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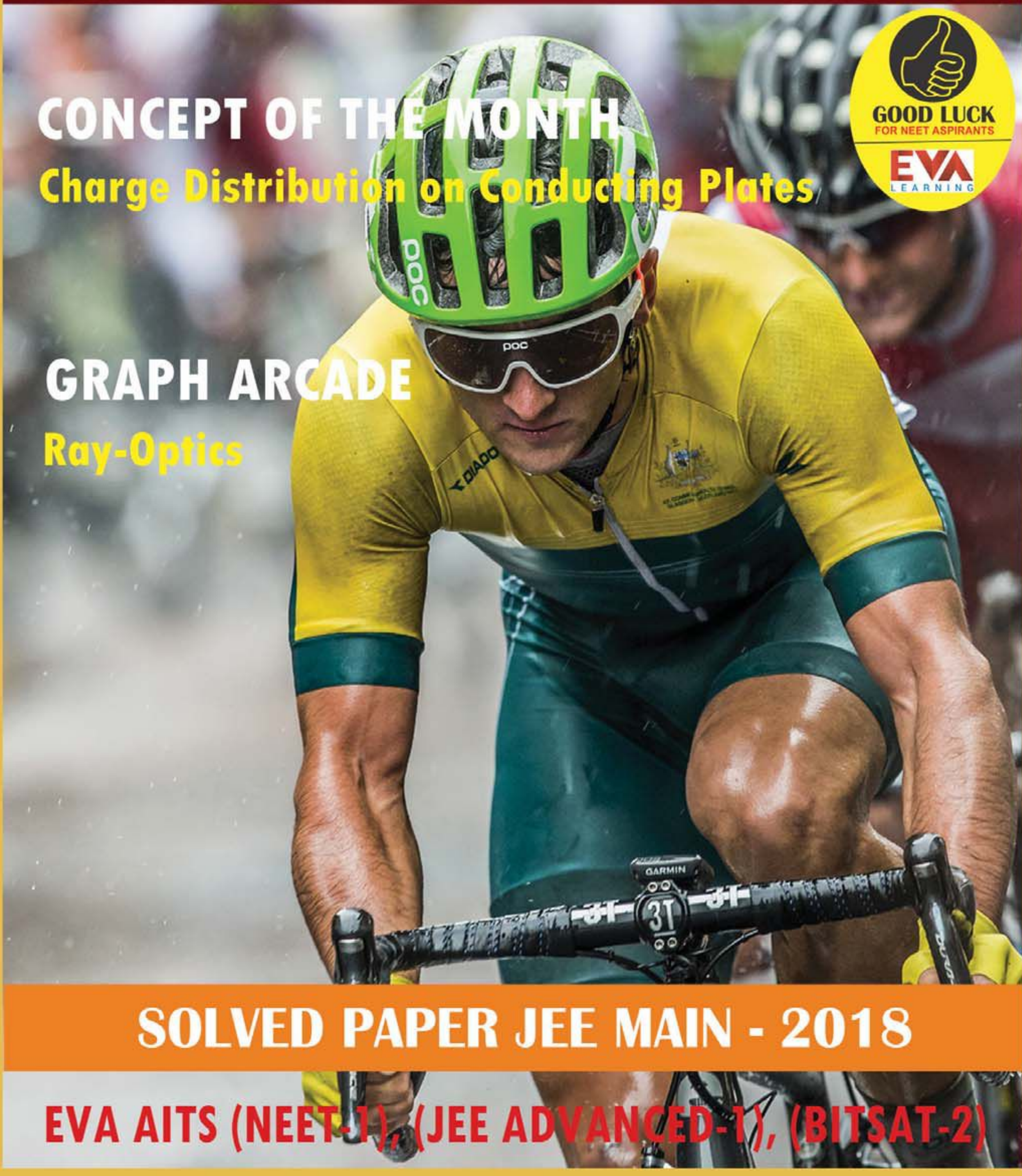

CONCEPT OF THE MONTH
Charge Distribution on Conducting Plates

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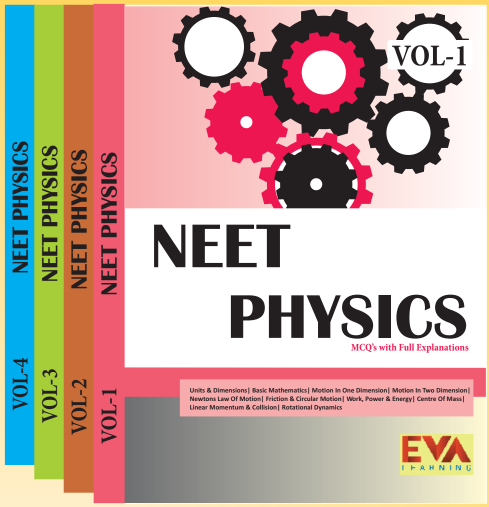

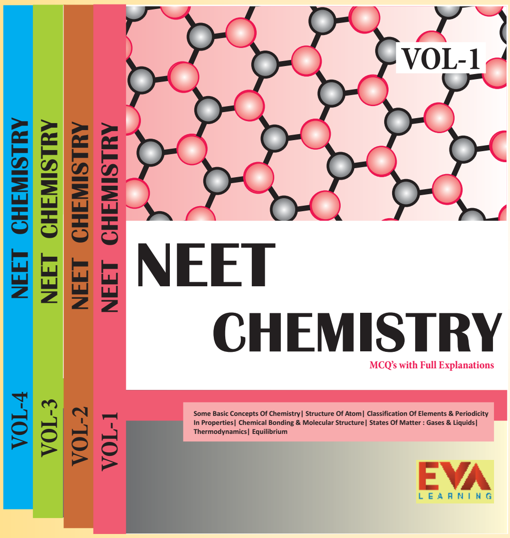

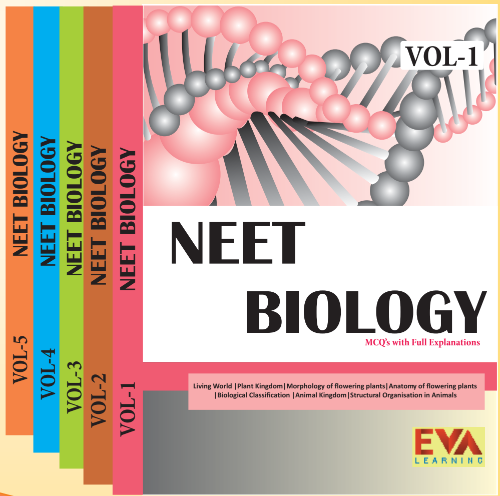

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- Chapter wise MCQ's with detailed solutions
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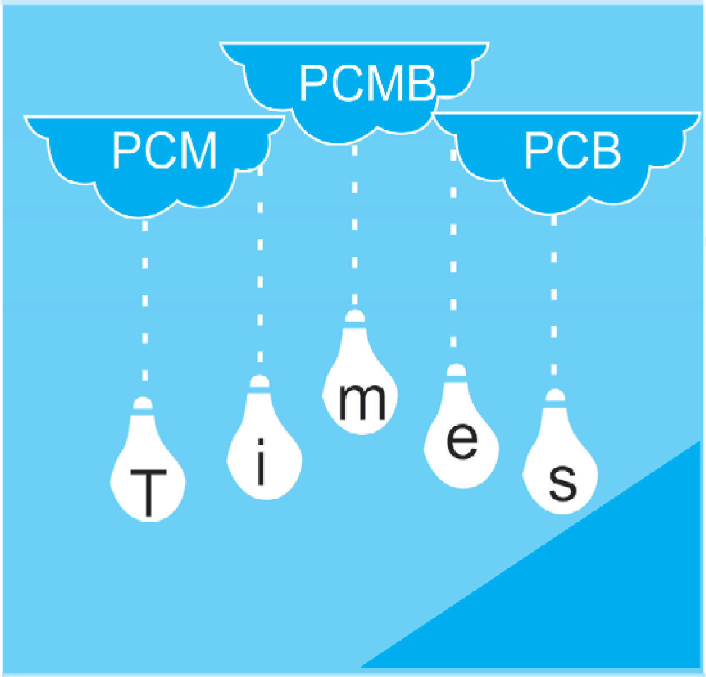

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Charge Distribution on Conducting Plates

Concept of the month

This column is aimed at preparing students for all competitive exams like JEE ADVANCED, BITSAT etc. Every concept has been designed by highly qualified faculty to cater to the needs of the students by discussing the most complicated and confusing concepts in Physics.

By. **Er. PRS. MURTHY(Raghav)** (Bangalore)
email: praghavsm1234@gmail.com

Introduction:

When a certain charge is given to a long conducting plate and in its vicinity if there is/are any other long parallel conducting plate/s, the intial charge distribution of the plate gets influenced. And also the charge distribution happens on the plates in the vicinity of first one, irrespective of whether they were initially charged or not. Ofcourse all this happens by following certain rules of physics. In this article we dicuss how the charge distribution happpens in a system of long parallel conducting plates in different situations like when no plate is earthed, one plate is (or some of plates are) earthed, two plates of the system are connected by a wire etc.

The points to be remembered throughout this discussion:

IMPORTANT POINTS

- The electrical field between the plates is uniform because the plates are assumed to be long enough. The end effects are always ignored.
- As each plate is in electrostatic conditions, the electric field at every point inside the material of the plate is zero.

Distribution of charge in case of a single long conducting plate:

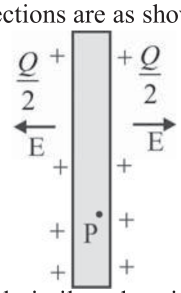
Illustration - 1

Let a charge Q is given to a long conductintg plate then each of its sides will get a charge Q/2 as shown in the figure. This is because field at point P (inside the plate) has to be zero. The fields due to charges on both sides have to be equal and opposite at point P.

On each side of the plate field is $E = \dfrac{\sigma}{\varepsilon_0}$

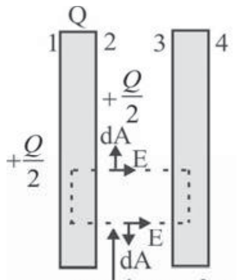
$$\Rightarrow E = \frac{Q}{2A\varepsilon_0} \qquad \left[\because \sigma = \frac{Q/2}{A} = \frac{Q}{2A}\right]$$

and its directions are as shown .

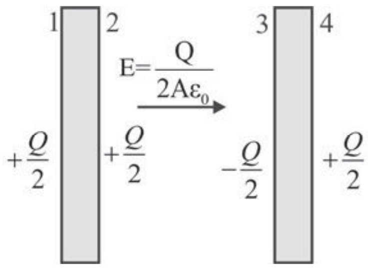


If a second similar plate is brought closer and parallel to it, the second plate will get [induced] charges on both of its sides. The first plate has a total charge +Q and surfaces 1and 2, each has a charge $+\dfrac{Q}{2}$.

To find out the charge distribution on face 3 (of second plate), let us imagine a gaussian surface having a small width perpendicular to paper, as shown in the figure.



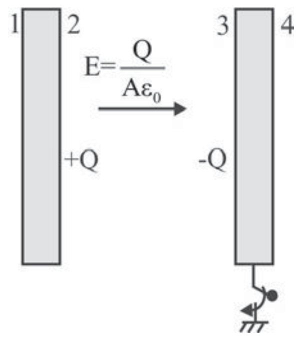
Along the vertical portions of the gaussian surface E=0 as they are inside the plates and along the horizontal portions $\overline{E}$ is perpendicular to $d\bar{A}$. Because of these reasons the term $\oint \overline{E}.d\overline{A}$ of gauss law becomes zero. Thus charge enclosed by this gaussian surface has to be zero. But surface 2 has some charge. Thus surface 3 should have a charge equal and opposite to that of surface 2. But second plate initially had no charge and its final charge also has to be zero, because it is not connected to any other body and has to be treated as an isolated body. Charge of an isolated body remains conserved. Thus, surface 4 of second plate should have a charge equal and opposite to that of surface 3. Thus the final charge distribution on all surfaces of this two plate system is as shown below.



From this basic discussion, it can be concluded that opposite inner faces of two plates of an isolated system of long parallel plates should have equal and opposite charges uniformly distributed over them. [This applies even if the number of plates is more than two].

Illustration - 2

Now, let us find what happens to the charge distribution of the second plate is grounded. Once this happens the charge on face 4 goes to earth. Note that charges on faces 2 and 3 are bound charges i.e., they hold each other and the charges on surfaces 1and 4 are free charges. Also, the grounding of second plate makes its potentral zero. If the potential of the plate becomes zero, the electrifield outside (here it is right side of face 4) the plate must be zero.



For this to happen, the charge on the grounded plate must be -Q . Thus the surface 3 has -Q charge and surface 2 has +Q charge now. That means all (free) charge from surface 1 must reach surface 2. If this were not the case, the field in the material of the plates cannot be zero. So finally charges on 1 and 4 are zero, charge on 2 is +Q and charge on 3 is -Q

Before grounding the net charge on 2nd plate was zero.

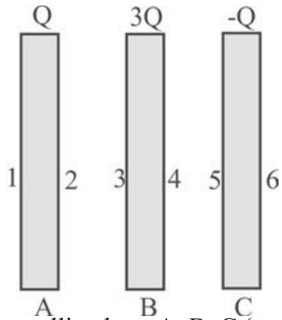
Now it is -Q. That means a charge of -Q has flowed from earth to the right side plate [or equivalently a charge of +Q has flowed from right side plate to the earth].

IMPORTANT POINTS

- ❑ If a body is at zero potential, the charge on it need not be necessarily zero and also if a body has no charge on it, its potential need not be necessarily zero. This is true in case of bodies which are not isolated but are under the influence of other charged bodies or charge distributions in their vicinity.
- ❑ Here it is concluded that if one of the plates is grounded the charges on outermost surfaces (i.e., left most and right most; here they are 1 and 4) become equal to zero.
- ❑ Also note that if any of the two plates of a system of parallel plates are connected by a conductor wire their potentials become equal.

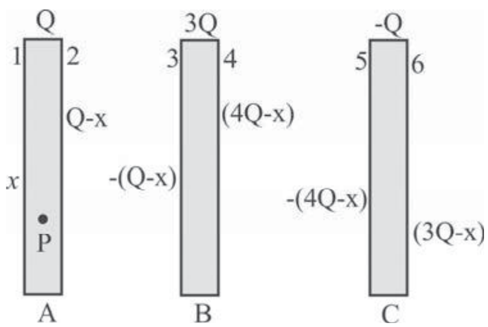
Let us discuss some problems in detail to master these concepts.

eg - 1



There long metallic plates A, B, C (see figure) are given charges Q, 3Q and -Q respectively. Determine the final charges on all the six surfaces.

Sol:



Let us assume, the final charge on surface 1 is x, then the charge on surface 2 will be Q-x. This is because the total charge on plate A must be conserved. As we already discussed the opposite faces should carry equal and opposite charges. So charge on 3 must be -(Q-x). But the total charge of plate B must be 3Q. So charge on face 4 is

$$q_4 = 3Q - [-(Q-x)] = 4Q - x$$

Again, as opposite faces should have equal and opposite charges $q_5 = -(4Q-x)$. The total charge on plate C should reman as -Q. Therefore

$$q_6 = 3Q - x$$

Now, we use the condition the field inside the material of plate must be zero. For this we choose point P in plate A .So $E_{at\,P} = 0$

If surface charge density on a single surface is 'σ' the field due to it is $\frac{\sigma}{2\varepsilon_o}$. or

$E = \frac{q/A}{2\varepsilon_O} = \frac{q}{2A\varepsilon_O}$ If A is constant $E \propto q$. We take rightward direction for E as positive and leftward direction as -ve.

So field at P, due to x on 1 is +ve, due to Q-x on 2 it is -ve, and due to (Q-x)on 3 it is +ve and so on. Thus at P, field is

$$E_p = \left(+\frac{x}{2A\varepsilon_o}\right) + \left(-\left(\frac{Q-x}{2A\varepsilon_o}\right)\right) + \left(\frac{Q-x}{2A\varepsilon_o}\right) +$$

$$\left(-\frac{4Q-x}{2A\varepsilon_o}\right) + \left(\frac{4Q-x}{2A\varepsilon_o}\right) + \left(-\frac{3Q-x}{2A\varepsilon_o}\right)$$

or simply $x + [-(Q-x)] + (Q-x) + [-(4Q-x)]$

$$+(4Q-x) + [-(3Q-x)] = 0$$

or $2x = 3Q \Rightarrow x = \frac{3Q}{2}$

Thus $q_1 = \frac{3Q}{2}, q_2 = Q - \frac{3Q}{2} = -\frac{Q}{2},$

$q_3 = +\frac{Q}{2}, q_4 = 4Q - \frac{3Q}{2}$

or $q_4 = \frac{5Q}{2}, q_5 = -\frac{5Q}{2}$ and $q_6 = \frac{3Q}{2}$

Alternatively:

The charges on surface 1 and surface 6 are equal and each must be equal to half of total charge.

$$\therefore q_1 = q_6 = \frac{Q+3Q-Q}{2} = \frac{3Q}{2}$$

$$q_1 + q_2 = Q \Rightarrow q_2 = -\frac{Q}{2}$$

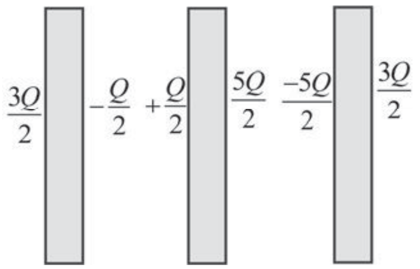
$$q_2 + q_3 = 0 \Rightarrow q_3 = \frac{Q}{2}$$

$$q_3 + q_4 = 3Q \Rightarrow q_4 = \frac{5Q}{2}$$

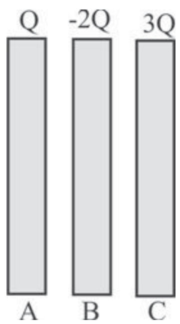
$$q_4 + q_5 = 0 \Rightarrow q_5 = -\frac{5Q}{2}$$

[Also $q_5 + q_6 = -Q \Rightarrow q_6 = \frac{3Q}{2}$]

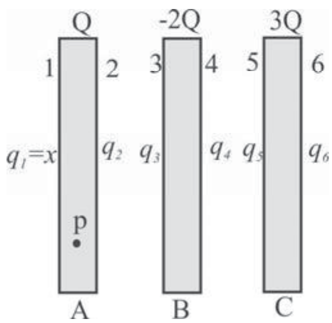
Finally the charge distribution is as shown below.



eg-2. In a system of long parallel plates A, B and C, the plates A, B and C are given charges Q,-2Q and 3Q respectively. Find the charges on the faces of plates.



Sol:



Let $q_1 = x$. Then $q_2 = Q - x$

$q_2 + q_3 = 0 \Rightarrow q_3 = -(Q - x)$

$q_3 + q_4 = -2Q \Rightarrow q_4 = -2Q + (Q - x)$

$= -(Q + x)$

$q_4 + q_5 = 0 \Rightarrow q_5 = (Q + x)$

$q_5 + q_6 = 3Q \Rightarrow q_6 = 3Q - (Q + x)$

$= 2Q - x$

Now electric field at P is zero.[Note that positive charge on left of P causes +ve E and on right of P causes -ve E and negative charge on right of P causes +ve E at the location of P]

$\therefore \frac{1}{2A\varepsilon_o}\left[+x - (Q - x) + (Q - x) + \right.$

$\left.(Q - x) - (Q + x) - (2Q - x)\right] = 0$

or $x - 2Q + x = 0 \Rightarrow x = Q$

$\therefore q_1 = Q, q_2 = Q - Q = 0, q_3 = -(Q - Q) = 0,$

$q_4 = -(Q + Q) = -2Q, q_5 = Q + Q = 2Q$ and

$= q_6 = 2Q - Q = Q$

Alternatively: The charges on surface 1 and 6 are equal and each is equal to half of total charge on plates.

$$\therefore q_1 = q_6 = \frac{Q - 2Q + 3Q}{2} = Q$$

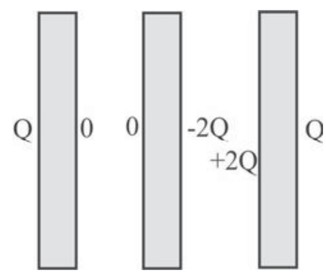
Now, $q_2 = Q - q_1 = 0,\ q_2 + q_3 = 0 \Rightarrow q_3 = 0$

$q_3 + q_4 = -2Q \Rightarrow q_4 = -2Q - 0 = -2Q$

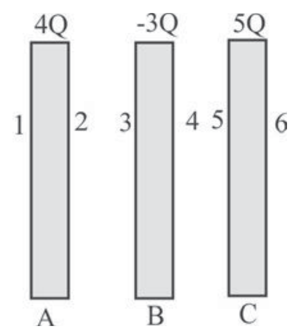
$q_4 + q_5 = o \Rightarrow q_5 = 2Q$

$q_5 + q_6 = 3Q \Rightarrow q_6 = Q$

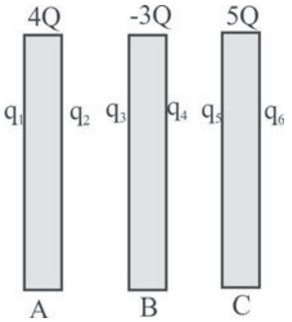
Thus, final charges on all faces are as shown below.



eg - 3. Three long parallel conductor plates A, B, C are given charges 4Q, -3Q and 5Q respectively. Find the final charge distribution on all the faces of three plates.



Sol:



We know that $q_1 = q_6 =$ Half of total charge of all the plates

$$\therefore q_1 = q_6 = \frac{4Q - 3Q + 5Q}{2} = 3Q. \text{ Now,}$$

$$q_1 + q_2 = 4Q \Rightarrow q_2 = 4Q - 3Q = Q$$

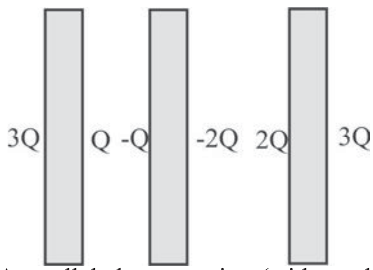
$$q_2 + q_3 = 0 \Rightarrow q_3 = -Q$$

$$q_3 + q_4 = -3Q \Rightarrow q_4 = -3Q - (-Q) = -2Q$$

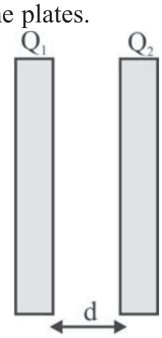
$$q_4 + q_5 = 0 \Rightarrow q_5 = 2Q$$

[Also $q_5 + q_6 = 5Q \Rightarrow q_6 = 5Q - 2Q = 3Q$].

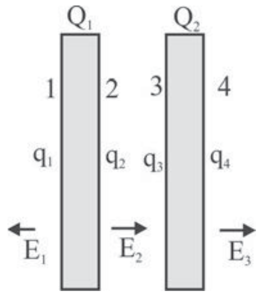
So the final distribution of charges is as shown below.



eg -4. A parallel plate capacitor (with no plate earthed) has plates of area A, separated by a small distance d. One plate has a total charge Q_1 and the other Q_2. Neglecting edge effects, calculate the charge per unit area on each of the four metal surfaces and the electric field just outside the plates and between the plates.



Sol:



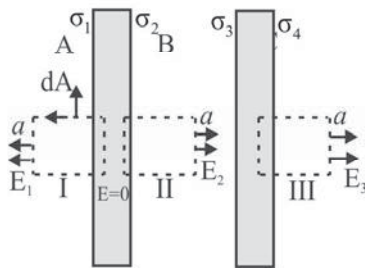
$$q_1 = q_4 = \frac{Q_1 + Q_2}{2}$$

Now, $q_1 + q_2 = Q_1 \Rightarrow q_2 = Q_1 - \frac{Q_1 + Q_2}{2} = \frac{Q_1 - Q_2}{2}$

$$q_2 + q_3 = 0 \Rightarrow q_3 = -\left(\frac{Q_1 - Q_2}{2}\right)$$

$$\sigma_1 = \frac{Q_1 + Q_2}{2A}, |\sigma_2| = |\sigma_3| = \left|\frac{Q_1 - Q_2}{2A}\right|, \sigma_4 = \frac{Q_1 + Q_2}{2A}$$

Now for fields E_1, E_2, E_3 we assume three gaussian surfaces as shown. Each surface has area 'a' perpendicular to plane of paper.



For gaussian surface I

$$\oint \overline{E}.d\overline{A} = \frac{q_{in}}{\varepsilon_o} \Rightarrow E_1 a = \frac{\sigma_1 a}{\varepsilon_o} = \left(\frac{Q_1 + Q_2}{2A\varepsilon_o}\right)a$$

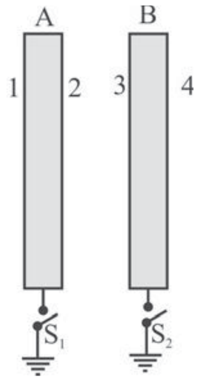
or $$E_1 = \frac{Q_1 + Q_2}{2A\varepsilon_o}$$

For gaussian surface II

$$\oint \overline{E}.d\overline{A} = \frac{q_{in}}{\varepsilon_o} \Rightarrow E_2 a = \frac{\sigma_2 a}{\varepsilon_o}$$

or $E_2 = \frac{Q_1 - Q_2}{2A\varepsilon_o}$ and similarly $E_3 = \frac{Q_1 + Q_2}{2A\varepsilon_o}$

eg - 5.



In the figure shown two large plates A and B are given charges $100\mu c$ and $60\mu c$ respectively.

(i) Find out charges on all surfaces when both the switches are open

(ii) If only switch S_1 is closed, findout charges on all surfaces.

(iii) Keeping S_1 closed, if S_2 is also closed, find out charges on all surfaces.

Sol: (i) $q_1 = q_4 = \dfrac{100+60}{2} = 80\mu C$

$q_1 + q_2 = 100\mu c \Rightarrow q_2 = 100 - 80 = 20\mu C$

$q_2 + q_3 = 0 \Rightarrow q_3 = -20\mu C$

$\therefore q_1 = 80\mu C, q_2 = 20\mu C, q_3 = -20\mu C$

and $q_4 = 80\mu C$

(ii) Now switch S_1 is closed $q_1 = 0 \Rightarrow q_4 = 0$

$q_3 + q_4 = 60\mu C$ (is constant in this case)

$\therefore q_3 = 60\mu C$

$q_2 + q_3 = 0 \Rightarrow q_2 = -60\mu C$

$\therefore q_1 = 0,\ q_2 = -60\mu C,\ q_3 = 60\mu C$ and $q_4 = 0$

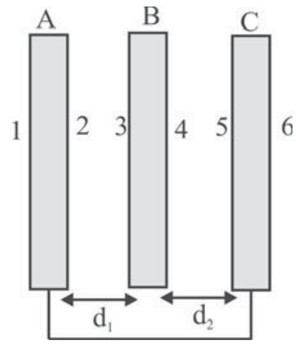
Note: A charge equal to $-160\mu c$ has flowed from the earth to plate A.

