varepsilon\mu}} = \dfrac{1}{\sqrt{\varepsilon_r\varepsilon_o\mu_r\mu_o}} = \dfrac{c}{\sqrt{\varepsilon_r\mu_r}}$

Hence, speed (v) depends on the electric and magnetic properties of the medium.

(b) According to the electromagnetic theory, accelerating charged particles radiate electromagnetic waves. An accelerated charged particle oscillating in space produces time varying electric field and time varying magnetic field. This process is repeated, again and again and hence an electromagnetic wave is produced.

(c) The *e.m.* wave propagates along z-axis.



24. Induced emf is given by,

$$e = -N\frac{d\phi}{dt} = -N\frac{d}{dt}(BA\cos\theta)$$

Magnetic field produced by solenoid, $B = \mu_0 ni$

Emf induced in coil $\varepsilon = -N\dfrac{d\phi}{dt}$; $IR = -N\dfrac{d}{dt}(BA)$

(I is the current induced in coil)

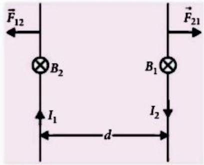
Hence, $iR = -N\dfrac{d}{dt}(\mu_0 niA)$; $i = -\dfrac{N}{R}\mu_0 nA\dfrac{di}{dt}$

Given, $di = 1.5$ A for $dt = 25$ ms, $n = 250$ turns/cm, $A = r(1.8 \times 10^{-2})^2$, $N = 100$ and $R = 5.0\ \Omega$;

$$i = (-)\frac{100}{5} \times 4\pi \times 10^{-7} \times \frac{250}{10^{-2}} \times \pi \times (1.8 \times 10^{-2})^2 \times \frac{1.5}{25 \times 10^{-3}}$$

$i = 0.0389$ A

25. (a) When two parallel infinite straight wires carrying currents I_1 and I_2 are placed at distance d from each other, then current I_1 produces magnetic field, which at any point on the second current carrying wire is



$B_1 = \dfrac{\mu_0 I_1}{2\pi d}$ directed inwards perpendicular to plane of wires.

So, this current (I_2) carrying wire then experiences a force due to this magnetic field which on its length l is given by

$$\vec{F}_{21} = I_2(\vec{l} \times \vec{B}_1)$$

$$F_{21} = F_{12} = I_2 l B_1 \sin 90° = I_2 l \times \frac{\mu_0 I_1}{2\pi d}$$

or $F_{21} = F_{12} = \dfrac{\mu_0 I_1 I_2}{2\pi d} l$

The vector product $(\vec{l} \times \vec{B}_1)$ has a direction away from the wire carrying current I_1. Hence, both the wires repel each other.

So, force per unit length that each wire exerts on the other is

$$F = \frac{\mu_0 I_1 I_2}{2\pi d}$$

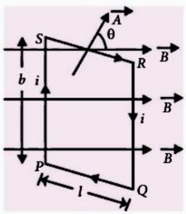
If $I_1 = I_2 = 1$ A and $d = 1$ m and $l = 1$ m

then $F = \dfrac{\mu_0}{2\pi} = 2 \times 10^{-7}\ \text{N m}^{-1}$

Thus, electric current through each of two parallel long wires placed at distance of 1 m from each other is said to be 1 ampere, if they exert a force of $2 \times 10^{-7}\ \text{N m}^{-1}$ on each other.

OR

(b) Consider a rectangular loop length of l, breadth b and carrying a current i lying in the plane of uniform magnetic field $\vec{B}$ and makes an angle θ with direction of $\vec{B}$. The forces will be acting on the four arms of the coil and calculated by $\vec{F} = \int i d\vec{l} \times \vec{B}$.



The direction of force can be found by right hand rule. Direction of force on limb PQ and RS are opposite in magnitude along the same straight line. As these makes equal angle with horizontal so these two forces must be equal in magnitude and cancel each other.

The forces on vertical limbs *i.e.* ($F = ilB$) PS and QR are also in opposite direction and thus form a couple and corresponding torque τ is given by

$$\tau = F\frac{b}{2}\sin\theta + F\frac{b}{2}\sin\theta = (ilB)\,b\sin\theta = iBA\sin\theta$$

where $A = lb$ is the area enclosed by the loop.

The couple formed by forces on coil PS and QR rotate the coil in clockwise direction.