(iii) Now if switch S_2 is also closed, keeping S_1 closed, the charges on different surfaces will be

$q_1 = 0,\ q_2 = 0,\ q_3 = 0,\ q_4 = 0$

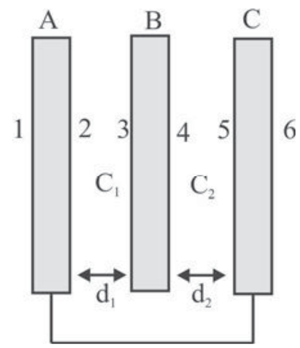
Note that A charge of $-60\mu C$ has flowed from the earth to plate B.

eg - 6.



In the arrangement of long parallel plates shown in the figure plate B is given a charge $60\mu C$ and it is given that $\dfrac{d_1}{d_2} = 2$. Find out the charges appearing on all surfaces of plates.

Sol:



The charges on outer surfaces will have to be half of the total charge of all the plates. Therefore,

$$q_1 = q_6 = \frac{60}{2} = 30\mu C$$

As plates A and C are connected $V_A = V_C = V$ (say)

$$\therefore V_A - V_B = V_C - V_B \Rightarrow \frac{|q_2|}{C_1} = \frac{|q_5|}{C_2}$$

or $\dfrac{q_2}{\varepsilon_o A / d_1} = \dfrac{q_5}{\varepsilon_o A / d_2} \Rightarrow d_1 q_2 = d_2 q_5$ or

$\dfrac{q_5}{q_2} = \dfrac{d_1}{d_2} = 2$ [it is given that $\dfrac{d_1}{d_2} = 2$]

So $q_5 = 2q_2$ which implies that $q_4 = 2q_3$

Charge given to plate B is $60\mu C$.

$$\therefore q_3 + q_4 = 60\mu C$$

$$\therefore 3q_3 = 60\mu C \Rightarrow q_3 = 20\mu C$$

So, $q_4 = 40\mu C$

$$q_2 + q_3 = 0 \Rightarrow q_2 = -20\mu C$$

and $q_4 + q_5 = 0 \Rightarrow q_5 = -40\mu C$

Therefore final charges on all sides are

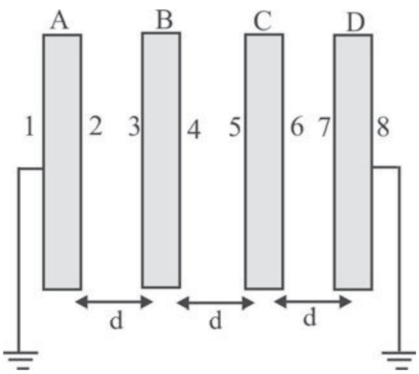
$q_1 = 30\mu C$, $q_2 = -20\mu C$,

$q_3 = 20\mu C$, $q_4 = 40\mu C$,

$q_5 = -40\mu C$ and $q_6 = 30\mu C$

Note A charge of $-10\mu C$ has flowed from plate A to plate C after B is given a charge of $60\mu C$.

eg-7. Four large parallel plates seperated by equal distance 'd' are arranged as shown in the figure. The area of each plate is A. Now the plate B is given a charge Q. Find out the potential difference between plates B and C



Sol: Let a charge x appears on surface 3.

$$q_3 + q_4 = Q \Rightarrow q_4 = Q - x$$

$$q_4 + q_5 = 0 \Rightarrow q_5 = -(Q - x)$$

$$q_5 + q_6 = 0 \ [\because \text{C has no charge}]$$

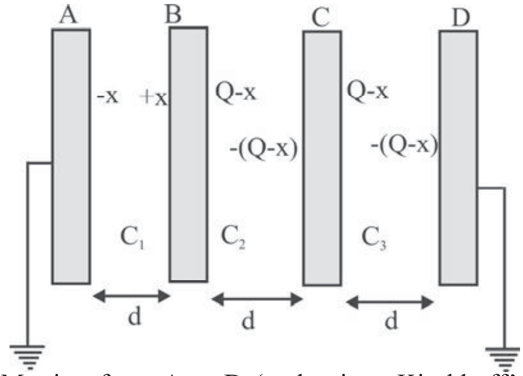
$$\therefore q_6 = Q - x$$

$$q_6 + q_7 = 0 \Rightarrow q_7 = -(Q - x)$$

$$q_2 + q_3 = 0 \Rightarrow q_2 = -x$$

Ofcourse $q_1 = q_8 = 0$. So charges on different surface are as shown below.

$$C_1 = C_2 = C_3 = C = \frac{\varepsilon_0 A}{d}$$



Moving from A to D (and using Kirchhoff's voltage law), we have

$$0 + \frac{x}{C_1} - \frac{Q-x}{C_2} - \frac{Q-x}{C_3} = 0$$

$$x = 2(Q - x) \Rightarrow 3x = 2Q \text{ or } x = \frac{2Q}{3}$$

$$[\because C_1 = C_2 = C_3]$$

$$\therefore V_A - V_B = \frac{-x}{C_1} = \frac{-2Q}{3}\left(\frac{d}{\varepsilon_o A}\right) = \frac{-2Qd}{3\varepsilon_o A}$$

and $V_C - V_D = \dfrac{Q-x}{C_3} = \left[\dfrac{Q - \frac{2Q}{3}}{\frac{\varepsilon_o A}{d}}\right] = \dfrac{Qd}{3\varepsilon_o A}$

As plates A and D are earthed $V_A = V_D = 0$

So, from above two equations $V_B = +\dfrac{2Qd}{3\varepsilon_o A}$ and

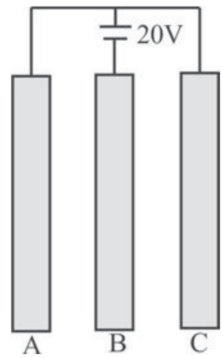
$$V_C = +\frac{Qd}{3\varepsilon_o A}$$

$$\therefore V_B - V_C = \frac{+2Qd}{3\varepsilon_o A} - \frac{Qd}{3\varepsilon_o A} = +\frac{Qd}{3\varepsilon A}$$

$$|V_{BC}| = \frac{Qd}{3\varepsilon_o A}$$

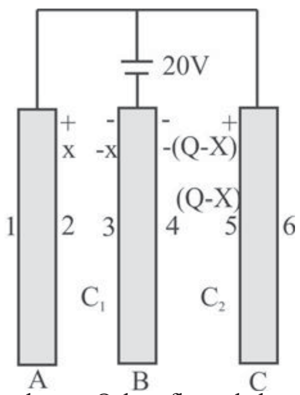
Note: A charge of $-\dfrac{2Q}{3}$ has flowed from earth to plate A and a charge of $\dfrac{-Q}{3}$ has flowed from the earth to plate D, after plate B is given a charge Q.

eg- 8.



Each of the three plates A, B and C shown has $2\times10^{-2}m^2$ area on one side and the gap between adjacent plates is 0.2mm. The emf of the battery shown is V=20V. Find the distribution of charges on various surfaces of plates. Also find out the equivalent capacitance of the system between the terminal points.

Sol:



Let a charge Q has flowed through the battery. Then total charge on plate B is -Q. Let $q_3=-x$

Then $q_4=-(Q-x)$

$q_2+q_3=0\Rightarrow q_2=+x$

$q_4+q_5=0\Rightarrow q_5=Q-x$

Ofcourse $q_1=q_6=0$

Let $V_A=V_C=20V$ then $V_B=0$

$$\therefore x=C_1(V_A-V_B)\Rightarrow x=\frac{\varepsilon_o A}{d}(2\theta)$$

$$x=\frac{8.825\times10^{-12}\times2\times10^{-2}}{0.2\times10^{-3}}(20)$$

or $x=1.765\times10^{-8}C$

$$V_A-V_B=V_C-V_B\Rightarrow\frac{x}{C_1}=\frac{Q-x}{C_2}$$

or $Q-x=x\Rightarrow Q=2x=3.530\times10^{-8}C$

$[\because C_1=C_2]$

$\therefore q_1=0,\ q_2=1.765\times10^{-8}C,\ q_3=-1.765\times10^{-8}C$

$q_4=-1.765\times10^{-8}C,\ q_5=1.765\times10^{-8}C$ and

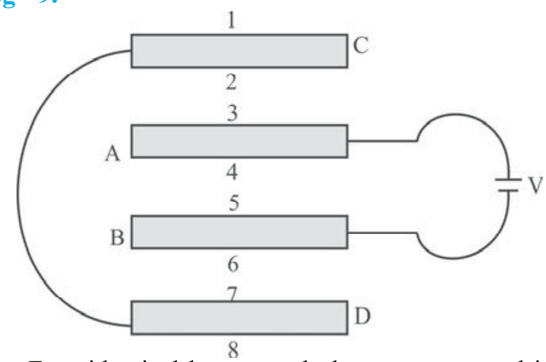
$q_6=0$

$$C_{eq}=2\frac{\varepsilon_o A}{d}=2\left[\frac{8.825\times10^{-12}\times2\times10^{-2}}{0.2\times10^{-3}}\right]$$

$$=17.650\times10^{-10}F$$

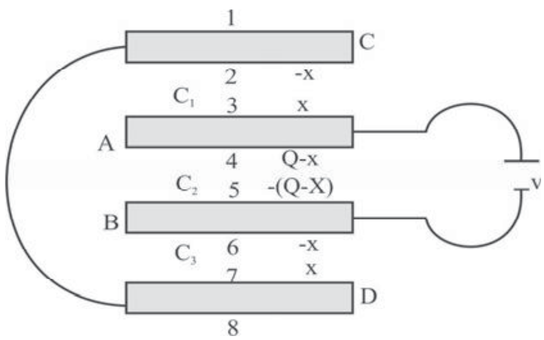
or $C_{eq}=1.765nF$

eg - 9.



Four identical large metal plates are arranged in air such that the distance bertween two adjacent plates is d. The area of each plate A. A battery of emf V is connected between plates A and B as shown. The plates C and D are connected by a conductor wire. Find out charges on each surface and also find out equivalent capacitance of system between the terminal points.

Sol:



let a charge Q has flowed through the battery and $q_3 = x$ [Note that net charge on plate A is Q and that on plate B is -Q].

$$\therefore\ q_4 = Q - x$$

$$q_4 + q_5 = 0 \Rightarrow q_5 = -(Q - x)$$

$$q_5 + q_6 = -Q \Rightarrow q_6 = -x$$

$$q_6 + q_7 = 0 \Rightarrow q_7 = x$$

$$q_3 + q_2 = 0 \Rightarrow q_2 = -x$$

Ofcourse $q_1 = q_8 = 0$

Let $V_B = 0$ Thus $V_A = V$ and also let $V_c = V_D = V'$ (say)

$$C_1 = C_2 = C_3 = \frac{\varepsilon_o A}{d}$$

$$x = C_1(V_A - V_C) = \frac{\varepsilon_o A}{d}(V - V') \qquad (1)$$

Also $Q - x = C_2(V_A - V_B) = \dfrac{\varepsilon_0 A}{d}(V - 0) \qquad (2)$

(1)+(2) gives $Q = \dfrac{2\varepsilon_0 A}{d}V - \dfrac{\varepsilon_0 A}{d}V'$ or

$$V' = \frac{\frac{2\varepsilon_0 A}{d}V - Q}{\frac{\varepsilon_0 A}{d}}$$

or $V' = 2V - \dfrac{Qd}{\varepsilon_0 A} \qquad$ (i)

Using this in eqn (1), we have

$$x = \frac{\varepsilon_0 A}{d}V - \frac{\varepsilon_0 A}{d}\left(2V - \frac{Qd}{\varepsilon_0 A}\right) = -\frac{\varepsilon_0 A}{d}V + Q$$

For surfaces 6 and 7

$$x = C_3(V' - 0) \Rightarrow x = \frac{\varepsilon_0 A}{d}V' \qquad (3)$$

(2)+(3)gives

$$Q = \frac{\varepsilon_0 A}{d}V + \frac{\varepsilon_o A}{d}V' \Rightarrow V' = \frac{Qd}{\varepsilon_0 A} - V \qquad \text{(ii)}$$

Equating (i) and (ii) gives $2V - \dfrac{Qd}{\varepsilon_0 A} = \dfrac{Qd}{\varepsilon_0 A} - V$

or $\dfrac{2Qd}{\varepsilon_0 A} = 3V$ or $Q = \dfrac{3\varepsilon_0 A}{2d}V$

Thus $x = \dfrac{-\varepsilon_0 A}{d}V + \dfrac{3\varepsilon_0 A}{2d}V$ or $x = \dfrac{\varepsilon_0 A}{2d}V$

$$\therefore q_2 = q_6 = -\frac{\varepsilon_0 A}{2d}V$$

$$q_3 = q_7 = \frac{\varepsilon_0 A}{2d}V$$

$$q_4 = \frac{\varepsilon_0 AV}{d} \qquad [\because q_4 = Q - x]$$

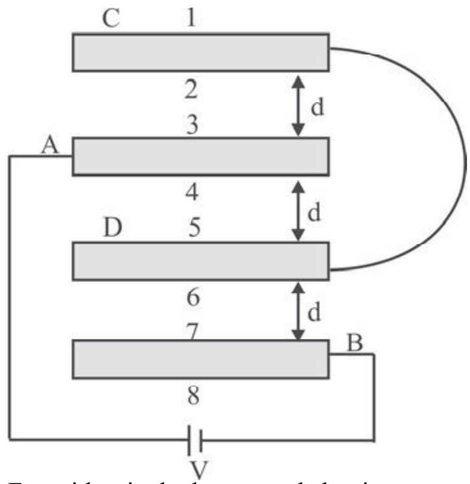
$$q_5 = -\frac{\varepsilon_0 AV}{d}$$

$$q_1 = q_8 = 0$$

$$C_{eq} = \frac{Q}{V} = \frac{3}{2}\frac{\varepsilon_0 A}{d}$$

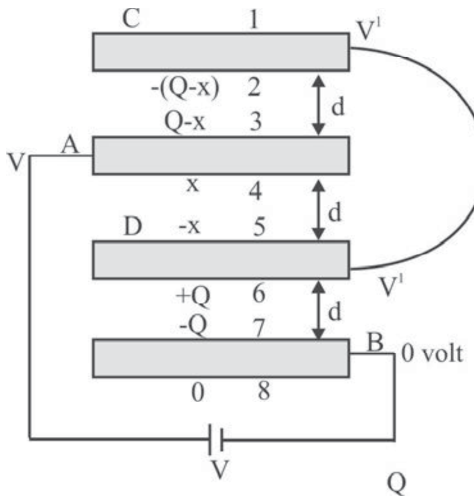
Note that a charge of $\dfrac{-\varepsilon_0 A}{2d}V$ has flowed from plate D to plate C through the conductor wire and charge flowed through the battery is $\dfrac{3\varepsilon_0 A}{2d}V$

eg - 10.



Four identical plates, each having area A, are arranged as shown in the figure. Find the charge on all sides of plates.

Sol: Let the potential of plate B is zero, that of plate A is V and that of C and D is V'. Let the charge supplied by battery is Q.



Let $\quad q_4 = x;\ q_3 + q_4 = Q \Rightarrow q_3 = Q - x$

$q_3 + q_2 = 0 \Rightarrow q_2 = -(Q - x)$

$q_4 + q_5 = 0 \Rightarrow q_5 = -x$

$q_7 = -Q;\ q_6 + q_7 = 0 \Rightarrow q_6 = Q$

and $\quad q_1 = q_8 = 0$

Between plates C and A

$Q - x = C(V - V')$ (i) $\quad [\because$ q= CV]

Between plates D and A

$x = C(V - V')$ $\quad$ (ii)

Between plates D and B, $Q = C(V' - 0)$ $\quad$ (iii)

From (iii) $V' = \dfrac{Q}{C}$; From (i) and (ii) $x = \dfrac{Q}{2}$

Using this in eqn (ii)

$$\frac{Q}{2} = \frac{\varepsilon_0 A}{d}\left(V - \frac{Q}{C}\right) = \frac{\varepsilon_0 A}{d}\left(V - \frac{Qd}{\varepsilon_0 A}\right)$$

or $\dfrac{Q}{2} = \dfrac{\varepsilon_0 A}{d}V - Q \Rightarrow \dfrac{3Q}{2} = \dfrac{\varepsilon_0 A}{d}V \Rightarrow Q = \dfrac{2}{3}\dfrac{\varepsilon_0 A}{d}V$

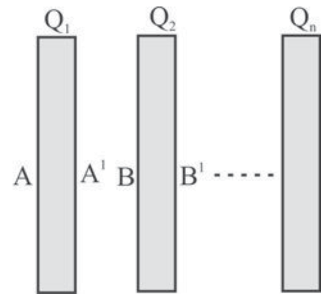
$\therefore x = \dfrac{\varepsilon_0 A}{3d}V$

$\therefore q_1 = 0, \quad q_2 = \dfrac{-2}{3}\dfrac{\varepsilon_0 AV}{d}, \quad q_3 = \dfrac{2}{3}\dfrac{\varepsilon_0 AV}{d},$

$q_4 = \dfrac{\varepsilon_0 AV}{3d}, \quad q_5 = \dfrac{-\varepsilon_0 AV}{3d}, \quad q_6 = \dfrac{2}{3}\dfrac{\varepsilon_0 AV}{d},$

$q_7 = -\dfrac{2}{3}\dfrac{\varepsilon_0 AV}{d}, \quad q_8 = 0$

eg -11. There are n large parallel plate conductors carrying charges $Q_1, Q_2, \dots Q_n$ respectively.



(i) Find the charge induced at surface A

(ii) Find the charge induced at surface B

(iii) If the left most conductor is earthed, find the magnitude of charge flowing from plate to earth

(iv) If any conductor is earthed, find the magnitude of charge flowing from plate to earth.

Sol: (i) $Q_A = \dfrac{Q_1 + Q_2 + \dots + Q_n}{2} = \dfrac{1}{2}\sum_{i=1}^{i=n} Q_i$

(ii) $Q_{A'} = Q_1 - Q_A = Q_1 - \dfrac{1}{2}$

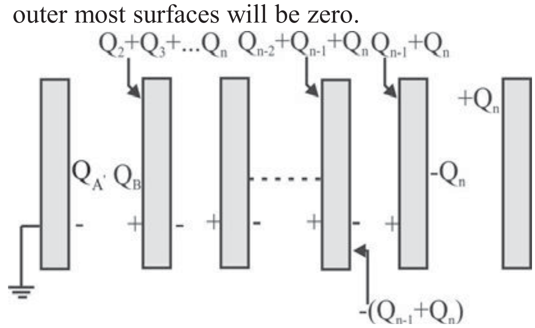
$\sum_{i=1}^{i=n} Q_i = Q_1 - \dfrac{Q_1 + Q_2 + \dots + Q_n}{2}$

$= \dfrac{Q_1 - Q_2 - Q_3 \dots - Q_n}{2}$

$Q_{A'} + Q_B = 0 \Rightarrow Q_B = -\left[\dfrac{Q_1 - Q_2 \dots - Q_n}{2}\right]$

$= -\dfrac{1}{2}\left[Q_1 - \sum_{i=2}^{i=n} Q_i\right]$

(iii) If the left most plate is earthed, the charges on outer most surfaces will be zero.



$Q_{A'} + Q_B = 0$; From fig

$$Q_B = Q_2 + Q_3 + ...Q_n = \sum_{i=2}^{i=n} Q_i$$

$$\therefore Q_{A'} = -\sum_{i=2}^{i=n} Q_i$$

Initial charge on plate $1 = Q_1$

Final charge on plate $1 = -\sum_{i=2}^{i=n} Q_i$

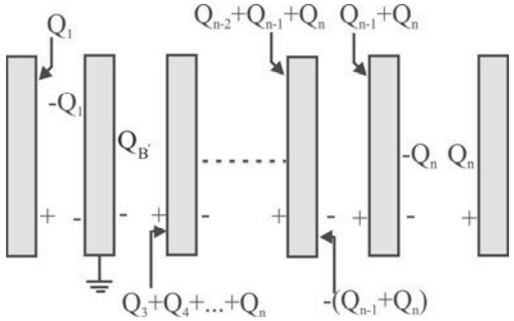
Let charge q' has flowed from earth to plate 1

$$\therefore q' + Q_1 = -\sum_{i=2}^{i=n} Q_i \Rightarrow q' = -\left[Q_1 + \sum_{i=2}^{i=n} Q_i\right]$$

So charge flowed from plate to earth

$$-q' = Q_1 + \sum_{i=2}^{i=n} Q_i = \sum_{i=1}^{i=n} Q_i$$

(iv) Let the second plate from left is earthed. The charges on outer most surface of system must be zero.



From fig $Q_{B'} = -(Q_3 + Q_4 + ... + Q_n)$

Charge on plate 2

$$= -Q_1 + Q_{B'} = -Q_1 - (Q_3 + Q_4 + ... + Q_n)$$

Initial charge on plate 2 $= Q_2$

Let a charge q'' has flowed from earth to plate 2.

Then $q'' + Q_2 = -Q_1 - (Q_3 + Q_4 + ... + Q_n)$

$$\Rightarrow q'' = -(Q_1 + Q_2 + Q_3 + ...Q_n) = -\sum_{i=1}^{i=n} Q_i$$

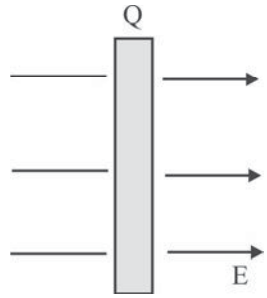
IMPORTANT POINTS

- So charge flowed from plate to earth

$$= -q'' = \sum_{i=1}^{i=n} Q_i \ .$$

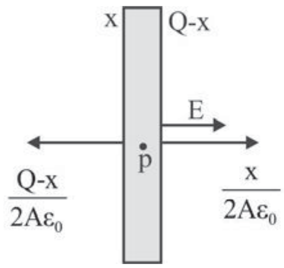
So in this system, if any plate is earthed a charge equal to $\sum_{i=1}^{i=n} Q_i$ flows from plate to earth.

eg -12.



An isolated conductor sheet of area A and carrying a charge Q is placed in a uniform electric field E, such that the electric field is perpendicular to the sheet and covers all the sheet.
Find out the charges appearing on its two surfaces.

Sol:



Let there be x charge on left side of the plate and Q-x charge on the right side. $E_p = 0$

$$\therefore \frac{x}{2A\varepsilon_0} + E = \frac{Q-x}{2A\varepsilon_0}$$

$$\frac{x}{A\varepsilon_0} = \frac{Q}{2A\varepsilon_0} - E$$

or $x = \frac{Q}{2} - EA\varepsilon_0$ and $Q - x = \frac{Q}{2} + EA\varepsilon_0$

So charge on left side $= \frac{Q}{2} - EA\varepsilon_0$ and charge on right side $= \frac{Q}{2} + EA\varepsilon_0$

Acknowledgements: Some concepts of this article have assumed the final form because of the intelligent questions asked by one of my students Mr Videh Aggarwal in Bangalore.

NEET EVA-AITS - 11

"A Colossal juncture to get introduced to the national standard mock tests of NEET"

1. The magnetic field due to a short magnet at a point on its axis at distance *d* from the middle point of the magnet is 200 gauss. The magnetic field at a point on the equilateral axis at a distance *d* from the middle of the magnet is
(a) 100 gauss (b) 400 gauss
(c) 50 gauss (d) 200 gauss

2. When a copper ball is heated, the largest percentage increase will occur in
(a) Diameter (b) Area (c) Volume (d) Density

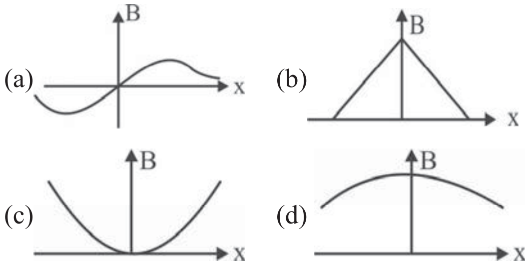
3. Two trains, each 50 m long, are travelling in opposite directions with velocities $10ms^{-1}$ and $15ms^{-1}$. The time of their crossing each other is
(a) 2 s (b) 4 s (c) $2\sqrt{3}$ (d) $4\sqrt{3}$

4. The speed of projectile at its maximum height is $\frac{\sqrt{3}}{2}$ times its initial speed. If the range of the projectile is n times the maximum height attained by it, n equal to:
(a) $\frac{4}{3}$ (b) $2\sqrt{3}$ (c) $4\sqrt{3}$ (d) $\frac{3}{4}$

5. Two wires A and B of same material and same mass have radii 2r and r. If resistance of wire A is $34\,\Omega$, then resistance of B will be
(a) $544\,\Omega$ (b) $372\,\Omega$ (c) $68\,\Omega$ (d) $17\,\Omega$

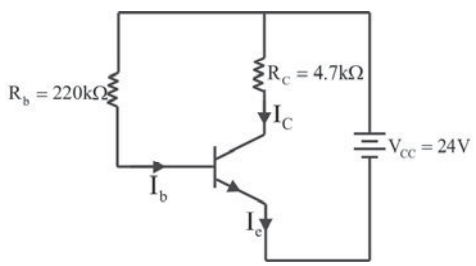
6. A 100 g iron ball having velocity 10m/s collides with a wall at an angle $30°$ and rebounds with the same angle. If the period of contact between the ball and wall is 0.1 second, then the force experienced by the wall is
(a) 10 N (b) 100 N (c) 1.0 N (d) 0.1 N

7. The graph between magnetic field induction 'B' due to a current carrying coil and distance 'x' along the axis from the centre is



8. A body is acted upon by a force which is proportional to the distance covered. If distance covered is denoted by *x*, then work done by the force will be proportional to:
(a) x (b) x^2
(c) $x^{\frac{3}{2}}$ (d) None of these

9. In the given circuit the value of β is 100. When $I_C = 1.5mA$ then the transistor is operating in



(a) Normal Active mode
(b) Saturation mode
(c) Inverse Active mode
(d) Cut off mode.

10. A 10 cm long rubber band obeys Hooke's law. When the rubber band is stretched to a total length of 12 cm the lowest resonant frequency is f_0. The rubber band is then stretched to a length of 13 cm. The lowest resonant frequency will now be

(a) Lower then f_0

(b) Higher then f_0

(c) The same as f_0

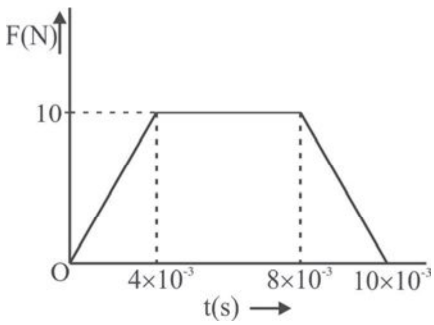
(d) Changed, but the direction of the change depends on the elastic constant and the original tension

11. Two spheres each of mass M and radius $\frac{R}{2}$ are connected at their centres with a massless rod of lenght 2R. What will be the moment of inertia of the system about an axis passing through the centre of one of the sphere and perpendicular to the rod?

(a) $\frac{21}{5}MR^2$ (b) $\frac{5}{2}MR^2$

(c) $\frac{4}{5}MR^2$ (d) $\frac{2}{5}MR^2$

12. A particle of mass 70g, moving at 50 cm/s, is acted upon by a variable force opposite to its direction of motion. The force F is shown as a function of time t.



(a) Its speed will be 50 cm/s after the force stops acting.

(b) Its direction of motion will reverse.

(c) Its average acceleration will be $1 m/s^2$ during the interval in which the force acts.

(d) Its average acceleration will be $10 m/s^2$ during the interval in which the force acts.

13. A projectile is launched from the surface of Earth with a velocity less than escape velocity. Its total mechanical energy is

(a) Positive (b) Negative

(c) Zero (d) Depends upon intial velocity

14. A sample of a liquid has an initial volume of 1.5L. The volume is reduced by 0.2 mL, when the pressure increases by 140 KPa.What is the bulk modulous of the liquid ?

(a) $1.05\times10^9\ pa$ (b) $1.6\times10^9\ pa$

(c) $1.7\times10^9\ pa$ (d) $1.4\times10^9\ pa$

15. The displacement from the position of equilibrium of a point 4 cm from a source of sinusoidal oscillations is half the amplitude at the moment $t=\frac{T}{6}$ (T is the time period). Assume that the source was at mean position at t=0.The wavelength of the running wave is:

(a) 0.96 m (b) 0.48 m (c) 0.24 m (d) 0.12 m

16. An ice cube containing a piece of lead floats in water. What would be the effect on the level of water if the ice cube melts?

(a) It would fall

(b) It would raise

(c) It would remain the same

(d) It would raise very high

17. A metallic block weigh 15 N in air. It weighs 12N when immersed in water and 13 N when immersed in another liquid. What is the specific gravity of the liquid?

(a) $\frac{1}{3}$ (b) $\frac{2}{3}$ (c) $\frac{12}{13}$ (d) $\frac{13}{15}$

18. A pebble is released from rest at a certain height and falls freely, reaching an impact speed of 4 m/s at the floor. Next, the pebble is thrown down with an initial speed of 3m/s from the same height. What is its speed at the floor ?

(a) 4 m/s (b) 5 m/s (c) 6 m/s (d) 7 m/s

19. 10 gm of ice at $-20°C$ is dropped into a calorimeter containing 10gm of water at $10°C$; the specific heat of water is twice that of ice. When equilibrium is reached, the calorimeter will contain:

(a) 20 gm of water

(b) 20 gm of ice

(c) 10 gm ice and 10 gm of water

(d) 5 gm ice and 15 gm of water

20. The position of centre of mass of system of particles at any moment does not depend on

(a) Masses of the particles
(b) Forces on the particles
(c) Positions of the particles
(d) Relative distances between the particles

21. The root mean square speed of the molecules of a diatomic gas is v. When the temperature is doubled, the molecules dissociate into two atoms. The new root mean square speed of the atom is

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

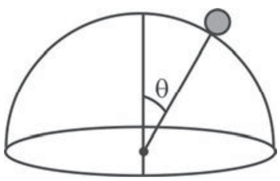
22. A particle executing S.H.M.of amplitude 4 cm and T=4 sec. The time taken by it to move from positive extreme position to half the amplitude is

(a) 1 sec (b) $\frac{1}{3}$ sec (c) $\frac{2}{3}$ sec (d) $\sqrt{\frac{3}{2}}$ sec

23. A particles is moving in a circle with uniform speed. Its motion is

(a) Not periodic
(b) Periodic and simple harmonic
(c) Periodic but not simple harmonic
(d) None of the above

24. A ball of mass m kept at top slide freely on frictionless hemispherical surface. At what minimum angle θ net force acting on ball would be equal to mg



(a) $\cos^{-1}(2/3)$ (b) 30^o

(c) 0^o (d) $\cos^{-1}(1/2)$

25. A wire of mass 1 g is kept horizontally on the surface of water. The length of the wire that does not break the surface film is (surface tension of water is 70 dyne cm^{-1})

(a) 3 cm (b) 4 cm (c) 7 cm (d) 14 cm

26. If a body is charged by rubbing it, its weight

(a) Always decreases slightly
(b) Always increase slightly
(c) May increase slightly or may decrease slightly
(d) Remains precisely the same

27. Charges $Q, -q, Q, -q$ are placed at the corners A,B,C,D of a square respectively. If the resultant force on the charge Q is Zero due to other charges, what is the relation between Q and q?

(a) $Q = -2\sqrt{2}q$ (b) $Q = -2q$

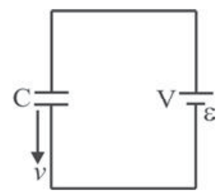
(c) $Q = -\sqrt{2}q$ (d) $Q = -\frac{1}{2\sqrt{2}}q$

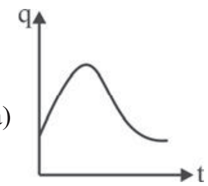
28. A thin spherical conducting shell of radius R has a charge q. Another charge Q is placed at the centre of the shell. The electrostatic potential at a distance $\frac{R}{2}$ from the centre is

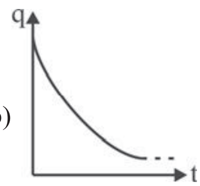
(a) $\frac{(q+Q)}{4\pi\varepsilon_o}\frac{2}{R}$ (b) $\frac{2Q}{4\pi\varepsilon_o R}$

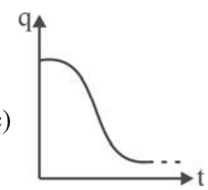
(c) $\frac{2Q}{4\pi\varepsilon_o R} - \frac{2q}{4\pi\varepsilon_o R}$ (d) $\frac{2Q}{4\pi\varepsilon_o R} + \frac{q}{4\pi\varepsilon_o R}$

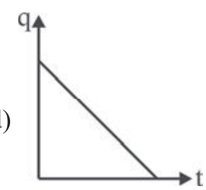
29. An ideal cell is connected across a capacitor as shown in figure. The initial separation between the plates of a parallel plate capacitor is d. The lower plate is pulled down with a uniform velocity v. Neglect the resistance of the circuit. Then the variation of charge on capacitor with time is given by:



(a)


(b)


(c)


(d)


30. The wavelength associated with an electron accelerated through a potential difference of 100V is nearly

(a) 100 A (b) 123 A (c)1.23 A (d) 0.123 A

31. A charged particle moves in a uniform magnetic field. The velocity of the particle at some instant makes an acute angle with the magnetic field. The path of the particle will be

(a) A straight line

(b) A circle

(c) A helix with uniform pitch

(d) A helix with non-uniform pitch

32. The torque on a bar magnet due to the earth's magnetic field is maximum when axis of the magnet is

(a) Perpendicular to the field of the earth

(b) Parallel to the vertical component of the earth's field

(c) At an angle of $33°$ with respect to the N-S direction

(d) Along the North-South(N-S) direction

33. Two circular, similar, coaxial loops carry equal currents in the same direction. If the loops are brought nearer, what will happen?

(a) Current will increase in each loop

(b) Current will decrease in each loop

(c) Current will remain same in each loop

(d) Current will increase in one and decrease in the other

34. Alternating current cannot be measured by DC ammeter because

(a) AC cannot pass through DC ammeter

(b) Average value of complete cycle is zero

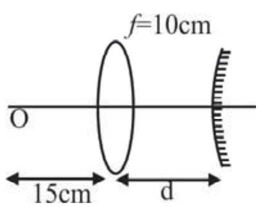
(c) AC is virtual

(d) AC changes its direction

35. Radius of curvature of concave mirror is 40 cm and the size of image is twice as that of object, then the object distance is

(a) 60 cm (b) 20 cm (c) 40 cm (d) 30 cm

36. An object is placed in front of convex lens of focal length (f=10cm). The distance d for which image of the object will coincide with the object (irrespective of focal length of the mirror)



(a) 30 (b) 10 (c) 20 (d) 15

37. Monochromatic light of wavelength λ_1 travelling in a medium of refractive index n_1 enters a denser medium of refractive index n_2. The wavelength in the second medium is

(a) $\lambda_1\left(\frac{n_1}{n_2}\right)$ (b) $\lambda_1\left(\frac{n_2}{n_1}\right)$

(c) λ_1 (d) $\lambda_1\left(\frac{n_2-n_1}{n_1}\right)$

38. In the interference pattern, energy is

(a) Created at the position of maxima

(b) Destroyed at the position of minima

(c) Conserved but is redistributed

(d) None of the above

39. When the kinetic energy of an electron is increased, the wavelength of the associated wave will

(a) Increase

(b) Decrease

(c) Wavelength does not depend on the kinetic energy

(d) None of the above

40. Two tall buildings are 30 m apart. The speed with which a ball must be thrown horizontally from a window 150 m above the ground in one building so that enters a window 27.5 m from ground in the other building is:

(a) $2ms^{-1}$ (b) $6ms^{-1}$ (c) $4ms^{-1}$ (d) $8ms^{-1}$

41. The potential at a point x (measured in μ m) due to some charges situated on the x-axis is given by

$V(x)=\frac{20}{x^2-4}$ volt. The electric field E at x = 4 μ m is given by

(a) $\frac{5}{3}\frac{V}{\mu m}$ and in the positive x - direction

(b) $\frac{10}{9}\frac{V}{\mu m}$ and in the negative x - direction

(c) $\frac{10}{9}\frac{V}{\mu m}$ and in the positive x-direction

(d) $\frac{5}{3}\frac{V}{\mu m}$ and in the negative direction

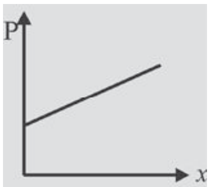
42. In a Mullikan's oil drop experiment the charge on an oil drop is calculated to be $6.35\times10^{-19}C$. The number of excess electrons on the drop is

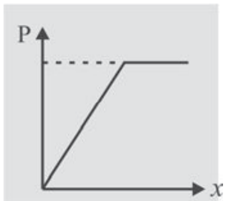
(a) 3.9 (b) 4 (c) 4.2 (d) 6

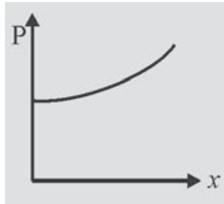
43. As compared $^{12}C\,atom$, $^{14}C\,atom$ has

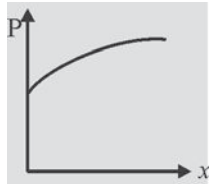
(a) Two extra protons and two extra electrons
(b) Two extra protons but no extra electrons
(c) Two extra neutrons and no extra electrons
(d) Two extra neutrons and two extra electrons

44. The cross-sectional area of a horizontal tube increases along its length linearly, as we move in the direction of flow. The variation of pressure, as we move along its length in the direction of flow (x-direction), is best depicted by which of the following graphs?

(a)


(b)


(c)


(d)


45. A hydrogen atom emits a photon corresponding to an electron transition from $n=5$ to $n=1$. The recoil speed of hydrogen atom is almost (mass of proton $\approx 1.6\times10^{-27}$ kg)

(a) 2×10^{-2} ms^{-1} (b) 8×10^{2} ms^{-1}

(c) $4\,\text{ms}^{-1}$ (d) $10\,\text{ms}^{-1}$

Student Name: .... **School/ College Name:** ....

OMR SHEET **NEET-11** **Physics**

Q.	a	b	c	d
1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d

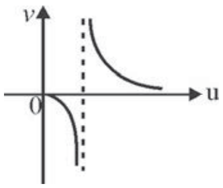
Total Marks: Marks Obtained:

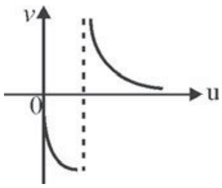
Graph Arcade

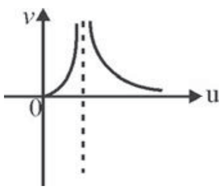
TARGET IIT-JEE/NEET

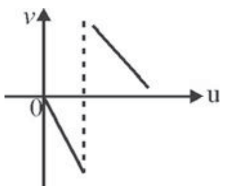
RAY OPTICS

1. The graph showing correctly the variation of image distance (v) as a function of object distance (u) in case of a convex mirror is

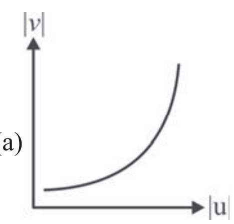
(a) 

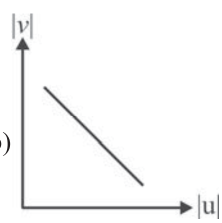
(b) 

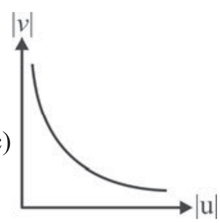
(c) 

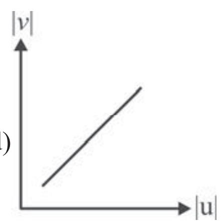
(d) 

2. In an experiment to find focal length of a concave mirror, a graph is drawn between the magnitude of u and v. The graph looks like

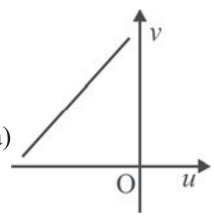
(a) 

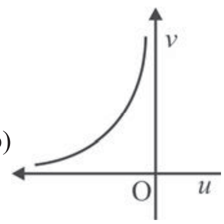
(b) 

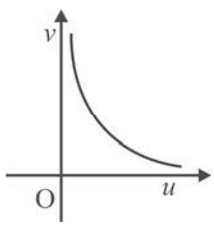
(c) 

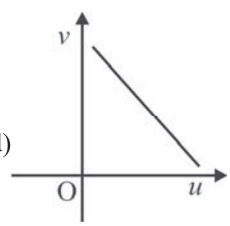
(d) 

3. A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like

(a) 

(b) 

(c) 

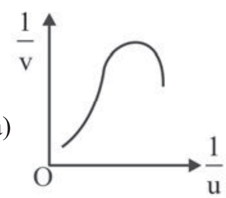
(d) 

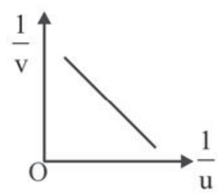
4. For a convex lens the distance of the object is taken on X-axis and the distance of the image is taken on Y-axis, the nature of the graph so obtained is

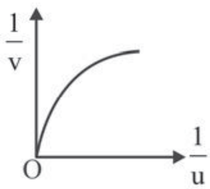
(a) Circle (b) Parabola

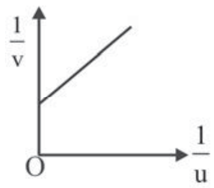
(c) Straight line (d) Hyperbola

5. From a spherical mirror, the graph of $1/v$ versus $1/u$ is given by

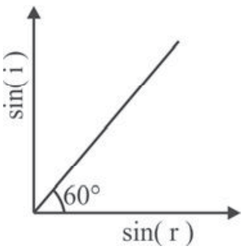
(a) 

(b) 

(c) 

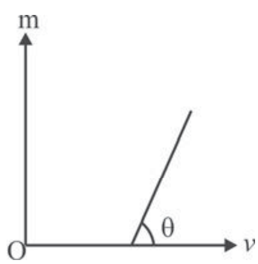
(d) 

6. A ray of light is incident on a medium with angle of incidence i and refracted into a second medium with angle of refraction r. The graph of sin(i) vs (r) is as shown in figure. Then, the velocity of light in the first medium is n times the velocity of light in the second medium. What should be the value of n?



(a) $\sqrt{3}$ (b) $2/\sqrt{3}$ (c) $1/\sqrt{3}$ (d) $\frac{\sqrt{3}}{2}$

7. Variation of magnification (m) produced by a thin convex lens versus distance (v) of image from pole of the lens is shown in the graph. Which of the following statement is not correct?



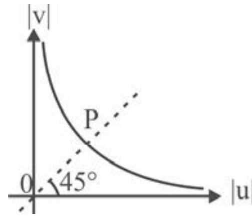
(a) Focal length of the lens is equal to intercept on v - axis

(b) Magnitude of intercept on m-axis is equal to unity.

(c) Focal length of the lens is equal to inverse of the slope of the line.

(d) Magnitude of intercept on v-axis is equal to unity.

8. In case of a spherical mirror of focal length f, a graph is plotted as shown.

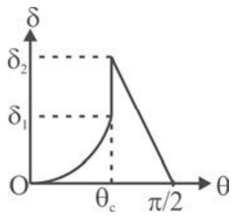


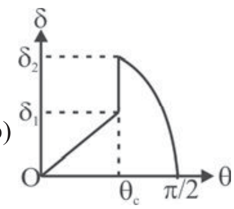
The coordinates of the point p are

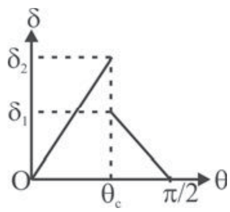
(a) $(2f, 2f)$ (b) (f, f)

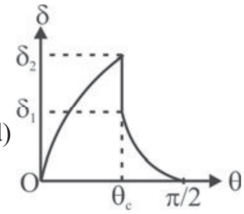
(c) $(f/2, f/2)$ (d) $(4f, 4f)$

9. A ray of light travels from a medium of refractive index μ to air. Its angle of incidence in the medium is θ, measured from the normal to the boundary, and its angle of deviation is δ. δ is plotted against θ. Which of the following best represents the resulting curve?

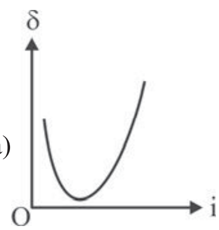
(a) 

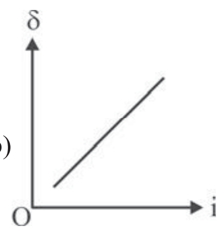
(b) 

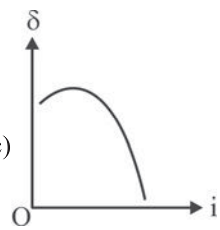
(c) 

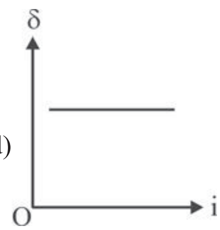
(d) 

10. A graph is plotted between angle of deviation (δ) and angle of incidence (i) for a prism. The nearly correct graph is

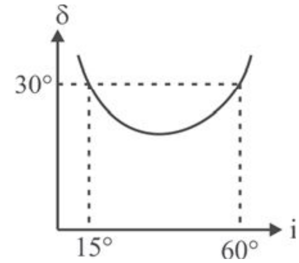
(a) 

(b) 

(c) 

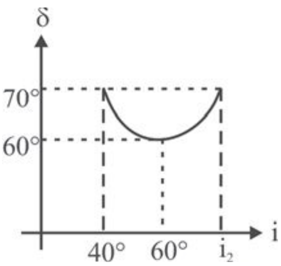
(d) 

11. Figure shows graph of deviation δ versus angle of incidence for a light ray striking a prism. Angle of prism is :



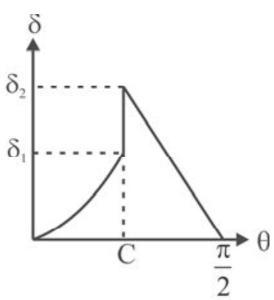
(a) 60° (b) 45° (c) 30° (d) 75°

12. The curve of angle of incidence versus angle of deviation shown has been plotted for prism. The value of refractive index of the prism used is :



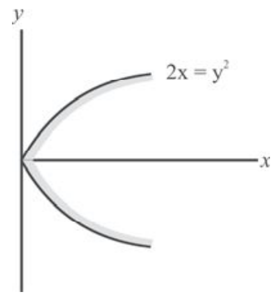
(a) $\sqrt{3}$ (b) $\frac{\sqrt{3}}{\sqrt{2}}$ (c) $\frac{2}{\sqrt{3}}$ (d) $\sqrt{2}$

13. A ray of light travels from a medium of refractive index μ to air. Its angle of incidence in the medium is θ, measured from the normal to the boundary and its angle of deviation is δ with the angle of refraction ϕ. A graph is plotted between δ and θ which is shown in the figure. The value of $\frac{\delta_2}{\delta_1}$ is



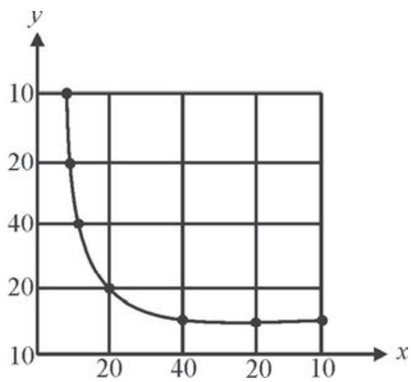
(a) 1 (b) 2 (c) 4 (d) $\frac{1}{2}$

14. The reflecting surface represented by the equation $2x = y^2$ as shown in figure. A ray travelling horizontal becomes vertical after reflection. The co-ordinates of the point of incidence can be:



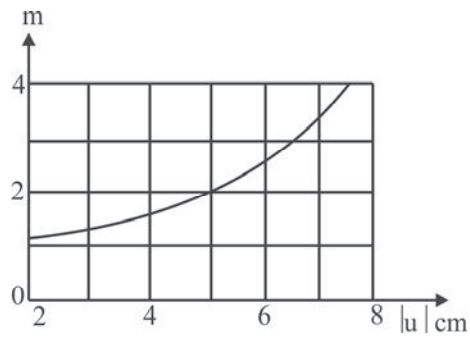
(a) (1,1/2) (b) (1/2,1/2)
(c) (1/2,1) (d) $(1/2, \pm 1)$

15. A lens forms a real image of an object. The distance from the object to the lens is x cm and that from the lens to the image is y cm. The graph shows the variation of y with x. It can be deduced that the lens is



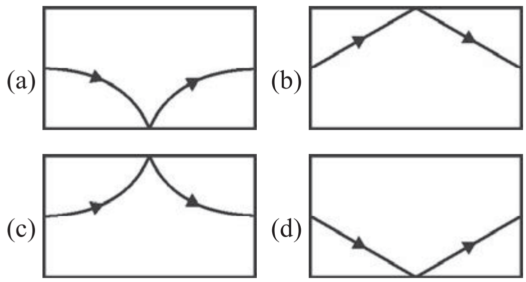
(a) Converging and of focal length 10 cm
(b) Diverging and of focal length 20 cm
(c) Converging and of focal length 20 cm
(d) Converging and of focal length 40 cm

16. An object kept on the principal axis and infront of a spherical mirror, is moved along the axis itself. Its lateral magnification m is measured, and plotted versus object distance $|\mu|$ for range of u as shown in figure. The magnification of the object when it is placed at a distance 20 cm in front of the mirror is

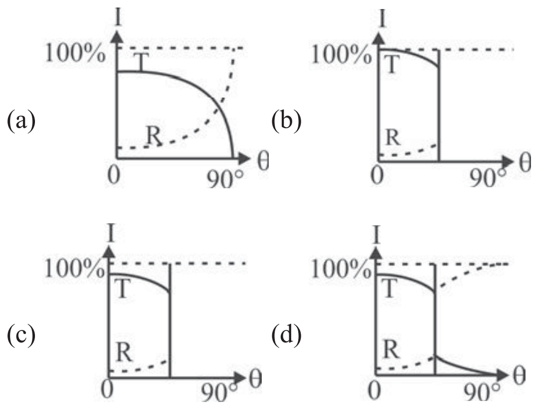


(a) -1 (b) 20 (c) 1 (d) 8

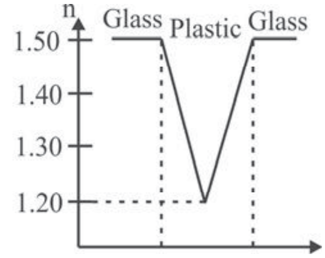
17. A cubic container is filled with a liquid whose refractive index increases linearly from top to bottom. which of the following represents the path of ray of light inside the liquid?



18. A light ray travelling in glass medium is incident on glass-air interface at an angle of incident θ . The reflected (R) and transmitted (T) intensities, both as function of θ , are plotted. The correct sketch is

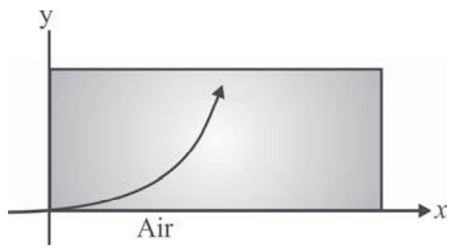


19. A thin plate of transparent plastic is embedded in a thick slab of glass. The index of refraction of the glass is n = 1.50, the index of refraction of the plate changes as shown in the diagram. A beam of light passes through glass and strikes the surface of the plastic plate. What maximum angle of incidence enables the beam to pass through the plate?