So, net torque on the coil if it has n turns; $\tau = niAB\sin\theta$

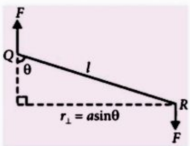
If the plane of loop is normal to the direction of magnetic field *i.e.*, $\theta = 0°$ between $\vec{B}$ and $\vec{A}$, then the loop does not experience any torque *i.e.*, $\tau_{min} = 0$.

If the plane of loop is parallel to the direction of magnetic field *i.e.*, $\theta = 90°$ between $\vec{B}$ and $\vec{A}$, then the loop experience maximum torque *i.e.*, $\tau_{max} = niAB$.

The vector expression for the torque exerted on a loop placed in uniform magnetic field $\vec{B}$ is

$$\vec{\tau} = i\vec{A}\times\vec{B} \quad \text{...(i)}$$

where $\vec{A}$ is the area vector *i.e.* vector perpendicular to plane of loop and has a magnitude equal to area of loop.



Here the product $i\vec{A}$ is defined to be magnetic dipole moment $\vec{M}$ or magnetic moment of the loop *i.e.*,

$$\vec{M} = i\vec{A} \quad \text{...(ii)}$$

Using equation (ii), torque can be expressed as follows :

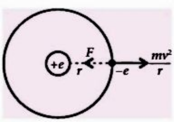
$$\vec{\tau} = \vec{M}\times\vec{B}$$

This result is analogous to equation $\vec{\tau} = \vec{p}\times\vec{E}$, the torque exerted on an electric dipole in the presence of electric field $\vec{E}$ where $\vec{p}$ is the electric dipole moment.

26. In H-atom, an electron having charge $-e$ revolves around the nucleus of charge +e in a circular orbit of radius r, such that necessary centripetal force is provided by the electrostatic force of attraction between the electron and nucleus.

i.e., $$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e.e}{r^2}$$

or $$mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r} \quad \text{...(i)}$$



From Bohr's quantization condition

$$mvr = \frac{nh}{2\pi} \text{ or } v = \frac{nh}{2\pi mr} \quad \text{...(ii)}$$

Using equation (ii) in (i), we get

$$m\cdot\left(\frac{nh}{2\pi mr}\right)^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r} \text{ or } \frac{m\cdot n^2h^2}{4\pi^2m^2r^2} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

or $$r = \frac{n^2h^2\varepsilon_0}{\pi me^2} \quad \text{...(iii)}$$

where $n = 1, 2, 3, ...$ is principal quantum number.

Equation (iii), gives the radius of n^{th} orbit of H-atom. So the radii of the orbits increase proportionally with n^2 *i.e.*, $[r \propto n^2]$. Radius of first orbit of H-atom is called Bohr radius a_0 and is given by

$$a_0 = \frac{h^2\varepsilon_0}{\pi me^2} \text{ for } n = 1 \text{ or } a_0 = 0.529 \text{ Å}$$

So, radius of n^{th} orbit of H-atom then becomes

$r = n^2 \times 0.529$ Å

27. de-Broglie wavelength for a particle of momentum 'p', mass m and kinetic energy K, is given as,

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

(a) $$\lambda = \frac{h}{\sqrt{2m}}\left(\frac{1}{\sqrt{K}}\right)$$

Here, according to the graph $\frac{h}{\sqrt{2m}}$ is the slope of the graph.

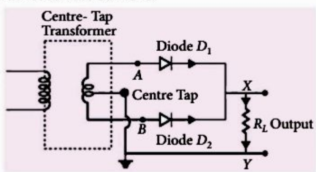
(b) Since slope for mass m_2 is greater, the value of $\frac{h}{\sqrt{2m}}$ is also greater, so, $\frac{h}{\sqrt{2m_2}} > \frac{h}{\sqrt{2m_1}}$; $m_1 > m_2$

m_1 is the heavier particle.

(c) For a photon, kinetic energy is, $K = \frac{hc}{\lambda}$

Hence, the given graph is not valid for photons, as the wavelength of photon is inversely proportional to kinetic energy and not the square root of kinetic energy.

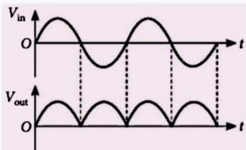
28. Two p-n junction diodes can be used to make full wave rectifier which is used to convert alternating current into direct current.



A full wave rectifier consists of two diodes connected in parallel across the ends of secondary winding of a center tapped step down transformer. The load resistance R_L is connected across secondary winding and the diodes between A and B as shown in the circuit.