(a) 73° (b) 63° (c) 53° (d) 43°

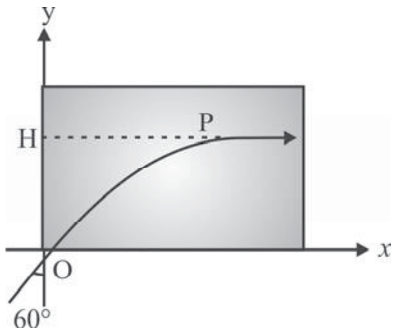
20. The refractive index of the medium with in a certain region, $x > 0, y > 0$, changes with y. A ray travelling in the x-direction strikes the medium at right angles and moves through the medium along a circular arc. The refractive index reaches a maximum value of 2.5 and then it remains constant. The maximum angular size of the arc is



(a) 30° (b) $\sin^{-1}\left(\frac{1}{2.5}\right)$

(c) 90° (d) $\cos^{-1}\left(\frac{1}{2.5}\right)$

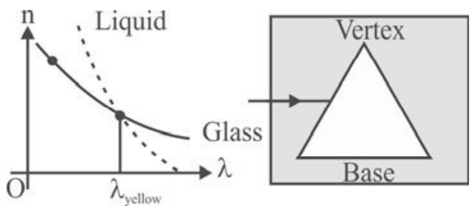
21. A system of coordinates is drawn in a medium whose refractive index varies as $\mu = \frac{\sqrt{2y^2 - 1}}{y}$, where $0 \le y \le 1$. A ray of light is incident at origin at an angle $60°$ with y-axis as shown in the figure. At point P, the ray becomes parallel to x-axis. The value of H is:



(a) $\frac{2}{\sqrt{5}}$ (b) $\left\{\left(\sqrt{3}\right)+1\right\}^{1/2}$

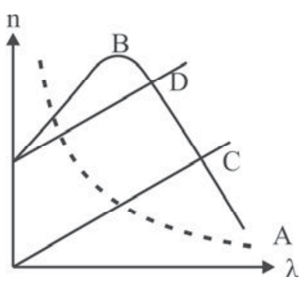
(c) $\left\{\frac{2}{\sqrt{3}}\right\}^{1/2}$ (d) $\left\{\left(\sqrt{3}\right)-1\right\}^{1/2}$

22. A glass prism is immersed in a hypothetical liquid. The curves showing the refractive index n as a function of wavelength λ for glass and liquid are as shown in figures. When *a* ray of white light is incident on the prism parallel to the base then predict the wrong option



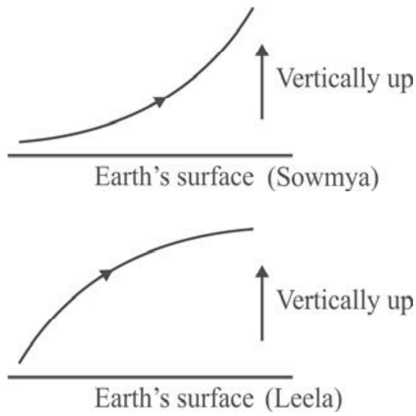
(a) Yellow ray travels without deviation
(b) Blue ray is deviated towards the vertex
(c) Red ray is deviated toward the base
(d) There is no dispersion

23. The correct curve between refractive index n and wavelength A will be



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

24. Sowmya and leela were asked to draw the trajectory of a light ray near earth's surface when refractive index is decreasing with increase in height. Figure shows the respective ray diagrams:



(a) Sowmya is correct
(b) Both are correct
(c) Leela is correct
(d) No conclusion can be drawn

ANSWER KEY

1. a	**2.** c	**3.** b	**4.** d	**5.** b
6. a	**7.** d	**8.** a	**9.** a	**10.** a
11. b	**12.** a	**13.** b	**14.** d	**15.** a
16. a	**17.** a	**18.** c	**19.** c	**20.** d
21. a	**22.** d	**23.** a	**24.** c	

HINTS & SOLUTIONS

1.Sol: The equation of a convex mirror is

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

When $u=f \Rightarrow v \to \infty$

When $u<f \Rightarrow v=(-)ve$

When $u>f \Rightarrow v=(+)ve$

The correct graph is (a)

2.Sol: The equation of the mirror is

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

When $u=-f \Rightarrow v \to \infty \Rightarrow |v| \to \infty \;\&\; |u|=f$

When $u=\infty \Rightarrow v \to -f \Rightarrow |v| = f \,\&\, |u| = \infty$

3.Sol: The equation of a convex lens is

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

When u = (-)ve object is real

v =(+) ve image is real

When u lies between -f to $-\infty$ then v is (+) ve

When u lies between -f to 0 then v is (-) ve

The correct graph is (b)

5.Sol: We have $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ or $\frac{1}{v}=-\frac{1}{u}+\frac{1}{f}$

Now, compare it with equation, y = mx + c.

Therefore, graph is a straight line having negative slope.

6.Sol: From Snell's law,

$$\mu_1 \sin i = \mu_2 \sin r \Rightarrow \frac{\mu_2}{\mu_1}=\frac{\sin i}{\sin r}$$

Where μ_1 and μ_2 are the refractive indices From the graph,

$$\tan 60^o = \frac{\sin i}{\sin r} \Rightarrow \frac{\sin i}{\sin r} = \sqrt{3} = \frac{\mu_2}{\mu_1}$$

$$\mu = \frac{c}{v} \Rightarrow = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$$

$$v_1 = \left(\frac{\mu_2}{\mu_1}\right) v_2 \Rightarrow v_1 = \sqrt{3}\, v_2$$

7.Sol: The equation of lens is

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$1-\frac{v}{u}=\frac{v}{f}$$

$$1-m=\frac{v}{f}$$

$$m+\frac{1}{f}v-1=0$$

8.Sol: As $\theta = 45^\circ$ the coordinates are equal.

$$\frac{1}{u}+\frac{1}{v}=\frac{-1}{f} \text{(concave)}$$

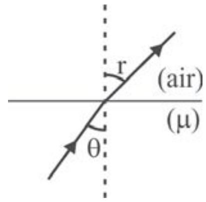
$$u=-2f \Rightarrow v=-2f$$

$$\frac{1}{u}+\frac{1}{v}=\frac{-1}{f} \text{(convex)}$$

$$u=-2f$$

The coordinates of point P are $(|u|,|v|)=(2f,2f)$

9.Sol: The refracted light ray is shown in the figure.



The deviation of the light ray is

$$\delta = r - \theta$$

From snell's law $n \sin\theta = \sin r$

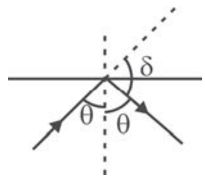
$$\delta = \sin^{-1}(n\sin\theta)-\theta$$

The graph between δ and θ is non linear but at

$$\theta=\theta_c \Rightarrow r = 90^\circ$$

$$\delta = 90^\circ - \theta_c$$

If $\theta > \theta_c$ then the ray undergoes TIR as shown in the figure.



$$\delta = 180 - 2\theta$$

So just after crossing θ_c the deviation becomes double from $90^\circ - \theta_c$ to $180 - 2\theta_c$.

The correct graph is (a).

10.Sol: For a prism, as the angle of incidence increase, the angle of deviation first decreases, goes to a minimum value and then increases. The correct graph is (a).

11.Sol: $\delta = i_1 - r_1 + i_2 - r_2$

$$\delta = (i_1+i_2)-(r_1+r_2)$$

$$\delta = i_1 + i_2 - A$$

$$30^\circ = 15^\circ + 60^\circ - A$$

$$A = 45^\circ$$

12.Sol: At minimum deviation

$$\delta_{min} = 2i - A$$

$$60^\circ = 2\left(60^\circ\right) - A$$

$$A = 60^\circ$$

The refractive index is

$$1\sin i = \mu \sin r$$

$$\sin 60^\circ = \mu \sin\left(\frac{A}{2}\right) = \mu \sin 30^\circ$$

$$\mu = \sqrt{3}$$

13.Sol: δ_1 is the deviation at critical angle

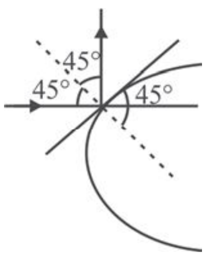
$$\delta_1 = 90^\circ - \theta_c$$

δ_2 is the deviation just after crossing critical angle

$$\delta_2 = 180^\circ - 2\theta_c$$

$$\frac{\delta_2}{\delta_1} = 2$$

14.Sol: Let $p(x, y)$ be the point where the light ray becomes vertical after reflection. The angle made by the tangent at P is 45°



The slope of the tangent is

$$\tan 45^\circ = \frac{dy}{dx} = 1$$

From the equation of the mirror

$$\frac{dy}{dx} = \frac{1}{\sqrt{2x}} = 1 \Rightarrow x = \frac{1}{2} \Rightarrow y = \pm 1$$

$$p(x, y) = \left(\frac{1}{2}, \pm 1\right)$$

15.Sol: From the lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

When $u = -2f \Rightarrow v = 2f$

$$|u| = 2f \Rightarrow v = 2f$$

From the graph 2f = 20 cm

f = 10 cm

As the lens is forming a real image so the lens is converging

16.Sol: From the equation of the mirror

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

$$m = \frac{f}{f - u}$$

From the graph when $u = -5\text{cm}$ and $m = 2$

$$2 = \frac{f}{f + 5} \Rightarrow f = -10\text{cm}$$

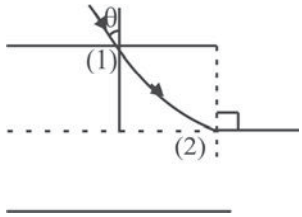
$$m = \frac{-10}{-10 - u} = \frac{-10}{-10 + 20} = -1$$

17.Sol: Since the refractive index is changing, the light cannot travel in a straight in the liquid as shown in option (b) and (d). Intially, it will bend towards normal and after reflecting from the bottom it will bend away from the normal as shown in below.

18.Sol: After critical angle, reflection will be 100% and transmission is 0%. Option (b) and (c) satisfy this condition. In option (b) transmission is given 100% at $\theta = 0^\circ$, which is not true.

$\therefore$ The correct answer is (c).

19.Sol: From the given graph it can be observed that refractive index of glass is constant and the refractive index of the transparent sheet decreases first and then increases. Assume that the light ray strikes the sheet at angle θ as shown in the figure. The light ray grazes the surface at the midpoint where the refractive index is minimum.



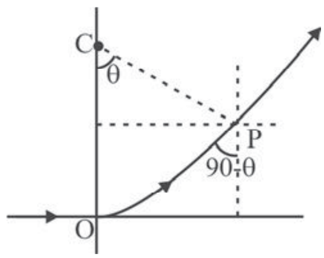
As refractive index decreases the light ray moves away from the normal and it follows curved path. By applying snell's law at (1) and (2)

$$n_1 \sin\theta = n_2 \sin 90^\circ$$

$$\sin\theta = \frac{1.2}{1.5} = \frac{4}{5}$$

$$\theta = 53^\circ$$

20.Sol: As μ increases along y direction the light ray bends towards the normal and it travels along straight line path after reaching $\mu = 2.5$



By applying snell's law at O and P

$$1\sin 90^\circ = 2.5\sin(90-\theta)$$

$$\theta = \cos^{-1}\left(\frac{1}{2.5}\right)$$

21.Sol: By applying the snell's law at the points O and P

$$(1)\sin 60^\circ = \mu \sin 90^\circ = \frac{\sqrt{2y^2 - 1}}{y}$$

$$\frac{\sqrt{3}}{2} = \frac{\sqrt{2H^2 - 1}}{H} \quad (y=H)$$

$$H = \frac{2}{\sqrt{5}}$$

22.Sol:

From the graph it can be observed that

$$n_{liq} = n_{glass} \text{ (For yellow)}$$

So the light ray travels without deviation

$$n_{liq} = n_{glass} \text{ (For red)}$$

So the light bends towards the base

$$n_{liq} > n_{glass} \text{ (For blue)}$$

So the light bends away from the base.

When white light is sent through the prism dispersion of light takes place

23.Sol: The refractive index in a medium is

$$\mu = \frac{\lambda}{\lambda_m}$$

λ – Wavelength in vaccum

λ_m – Wavelength in the medium

The graph between λ_m and μ is a hyperbola.

24.Sol:

As the ray is moving from denser to the rarer medium the light ray bends away from the normal. So leela is correct.

BIT SAT EVA-AITS - 1

"A Colossal juncture to get introduced to the national standard mock tests of BITSAT"

1. Two skaters have weight in the ratio 4:5 and are 9 m apart, on a smooth frictionless surface. They pull on a rope stretched between them. The ratio of the distance covered by them when they meet each other will be

(a) 5:4 (b) 4:5 (c) 25:16 (d) 16:25

2. The resistance of a metal is given by $R = V/I$, where V is potential difference and I is the current in a circuit, the potential difference across resistance is $V = (8 \pm 0.5)V$ and current in resistance, $I = (4 \pm 0.2)A$. What is the value of resistance with its percentage error?

(a) $(2 \pm 5.6\%)\Omega$ (b) $(2 \pm 0.7\%)\Omega$

(c) $(2 \pm 35\%)\Omega$ (d) $(2 \pm 11.25\%)\Omega$

3. A projectile has a time of flight *T* and range *R*. If the time of flight is doubled, keeping the angle of projection same, what happens to the range?

(a) R/4 (b) R/2 (c) 2R (d) 4R

4. A ball is projected in a direction inclined to the vertical and bounces on a smooth horizontal plane. The range of one rebound is *R*. If the coefficient of restitution is *e*, then range of the next rebound is

(a) $R' = eR$ (b) $R' = e^2R$

(c) $R' = \frac{R}{e}$ (d) $R' = R$

5. A constant force starts acting on a body of mass *m* at rest. The velocity v acquired in traveling a specific distance depends on *m* as

(a) $v \propto \frac{1}{\sqrt{m}}$ (b) $v \propto \frac{1}{m}$

(c) $v \propto \sqrt{m}$ (d) $v \propto m$

6. The distance between the centres of the Moon and the earth is *D*. The mass of the earth is 81 times the mass of the Moon. At what distance from the centre of the Earth, the gravitational force will be zero?

(a) $\frac{D}{2}$ (b) $\frac{2D}{3}$ (c) $\frac{4D}{3}$ (d) $\frac{9D}{10}$

7. The speed *v* reached by a car of mass *m* in travelling a distance *x*, driven with constant power *P*, is given by

(a) $v = \frac{3xP}{m}$ (b) $v = \left(\frac{3xP}{m}\right)^{1/2}$

(c) $v = \left(\frac{3xP}{m}\right)^{1/3}$ (d) $v = \left(\frac{3xP}{m}\right)^{2}$

8. The equations of motion of a projectile are given by $x = 36t\ m$ and $2y = 96t - 9.8t^2 m$. The angle of projection is

(a) $\sin^{-1}\left(\frac{3}{5}\right)$ (b) $\sin^{-1}\left(\frac{4}{5}\right)$

(c) $\sin^{-1}\left(\frac{3}{4}\right)$ (d) $\sin^{-1}\left(\frac{4}{3}\right)$

9. Young's modulus of brass and steel are $10 \times 10^{10} N/m$ and $20 \times 10^{10} N/m$ respectively. A brass wire and a steel wire of the same length are extended by 1 mm under the same force. The radii of the brass and steel wires are R_B and R_S, respectively. Then

(a) $R_S = \sqrt{2}R_B$ (b) $R_S = \frac{R_B}{\sqrt{2}}$

(c) $R_S = 4R_B$ (d) $R_S = \frac{R_B}{4}$

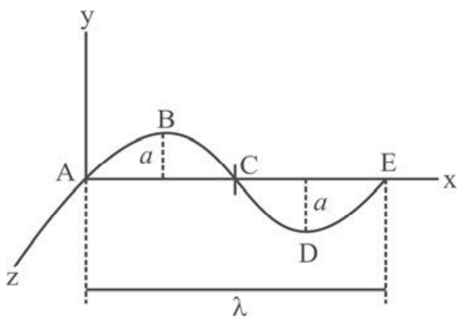
10. A block of silver of mass 4 kg hanging from a string is immersed in a liquid of relative density $0\cdot72$. If relative density of silver is 10, then tension in the string will be
(a) 37.12 N (b) 42 N (c) 73 N (d) 21 N

11. A rectangular body has maximum wavelength λ_m at 2000 K. Its corresponding wavelength at 3000 K will be

(a) $\frac{2}{3}\lambda_m$ (b) $\frac{3}{2}\lambda_m$

(c) $\frac{81}{16}\lambda_m$ (d) $\frac{16}{81}\lambda_m$

12. A conductor ABCDE, shaped as shown, carries current I. It is placed in the x - y plane with the ends A and E on the x-axis. A uniform magnetic field of magnitude B exists in the region. Predict the wrong option for the force on the wire



(a) zero, if B is along x - direction
(b) λBI in the z-direction, if B is in the y-direction
(c) λBI in the negative y-direction, if B is in the z-direction
(d) λBI , if B is in the x-direction

13. Two circular discs are of same thickness. The diameter of *A* is twice that of *B*. The moment of inertia of *A* as compared to that of *B* is
(a) Twice as large
(b) Four times as large
(c) Eight times as large
(d) 16 times as large

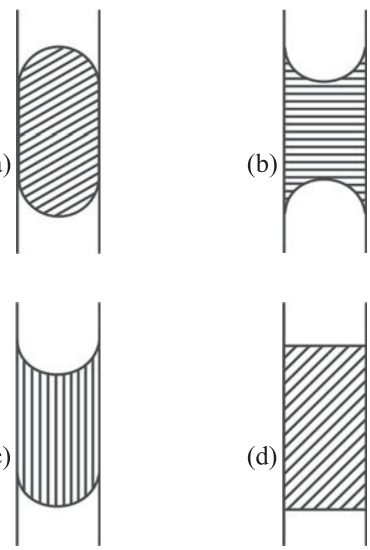
14. The capacity of a vessel is 3 L. It contains 6 g oxygen, 8 g nitrogen and 5 g CO_2 mixture at $27^0 C$. If $R = 8.31 J/mol\,K$, then the pressure in the vessel in N/m^2 will be (approx)
(a) 5×10^5 (b) 5×10^4 (c) 10^6 (d) 10^5

15. A proton and an α – particle enter a uniform magnetic field moving with the same speed. If the proton takes 25 μs to make 5 revolutions, then the periodic time for the α – particle would be
(a) 50 μs (b) 25 μs (c) 10 μs (d) 5 μs

16. In a series LCR circuit, the voltage across the resistance, capacitance and inductance is 10V each. If the capacitance is short circuited, the voltage across the inductance will be
(a) 10V (b) $5\sqrt{2}\,V$ (c) $(10/3)\,V$ (d) $20V$

17. An object of mass 0.2 kg executes simple harmonic motion along the x – axis with a frequency of $25/\pi$ Hz. At the position $x = 0.04\,m$, the object has a kinetic energy of 0.5 J and potential energy of 0.4J. The amplitude of oscillation is
(a) 0.05 m (b) 0.06 m
(c) 0.01 m (d) None of these

18. A vertical glass capillary tube open at both ends contains some H_2O. Which of the following shapes for water is correct?

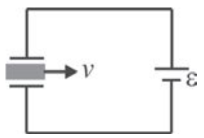

(a) (b) (c) (d)

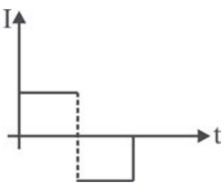
19. A wire of length 'l' having tension T and radius 'r' vibrates with fundamental frequency 'f'. Another wire of the same metal with length '$2l$' having tension $2T$ and radius $2r$ will vibrate with fundamental frequency:

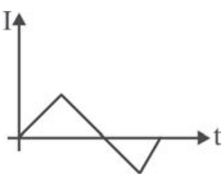
(a) f (b) $2f$

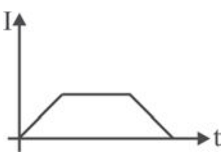
(c) $\frac{f}{2\sqrt{2}}$ (d) $\frac{f}{2}\sqrt{2}$

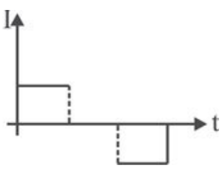
20. A dielectric slab of area A and thickness d is inserted between the plates of capacitor of area A and distance between the plates d with a constant speed v as shown in the figure. The capacitor is connected to a battery of emf ε. The current in the circuit varies with time as:



(a)


(b)


(c)


(d)


21. Three equal charges, each +q, are placed on the corners of an equilateral triangle. The electric field intensity at the centroid of the triangle is

(a) kq/r^2 (b) $3kq/r^2$ (c) $\sqrt{3}kq/r^2$ (d) Zero

22. The capacitor of an oscillatory circuit of frequency 10000 Hz is enclosed in a container. When the container is evacuated, the frequency changes by $50\,Hz$, the dielectric constant of the gas is

(a) 1.1 (b) 1.01 (c) 1.001 (d) 1.0001

23. Two normal uniform magnetic fields B_1 *and* B_2 contain a magnetic needle making an angle 60^0 with B_1. Then the ratio of B_1/B_2 is

(a) 1:2 (b) 2:1 (c) $\sqrt{3}:1$ (d) $1:\sqrt{3}$

24. In a two-slit experiment with white light, a white fringe is observed on a screen kept behind the slits. When the screen in moved away by 0.05m, this white fringe

(a) Does not move at all
(b) Gets displaced from its earlier position
(c) Becomes colored
(d) Disappears

25. X-rays are not used for radar purposes, because they are not

(a) Reflected by target
(b) Partly absorbed by target
(c) Electromagnetic waves
(d) Completely absorbed by target

26. Which of the following parameters are the same for all hydrogen-like atoms and ions in their ground states?

(a) Radius of the orbit
(b) Speed of the electron
(c) Energy of the atom
(d) Orbital angular momentum of the electron

27. A convex lens of focal length 20 cm and a concave lens of focal length f are mounted coaxially 5 cm apart. Parallel beam of light incident on the convex lens emerges from the concave lens as a parallel beam. Then, f in cm is

(a) 35 (b) 25 (c) 20 (d) 15

28. A monochromatic source of light is placed at a large distance d from a metal surface. Photoelectrons are ejected at rate *n,* the kinetic energy being *E.* If the source is brought nearer to distance $d/2$, the rate and kinetic energy per photoelectron become nearly

(a) $2n$ and $2E$ (b) $4n$ and $4E$

(c) $4n$ and E (d) n and $4E$

29. Which of the following statements is incorrect for nuclear forces?

(a) These are strongest in magnitude
(b) They are charge dependent
(c) They are effective only for short ranges
(d) They result from interaction of every nucleon

30. Which of the following is the reason for disadvantage of FM over AM

(a) Larger band width requirement
(b) Larger noise
(c) Higher modulation power
(d) Low efficiency

31. The rain drops are in spherical shape due to
(a) Viscosity (b) Surface tension
(c) Thrust on drop (d) Both (a) and (b)

32. If two balls of same metal weighing 5 gm and 10 gm strike with a target with the same velocity. The heat energy so developed is used for raising their temparature alone, then the temparature will be higher
(a) For bigger ball
(b) For smaller ball
(c) Equal for both the balls
(d) None is correct from above three

33. A solid sphere is rotating in free space. If the radius of the sphere increases by itself keeping mass same which one of the following will not be affected?
(a) Moment of inertia
(b) Angular momentum
(c) Rotational kinetic energy
(d) None of these

34. A car of mass m moves in a horizontal circular path of radius r meter. At an instant its speed is V m/s and is increasing at a rate of $a\ m/\sec^2$. Then the acceleration of the car is:
(a) $\frac{V^2}{r}$ (b) a
(c) $\sqrt{a^2+\left(\frac{V^2}{r}\right)^2}$ (d) $\sqrt{a+\frac{V^2}{r}}$

35. The vector projection of a vector $3\hat{i}+4\hat{k}$ on y-axis is
(a) 5 (b) 4 (c) 3 (d) Zero

36. A heavy weight is suspended from a spring. A person raises the weight till the spring becomes slack. The work done by him is W. The energy stored in the stretched spring was E. What will be the gain in gravitational potential energy?
(a) W (b) E (c) $W+E$ (d) $W-E$

37. A body starts with some initial velocity along a straight line. After 3 s it is found to be at a distance of 15 m from the starting point. At 4 s it is at starting point. What is the initial velocity of the body? (Asssume constant acceleration)
(a) $20\,ms^{-1}$ (b) $10\,ms^{-1}$ (c) $5\,ms^{-1}$ (d) $15\,ms^{-1}$

38. A cork of mass 10 g is floating on water. The net force acting on the cork is
(a) $10\,N$ (b) $10^{-3}\,N$ (c) $10^{-2}\,N$ (d) zero

39. A body of mass m is placed on earth surface which is taken from earth surface to a height of $h=3R$, then change in gravitational potential energy is
(a) $\frac{mgR}{4}$ (b) $\frac{2}{3}\,mgR$
(c) $\frac{3}{4}\,mgR$ (d) $\frac{mgR}{2}$

40. A particle executes SHM of amplitude A and time period T. The distance travelled by the particle in the duration its phase changes from $\frac{\pi}{12}$ to $\frac{5\pi}{12}$
(a) $\frac{1}{\sqrt{2}}A$ (b) $\sqrt{\frac{3}{2}}A$
(c) $\frac{2}{\sqrt{3}}A$ (d) $\sqrt{\frac{2}{3}}A$

41. A U-tube containing a liquid is accelerated horizontally with a constant acceleration a. If the separation between the two vertical limbs is l, then the difference in the heights of the liquid in the two arms is:
(a) Zero (b) l
(c) $\frac{la}{g}$ (d) $\frac{lg}{a}$

42. The equation of a wave is given by (all quantity expressed in S.I. units) $y=5\sin 10\pi(t-0.01x)$ along the x-axis. The magnitude of phase difference of 10 m along x-axis is
(a) $\pi/2$ (b) π (c) 2π (d) $\pi/4$

43. If the length of a cylinder on heating increases by 2%, the area of its base will increase by
(a) 0.5% (b) 2% (c) 1% (d) 4%

44. A suitable unit for gravitational constant is
(a) $kg\,m\sec^{-1}$ (b) $Nm^{-1}\sec$
(c) $N\,m^2\,kg^{-2}$ (d) $kg\,m\sec$

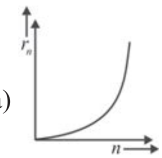
45. A particle of mass 1 kg is moving along the line $y=x+2$ (here x and y are in m) with speed 2 m/s. The magnitude of angular momentum of the particle about origin is:
(a) $4\,kgm^2\,s^{-1}$ (b) $2\sqrt{2}\,kgm^2s^{-1}$
(c) $4\sqrt{2}\,kgm^2s^{-1}$ (d) $2\,kgm^2s^{-1}$

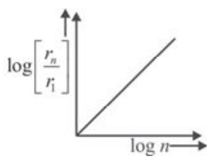
JEE-ADVANCED EVA-AITS - 2

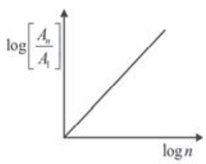
"A Colossal juncture to get introduced to the national standard mock tests of JEE ADVANCED"

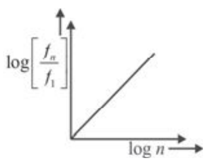
Section-I
(SINGLE ANSWER TYPE)

1. If in a hydrogen atom, radius of nth Bohr orbit is r_n, frequency of revolution of electron in nth orbit is f_n, and area enclosed by the nth orbit is A_n, then which of the following graphs is not correct?

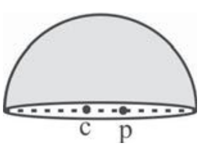
(a) 

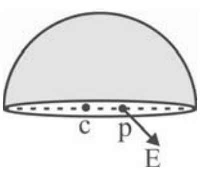
(b) 

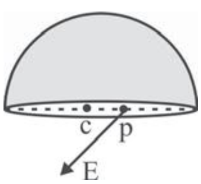
(c) 

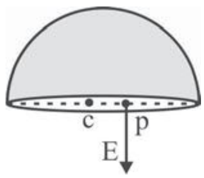
(d) 

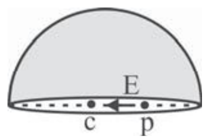
2. A thin non-conducting hemispherical shell contains a positive charge q on it, which is uniformly distributed on the shell. A point p lies on the diameter of shell as shown in figure. Then the direction of electric field at the point 'p' is



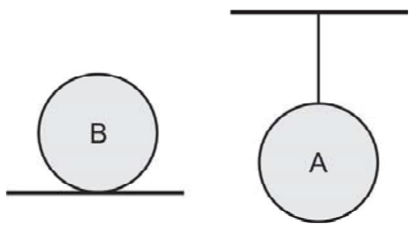
(a) 

(b) 

(c) 

(d) 

3. Consider two identical homogeneous spheres, A and B, with the same initial temperatures. One of them is at rest on a horizontal plane, while the second one hangs on a thread. The same quantity of heat has been supplied to both balls. Which of the following statement is true about the temperatures of A and B?