During positive half cycle of input a.c., end A of the secondary winding becomes positive and end B negative. Thus diode D_1 becomes forward biased, whereas diode D_2 reverse biased. So diode D_1 allows the current to flow through it, while diode D_2 does not, and current in the circuit flows from D_1 and through load R_L from X to Y.

During negative half cycle of input a.c., end A of the secondary winding becomes negative and end B positive, thus diode D_1 becomes reverse biased, whereas diode D_2 forward biased. So diode D_1 does not allow the current to flow through it but diode D_2 does, and current in the circuit flows from D_2 and through load R_L from X to Y.



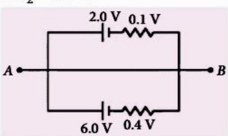
Input-Output waveforms

Since in both the half cycles of input a.c., electric current through load R_L flows in the same direction, so d.c. is obtained across R_L. Although direction of electric current through R_L remains same, but its magnitude changes with time, so it is called pulsating d.c.

29. (i) (b) : With the increase in temperature of the electrolyte, ions gains more energy and hence the resistance against their movement is reduced. Thus, internal resistance of a cell is inversely proportional to the temperature of the electrolyte.

(ii) (b) : Given, $\varepsilon_1 = 2.0$ V $\varepsilon_2 = 6.0$ V

$r_1 = 0.1\ \Omega$ and $r_2 = 0.4\ \Omega$



Now, equivalent emf of the circuit,

$$\varepsilon = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{2.0 \times 0.4 + 6.0 \times 0.1}{0.1 + 0.4} = \frac{1.4}{0.5}$$

$\therefore\ \varepsilon = 2.8$ V

(iii) (b) : As the positive electrode is at potential $V_+ > 0$ and the negative electrode develops potential $(-V_- \geq 0)$. The electromotive force is the potential difference of open circuit when no current is drawn by circuit.

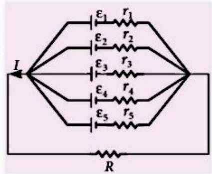
Hence, $E = V_+ - V_- > 0$.

(iv) (a) (d) : Given that,

$\varepsilon_1 = \varepsilon_2 = \varepsilon_3 = \varepsilon_4 = \varepsilon_5 = 2$ V

$r_1 = r_2 = r_3 = r_4 = r_5 = 0.1\ \Omega$

Since, all the cells are connected in parallel, current through external resistance R is



$$I = \frac{\varepsilon}{\frac{r}{n} + R} = \frac{2}{\frac{0.1}{5} + 9.98}$$

or $I = 0.2$ A

OR

(b) (a) : When $I = 0$, $E = 6$ V

when $I = 2$ A, V = 4 V

Internal resistance of the cell

$$r = \frac{E - V}{I} \text{ or } r = \frac{6-4}{2} = 1\ \Omega$$

30. (i) (d) : When $i = c$, $r = 90°$

When $i > c$, total internal reflection takes place.

(ii) (b) : Given, wavelength of incident light

$\lambda = 600$ nm $= 6 \times 10^{-7}$ m

Refractive index of water, $n = \frac{4}{3}$

Frequency of the given light,

$$\upsilon = c/\lambda = \frac{3 \times 10^8}{6 \times 10^{-7}} = 5 \times 10^{14} \text{ Hz}$$

For the angle less than the critical angle, refraction takes place. Frequency of light, remain same.

Speed of light in water, $v = \frac{c}{n}$

$$\therefore\ v = \frac{3 \times 10^8}{4/3} = 2.25 \times 10^8 \text{ m/s}$$

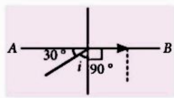
Now, wavelength of light in water $\lambda' = \frac{v}{\upsilon}$

$$\therefore\ \lambda' = \frac{2.25 \times 10^8}{5 \times 10^{14}} \text{ or } \lambda' = 450 \text{ nm}$$

(iii) (a) : Here, angle of incidence,

$i = 90° - 30° = 60°$

Since, the refracted ray is parallel to the interface, angle of refraction, $r = 90°$



Using snell's law

$\mu = \frac{\sin i}{\sin r}$ or $\mu = \frac{\sin 60°}{\sin 90°}$ $\therefore$ $\mu = \frac{\sqrt{3}}{2}$

OR

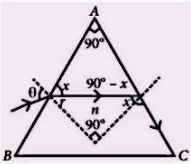
(iii) (b) : $\sin\theta_c = \frac{\mu_2}{\mu_1} = \frac{v_A}{v_B}$

where v_A and v_B are the speed of light in medium A and B respectively.

Given, that, $v_A = 2 \times 10^8$ m s^{-1} and $v_B = 2.5 \times 10^8$ m s^{-1}

$\therefore$ $\sin\theta_c = \frac{2\times10^8}{2.5\times10^8}$ or $\sin\theta_c = \frac{4}{5}$ or $\theta_c = \sin^{-1}\left(\frac{4}{5}\right)$

(iv) (a) : Let angle of refraction at side AB is r.



Here, In figure,

$\angle r + \angle x = 90°$

$\angle r = 90° - \angle x$

Applying Snell's law at face, AB

$1 \sin\theta = n \text{ Sin } r$

$\sin\theta = n \sin(90 - x)$

$\sin\theta = n \cos x$ ...(i)

Applying snell's law at face AC,

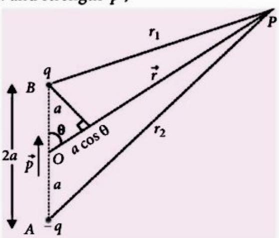
$n \sin x = \sin 90°$

$\frac{1}{\sin x} \Rightarrow \sin x = \frac{1}{n}$ so, $\cos x = \sqrt{\frac{n^2-1}{n^2}} = \sqrt{\frac{n^2-1}{n}}$ ...(ii)

Put eqn. (ii) in (i)

$\sin\theta = n\sqrt{\frac{n^2-1}{n}} \Rightarrow \theta = \sin^{-1}\sqrt{n^2-1}$

31. (a) (i) At any point due to short electric dipole of length $2a$ and strength $\vec{p}$,



In the given diagram, $OP = r$, $PB = r - a\cos\theta$ and $PA = r + a\cos\theta$

$V_P = V_{PA} + V_{PB}$

or $V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{-q}{r + a\cos\theta} + \frac{q}{r - a\cos\theta}\right]$,

where q and $-q$ are charges placed at a distance '$2a$' apart.

or $V_P = \frac{1}{4\pi\varepsilon_0}\frac{q\,2a\cos\theta}{(r^2 - a^2\cos^2\theta)}$ $(p = q\,(2a))$

or $V_P = \frac{1}{4\pi\varepsilon_0}\frac{p\cdot\cos\theta}{(r^2 - a^2\cos^2\theta)}$

On simplification using approximation $r >> a$

$V_P = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{\bar{p}\cdot\hat{r}}{r^2}$

(ii) Let side of the equilateral triangle be r.

Potential energy of the system,

$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q(2q)}{r} + \frac{2q(nq)}{r} + \frac{nq(q)}{r}\right]$

$V = \frac{1}{4\pi\varepsilon_0}\frac{1}{r}\left[2q^2 + 2nq^2 + nq^2\right]$

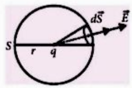
Since $V = 0$;

$\therefore$ $2q^2 + 2nq^2 + nq^2 = 0$

or $2q^2 + 3nq^2 = 0$ or $q^2(2 + 3n) = 0$ or $n = \frac{-2}{3}$

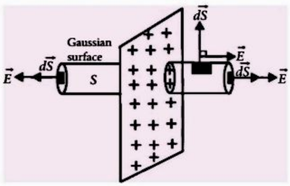
OR

(b) (i) Gauss's law : For a closed surface enclosing a net charge q, the net electric flux ϕ emerging out is given by $\phi = \oint_S \vec{E}\cdot d\vec{S} = \frac{q}{\varepsilon_0}$



Consider an infinitely large plane sheet of surface charge density 'σ'.

Assume a cylindrical Gaussian surface S cutting through plane sheet of charge, such that point P lies on its plane face, then net electric flux through surface S is



$$\phi = \oint_S \bar{E}\cdot\bar{ds} = \int_{\substack{\text{left}\\\text{plane}\\\text{face}}} \bar{E}\cdot\bar{ds} + \int_{\substack{\text{curved}\\\text{surface}}} \bar{E}\cdot\bar{ds} + \int_{\substack{\text{right}\\\text{plane}\\\text{face}}} \bar{E}\cdot\bar{ds}$$

$$\text{or } \phi = \int_{\substack{\text{left}\\\text{plane face}}} Eds\cos 0° + \int_{\substack{\text{curved}\\\text{surface}}} Eds\cos 90° + \int_{\substack{\text{right}\\\text{plane face}}} Eds\cos 0°$$

or $\phi = EA + 0 + EA = 2EA$

But by Gauss's theorem $\phi = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0}$

where q is the charge in area A of sheet enclosed by cylindrical surface S and σ is uniform surface charge density of sheet.