(a) $T_A < T_B$

(b) $T_A > T_B$

(c) $T_A = T_B$

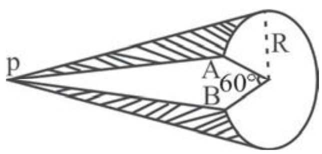
(d) Can't be predicted

4. Magnetic field exist in the space and given as $\vec{B} = -\frac{B_0}{l^2}x^2\hat{k}$, where B_0 and l are positive constants. A particle having positive charge 'q' and mass 'm' is projected with speed 'v_0' along positive x-axis from the origin. What is the maximum distance of the charged particle from the y-axis before it turns back due to the magnetic field. (ignore any interaction other than magnetic field)

(a) $\left(\dfrac{ml^2 v_0}{3qB_0}\right)^{1/3}$ (b) $\left(\dfrac{3ml^2 v_0}{3qB_0}\right)^{1/3}$

(c) $\left(\dfrac{3ml^2 v_0}{qB_0}\right)^{1/3}$ (d) $\left(\dfrac{ml^2 v_0}{qB_0}\right)^{1/3}$

5. A non-conducting hollow cone has charge density σ. Part ABP is cut and removed from the cone. The potential due to the remaining portion of the cone at point 'P' is

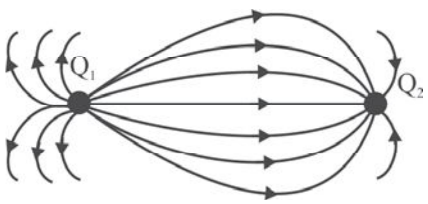


(a) $\dfrac{5}{6}\dfrac{\sigma R}{\varepsilon_0}$ (b) $\dfrac{5}{24}\dfrac{\sigma R}{\varepsilon_0}$

(c) $\dfrac{5}{3}\dfrac{\sigma R}{\varepsilon_0}$ (d) $\dfrac{5}{12}\dfrac{\sigma R}{\varepsilon_0}$

Section -II
(MORE THAN ONE ANSWER TYPE)

1. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis are shown in the figure. These lines suggest that



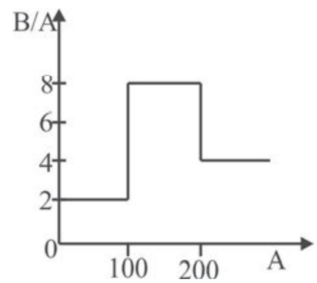
(a) $|Q_1| > |Q_2|$

(b) $|Q_1| < |Q_2|$

(c) At a finite distance to the left of Q_1 the electric field is zero

(d) At a finite distance to the right of Q_2 the electric field is zero

2. Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below:



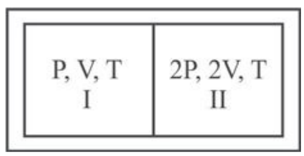
(a) Fusion of two nuclei with mass numbers lying in the range of 1 < A < 50 will release energy

(b) Fusion of two nuclei with mass numbers lying in the range of 51 < A < 100 will release energy

(c) Fission of a nucleus lying in the mass range of 100 < A < 200 will release energy when broken into two equal fragments

(d) Fission of a nucleus lying in the mass range of 200 < A < 260 will release energy when broken into two equal fragments

3. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position?



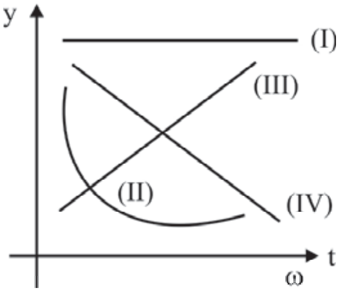
(a) The pressure in the two compartments are equal

(b) Volume of compartment I is 3V/5

(c) Volume of compartment II is 12V/5

(d) Final pressure in compartment I is 5P/3

4. In a series L-C-R circuit, different physical quantities vary with frequency ω. Which of the following curves represent correct frequency variation of the corresponding quantity.



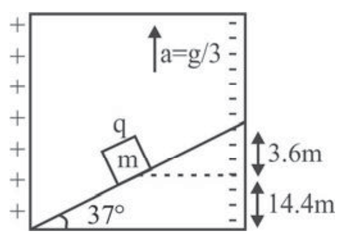
(a) Curve I for R (b)Curve II for current I

(c) Curve III for X_L (d) Curve IV for X_C

5. A uniform conducting ring of mass m=2 kg, radius r=2m and resistance 8Ω is kept on smooth horizontal surface. A time varying magnetic field $\vec{B} = (\hat{i} + t^2\hat{j})$ tesla is present in the region, where t is time in second and take vertical as y-axis. (Take $\pi^2 = 10$). Then

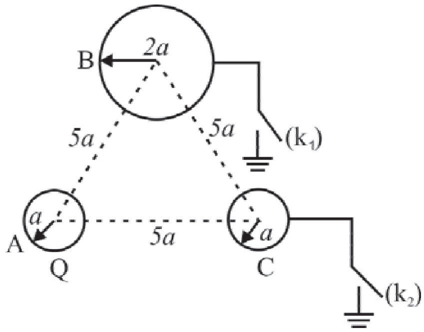
(a) Time when ring starts toppling is 1 sec
(b) Time when ring starts topping is 3/4 sec
(c) Heat generated through the ring all instant when the ring start toppling is 40/3 joule.
(d) Heat generated through the ring till the instant when the ring start toppling is 80/3 joule

6. A small block of mass 'm' is kept on a smooth inclined plane of angle 37⁰, placed in an elevator going upward with acceleration $a = \frac{g}{3}$ as shown in the figure. A horizontal electric field E perpendicular to the left and right vertical wall of the elevator exists. The charge on the block is +q. Then (take $g = 10m/s^2$ and $\frac{qE}{m} = 25m/s^2$)



(a) The block hits the wall at 1s
(b) The block hits the wall at 2s
(c) The block does not move w.r.to the lift
(d) In the absence of E the block slides down the incline

7. The following diagram shows three metal balls. Ball 'A' is charged to 'Q' coulomb and B,C are uncharged. The charges on balls B and C when the switches K_1 and K_2 are closed are respectively



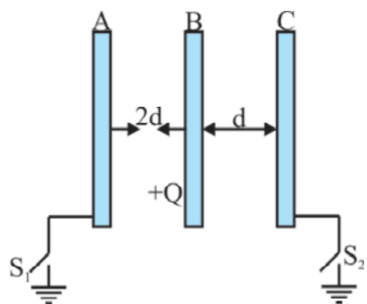
(a) Charge on B is $\frac{-8Q}{23}$

(b) Charge on B is $\frac{2Q}{23}$

(c) Charge on C is $\frac{-3Q}{23}$

(d) Charge on C is $\frac{Q}{23}$

8. Three identical parallel conducting plates A, B and C are placed as shown. Switches S_1 and S_2 are opened and A and C are connected to earth when closed +Q charge is given to B. After closing S_1 and S_2



(a) $\frac{-Q}{3}$ passes through S_1

(b) $\frac{2Q}{3}$ passes through S_2

(c) $\frac{2Q}{3}$ passes through S_1

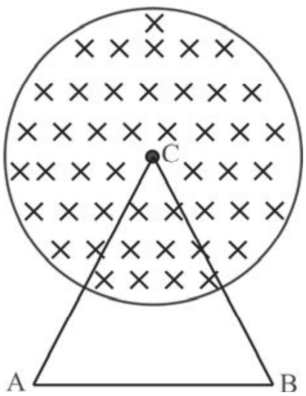
(d) $\frac{Q}{4}$ passes through S_2

Section -III
(INTEGER TYPE)

1. A coil of inductance L=5H and resistance $R = 55\Omega$ is connected in series to the mains alternating voltage of frequency f=50 Hz in series. What can be the non-zero capacitance of the capacitor (in μF) connected in series with the coil if the power dissipated has to remain unchanged. (take $\pi^2 = 10$)

2. The electrostatic potential existing in the space is given as $V = -\left(\frac{x^3}{6\varepsilon_0} + 2\right)$ volts. Find that the charge density (in coulomb/ m^3) at x=2m.

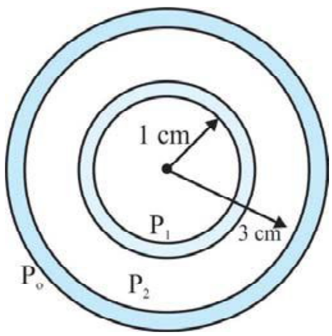
3. A uniform magnetic field $B = C_1 t + C_2$ is directed into the plane of paper in the cylindrical volume of radius 'r'. Here C_1 and C_2 are positive constants and 't' is in seconds. A loop in the form of an equilateral triangle 'ABC' of side length '2r' is placed such that vertex C lies on the axis of cylindrical region and the plane of loop is perpendicular to the axis. Resistance of unit length of wire is $'\lambda'\,\Omega/m$. The emf across AB after some time t is $\frac{C_1 \pi r^2}{x}$. The value of x is



(a) $+\frac{C_1 \pi r^2}{6}$ (b) $\frac{C_1 \pi r^2}{3}$

(c) $+\frac{C_1 \pi r^2}{2}$ (d) $\frac{C_1 \pi r^2}{9}$

4. A spherical soap bubble of radius 1 cm is formed inside another of radius 3cm the radius of single soap bubble which maintains the same pressure difference as inside the smaller and outside the larger soap bubble is $\frac{x}{4}$ cm. The value of x is



(a) 4/3 (b) 3/4 (c) 1/2 (d) 2

5. An ac source of angular frequency ω is fed across a resistor r and a capacitor C in series. The current registered is I. If the frequency of source is changed to $\omega/3$ (maintaining the same voltage), the current in the circuit is found to be halved. The ratio of reactance to resistance at the original frequency ω is $\sqrt{\frac{x}{5}}$. The value of x is

SOLVED PAPER

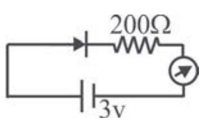
★ Physics ★

JEE MAIN 2018

1. The angular width of the central maximum in a single sit diffraction pattern is $60°$. The width of the slit is 1 μm. The slit is illuminated by monochromatic plane waves. If another slit of same width is made near it, Young's fringes can be observed on a screen placed at a distance 50 cm from the slits. If the observed fringe width is 1 cm, what is slit separation distance ?(i.e., distance between the centres of each slit.)
   (a) 50 μm (b) 75 μm
   (c) 100 μm (d) 25 μm

2. An electron from various excited state of hydrogen atom emit radiation to come to the ground state. Let λ_n, λ_g be the de broglie wavelenght of the electron in the n^{th} state and the ground state respectively. Let $\wedge_n$ be the wavelenght of the emitted photon in the transition from the n^{th} state to the ground state. For large n, (A, B are constants)
   (a) $\wedge_n \approx A + B\lambda_n$ (b) $\wedge_n^2 \approx A + B\lambda_n^2$
   (c) $\wedge_n^2 \approx \lambda$ (d) $\wedge_n \approx A + \frac{B}{\lambda_n^2}$

3. The reading of the ammeter for a silicon diode in the given circuit is :



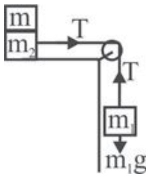
   (a) 15 mA (b) 11.5 mA
   (c) 13.5 mA (d) 0

4. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the density is :
   (a) 3.5% (b) 4.5 % (c) 6% (d) 2.5%

5. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B.The relation between r_e, r_p, r_α is
   (a) $r_e < r_p = r_\alpha$ (b) $r_e < r_p < r_\alpha$
   (c) $r_e < r_\alpha < r_p$ (b) $r_e > r_p = r_\alpha$

6. Three concentric metal shells A, B and C of respective radii a,b and c $(a < b < c)$ have surface charge densities $+\sigma, -\sigma$ and $+\sigma$ respectively. The potential of shell B is :
   (a) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$ (b) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2 - c^2}{b} + a\right]$
   (c) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2 - c^2}{c} + a\right]$ (d) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2 - b^2}{a} + c\right]$

7. Two masses $m_1 = 5kg$ and $m_2 = 10kg$, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is .015. The minimum weight m that should be put on top m_2 to stop motion is :



(a) 27.3 kg (b) 43.3 kg
(c) 10.3 kg (d) 18.3 kg

8. A particle is moving in a circular path of radius a under the action of an attractive potential $U=-\frac{k}{2r^2}$. Its total energy is :

(a) $\frac{k}{2a^2}$ (b) Zero (c) $-\frac{3}{2}\frac{k}{a^2}$ (d) $-\frac{k}{4a^2}$

9. A parallel plate capacitor of capacitance 90 pF is connected to a battery of emf 20V. If a dielectric material of dielectric constant $k=\frac{5}{3}$ is inserted between the plates, the magnitude of the induced charge will be

(a) 0.3 n C (b) 2.4 n C (c) 0.9n C (d) 1.2 n C

10. A silver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of 10^{12} / sec. What is the force constant of the bonds connecting one atom with the other ? (Mole wt. of silver=108 and Avagadro number $=6.02\times10^{23}$ $gm\,mole^{-1}$)

(a) 7.1 N/m (b) 2.2 N/m
(c) 5.5 N/m (d) 6.4 N/m

11. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d ; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c. The values of p_d and p_c are respectively :

(a) (.28, .89) (b) (0, 0)
(c) (0, 1) (d) (.89, .28)

12. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. Where the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is:

(a) $\sqrt{3}$ (b) $\sqrt{2}$ (c) $\frac{1}{\sqrt{2}}$ (d) 2

13. In a potentiometer experiment, it is found that no current passes through the glavanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of 5Ω, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell.

(a) 1.5 Ω (b) 2 Ω (c) 2.5 Ω (d) 1 Ω

14. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz?

(a) 2×10^4 (b) 2×10^5
(c) 2×10^6 (d) 2×10^3

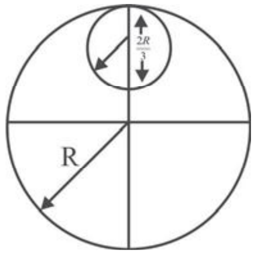
15. Unpolarized light of intensity 1 passes through an ideal polarizer A. Another identical polarizer B is placed behind A. The intensity of light beyond B is found to be $\frac{1}{2}$. Now another identical polarizer C is placed between A and B. The intensity beyond B is now found to be $\frac{1}{8}$. The angle between polarizer A and C is:

(a) 30° (b) 45° (c) 60° (d) 0°

16. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1 $k\Omega$. How much was the resistance on the left slot before interchanging the resistances?

(a) 505 $k\Omega$ (b) 550 $k\Omega$
(c) 910 $k\Omega$ (d) 990 $k\Omega$

17. From a uniform circular disc of radius R and mass 9M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is :



(a) $\frac{40}{9}MR^2$ (b) $10MR^2$

(c) $\frac{37}{9}MR^2$ (d) $4MR^2$

18. In a collinear collision, a particle with an initial speed V_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is:

(a) $\sqrt{2}V_0$ (b) $\frac{V_0}{2}$ (c) $\frac{V_0}{\sqrt{2}}$ (d) $\frac{V_0}{4}$

19. An EM wave from air enters a medium. The electric fields are

$\vec{E}_1 = E_{01}\hat{x}\cos\left[2\pi v\left(\frac{z}{c}-t\right)\right]$ in air and

$\vec{E}_2 = E_{02}\hat{x}\cos\left[k\left(2z-ct\right)\right]$ in medium, where the wave number k and frequency v refer to their values in air. The medium is non-magnetic. If ε_{r1} and ε_{r2} refer to relative permittivity of air and medium respectively, where of the following options is correct?

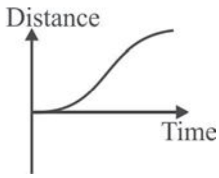
(a) $\frac{\varepsilon_{r1}}{\varepsilon_{r2}} = 2$ (b) $\frac{\varepsilon_{r1}}{\varepsilon_{r2}} = \frac{1}{4}$

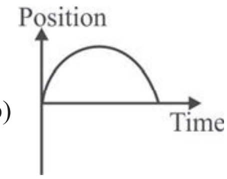
(c) $\frac{\varepsilon_{r1}}{\varepsilon_{r2}} = \frac{1}{2}$ (d) $\frac{\varepsilon_{r1}}{\varepsilon_{r2}} = 4$

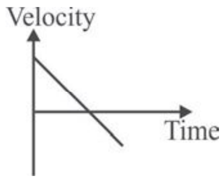
20. For an RLC circuit driven with voltage of amplitude v_m and frequency $\omega_0 = \frac{1}{\sqrt{LC}}$ the current exhibits resonance. The quality factor, Q is given by:

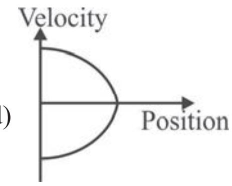
(a) $\frac{\omega_0 R}{L}$ (b) $\frac{R}{(\omega_0 C)}$ (c) $\frac{CR}{\omega_0}$ (d) $\frac{\omega_0 L}{R}$

21. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up

(a)


(b)


(c)


(d)


22. Two batteries with e.m.f 12V and 13V are connected in parallel across a load resistor of 10Ω. The internal resistances of the two batteries are 1Ω *and* 2Ω respectively. The voltage across the load lies between.

(a) 11.5 V and 11.6 V (b) 11.4 V and 11.5 V
(c) 11.7 V and 11.8 V (d) 11.6 V and 11.7 V

23. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n^{th} power of R. If the period of rotation of the particle is T, then,

(a) $T \propto R^{\frac{n}{2}+1}$ (b) $T \propto R^{(n+1)/2}$

(c) $T \propto R^{n/2}$ (d) $T \propto R^{3/2}$ for any n

24. If the series limit frequency of the lyman series is V_L, then the series limit frequency of the pfund series is :

(a) 16 V_L (b) $V_L/16$ (c) $V_L/25$ (d) 25 V_L

25. In an a.c circuit, the instataneous e.m.f and current are given by

$e = 100\sin 30t$ $\quad$ $i = 20\sin\left(30t - \frac{\pi}{4}\right)$

In one cycle of *a.c.*, the average power consumed by the circuit and the wattless current are, respectively.

(a) $\frac{1000}{\sqrt{2}},10$ (b) $\frac{50}{\sqrt{2}},0$

(c) 50,0 (d) 50, 10

26. Two moles of an ideal monoatomic gas occupies a volume V at $27°C$. The gas expands adiabatically to a volume 2V. Calculate (a) the final temperature of the gas and (b) change in its internal energy.

1.(a) 195 K (b) -2.7 kJ

2. (a) 189 K (b) -2.7 kJ

3. (a) 195 K (b) 2.7 kJ

4. (a) 189 K (b) 2.7 kJ

27. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area a floats on the sueface of the liquid, convering entire cross section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$, is:

(a) $\frac{Ka}{3mg}$ (b) $\frac{mg}{3Ka}$ (c) $\frac{mg}{Ka}$ (d) $\frac{Ka}{mg}$

28. A granite rod of 60 cm length is clamped at its middle point is set into longitudinal vibrations. The density of granite is $2.7\times10^3 kg/m^3$ and its young's modulus is 9.27×10^{10} pa. What will be the fundamental frequency of the longitudinal vibrations?

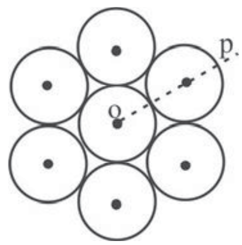
(a) 2.5kHz (b) 10 kHz (c) 7.5 kHz (d) 5 kHz

29. The mass of a hydrogen molecule is $3.32\times10^{-27} kg$. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area $2cm^2$ at an angle of $45°$ to the normal, and rebound elastically with a speed of 10^3 m/s, then the pressure on the wall is nearly:

(a) $4.70\times10^3 N/m^2$ (b) $2.35\times10^2 N/m^2$

(c) $4.70\times10^2 N/m^2$ (d) $2.35\times10^3 N/m^2$

30. Seven identical circular planar disks, each of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is:



(a) $\frac{55}{2}MR^2$ (b) $\frac{73}{2}MR^2$

(c) $\frac{181}{2}MR^2$ (d) $\frac{19}{2}MR^2$

ANSWER KEY

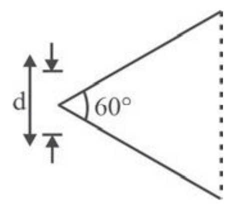
1. d	2. d	3. b	4.b	5. a
6. a	7. a	8. b	9. d	10. a
11. d	12. b	13. a	14. b	15. b
16. b	17. d	18. a	19. b	20. d
21. a	22. a	23. b	24. c	25. a
26. b	27. b	28. d	29. d	30. c

HINTS & SOLUTIONS

1. Sol: In diffraction

$$d\sin 30° = \lambda$$

$$\lambda = \frac{d}{2}$$



Young's fringe width

[d'-separation between two slits]

$$\beta = \frac{\lambda\times D}{d'}$$

$$10^{-2} = \frac{d}{2}\times\frac{50\times10^{-2}}{d'}$$

$$10^{-2} = \frac{10^{-6} \times 50 \times 10^{-2}}{2 \times d'}$$

$$d' = 25\mu m$$

2.Sol:

$$\lambda_n = \frac{h}{mu} = \frac{h}{\sqrt{2mk_n}}$$

$$\Rightarrow k_n = \frac{h^2}{2m\lambda_n^2}; k_g = \frac{h^2}{2m\lambda_g^2}$$

$$\Rightarrow k_g - k_n = \frac{h^2}{2m}\left[\frac{1}{\lambda_g^2} - \frac{1}{\lambda_n^2}\right]$$

$$E_n = -k_n$$

For emitted photon

$$\frac{hc}{\wedge_n} = E_n - E_g = K_g - K_n$$

$$\frac{1}{\wedge_n} = \frac{K_g - K_n}{hc}$$

$$\wedge_n = \frac{hc}{K_g - K_n} \Rightarrow \wedge_n = \frac{hc}{\frac{h^2}{2m}\left[\frac{1}{\lambda_g^2} - \frac{1}{\lambda_n^2}\right]}$$

$$\wedge_n = \frac{2mc}{h\left(\frac{\lambda_n^2 - \lambda_g^2}{\lambda_g^2 \lambda_n^2}\right)}$$

$$\wedge_n = \frac{2mc\lambda_g^2 \lambda_g^2}{h\left(\lambda_n^2 - \lambda_g^2\right)}$$

as $\lambda_n \propto n$

$$\lambda_n >> \lambda_g$$

$$\wedge_n = \frac{2mc\lambda_g^2}{h}\left[1 - \left(\frac{\lambda_g}{\lambda_n}\right)^2\right]^{-1}$$

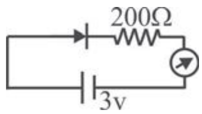
$$\wedge_n = \frac{2mc\lambda_g^2}{h}\left[1 + \left(\frac{\lambda_g}{\lambda_n}\right)^2 + \text{higher powers of } \frac{\lambda_g}{\lambda_n}\right]$$

$$\wedge_n \approx A + \frac{B}{\lambda_n^2}$$

where $A = \frac{2mc\lambda_g^2}{h}$

$$\& B = \frac{2mc\lambda_g^4}{h}$$

3.Sol:



Silicon diode is in forward bias
Hence across diode potential barrier

$$\Delta V = 0.7 \text{ volts}$$

$$I = \frac{V - \Delta V}{R} = \frac{3 - 0.7}{200}$$

$$= \frac{2.3}{200} = 11.5mA$$

4.Sol: Density $= \frac{Mass}{Volume}$

$$\frac{1\Delta d}{d} = \frac{1\Delta M}{M} + \frac{3\Delta L}{L}$$

$$= 1.5 + 3(1)$$

$$= 4.5\%$$

5.Sol: Radius of circular path in magnetic field is given by $R = \frac{\sqrt{2Km}}{qB}$

where K=Kinetic energy of particle
m=mass of particle
q=charge on particle
B=magnetic field intensity
R=radius of path

For electron

$$r_e = \frac{\sqrt{2k\, m_e}}{eB} \quad ...(i)$$

For proton

$$r_p = \frac{\sqrt{2k\, m_p}}{eB} \quad ...(ii)$$

For α particle

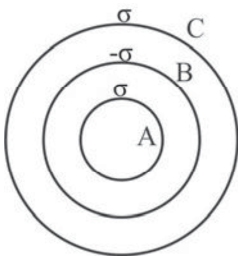
$$r_\alpha = \frac{2k\, m_\alpha}{q_\alpha B} = \frac{\sqrt{2k\, 4m_p}}{2eB} = \frac{\sqrt{2k\, m_p}}{eB} \quad ...(iii)$$

as $m_e < m_p$ so $r_e < r_p = r_\alpha$

6.Sol: $V_{outside} = \frac{KQ}{r}$

Where r is distance of point from centre of shell

$$V_{inside} = \frac{KQ}{R}$$



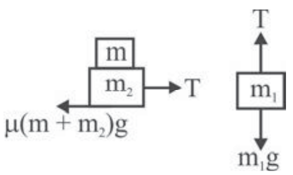
Where 'R' is radius of the shell

$$V_b = \frac{kq_A}{r_b} + \frac{kq_B}{r_b} + \frac{kq_c}{r_c}$$

$$V_B = \frac{1}{4\pi \in_0}\left[\frac{\sigma 4\pi a^2}{b} - \frac{\sigma 4\pi b^2}{b} + \frac{\sigma 4\pi c^2}{c}\right]$$

$$V_B = \frac{\sigma}{\in_0}\left[\frac{a^2 - b^2}{b} + c\right]$$

7.Sol:



$$T - 0.15(m+10)g = 0$$

$$5 = \frac{3}{20}(m+10)$$

$$\frac{100}{3} = m + 10$$

$$m = 23.3kg$$

8.Sol: $F = -\frac{\partial u}{\partial r} = \frac{K}{r^3}$

Since it is performing circular motion

$$F = \frac{mv^2}{r} = \frac{K}{r^3}$$

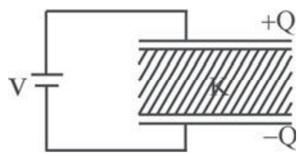
$$mv^2 = \frac{K}{r^2}$$

$$\Rightarrow K.E = \frac{1}{2}mv^2 = \frac{K}{2r^2}$$

Total energy $= P.E. + K.E$

$$= -\frac{K}{2r^2} + \frac{K}{2r^2} = Zero$$

9.Sol:



$$Q = (KC)V$$

$$= \left(\frac{5}{3} \times 90\,pF\right)(20V)$$

$$= 3000\,pC$$

$$= 3n\,C$$

Induced charges on dielectric

$$Q_{ind} = Q\left(1 - \frac{1}{k}\right) = 3nC\left(1 - \frac{3}{5}\right) = 1.2nC$$

10.Sol: Time period of SHM given by

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

$$\text{Frequency} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = 10^{12}$$

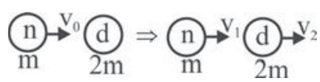
Where m=mass of one atom

$$= \frac{108}{(6.02 \times 10^{23})} \times 10^{-3} kg$$

$$\frac{1}{2\pi}\sqrt{\frac{k}{108 \times 10^{-3}} \times 6.02 \times 10^{23}} = 10^{12}$$

11.Sol: Let initial speed of neutron is V_o and kinetic energy is K.