$\therefore \quad 2EA = \frac{\sigma A}{\varepsilon_0}$ or $E = \frac{\sigma}{2\varepsilon_0}$

directed normal to surface of charged sheet (i) away from it, if it is positively charged and (ii) towards it, if it is negatively charged.

(ii) Electric field intensity due to a long straight uniformly charged wire is, $E = \frac{\lambda}{2\pi\varepsilon_0 r}$, where λ is linear charge density and r is the distance of the point from the wire.

For wire 1 : $\lambda_1 = 10\ \mu C/m = 10 \times 10^{-6}$ C/m

$r_1 = 10$ cm $= 10 \times 10^{-2}$ m

$$\therefore\ E_1 = \frac{2\times 9\times 10^9 \times 10\times 10^{-6}}{10\times 10^{-2}} = 18\times 10^5\ \text{V/m}$$

(using (i))

Magnitude of force experienced by a charged particle in an electric field is given by,

$F = qE$ ...(ii)

Using eq(ii), force experienced by electron due to wire 1,

$F_1 = qE_1$ or $F_1 = 18e \times 10^5$ N and $\vec{F_1} = 18e \times 10^5(-\hat{j})$ N

For wire 2 : $\lambda_2 = -20\ \mu C/m = -20 \times 10^{-6}$ C/m

$r_2 = (30 - 10)$ cm $= 20$ cm $= 20 \times 10^{-2}$ m (using (i))

$$\therefore\ E_2 = \frac{2\times 9\times 10^9 \times (-20\times 10^{-6})}{20\times 10^{-2}} = -18\times 10^5\ \text{V/m}$$

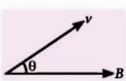
Using eq (ii), force experienced by the electron due to wire 2,

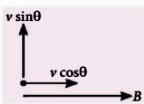
$F_2 = qE_2 \Rightarrow F_2 = -18e \times 10^5$ N $\hat{j}$

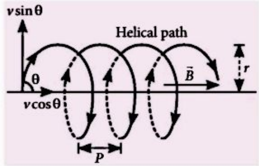
Net force on the electron, $F = F_1 + F_2 = 36e \times 10^5(-\hat{j})$ N

32. (a) (i) When $\vec{v}$ and $\vec{B}$ are not perpendicular or parallel :

If velocity $\vec{v}$ is at angle θ to $\vec{B}$, component of velocity parallel to magnetic field ($v \cos\theta$) remains constant and component of velocity perpendicular to magnetic field ($v \sin\theta$) is responsible for circular motion, thus the charge particle moves in a helical path.







The plane of the circle is perpendicular to the magnetic field and the axis of the helix is parallel to the magnetic field. The charged particle moves along helical path touching the line parallel to the magnetic field passing through the starting point after each rotation.

Radius of circular path :

$$\frac{m(v\sin\theta)^2}{R} = q(v\sin\theta)B \Rightarrow R = \frac{mv\sin\theta}{qB} = \frac{mv_\perp}{qB}$$

Time period of one revolution :

$$T = \frac{2\pi R}{v\sin\theta} \Rightarrow T = \frac{2\pi\left(\frac{mv\sin\theta}{qB}\right)}{v\sin\theta} \Rightarrow T = \frac{2\pi m}{qB}$$

$$\upsilon = \frac{1}{T} \Rightarrow \upsilon = \frac{qB}{2\pi m}$$

(ii) Given, radius, $r = 2$Å $= 2 \times 10^{-10}$ m

Frequency, $\upsilon = 8 \times 10^{14}$ rps

Charge on electron, $e = 1.6 \times 10^{-19}$ c

Current, $I = \frac{q}{t}$ or $I = e\upsilon$

Area of the orbit, $A = \pi r^2$

Magnetic moment, $m = IA$

$\therefore\ m = e\upsilon\pi r^2$

or $m = 1.6 \times 10^{-19} \times 8 \times 10^{14} \times 3.14 \times (2 \times 10^{-10})^2$

or $m = 1.6 \times 10^{-23}$ Am^2

OR

(b) (i) Current sensitivity is defined as the deflection of coil per unit current flowing in it.

The current sensitivity is given by, $I_S = \frac{\theta}{I} = \frac{NAB}{k}$

Current sensitivity can be increased when

(i) Number of turns (N) be increased.

(ii) Area of coil (A) will be increased.

(iii) Magnetic field (B) should be radial.

Voltage sensitivity is given by, $V_S = \frac{NBA}{kR}$ where R is the resistance of the wire.

Voltage sensitivity = Current sensitivity/R

Thus, on increasing the current sensitivity, voltage sensitivity may or may not increase because of similar changes in the resistance of the coil, which may also increase due to increase in temperature.

(ii) A galvanometer can be converted into a voltmeter of given range by connecting a suitable resistance R in series with galvanometer; whose value is given by,

$$R=\frac{V}{I_g}-G \quad \text{...(i)}$$

where V is the voltage to be measured.

Here, $I_g = 20\text{ mA} = 20\times10^{-3}\,A$, $G = 15\,\Omega$ and $V = 100$

from eq. (i), we have $V = I_g(R+G)$

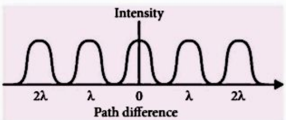
$\therefore\;\; 100 = 20\times10^{-3}(R+15)$

or $\;R+15 = 5000\;$ or $\;R = 4985\,\Omega$

33. (a) (i) Difference between interference and diffraction

Interference	Diffraction
1. Interference is caused by superposition of two waves starting from two coherent sources.	1. Diffraction is caused by superposition of a number of waves starting from the slit.
2. All bright and dark fringes are of equal width.	2. Width of central bright fringe is double of all other maxima.
3. All bright fringes are of same intensity.	3. Intensity of bright fringes decreases sharply as we move away from central bright fringe.
4. Dark Fringes are perfectly dark.	4. Dark fringes are not perfectly dark.

(ii) Double slit interference:



(iii) Intensity at a point, $I=4I_0\cos^2\left(\frac{\phi}{2}\right)$

Phase difference $=\frac{2\pi}{\lambda}\times$ Path difference

At path difference λ,

Phase difference, $\phi=\frac{2\pi}{\lambda}\times\lambda=2\pi$

$\therefore$ Intensity, $K=4I_0\cos^2\left(\frac{2\pi}{2}\right)$

[$\because$ Given $I = K$, at path difference λ]

$$K = 4I_0 \quad \text{...(i)}$$

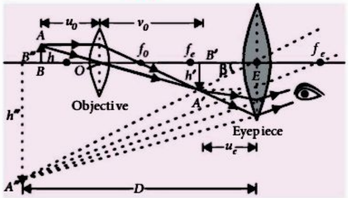
If path difference is $\frac{\lambda}{6}$, then phase difference will be

$$\phi'=\frac{2\pi}{\lambda}\times\frac{\lambda}{6}=\frac{2\pi}{3}$$

$\therefore$ Intensity, $I'=4I_0\cos^2\left(\frac{2\pi}{3}\right)=\frac{K}{4}$ (Using (i))

OR

(b) (i)



Compound microscope consists of two convergent lenses of short focal lengths and apertures arranged co-axially. Lens (of focal length f_o) facing the object is known as objective or field lens while the lens (of focal length f_e) facing the eye, is known as eye-piece or ocular. The objective has a smaller aperture and smaller focal length than eye-piece. Magnifying power of a compound microscopem, $m = m_o \times m_e$

If α is the angle subtended at the eye by the object when it is at least distance of distinct vision from eye.

$$m=\frac{\beta}{\alpha}=\frac{\tan\beta}{\tan\alpha}=\frac{h'/u_e}{h/D}=\frac{h'}{h}\cdot\frac{D}{u_e}=m_o m_e$$

Here, $m_o=\frac{h'}{h}=\frac{v_o}{u_o}$

As the eyepiece acts as a simple microscope, so

$$m_e=\frac{D}{u_e}=1+\frac{D}{f_e}\quad\therefore\; m=\frac{v_o}{u_o}\left(1+\frac{D}{f_e}\right)$$

(ii) Given, $f_0 = 100$ cm and $f_e = 5$ cm

When image is formed at infinity, $m=\frac{f_0}{f_e}$

$\therefore$ Magnifying power, $m=\frac{100}{5}=20$

Motivational Quote

"If you want to shine like a sun, first burn like a sun."

– APJ Abdul Kalam