I^{st} *collision* :



by momentum conservation

$$mv_0 = mv_1 + 2mv_2 \Rightarrow v_1 + 2v_2 = v_0$$

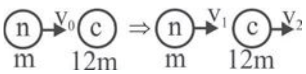
by $e = 1$ $\quad v_2 - v_1 = v_0$

$$\Rightarrow v_2 = \frac{2v_0}{3}; v_1 = -\frac{v_0}{3}$$

$$\text{Fractional loss} = \frac{\frac{1}{2}mv_0^2 - \frac{1}{2}m\left(\frac{v_0}{3}\right)^2}{\frac{1}{2}mv_0^2}$$

$$\Rightarrow p_d = \frac{8}{9} \approx .89$$

2^{nd} collision:



by momentum conservation

$$mv_0 = mv_1 + 12mv_2 \Rightarrow v_1 + 12v_2 = v_0$$

by $e = 1$ $\quad v_2 - v_1 = v_0$

$$v_2 = \frac{2v_0}{13}; v_1 = \frac{-11v_0}{13}$$

Now fraction loss of energy

$$p_c = \frac{\frac{1}{2}mv_0^2 - \frac{1}{2}m\left(\frac{11v_0}{13}\right)^2}{\frac{1}{2}mv_0^2} = \frac{48}{169} \approx 0.28$$

12.Sol: Dipole moment of circular loop is m

$m_1 = I.A = I..\pi R^2$ {R=radius of the loop}

$$B_1 = \frac{\mu_0 I}{2R}$$

moment becomes double

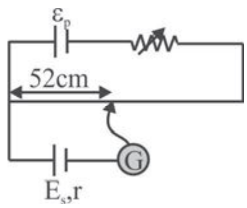
$\Rightarrow$ R becomes $\sqrt{2}R$ (keeping current constant)

$$m_2 = I.\pi\left(\sqrt{2}R\right)^2 = 2.I\pi R^2 = 2m_1$$

$$B_2 = \frac{\mu_0 I}{2\left(\sqrt{2}R\right)} = \frac{B_1}{\sqrt{2}}$$

$$\frac{B_1}{B_2} = \sqrt{2}$$

13.Sol: Without shunting condition

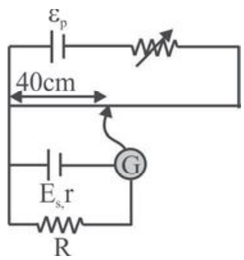


$$E_s = 52 \times x \qquad (1)$$

when balanced

Where, x = potential gradient of wire.

With shunting condition



On balancing

$$E_s - \frac{E_s}{(r+R)}r = 40 \times x \qquad (2)$$

On solving:

$$\frac{(1)}{(2)} \Rightarrow \frac{1}{1 - \frac{r}{r+R}} = \frac{52}{40} \therefore r = 1.5\Omega$$

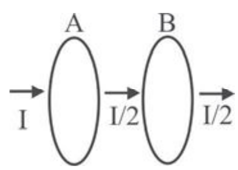
14.Sol: Since the carrier frequency is distributed as band width frequency, so

10% of 10 GHz $= n \times 5$ kHz

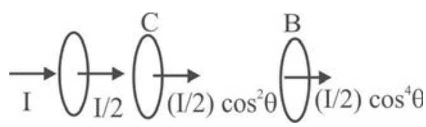
$$\frac{10}{100} \times 10 \times 10^9 = n \times 5 \times 10^3$$

$n = 2 \times 10^5$ telephonic channels

15.Sol: Axis of transmission of A & B are parallel



Now,

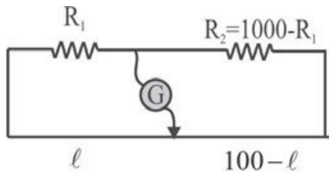


$$\frac{I}{2}\cos^4\theta = \frac{I}{8} \Rightarrow \cos^4\theta = \frac{I}{4}$$

$$\cos\theta = \frac{1}{\sqrt{2}}$$

$$\theta = 45°$$

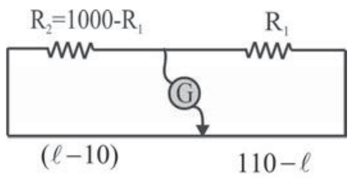
16.Sol: $R_1 + R_2 = 1000 \Rightarrow R_2 = 1000 - R_1$



On balancing condition

$$R_1(100-\ell) = (1000 - R_1)\ell \quad ...(1)$$

On inter changing resistance



On balancing condition

$$(1000 - R_1)(110-\ell) = R_1(\ell - 10)$$

or $R_1(\ell-10) = (1000-R_1)(110-\ell) \quad ....(2)$

$(1) \div (2)$

$$\frac{100-\ell}{\ell-10} = \frac{\ell}{110-\ell}$$

$$\Rightarrow (100-\ell)(110-\ell) = \ell(\ell-10)$$

$$\Rightarrow 11000 - 100\ell - 110\ell + \ell^2 - 10\ell$$

$$\Rightarrow 11000 = 200l$$

$\ell = 55$

put in eq(1)

$$R_1(100-55) = (1000-R_1)55$$

$$R_1(45) = (1000-R_1)55$$

$$R_1(9) = (1000-R_1)11$$

$$20R_1 = 11000$$

$$R_1 = 550$$

17.Sol: MOI of removed part about axis passing through COM & $\perp$ to plane of disc

$$= I_{cm} + md^2$$

$$\frac{(m)(R/3)^2}{2} + m\left[\frac{4R^2}{9}\right] = \frac{mR^2}{2}$$

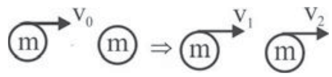
So MOI of remaining portion

=[MOI of whole disc-MOI of removed part]

$$= (9m)\frac{R^2}{2} - \frac{mR^2}{2} = \frac{mR^2}{2}[8]$$

$$I_{remaining} = 4mR^2$$

18.Sol: initial



$$\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{3}{2}\left(\frac{1}{2}mv_0^2\right)$$

$$\Rightarrow V_1^2 + V_2^2 = \frac{3}{2}V_0^2 \quad ...(1)$$

from momentum conservation

$$mv_0 = m(v_1 + v_2) \quad ...(2)$$

$$(v_1+v_2)^2 = v_0^2$$

$$\Rightarrow v_1^2 + v_2^2 + 2v_1v_2 = v_0^2$$

$$2v_1v_2 = -\frac{v_0^2}{2}$$

$$(v_1 - v_2)^2 = v_1^2 + v_2^2 - 2v_1v_2 = \frac{3}{2}v_0^2 + \frac{v_0^2}{2}$$

$$v_1 - v_2 = \sqrt{2}v_0$$

19.Sol: Velocity of EM wave is given by $\frac{1}{\sqrt{\mu\varepsilon}}$

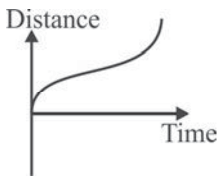
velocity in air $\frac{\omega}{k} = c$

velocity in medium $\frac{c}{2}$

$$\therefore \frac{\frac{1}{\sqrt{\varepsilon_{r1}}}}{\frac{1}{\varepsilon_{r2}}} = \frac{c}{\left(\frac{c}{2}\right)} = 2 \Rightarrow \frac{\varepsilon_{r1}}{\varepsilon_{r2}} = \frac{1}{4}$$

20.Sol: Quality factor $=\dfrac{\omega_0 L}{R}$

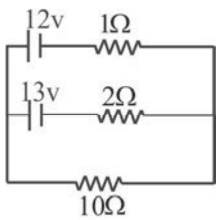
21.Sol: In this question option (2) and (4) are the corresponding position -time graph and velocity-position graph of option (3) and its distance-time graph is given as



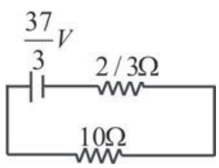
Hence incorrect graph is option(1)

22.Sol:

$$\frac{\frac{12}{1}+\frac{13}{2}}{\frac{1}{1}+\frac{1}{2}}=\frac{37}{3}V$$



$$r_{eq}=\frac{2\times 1}{2+1}=\frac{2}{3}\Omega$$



Now its equivalent circuit is :

$$i=\frac{37/3}{10+\frac{2}{3}}=\frac{37}{32}$$

$$\therefore V_{10\Omega}=i\times 10=\frac{37}{32}\times 10=\frac{370}{32}=11.56 \text{ volt}$$

23.Sol: $m\omega^2 R=$ force $\propto \dfrac{1}{R^n}$

$$\Rightarrow \omega^2 \propto \frac{1}{R^{n+1}} \Rightarrow \omega \propto \frac{1}{R^{\frac{n+1}{2}}}$$

Time period $T=\dfrac{2\pi}{\omega}\propto R^{\frac{n+1}{2}}$

24.Sol: $h\nu = E_0\left[\dfrac{1}{n_1^2}-\dfrac{1}{n_2^2}\right]$

For Lyman series for series limit $n_2=\infty, n_1=1$

$$h\nu_L = E_0[1] \qquad ....(1)$$

for-p-fund series

for series limit $n_2=\infty, n_1=5$

$$h\nu_p = E_0\left[\frac{1}{25}\right] \qquad ....(2)$$

By dividing equation (1) and (2)

$$\frac{\nu_L}{\nu_p}=\frac{25}{1}\Rightarrow \nu_p=\nu_L/25$$

25.Sol: $P_{avg}=V_{rms}I_{rms}\cos\theta$

$$=\left(\frac{v_0}{\sqrt{2}}\right)\left(\frac{I_0}{\sqrt{2}}\right)\cos\theta$$

$$=\left(\frac{1000}{\sqrt{2}}\right)\left(\frac{20}{\sqrt{2}}\right)\cos 45^\circ=\frac{1000}{\sqrt{2}} \text{ watt}$$

Wattless current $=I_{rms}\sin\theta$

$$=\frac{I_0}{\sqrt{2}}\sin\theta=\frac{20}{\sqrt{2}}\sin 45^\circ=10 \text{ amp.}$$

26.Sol: In an adiabatic process

$PV^\gamma=$ constant

and,PV = nRT, gives

$$\Rightarrow V^{\gamma-1}\propto \frac{1}{T}$$

$$\left(\frac{V_1}{V_2}\right)^{\gamma-1}=\left(\frac{T_2}{T_1}\right)$$

$$T_2=T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} \quad \text{monoatomic gas : } \gamma=\frac{5}{3}$$

$$\Rightarrow T_2 = (300K)\left(\frac{V}{2V}\right)^{\frac{5}{3}-1}$$

=189 K (final temperature)
change in internal energy

$$\Delta U = n\frac{f}{2}R\ \Delta T$$

$$= 2\left(\frac{3}{2}\right)\left(\frac{25}{3}\right)(-111) = -2.7kJ$$

27.Sol: [Bulk modules $= \frac{volumetric\ \ stress}{volumetric\,strain}$]

$$K = \frac{mg}{a\left(\frac{dV}{V}\right)}$$

$$\frac{dV}{V} = \frac{mg}{Ka} \qquad ....(i)$$

Volume of sphere $\rightarrow V = \frac{4}{3}\pi R^3$

Fractional change in volume

$$\text{ume}\ \frac{dV}{V} = \frac{3dr}{r} \qquad ...(ii)$$

Using eq. (i) & (ii) $\frac{3dr}{r} = \frac{mg}{Ka}$

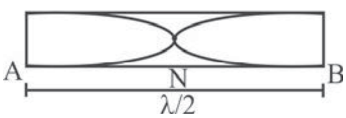
$$\frac{dr}{r} = \frac{mg}{3Ka}$$

28.Sol: Velocity of wave $= \sqrt{\frac{V}{\rho}}$

$$= \sqrt{\frac{9.27\times 10^{10}}{2.7\times 10^3}} = \sqrt{3.433\times 10^7} = 10^3\times\sqrt{34.33}$$

$v_\omega = 5.85\times 10^3\,m/\sec$.

Since rod is clamped at middle
fundamental wave shape is as follow



$$\frac{\lambda}{2} = L$$

$$\lambda = 2L$$

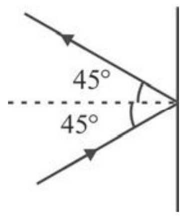
$L = 60cm = 0.6m$ (given)

$$\lambda = 1.2m$$

$$f = \frac{v}{\lambda} = \frac{5.85\times 10^3}{1.2}$$

$$= 4.88\times 10^3\,Hz \simeq 5KHz$$

29.Sol: $F = \frac{dp}{dt} = 2n\,mv\cos 45°$

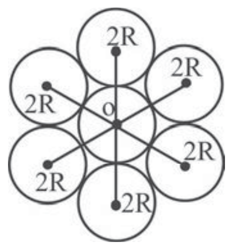


$$\text{Pressure} = \frac{F}{A} = \frac{2n\,mv\cos 45°}{Area}$$

$$= \frac{2\times 10^{23}\times 3.3\times 10^{-27}\times 10^3\times\left(\frac{1}{\sqrt{2}}\right)}{2\times 10^{-4}}$$

$$= 2.35\times 10^3\,N/m^2$$

30.Sol:



$$I_P = I_{cm} + md^2$$

$$= \frac{7MR^2}{2} + 6\left(M\times(2R)^2\right) = \frac{55MR^2}{2}$$

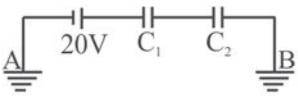
$$I_P = I_0 + md^2$$

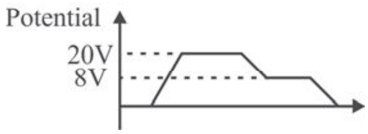
$$= \frac{55MR^2}{2} + 7M\left(3R^2\right) = \frac{181}{2}MR^2$$

BIT SAT EVA-AITS - 2

"A Colossal juncture to get introduced to the national standard mock tests of BITSAT"

1. Two capacitors C_1 and C_2 connected with10V battery and terminal A and B are earthed.The graph shows the variation of potential as one moves from left to right. Then the ratio C_1 / C_2 is





(a) 2/3 (b) 2/5 (c) 4/3 (d) 5/2

2. The sodium nucleus $^{23}_{11}Na$ contains

(a) 11 electrons (b) 12 protons
(c) 23 protons (d) 12 neutrons

3. Resistance of tungsten wire at 150° C is 133 Ω. Its resistance temperature coefficient is 0.0045 / °c. The resistance of this wire at 500°c will be

(a) 140 Ω (b) 225 Ω
(c) 171 Ω (d) 317 Ω

4. Lenz's law is consequence of the law of conservation of

(a) Charge (b) Momentum
(c) Mass (d) Energy

5. There are two metallic spheres of same radii but one is solid and the other is hollow, then

(a) Solid sphere can be given more charge
(b) Hollow sphere can be given more charge
(c) They can be charged equally (maximum)
(d) None of the above

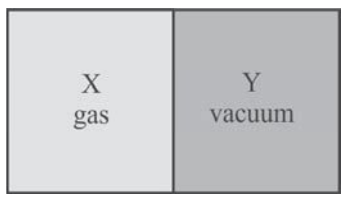
6. Four metal conductors having different shapes
(1) sphere
(2) Cylinder
(3) Pear
(4) Irregular shaped conductor
Are mounted on insulating stands and charged. The one which is best suited to retain the charges for a longer time is

(a) 1 (b) 2 (c) 3 (d) 4

7. The expected energy of the electrons at absolute zero is called

(a) Fermi energy (b) Emission energy
(c) Work function (d) Potential energy

8. A closed container is fully insulated from outside. One half of it is filled with an ideal gas X separated by a plate from the other half Y which contains a vacuum as shown in fig. When the plate is removed, X moves into Y. Which of the following statements is correct?



(a) No work is done by X
(b) X decreases in temperature
(c) X increases in internal energy
(d) X doubles in pressure

9. Electromagnetic waves are transverse in nature is evident by

(a) Polarisation (b) Interference
(c) Diffraction (d) Reflection

10. The frequency of e.m. wave which is best suit to observe a particle of radius $3\times10^{-4}cm$ is of the order of:

(a) 10^{15} (b) 10^{14} (c) 10^{13} (d) 10^{12}

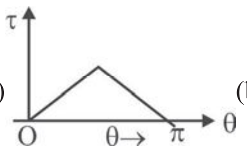
11. A concave mirror of focal length 15 cm forms an image having twice the linear dimensions of the object. The position of the object when the image is virtual will be

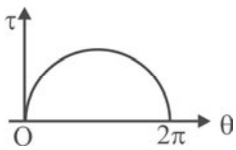
(a) 22.5 cm (b) 7.5 cm
(c) 30 cm (d) 45 cm

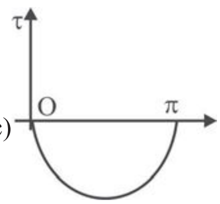
12. If the de-Broglie wavelength for a proton and for a α -particle are equal, then the ratio of their velocities will be

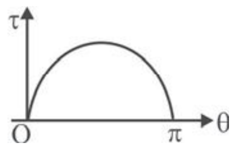
(a) 4:1 (b) 2:1 (c) 1:2 (d) 1:4

13. A current carrying coil is free to move in uniform magnetic field 'B'. The correct graph between torque experienced by the coil and angle made by area of the coil with field among the following is

(a)


(b)


(c)


(d)


14. If an interference pattern have maximum and minimum intensities in 36:1 ratio, then what will be ratio of amplitudes?

(a) 5:7 (b) 7:4
(c) 4:7 (d) 7:5

15. The de-Broglie wavelenght λ associated with an electron having kinetic energy E is given by the expression

(a) $\frac{h}{\sqrt{2mE}}$ (b) $\frac{2h}{mE}$

(c) $2mhE$ (d) $\frac{2\sqrt{2mE}}{h}$

16. A photocell employs photoelectric effect to convert

(a) Change in the frequency of light into a change in electric voltage

(b) Change in the intensity of illumination into a change in photoelectric current

(c) Change in the intensity of illumination into a change in the work function of the photocathode

(d) Change in the frequency of light into a change in the electric current

17. The frequency of an alternating voltage is 50 cycles/sec and its amplitude is 120V. Then the r.m.s. value of voltage is

(a)101.3 V (b) 84.8 V
(c) 70.7 V (d) 56.5 V

18. If the current is halved in a coil, then the energy stored is how much times the previous value

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

19. A bar magnet of magnetic moment $10^4 J/T$ is free to rotate in a horizontal plane . The work done in rotating the magnet slowly from a direction parallel to a horozontal magnetic field of 4×10^{-5} T to a direction $60°$ from the field will be

(a) 0.2J (b) 2.0J
(c) 4.18J (d) $2\times10^2 J$

20. An α -particle and a proton are both simultaneously projected in opposite directions into a region of constant magnetic field perpendicular to the direction of the field. After some time it is found that the velocity of the α -particle has changed in direction by $45°$. Then at this time, the angle between velocity vectors of α -particle and proton is

(a) $90°$ (b) $45°$ (c) $135°$ (d)None

21. A hollow metal sphere of radius 5 cm is charged so that the potential on its surface is 10V. The potential at the centre of the sphere is

(a) 0 V
(b) 10V
(c) Same as at point 5 cm away from the surface
(d) Same as at point 25 cm away from the surface

22. A screw gauge gives the following reading when used to measure the diameter of a wire. Main scale reading :0mm Circular scale reading :52 divisions. Given that 1 mm on main scale corresponds to 100 division of the circular scale.
The diameter of wire from the above data is :

(a) 0.52 cm (b) 0.052 cm
(c) 0.026 cm (d) 0.005 cm

23. Suppose refractive index μ is given as

$$\mu = A + \frac{B}{\lambda^2}$$

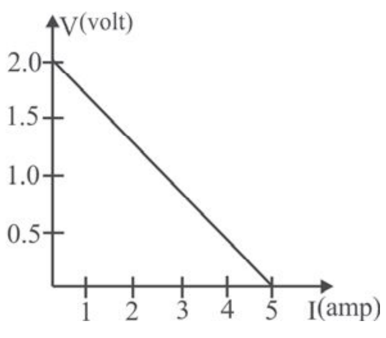
where A and B are constants and λ is wavelength, then dimensions of B are same as that of
(a) Wavelength (b) Volume
(c) Pressure (d) Area

24. Laser beams are used to measure long distance because
(a) They are monochromatic
(b) They are hightly polarised
(c) They are coherent
(d) They have high degree of parallelism

25. A ball is released from the top of a tower of height h. It takes time T to reach the ground. What is the position of the ball(from ground) after time T/3?
(a) h/9 m (b) 7h/9 m
(c) 8h/9 m (d) 17h/18 m

26. A plane flying horizontal at $100 ms^{-1}$ releases an object which reaches the ground in 10 s. At what angle with horizontal it hits the ground?
(a) 55° (b) 45° (c) 60° (d) 75°

27. For a cell, a graph is plotted beween the potential difference V across the terminals of the cell and the current I drawn from the cell shown in the figure. Find the internal resistance of the cell.



(a) 0.4Ω (b) 0.8Ω (c) 2Ω (d) 1Ω

28. A block is lying on the horizontal frictionless surface. One end of a uniform rope is fixed to the block which is pulled in the horizontal direction by applying a force F at the other end. If the mass of the rope is half the mass of the block, the tension in the middle of the rope will be
(a)F (b) F/3 (c) F/5 (d) 5F/6

29. A box of mass 8 kg is placed on a rough inclined plane of inclination θ. Its downward motion can be prevented by applying an upward pull F and it can be made to slide upwards by applying a force 2F. The coefficient of friction between the box and the inclined plane is
(a) $(\tan\theta)/3$ (b) $3\tan\theta$
(c) $(\tan\theta)/2$ (d) $2\tan\theta$

30. The binding energy of an electron in the ground state of He-atom is $E_o = 24.6 eV$. The energy required to remove both the electrons from the atom is
(a) 24.6eV (b) 79.0eV
(c) 54.4eV (d) None of these

31. An engine pumps up 100 kg of water through a height of 10 min 5 s. Given that the efficiency of the engine is 60%, what is the power of the engine? Take $g = 10 ms^{-2}$.
(a) 33 kW (b) 3.3kW
(c) 0.33kW (d) 0.033kW

32. In Bohr's model of hydrogen atom, let PE represent potential energy and TE the total energy. In going to a higher orbit,
(a) PE increases, TE decreases
(b) PE decreases, TE increases
(c) PE increases, TE increases
(d) PE decreases, TE decrease

33. If the intensity of radiation incident on a photocell be increased four times, then the number of photoelectrons and the energy of photoelectrons emitted respectively become
(a) Four times, doubled
(b) Doubled, remains unchanged
(c) Remains unchanged, doubled
(d) Four times, remains unchanged

34. A ball falls vertically onto a floor with momentum, and then bounces repeatedly. If the coefficient of restitution is e, then the total momentum imparted by the ball on the floor till the ball comes to rest is

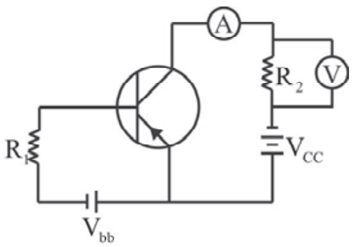
(a) $p(1+e)$ (b) $\frac{p}{1-e}$

(c) $p\left(1+\frac{1}{e}\right)$ (d) $p\left(\frac{1+e}{1-e}\right)$

35. Work done in converting 1 g of ice at $-10°$ C into steam at $100°C$ is

(a) 3045 J (b) 6056 J
(c)721 J (d) 6 J

36. If the resistance R_1 is increased, how will the readings of the ammeter and voltmeter change ?



(a) other increases
(b) both decreases
(c) ammeter increases & voltmeter decreases
(d) ammeter decreases & voltmeter increases

37. Light from a denser medium 1 passes to a rarer medium 2.When the angle of incidence is θ the partially reflected and refracted rays are mutually perpendicular. The critical angle will be

(a) $\sin^{-1}(\cot\theta)$ (b) $\sin^{-1}(\tan\theta)$

(c) $\sin^{-1}(\cos\theta)$ (d) $\sin^{-1}(\sec\theta)$

38. The gravitational potential due to earth at infinite distance from it is zero. Let the gravitational potential at a point p be -5 J kg^{-1}. Suppose, we arbitrarity assume gravitational potential at infinity as $10JKg^{-1}$ then the gravitational potential at p will be

(a) $-5\ J\ kg^{-1}$ (b) $+5\ J\ kg^{-1}$

(c) $-15\ J\ kg^{-1}$ (d) $+15\ J\ kg^{-1}$

39. A cube is shifted to a depth of 100 m in a lake. The change in volume is 0.1%. The bulk modulus of the material is nearly

(a) 10 pa (b) 10^4 pa

(c) 10^7 pa (d) 10^9 pa

40. A hole is made at the bottom of a tank filled with water $(density = 10^3 kg/m^3)$. If the total pressure at the bottom of the tank is 3atm $(1atm = 10^5 N/m^2)$, then the velocity of efflux is

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

(c) $\sqrt{600}$ m/s (d) $\sqrt{500}$ m/s

41. A gas is heated at a constant pressure. The fraction of heat supplied used for external work is

(a) $\frac{1}{\gamma}$ (b) $\left(1-\frac{1}{\gamma}\right)$

(c) $\gamma-1$ (d) $\left(1-\frac{1}{\gamma^2}\right)$

42. A block of mass 1 kg hangs without vibrating at the end of a spring whose force constant is 200 N/m and which is attached to the ceiling of an elevator. The elevator is rising with an upward acceleration of g/3 when the accelaration suddenly ceases. The angular frequency of the block after the acceleration ceases is

(a) 13 rad/s (b) 14 rad/s
(c) 15 rad/s (d) None of these

43. The equation of a transverse wave travelling on a rope is given by y=10 $\sin\pi(0.01x-2.00t)$ where y and x are in centimetres and t in second. The maximum transverse speed of a particle in the rope is about

(a) 63 cm/s (b) 75 cm/s
(c) 100 cm/s (d) 121 cm/s

44. An electric charge q exerts a force F on a similar electric charge q separated by a distance r. A third charge q/4 placed midway between the two charges. Now, the force F will

(a) Become F/3 (b) Become F/9
(c) Become F/27 (d) Remain F

45. A charged particle moves along a circle under the action of possible constant electric and magnetic fields. Which of the following are possible?

(a) E=0, B=0 (b) $E=0, B\neq 0$

(c) $E\neq 0, B=0$ (d) $E\neq 0, B\neq 0$

EVAAITS (NEET - 11) SOLUTIONS

ANSWER KEY

1. a	2. c	3. b	4. c
5. a	6. a	7. d	8. b
9. c	10. d	11. a	12. b
13. b	14. a	15. b	16. a
17. b	18. b	19. c	20. b
21. c	22. c	23. c	24. a
25. c	26. c	27. a	28. d
29. b	30. c	31. c	32. a
33. b	34. b	35. d	36. a
37. a	38. c	39. b	40. b
41. c	42. b	43. c	44. d
45. c			

HINTS & SOLUTIONS

1. Sol: Along the axis of magnet $B_a = \frac{2M}{d^3} = 200$ Gauss $\Rightarrow B_a = \frac{M}{d^3} = 100$ gauss

2.Sol: When a copper ball is heated, its size increases. As volume $\propto (radius)^3$ and area $\propto (radius)^2$, So percentage increase will be largest in its volume.

3.Sol: Total length to be crossed =50+50=100m
Relative velocity=10+15=25m/s

$$\text{Time taken} = \frac{100}{25} = 4s$$

4.Sol: Given $\frac{\sqrt{3}}{2}u = u\cos\theta =$ speed at maximum height

$$\cos\theta = \frac{\sqrt{3}}{2} \Rightarrow \theta = 30°$$

Given that $nH_{max.} = R$

we know $H_{max.} = \frac{R\tan\theta}{4}$

$$n = \frac{4}{\tan\theta} = \frac{4}{\tan 30°} = 4\sqrt{3}$$

5.Sol: $R = \rho\frac{l}{A}$ and

mass m=volume (V) × density (d) =(Al) d
Since wires have same material so ρ and d are same for both, also they have same mass

$$\Rightarrow Al = \text{constant}$$

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^4$$

$$\Rightarrow \frac{34}{R_2} = \left(\frac{r}{2r}\right)^4 \Rightarrow R_2 = 544\Omega$$

6.Sol: During collision of ball with the wall horizontal momentum changes (vertical momentum remains constant)

$$\therefore F = \frac{\text{Change in horizontal momentum}}{\text{Time of contact}}$$

$$= \frac{2p\cos\theta}{0.1} = \frac{2mv\cos\theta}{0.1}$$

$$= \frac{2 \times 0.1 \times 10 \times \cos 60°}{0.1} = 10N$$

7.Sol: The magnetic field on the axis of a coil which is perpendicular to its plane and passing through its centre is $B = \frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$

8.Sol: Given $F \propto x \Rightarrow F = kx, W = \int kx\,dx = \frac{kx^2}{2}$

9.Sol: $I_b = \frac{I_C}{\beta} = \frac{1.5\times10^{-3}}{100} = 1.5\times10^{-5}$ A

Applying KVL to the closed part of the circuit containing R_b and emitter base junction, we have

$$V_{CC} = V_{be} + I_b R_b$$

$$V_{be} = V_{CC} - I_b R_b$$

$$= 24 - (1.5\times10^{-5})(220\times10^3)$$

$$= 20.7V$$

Applying KVL to the closed part of the circuit containing R_b, R_c and base collector junction, we have

$$V_{BC} + I_b R_b - I_c R_c = 0$$

$$V_{BC} = I_c R_c - I_b R_b = 3.75V$$

As both V_{BE} & V_{BC} are positive, i.e., both the junctions are in forward biasing condition, transistor is in satruation state.

10.Sol: $f_0 = \frac{1}{2l}\sqrt{\frac{T}{M}}$

for elastic wire $T = kx$

$x \rightarrow$ elongation from natural length

Hence frequency depends on K and original tension

11.Sol: The moment of inertial of the system is

$$= \frac{2}{5}M\left(\frac{R}{2}\right)^2 + \frac{2}{5}M\left(\frac{R}{2}\right)^2 + M(2R)^2$$

$$= \frac{21}{5}MR^2$$

12.Sol: The impulse given to the particle is equal to the area under the F - t graph.

$$\Delta P = \frac{1}{2} \times 4 \times 10^{-3} \times 10 + 10 \times 4 \times 10^{-3}$$

$$+ \frac{1}{2} \times 4 \times 10^{-3} \times 10$$

$$\Delta P = 0.08\, N.S$$

The initial momentum of the particle is

$$mu = 0.035\, N.S$$

Hence, the particle will reverse in direction.

13.Sol: The potential energy at infinity is taken as 0. The total minimum energy at infinity in case of the escape velocity should be 0. If an object thrown with velocity less than escape velocity then the particle will have energy less than Zero, i.e., negative.

14.Sol: $B = -\frac{\Delta p}{\Delta V / V} = -\frac{V \Delta p}{\Delta V}$

$$= -\frac{1.5 \times 140 \times 10^3}{-0.2 \times 10^{-3}} = 1.05 \times 10^9\, pa$$

15.Sol: Equation of wave is $y = A \sin(\omega t - kx)$

$$\Rightarrow \frac{A}{2} = A \sin\left(\frac{2\pi}{T} \times \frac{T}{6} - \frac{2\pi}{\lambda} \times 4\right)$$

$$\Rightarrow \frac{\pi}{6} = \frac{\pi}{3} - \frac{2\pi}{\lambda} \times 4 \Rightarrow \frac{2\pi}{\lambda} \times 4 = \frac{\pi}{6}$$

$$\lambda = 48cm = 0.48m$$

16.Sol: Let M and m represent the masses of ice and lead respectively.

Now, $(M+m)g = V \rho_w g$

$$\therefore V = \frac{M+m}{\rho_w}$$

after melting of ice, volume of water and lead,

$$V' = \frac{M}{\rho_w} + \frac{m}{\rho_l}$$

Since $\rho_l > \rho_w, \therefore V^1 < V$

So, level of water goes down.

17.Sol: $\frac{\sigma}{\rho_W} = \frac{15}{15-12}, \quad \frac{\sigma}{\rho_l} = \frac{15}{15-13}$

$$\Rightarrow \frac{\rho_1}{\rho_W} = \frac{2}{3}$$

18.Sol: Take downward direction as positive. Since the pebble is released from rest,

$$v^2_f = v^2_i + 2ah$$

$$v^2_f = (4m/s)^2 = 0^2 + 2gh.$$

next, when the pebble is thrown with speed 3.0 m/s from the same height h, we have

$$v^2_f = (3m/s)^2 + 2gh = (3m/s)^2 + (4m/s)^2$$

$$\Rightarrow v_f = 5m/s$$

19.Sol: $Q_1 = 10 \times 1 \times 10 = 100\, cal$

$$Q_2 = 10 \times 0.5(0-(-20)) + 10 \times 80$$

=(100+800) cal=900 cal.

As $Q_1 < Q_2$, so ice will not completely melt and final temperature $= 0°$ C.

As heat given by water in cooling up to $0°$ C is only sufficient to increase the temperature of ice from $-20°C \, to \, 0°C$, hence mixture in equilibrium will consist 10 gm of water and 10 gm of ice, at $0°$ C.

20.Sol: The position of centre of mass of a system of particles at any instant depends only on the masses of the particles and their location at that instant.

21.Sol: $v_{rms} = \sqrt{\frac{3RT}{M}}$.

According to problem

T will become 2T and M will become $\frac{M}{2}$ so the value of v_{rms} will increase by 2 times

i.e., new root mean square velocity will be $2v$.

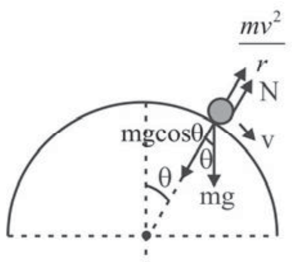
22.Sol: Equation of motion $y = a\cos\omega t$

$$\Rightarrow \frac{a}{2} = a\cos\omega t \Rightarrow \cos\omega t = \frac{1}{2} \Rightarrow \omega t = \frac{\pi}{3}$$

$$\Rightarrow \frac{2\pi t}{T} = \frac{\pi}{3} \Rightarrow t = \frac{\frac{\pi}{3}\times T}{2\pi} = \frac{4}{3\times 2} = \frac{2}{3}\text{ sec}$$

23.Sol: The motion of particle will not be SHM but its projection on a diameter will be SHM. However the motion of particle will be periodic.

24.Sol: When the net force is equal to mg then the particle looses contact with the surface.



i.e. $N + \frac{mv^2}{r} = mg\cos\theta \quad \rightarrow (1) \quad (N = 0)$

From conservation of energy

$$mgr(1-\cos\theta) = \frac{1}{2}mv^2 \rightarrow (2)$$

From (1) & (2) we get

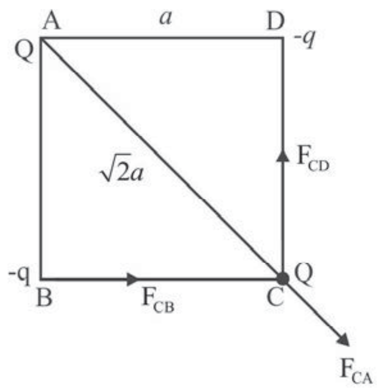
$\cos\theta = 2/3$

25.Sol: $2l\sigma = 1\times 980 \text{ or } l = \frac{980}{2\times 70}cm = 7cm$

26.Sol: Weight may increase or decrease depending upon whether the body is charged negatively or positively.

27.Sol: Different forces on C are shown in figure, a is the side of square

$$F_{CA} = \frac{1}{4\pi\varepsilon_o}.\frac{Q^2}{2a^2} \text{ along AC}$$



Resultant of F_{CB} and F_{CD} is in the direction of CA is given by

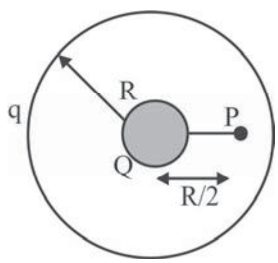
$$\frac{1}{4\pi\varepsilon_o}.\frac{Qq}{a^2}.\frac{1}{\sqrt{2}} + \frac{1}{4\pi\varepsilon_o}.\frac{Qq}{a^2}.\frac{1}{\sqrt{2}} = \sqrt{2}.\frac{1}{4\pi\varepsilon_o}.\frac{Qq}{a^2}$$

$$\sqrt{2}.\frac{1}{4\pi\varepsilon_o}\frac{qQ}{a^2} = \frac{1}{4\pi\varepsilon_o}.\frac{Q^2}{2a^2}$$

$$|Q| = 2\sqrt{2}|q|$$

As q is negative, $Q = -2\sqrt{2}q$

28.Sol: Electric potential at p



The net potential produced by the induced charges is zero everywhere inside the shell.

$$V = \frac{k.Q}{\frac{R}{2}} + \frac{k.q}{R}$$

$$= \frac{2Q}{4\pi\varepsilon_o R} + \frac{q}{4\pi\varepsilon_o R}$$

29.Sol: Let the area of parallel plate be A. Then the capacitance of the capacitor at any time t is

$$C = \frac{A\varepsilon_0}{d + vt}.$$

Hence the charge on capacitor at any instant t is

$$q = \frac{A\varepsilon_0}{d + vt}\varepsilon .$$

The correct graph is option (b).

30.Sol: $\lambda = \frac{h}{\sqrt{2mQV}}$

$$= \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times100}}$$

=1.23 A

31.Sol: When particle enters at angle other than $0°\, or 90°\, or 180°,$ path followed is helix.

32.Sol: Torque on a bar magnet in earth's magnetic field (B_H) is $\tau = MB_B \sin\theta$. τ will be maximum if $\theta = 90°$. Hence, axis of the magnet is perpendicular to the field of earth.

33.Sol: When the loops are brought nearer, magnetic flux linked with each loop increases. Thus the current will be induced in each loop in a direction opposite to its own current in order to oppose increase in magnetic flux. This is in accordance with Lenz's law current will decrease in each loop.

34.Sol: In DC ammeter, a coil is free to rotate in the magnetic field of a fixed magnet.
If an alternating current is passed through such a coil, the current changes its direction and the average value of the torque will be zero.

35.Sol: $f = \frac{R}{2} = -20\,cm,\quad m = 2$ for real image;

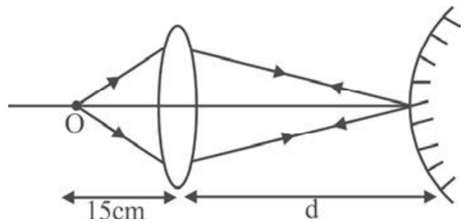
m = -2, for virtual image

Now, $m = \frac{f}{f-u} \Rightarrow -2 = \frac{-20}{-20-u} \Rightarrow u = -30cm$

For virtual image; m=+2

So, $+2 = \frac{-20}{-20-u} \Rightarrow u = -10cm$

36.Sol: The ray diagram is



We should keep the mirror at a distance where the image of the lens coincides with the pole of the mirror. The light ray will be reflected back and final image is formed at O.

$$\frac{1}{V} - \frac{1}{U} = \frac{1}{F}$$

$$\frac{1}{d} - \frac{1}{-15} = \frac{1}{10} \quad \Rightarrow d = 30cm$$

37.Sol: $n_1 = \frac{c}{v_1} = \frac{\upsilon\lambda}{\upsilon\lambda_1} = \frac{\lambda}{\lambda_1}$

$$n_2 = \frac{c}{v_2} = \frac{\upsilon\lambda}{\upsilon\lambda_2} = \frac{\lambda}{\lambda_2}$$

Now, $\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1}$

or $\lambda_2 = \left(\frac{n_1}{n_2}\right)\lambda_1$

38. Sol: In interference of light the energy is transferred from the region of destructive interference to the region of constructive interference. The average energy being always equal to the sum of the energies of the interfering waves. The phenomena of interference is in agrement with the law of conservation of energy.

39.Sol: The kinetic energy,

$$\frac{1}{2}mv^2 = E \Rightarrow mv = \sqrt{2mE}$$

$$\therefore \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}}$$

Hence, the wavelength of the associated wave will decrease.

40.Sol: h=150-27.5=122.5 m

$$R = ut,\ t = \sqrt{\frac{2h}{g}}$$

$$R = u\sqrt{\frac{2h}{g}}$$

$$t = \sqrt{\frac{2\times 122.5}{9.8}} = 5\,\text{sec}$$

Hence $u = \frac{R}{t} = \frac{30}{5} = 6ms^{-1}$

41.Sol: $E = -\frac{dV}{dx}$

42.Sol: $n = \frac{Q}{e} = \frac{6.35\times 10^{-19}}{1.6\times 10^{-19}} \approx 4$

43.Sol: For ${}_6C^{12}, p = 6, e = 6, N = 6$

for ${}_6C^{14}, p = 6, e = 6, N = 8$

44.Sol: From the equation of continuity and Bernoulli's theorem AV = constant

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

When A increases velocity decreases and the pressure increases non linearly.

45.Sol: The hydrogen atom before the transition was at rest. Therefore, from conservation of momentum So,

$$P_{\text{H-atom}} = P_{\text{photon}} = \frac{E_{\text{radiated}}}{c} = \frac{13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{eV}}{c}$$

$$\Rightarrow \quad 1.6\times 10^{-27}\times v = \frac{13.6\left(\frac{1}{1^2} - \frac{1}{5^2}\right)\times 1.6\times 10^{-19}}{3\times 10^8}$$

$\therefore \quad v = 4.352\ \text{ms}^{-1} \approx 4\ \text{ms}^{-1}$

EVA AITS (JEE ADVANCED - 2) SOLUTIONS

ANSWER KEY

Section-I

1. d	**2.** a	**3.** b	**4.** c
5. d			

Section-II

1. a,b	**2.** b,d	**3.** a,b,c,d	**4.** a,c
5. a,d	**6.** a,d	**7.** a,c	**8.** a,b

Section-III

1. 1	**2.** 2	**3.** 3	**4.** 3
5. 3			

HINTS & SOLUTIONS

Section-I

1.Sol: In hydrogen atom the radius of nth orbit is $r_n \propto n^2$, therefore graph between r_n and n will be a parabola through origin and having increasing slope. Therefore, option (a) is correct.

r_1 – radius of the 1^{st} oribit and it is a constant

$\frac{r_n}{r_1} = n^2$ Hence, $\log(r_n / r_1) = 2\log n$

It means, graph between $\log(r_n / r_1)$ and $\log n$ will be a straight line passing through origin and having positive slope $(\tan\theta = 2)$. Therefore option (b) is also correct. If radius of an orbit is equal to r, then area enclosed by it will be equal to $A = \pi r^2$.

Since $r_n \propto n^2$, therefore $A_n \propto n^4$

Hence, $\frac{A_n}{A_1} = n^4$ or $\log\left(\frac{A_n}{A_1}\right) = 4\log n$

It means, graph between $\log(A_n / A_1)$ and $\log n$ will be a straight line passing through origin and having positive slope $(\tan\theta = 4)$. Therefore, option (c) is also correct.

If frequency of revolution of electron is f, then its angular velocity will be equal to $\omega = 2\pi f$. Hence, its angular momentum will be equal to $I\omega = mr^2\omega$.

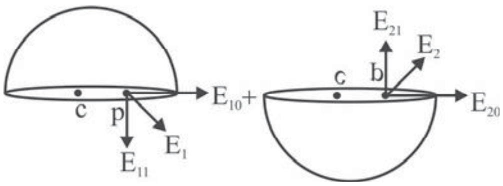
But according to Bohr's theory, it is equal to $nh/2\pi$, therefore,

$$mr^2(2\pi f) = \frac{nh}{2\pi} \quad \text{or} \quad f = \frac{nh}{4\pi^2 mr^2}$$

Since $r \propto n^2$, therefore $f \propto \frac{1}{n^3}$

Hence, $\frac{f_n}{f_1} = \frac{1}{n^3}$ or $\log\left(\frac{f_n}{f_1}\right) = -3\log n$

2.Sol: E_1 and E_2 are the magnitude of electric field due to upper hemispherical shell and lower spherical shell respectively, whose components along the diameter and its perpendicular direction are shown in the figure. By the combination of two hemispherical shells: At p, $E_{11} = E_{21}$ and $E_{10} = E_{20} = 0$ net electric field must be zero



3.Sol: As heat is given both expands by the same values. C.M of Sphere B raises up and C.M sphere A goes down slightly. The raise in P.E of B should come from the expense of heat supplied. Whereas decrease in P.E of A will be converted into heat.

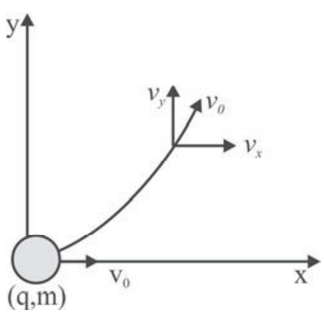
$\Rightarrow T_A > T_B$

4.Sol: Method-1

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

$$= q(v_x\hat{i} + v_y\hat{j})\vec{B}$$

$$F_y = q\frac{B_0}{l^2}x^2 v_x$$



$$\int_0^{v_0} dv_y = \frac{qB_0}{ml^2}\int_0^{x_{max}} x^2 dx$$

$$v_0 = \frac{qB_0}{ml^2}\frac{x^3_{max}}{3}$$

$$x_{max} = \left(\frac{3ml^2 v_0}{qB_0}\right)^{1/3}$$

Method-2

From the concept of impluse

$$\int_0^{x_{max}} \frac{qB_0 x^2}{l^2} v_x dt = mv_0$$

$$\therefore \int_0^{x_{max}} \frac{qB_0 x^2}{l^2} dx = mv_0$$

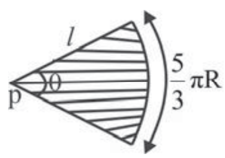
$$\therefore x_{max} = \left(\frac{3ml^2 v_0}{qB_0}\right)^{1/3}$$

5.Sol: Potential due to circular non conducting disc at the centre is, $V_c = \frac{\sigma r}{2\varepsilon_0}$ (Where r is radius of disc)

We can consider the remaining portion as a sector.

So, $$V_p = \left(\frac{\theta}{2\pi}\right)\left(\frac{\sigma . l}{2\varepsilon_0}\right)$$

$$= \left(\frac{\sigma l}{2\varepsilon_0}\right)\left(\frac{5\pi R}{3(l)}\right)\left(\frac{1}{2\pi}\right) = \frac{5\sigma R}{12\varepsilon_0}$$



Section -II

1.Sol: The magnitude of charge Q_1 is more than that of Q_2. Q_1 is (+) ve and Q_2 is (-)ve. The field at point on the right side of Q_2 is equal to zero.

2.Sol: In a nuclear reaction binding energy per nucleon increases, energy is released. In both options b & d the products will have more binding energy per nucleon.

3.Sol : At equilibrium the temperatures and pressures on both sides are equal.

From conservation of energy

$$n_1C_VT + n_2C_VT = n_1C_VT' + n_2C_VT'$$

$$T' = T$$

As the pressures are equal

$$\frac{n_1RT}{V_1} = \frac{n_2RT}{V_2} \quad -(1)$$

$$n_1 = \frac{PV}{RT} \ \& \ n_2 = \frac{(2P)(2V)}{RT}$$

$$V_1 + V_1 = 3V \quad -(2)$$

From the eq's (1) and (2) we get

$$V_1 = \frac{3V}{5} \ \& \ V_2 = \frac{12V}{5} \ \& \ P_1 = \frac{5P}{3}$$

4.Sol: R is independent of frequency

Hence (a) is true

Current becomes maximum at resonance.

$\therefore$ (b) cannot be true.

$$X_L = \omega_L = 2\pi fL$$

$\therefore$ (c) is true.

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$$

$\therefore$ (d) cannot be true.

5.Sol: $\phi = BA = (t^2)(\pi r^2)$

$$\varepsilon = \frac{d\phi}{dt} = 2\pi r^2 t$$

$$i = \frac{\varepsilon}{R} = \frac{2\pi r^2 t}{R}$$

For toppling

$$\tau = \left|\vec{\mu} \times \vec{B}\right| \geq \text{mgr}$$

$$(i.\pi r^2).1 \geq \text{mgr}$$

$$\frac{2\pi r^2 t}{R}.\pi r^2 \geq \text{mgr}$$

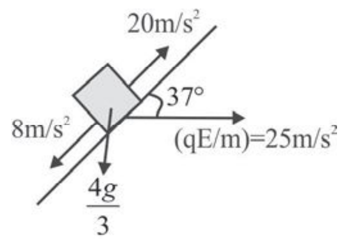
$$t \geq \frac{mgR}{2\pi^2 r^3} = 1 \text{ sec}$$

$$\text{Heat} = \int i^2 R dt = \int \left(\frac{2\pi r^2 t}{R}\right)^2 dt.R$$

$$\text{Heat} = \frac{4\pi^2 r^4}{R}\int_0^1 t^2 dt = \frac{80}{3} \text{ joule}$$

6.Sol: F.D.B. of block

$a_{net} = 12 m/s^2$, up the incline plane



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

$$3.6 \times \frac{5}{3} = \frac{1}{2} \times 12 \times t^2$$

$$\Rightarrow t = 1 \text{ sec}$$

7.Sol: Let q_1 and q_2 be the charges on shells B and C. After closing the switches K_1 and K_2 the net potentials of B and C will be equal to zero

$$V_B = \frac{Q}{4\pi\varepsilon_0(5a)} + \frac{q_1}{4\pi\varepsilon_0(2a)} + \frac{q_2}{4\pi\varepsilon_0(5a)} = 0 \rightarrow (1)$$

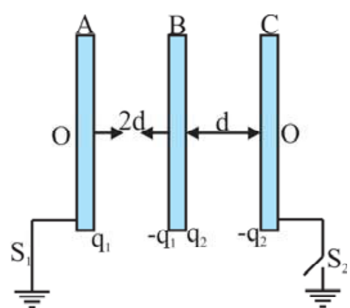
$$V_C = \frac{Q}{4\pi\varepsilon_0(5a)} + \frac{q_1}{4\pi\varepsilon_0(5a)} + \frac{q_2}{4\pi\varepsilon_0(a)} = 0 \rightarrow (2)$$

By solving 1 & 2 we get

$$q_1 = \frac{-8Q}{23} \ \& \ q_2 = \frac{-3Q}{23}$$

8.Sol: If a conducting plate is given earthing then total charge of the system is zero. Charges on the extreme faces are equal and charge on any one of them is equal to half of the total charge.

S_1 **is closed and** S_2 **is opened**



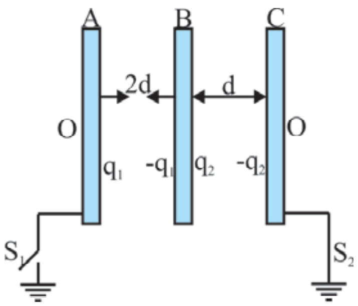
From conservation of charge on plate $C \Rightarrow q_2 = 0$

From conservation of charge on B

$$q_2 - q_1 = Q \quad \Rightarrow q_1 = -Q$$

After closing S_1 a charge of -Q flows through the switch.

S_2 is closed and S_1 is opened



From conservation of charge on A

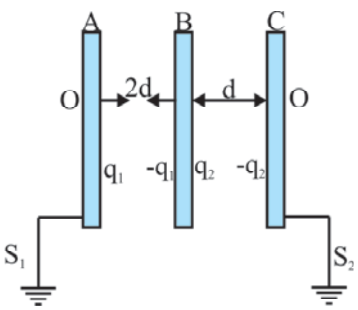
$$q_1 = 0$$

From conservation of charge on B

$$q_2 - q_1 = Q \quad \Rightarrow q_2 = Q$$

After closing the switch S_2 the charge that flows through it is $-Q$

S_1 and S_2 are closed



Charge is not conserved on A & C

From conservation of charge on B

$$q_2 - q_1 = Q \qquad -(1)$$

$$V_A - V_B = E_1(2d) = \frac{q_1}{A\varepsilon_o}2d \quad -(2)$$

$$V_B - V_C = E_2 d = \frac{q_2}{A\varepsilon_o}d \quad -(3)$$

By adding (2) & (3) we get

$$q_2 = -2q_1 \qquad -(4)$$

From (1) & (4) we get $q_1 = \frac{-Q}{3}$ & $q_2 = \frac{2Q}{3}$

After closing S_1 & S_2

$\frac{-Q}{3}$ passes through S_1 and $\frac{2Q}{3}$ passes through S_2.

Section -III

1.Sol: $p_{AV} = VI\cos\phi = V\left(\frac{V}{Z}\right)\left(\frac{R}{Z}\right) = \frac{V^2R}{Z^2}$

it means Z has to be same in both cases

$$Z_1 = Z_1 \Rightarrow \sqrt{R^2 + X_L{}^2} = \sqrt{R^2 + (X_C - X_L)^2}$$

$$2X_L = X_C$$

$$\Rightarrow C = \frac{1}{2\omega^2 L} = 10^{-6} = 1\times10^{-6}$$

2.Sol: $E = -\frac{\partial V}{\partial x} = \frac{3x^2}{6\varepsilon_0} = \frac{x^2}{2\varepsilon_0}$

$$\nabla\vec{E} = \frac{\rho}{\varepsilon_0} \Rightarrow \frac{x}{\varepsilon_0} = \frac{\rho}{\varepsilon_0} \Rightarrow \rho = x$$

If $x = 2 \Rightarrow \rho = 2$

3.Sol: The net emf induced in the total triangle is

$$\varepsilon = \frac{d\Phi}{dt}$$

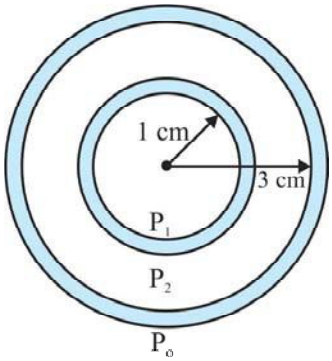
$$\Phi = BA = B\frac{\pi}{3}r^2$$

$$\varepsilon = \frac{\pi r^2}{3}\frac{dB}{dt}$$

Given $B = C_1 t + C_2 \quad \Rightarrow \frac{dB}{dt} = C_1$

$$\varepsilon = \varepsilon_{ABC} = \varepsilon_{AB} = \frac{\pi r^2 C_1}{3}$$

4.Sol: The given soap bubble is



Let P_1, P_2 & P_o are the pressures shown in the figure

$$P_2 - P_o = \frac{4T}{3cm} \qquad \text{-(1)}$$

$$P_1 - P_2 = \frac{4T}{1cm} \qquad \text{-(2)}$$

From Eq's (1) & (2) we get

$$P_1 - P_o = 4T\left[\frac{1}{3cm} + \frac{1}{1cm}\right] = \frac{16T}{3cm}$$

The radius of the single soap bubble that maintains the same pressure difference is

$$\frac{16T}{3cm} = \frac{4T}{r}$$

$$\Rightarrow r = \frac{3}{4}cm$$

5.Sol: At angular frequency ω, the current in RC circuit is given by

$$i_{rms} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \qquad \text{....(i)}$$

Also

$$\frac{i_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\frac{\omega}{3}C}\right)^2}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}} \qquad \text{....(ii)}$$

From equation (i) and (ii) we get

$$3R^2 = \frac{5}{\omega^2 C^2} \Rightarrow \frac{\frac{1}{\omega C}}{R} = \sqrt{\frac{3}{5}} \Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$$

EVAAITS (BITSAT- 1) SOLUTIONS

ANSWER KEY

1. a	2. d	3. d	4. a	5. a
6. d	7. c	8. b	9. b	10. a
11. a	12. d	13. d	14. a	15. c
16. b	17. b	18. c	19. c	20. d
21. d	22. b	23. d	24. a	25. a
26. d	27. d	28. c	29. b	30. a
31. b	32. c	33. b	34. c	35. d
36. c	37. a	38. d	39. c	40. a
41. c	42. b	43. d	44. c	45. b

HINTS & SOLUTIONS

1.Sol: Let F is the tension in the string. Acceleration of the skaters will be in the ratio

$$\frac{F}{4} : \frac{F}{5} \text{ or } 5:4$$

Now according to the problem, $s = 0 + \frac{1}{2}at^2$, we get

$$\frac{s_1}{s_2} = \frac{a_1}{a_2} = \frac{5}{4}$$

2.Sol: $R = \frac{V}{I} = \frac{8}{4} = 2\,\Omega$

The maximum percentage error is

$$\frac{\Delta R}{R}\times 100=\frac{\Delta V}{V}\times 100+\frac{\Delta I}{I}\times 100$$

$$=\frac{0.5}{8}\times 100+\frac{0.2}{4}\times 100=11.25\%$$

$$\Rightarrow R=(2\pm 11.25\%)\Omega$$

3.Sol: $\frac{R}{T^2}=\frac{u^2\sin 2\theta/g}{4u^2\sin^2\theta/g^2}=\frac{g}{2}\cot\theta$

i.e., $gT^2=2R\tan\theta$

If T is doubled, then R becomes 4 times.

4.Sol: $R=\frac{2u\cos\theta\cdot u\sin\theta}{g}$

After impact horizontal component remains the same $=u\cos\theta$

The vertical component becomes $e(u\sin\theta)$

New range $R'=\frac{2u\cos\theta\cdot eu\sin\theta}{g}$

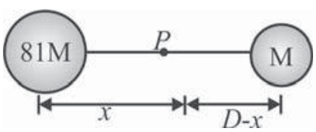
$R'=eR$

5.Sol: $u=0, a=F/m,$ Apply $v^2=u^2+2as$

$$\Rightarrow v^2=0^2+\frac{2F}{m}s\Rightarrow v^2=\frac{2Fs}{m}$$

$$\Rightarrow v^2\propto\frac{1}{m}\Rightarrow v\propto\frac{1}{\sqrt{m}}$$

6.Sol:



$$\frac{81GM}{x^2}=\frac{GM}{(D-x)^2}$$

$$\frac{9}{x}=\frac{1}{(D-x)}$$

$$x=\frac{9}{10}D$$

7.Sol: $P=Fv=m\frac{dv}{dt}v$

$$\Rightarrow v\frac{dv}{dt}=\frac{P}{m}$$

$$\Rightarrow v\frac{dv}{dx}\frac{dx}{dt}=\frac{P}{m}$$

$$\Rightarrow v^2\frac{dv}{dx}=\frac{P}{m}\quad\Rightarrow v^2dv=\frac{P}{m}dx$$

$$\frac{v^3}{3}=\frac{P}{m}x$$

8.Sol: Given, $x=36t$

and $2y=96t-9.8t^2$

or $y=48t-4.9t^2$

Let the initial velocity of projectile be u and angle of projection is θ. then,

Initial horizontal component of velocity,

$$u_x=u\cos\theta=\left(\frac{dx}{dt}\right)_{t=0}=36$$

Similarly $u\sin\theta=48$ (ii)

Dividing (ii) by (i), we get

$$\therefore\tan\theta=\frac{48}{36}=\frac{4}{3}$$

$$\sin\theta=\frac{4}{5}\text{ or }\theta=\sin^{-1}\left(\frac{4}{5}\right)$$

9.Sol: $Y=\frac{F/A}{\Delta l/l}=\frac{Fl}{\Delta lA}=\frac{Fl}{\Delta l\left(\pi R^2\right)}$

Hence $Y\alpha\frac{1}{R^2}$

$$\frac{Y_B}{Y_S}=\frac{R_S^2}{R_B^2}$$

$$\frac{10\times 10^{10}}{20\times 10^{10}}=\frac{R_S^2}{R_B^2}$$

$$R_B^2=2R_S^2$$

$$R_B=\sqrt{2}R_S$$

$$\Rightarrow R_S=\frac{R_B}{\sqrt{2}}$$

10.Sol: Let ρ_S and ρ_L be the densities of silver and liquid, respectively, and m and V be the mass and volume, respectively, of the silver block. Therefore, Tension in the string $= mg -$ buoyant force

$$\Rightarrow T = (\rho_S V - \rho_L V)g = (\rho_S - \rho_L)Vg$$

Also, $V = \frac{m}{\rho_S}$

$$\therefore \quad T = \left(\frac{\rho_S - \rho_L}{\rho_S}\right)mg$$

$$= \frac{(10-0.72)\times 10^3}{10\times 10^3}\times 4\times 10 = 37.12N$$

11.Sol: According to Wein's law, $\lambda_m \propto \frac{1}{T}$

When temperature becomes $\frac{3}{2}$ times λ_m becomes $\frac{2}{3}$ times

12.Sol: To find the Ampere's force on a conductor of any shape, replace the conductor by an imaginary straight conductor joining the two ends of the given conductor.

So, if B is in x-direction, then the imaginary straight conductor will be along the field and the force acting on it will be zero.

If B is in y-direction, then the force will be λBI acting along the z-direction.

Similary, if B is in the z-direction, then the force will be λBI, acting along the negative y-direction.

13.Sol: $M_A = 4M_B (as\ R_A = 2R_B)$

$$\frac{I_A}{I_B} = \frac{\frac{1}{2}M_A R_A^2}{\frac{1}{2}M_B R_B^2} = 16$$

14.Sol: $P = P_1 + P_2 + P_3$

$$= \frac{n_1 RT}{V} + \frac{n_2 RT}{V} + \frac{n_3 RT}{V}$$

$$= \left(\frac{6}{32} + \frac{5}{44} + \frac{8}{28}\right)\frac{R\times 300}{3\times 10^{-3}} = 5\times 10^5\, Pa$$

15.Sol: Time period $T = \frac{2\pi r}{\upsilon} \Rightarrow T\ \alpha\ \frac{m}{q}$

$$\frac{T_1}{T_2} = \frac{m_1}{m_2}\times\frac{q_2}{q_1} = \frac{1}{4}\times\frac{2}{1} = \frac{1}{2}$$

$$T_2 = 2T_1 = 10\mu s$$

16.Sol: Here $R = X_L = X_C$

($\therefore$ voltage across them is same)

After short circuiting the capacitor

$$I = \frac{10}{\left(R^2 + X_L^2\right)^{1/2}} = \frac{10}{\sqrt{2}R}$$

$\therefore$ Potential drop across inductance

$$= IX_L = IR = 5\sqrt{2}\,V$$

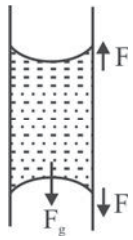
17.Sol: $E = \frac{1}{2}m\omega^2 A^2 = \frac{1}{2}m(2\pi f)^2 A^2$

$$A = \frac{1}{2\pi f}\sqrt{\frac{2E}{m}}$$

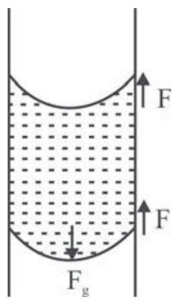
Putting $E = K + U$, we get

$$A = \frac{1}{2\pi(25/\pi)}\sqrt{\frac{2\times(0.5+0.4)}{0.2}} = 0.06\, m$$

18.Sol: The weight of the liquid should be balanced by the net surface tension force.



If the liquid is present as shown then both surface tension forces each of magnitude F cancels and hence the liquid can't be in equilibirum.



The two surface tension forces balance the weight of the liquid.

19.Sol: $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

If radius is doubled, mass per unit length will become four times. Hence

$$f' = \frac{1}{4l}\sqrt{\frac{2T}{4\mu}} = \frac{f}{2\sqrt{2}}$$

20.Sol: Let l is the length of the slab and b is its breadth.

Inward motion

Consider that after time t the slab enters a distance vt.

The capacitance of the system is

$$C = \frac{k\varepsilon_0 b(vt)}{d} + \frac{\varepsilon_0 b(l - vt)}{d}$$

The charge on the capacitor is

$$Q = C\varepsilon = \left[\frac{k\varepsilon_0 b(vt)}{d} + \frac{k\varepsilon_0 b(l - vt)}{d}\right]\varepsilon$$

The current through the circuit is

$$i = \frac{dQ}{dt} = \frac{k\varepsilon_0 bv\varepsilon}{d} - \frac{\varepsilon_0 bv\varepsilon}{d} = \frac{\varepsilon_0 bv\varepsilon}{d}[k-1]$$

Outward motion

When the slab is leaving the capacitor the current will be in opposite direction and its magnitude remains constant.

$$i = \frac{\varepsilon_0 bv\varepsilon}{d}[1-k]$$

21.Sol: Each charge will produce the same magnitude of intensity, say E, at the centroid. These are directed at angles of 120^0 with each other. So, their vector sum will be zero.

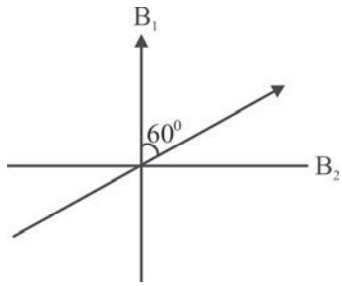
22.Sol: $f = \frac{1}{2\pi\sqrt{LC}}, f + 50 = \frac{1}{2\pi\sqrt{LC/K}}$

$$\Rightarrow K = \left(\frac{f+50}{f}\right)^2 = \left(1 + \frac{50}{f}\right)^2$$

$$\Rightarrow K = 1 + \frac{100}{f} = 1 + \frac{100}{10,000} = 1.01$$

23.Sol: $\tan 60^0 = \frac{B_2}{B_1}$

$$\frac{B_1}{B_2} = \frac{1}{\sqrt{3}}$$



24.Sol: White fringe is formed at the centre of screen. Position of central fringe will remain unchanged on moving the screen.

25.Sol: X-rays are not reflected from the target, so cannot be used for radar.

26.Sol: $L = \frac{nh}{2\pi}$

L is independent of Z.

27.Sol: Clearly, power of the system is zero.

$$\therefore\ 0 = \frac{1}{20} + \frac{1}{f} - \frac{5}{20f}$$

or $-\frac{1}{20} = \frac{15}{20f}$ or $f = -15\ cm$

28.Sol: Kinetic energy is same, as frequency remain constant

$$\frac{I_1}{I_2} = \frac{r_2}{r_1} = \frac{1}{4}$$

$$I_2 = 4I_1$$

29.Sol: Nuclear forces are charge independent.

30.Sol: Frequency modulation requires much wider channel (7 to 15 times) as compared to AM.

31.Sol: Surface tension tends to make the area of rain drop minimum.

32.Sol:

$$\text{Energy} = \frac{1}{2}mv^2 = mc\,\Delta T ;\Rightarrow \Delta T\ \alpha\ v^2$$

Temparature does not depend upon the mass of the balls.

33.Sol: In free space, there will be no torque acting on the sphere. Therefore the angular momentum of the sphere will not be affected.

34.Sol: Radial acceleration $a_r = \frac{v^2}{r}$

Tangential acceleration $a_t = a$

$\therefore$ Resultant acceleration

$$a' = \sqrt{a_r^2 + a_t^2} = \sqrt{\left(\frac{v^2}{r}\right)^2 + a^2}$$

35.Sol: As the multiple of $\hat{j}$ in the given vector is zero therefore this vector lies in XZ plane and projection of this vector on y-xis is zero.

36.Sol: Total gravitational energy gained

= Work done by the external agent + Energy released by the spring

$= W + E$.

37.Sol: From the given information

At t = 3s : $15 = u(3) + \frac{1}{2}a(3)^2$ - (i)

At t = 4s : $0 = u(4) + \frac{1}{2}a(4)^2$ -(ii)

Solving (i) & (ii) we get

$|a| = 10m/s^2, |u| = 20m/s$

38.Sol: When the cork is floating, its weight is balanced by the upthrust. Therefore, net force on the cork is zero.

39.Sol: $\Delta U = -\left(\frac{GMm}{R+H}\right) - \left(-\frac{GMm}{R}\right)$

$H = 3R$

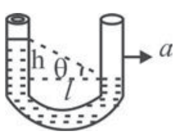
$$\Delta U = -\frac{GMm}{4R} + \frac{GMm}{R} = \frac{3GMm}{4R^2} \times R$$

$$\Delta U = \frac{3}{4} mgR$$

40.Sol: Distance travelled by the particle

$$= A\sin\frac{5\pi}{12} - A\sin\frac{\pi}{12} = \frac{A}{\sqrt{2}}$$

41.Sol: We know; $\tan\theta = \frac{a}{g}$



In the present problem, $\tan\theta = \frac{h}{l}$

So $\frac{h}{l} = \frac{a}{g}$ or $h = \frac{al}{g}$

(Where h is the difference in the heights in the two limbs)

42.Sol: The magnitude of phase difference between the points seperated by distance 10 meters

$= k \times 10 = [10\pi \times 0.01] \times 10 = \pi$

43.Sol: $\frac{\Delta A}{A} = (2\alpha)\Delta T$ ....(i)

$\frac{\Delta L}{L} = \alpha\,\Delta T$ ....(ii)

From the above two equations.

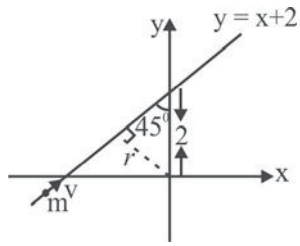
$$\frac{\Delta A}{A} = 2 \cdot \frac{\Delta L}{L}$$

$$\Rightarrow \frac{\Delta A}{A} = 2 \times 2 = 4\%$$

44.Sol: $F = \frac{Gm_1m_2}{d^2}$

$$\therefore\ G = \frac{Fd^2}{m_1m_2} = Nm^2/kg^2$$

45.Sol: Angular momentum of particle about origin O is:



Here $m = \tan 45^\circ = 1$

$$r = 2\left(\frac{1}{\sqrt{2}}\right) = \sqrt{2}$$

$$L = mvr = (1)(2\cos 45^0)\sqrt{2} = 2\sqrt{2}\ kgm^2s^{-1}$$

EVAAITS (BITSAT-2) SOLUTIONS

ANSWER KEY

1. a	2. d	3. c	4. d	5. c
6. a	7. a	8. a	9. a	10. a
11. b	12. a	13. d	14. d	15. a
16. b	17. b	18. b	19. a	20. c
21. b	22. b	23. d	24. d	25. c
26. b	27. a	28. d	29. a	30. b
31. b	32. c	33. d	34. d	35. a
36. b	37. b	38. b	39. d	40. a
41. b	42. b	43. a	44. d	45. b

HINTS & SOLUTIONS

1.Sol: Potential drops across C_1 and C_2 are 12 V and 8 V, respectively. Since they are in series, same charge flows through them and

$$\frac{C_1}{C_2}=\frac{V_2}{V_1}=\frac{8}{12}=\frac{2}{3}$$

2.Sol: Number of neutrons = A-z = 23 -11=12.

3.Sol: $\frac{R_{150}}{R_{500}}=\frac{[1+\alpha(150)]}{[1+\alpha(200)]}$. putting $R_{150}=133\Omega$ and

$\alpha=0.0045/°c$, we get $R_{200}=171\Omega$

4.Sol: The energy of the field increases with the magnitude of the field. Lenz's law infers that there is an opposite field created due to increase or decrease of magnetic flux around a conductor so as to hold the law of conservation of energy.

5.Sol: Because in case of metallic sphere either solid or hollow, the charge will reside on the surface of the sphere. Since both spheres have same surface area, so they can hold equal maximum charge.

6.Sol: In case of spherical metal conductor the charge quickly spreads uniformly over the entire surface because of surface charges stay for longer time on the spherical surface. While in case of non-spherical surface, the charge concentration is different at different points due to which the charge do not stay on the surface for longer time.

7.Sol: The highest energy level which an electron can occupy in the valence band at 0K, is called fermi energy level.

8.Sol: In free expansion of a gas workdone is zero and temperature remains constant.

9.Sol: Polarisation is shown by only transverse waves

10.Sol: Radius of particle is λ

$$\therefore v=\frac{c}{\lambda}=\frac{3\times10^8}{3\times10^{-6}}=10^{14}$$

For observation of particle the wave frequency should be more than 10^{14} Hz, or wavelength should be smaller.

11.Sol: $f=-15cm, m=+2$ (positive because image is virtual)

$\therefore m=-\frac{v}{u}\Rightarrow v=-2u$. By using mirror formula

$$\frac{1}{-15}=\frac{1}{(-2u)}+\frac{1}{u}\Rightarrow u=-7.5cm$$

12.Sol: As $\lambda=\frac{h}{mv}$

$$\frac{v_p}{v_\alpha}=\frac{m_\alpha}{m_p}=\frac{4}{1}$$

13.Sol: $\tau=\mu B\sin\theta$

The graph between τ and θ ia a sine curve.

14.Sol: $\frac{I_{max}}{I_{max}}=\left(\frac{a_1+a_2}{a_1-a_2}\right)^2\Rightarrow\frac{a_1+a_2}{a_1-a_2}=6$

$$\Rightarrow\frac{a_1}{a_2}=\frac{7}{5}$$

15.Sol:

$$\frac{1}{2}mv^2=E\Rightarrow mv=\sqrt{2mE};\therefore E=\frac{h}{mv}=\frac{h}{\sqrt{2mE}}$$

16.Sol: In a photoelectric effect when monochromatic radiations of suitable frequency fall on the photosensitive plate called cathode, the photoelectrons are emitted. These electrons flow in the outer circuit resulting in the photoelectric current. Using the incident radiations of a fixed frequency, it is found that the photoelectric current increases with the intensity of incident light.

Hence, a photocell employs photoelectric effect to convert change in the intensity of illumination into a change in photoelectric current.

17.Sol: $V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{120}{1.414} = 84.8V$

18.Sol: $U = \frac{1}{2}Li^2$ i.e. $\frac{U_2}{U_1} = \left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

$\Rightarrow U_2 = \frac{1}{4}U_1$

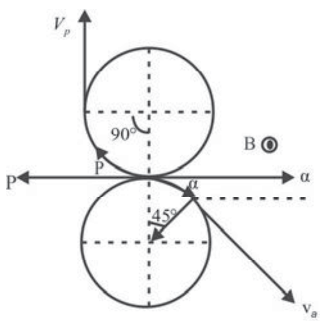
19.Sol: Magnetic moment of bar $M = 10^4 J/T$

Hence, work done $W = \vec{M}.\vec{B}$

$$= 10^4 \times 4 \times 10^{-5} \times \cos 60° = 0.2J$$

20.Sol: $\omega = qB/m, \omega_p = eB/m, \omega_\alpha = \frac{2eB}{4m}$

$\omega_\alpha = \frac{\omega_P}{2}$



So proton will cover double angle in same time as that of α -particle. Clearly from figure angle between v_α and v_p is 135°

21.Sol: Potential inside the hollow sphere is same as that on the surface

22.Sol: Least count of screw gauge $= \frac{1}{100}$ mm

Diameter=Divisions on circular scale $\times$ least count+main scale reading = 0.052 cm

23.Sol: μ is dimensionless. Thus, each term on the RHS of given equation should be dimensionless, i.e., B/λ^2 is dimensionless, i.e., B should have dimension of λ^2, i.e., m^2, i.e., area.

24.Sol: Laser beams are perfectly parallel. So that they are very narrow and can travel a long distance without spreading.

25.Sol: We have $h = \frac{1}{2}gT^2$

In T/3 second, distance fallen $= \frac{1}{2}g\left(\frac{T}{3}\right)^2 = \frac{h}{9}$

So position of the ball from the ground is

$$h - \frac{h}{9} = \frac{8h}{9}m$$

26.Sol: $v_x = u_x = 100ms^{-1}, v_y = u_y + a_y t = 0 + 10 \times 10$

$\tan\theta = \frac{v_y}{v_x} = \frac{100}{100} = 1 \Rightarrow \theta = 45°$

27.Sol: When I = 0 (open circuit)

potential difference $= \varepsilon - \text{Ir} = \varepsilon = 2\text{V}$

When, p.d $\text{P.d} = \varepsilon - \text{Ir} = 0$

$\text{P.d} = \varepsilon - \text{Ir} \Longrightarrow \text{r} = \frac{\varepsilon}{\text{I}} = \frac{2}{5} = 0.4\Omega$

Internal resistance $r = 0.4\Omega$

28.Sol: The acceleration of block -rope system is

$a = \frac{F}{(M+m)}$, where M is the mass of block and m is the mass of rope.

So the tension in the middle of the rope will be

$T = \{M + (m/2)\}a = \frac{[M + (m/2)]F}{M+m}$

Given that m=M/2

$\therefore T = \left[\frac{M + (M/4)}{M + (M/2)}\right]F = \frac{5F}{6}$

29.Sol: During downward motion:

$$F = mg\sin\theta - \mu mg\cos\theta$$

During upward motion:

$$2F = mg\sin\theta + \mu mg\cos\theta$$

Solving above two equations, we get

$$\mu = (\tan\theta)/3$$

30.Sol: The total energy required to make the electron free from nucleus is the sum of the energy required to separate the electrons from the influence of each other and the energy required to separate the electrons from the influence of nucleus, i.e.,

Total required energy=BE of electron in He atom+ionisation energy of He atom

$= (24.6 + 54.4)eV = 79eV$

31.Sol: Power used to pump the water

$$= \frac{mgh}{t} = \frac{100\times10\times10}{5} = 2000W$$

Power of engine $= 2000\times\frac{100}{60} = 3.3kW$

32.Sol: Potential energy $= -c/r^2$ and total energy $= Rhc/n^2$. With higher orbit, both r and n increase. So, both become less negative; hence both increase.

33.Sol: Since the number of photoelectrons emitted is directly proportional to the intensity of incident radiation, the number of photoelectrons emitted becomes four times. The energy of photoelectrons does not change with the intensity of light.

34.Sol: $\Delta p = (p+ep)+(ep+e^2p)+(e^2p+e^3p)+....$

$$= p(1+e)[1+e+e^2+.....] = \frac{p(1+e)}{1-e}$$

35.Sol: Work done in converting 1 g of ice at $-10°$ c to steam at $100°c$ = Heat supplied to raise temperature of 1 g of ice from $-10°$ to $0°$ C + Heat supplied to convert 1 g ice into water at $0°$ + Heat supplied to raise temperature of 1 g of water from $0°$ to $100°$ C + Heat supplied to convert 1g of water at $100°$ C to steam.

$$= [m\times c_{ice}\times\Delta T]+[m\times L_{ice}]+$$

$$[m\times c_{water}\times\Delta T]+[m\times L_{vapour}]$$

$$= [1\times0.5\times10]+[1\times80]+[1\times1\times100]+[1\times540]$$

$$= 725cal = 725\times4.2 = 3045J$$

36.Sol: $I_B = \frac{V_{BB}-V_{BE}}{R_1}$.

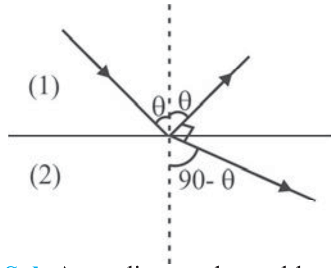
If R_1 is increased, I_B will decrease. Since $I_C = \beta I_B$, it will result in decrease in I_C.

37.Sol: $\mu_1\sin\theta = \mu_2\times\sin(90°-\theta)$

$$\Rightarrow \frac{\mu_1}{\mu_2} = \cot\theta$$

$$\Rightarrow \mu_1\times\sin\theta_c = \mu_2\times\sin(90°)$$

$$\sin\theta_c = \frac{\mu_2}{\mu_1} = \tan\theta$$



38.Sol: According to the problem, as the potential at ∞ increases by $+10\ J\ kg^{-1}$, hence potential will increase by the same amount everywhere (potential gradient will remain constant). Hence, potential at point $p = -5+10 = +5J\ kg^{-1}$

39.Sol: 10 m column of water exerts nearly 1 atmosphere pressure. So, 100 m column of water exerts nearly 10 atmosphere pressure, i.e., 10^6 pa

Now, $k = \frac{(\Delta p)V}{\Delta V} = \frac{10^6\times100}{0.1}pa = 10^9\ pa$

40.Sol: Total pressure at the bottom =3 atm pressure due to water in the tank =3 atm -1 atm =2 atm =20 m of water column

Heigher of water in the tank is h =20 m So, velocity of efflux

$$= \sqrt{2gh} = \sqrt{2\times10\times20} = 20m/s$$

41.Sol: $\Delta Q = nC_P\Delta T$

$$\Delta U = nC_V\Delta T$$

$$\frac{W}{\Delta Q} = \frac{\Delta Q-\Delta U}{\Delta Q} = \frac{nC_P\Delta T - nC_V\Delta T}{nC_P\Delta T} = 1-\frac{1}{\gamma}$$

42.Sol: The angular frequency is independent of the frame of reference

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{200}{1}} \approx 14\,rad/s$$

43.Sol: Standard equation of travelling wave y=4 $\sin(kx-\omega t)$. By comparing with the given equation

$$y = 10\sin(0.01\pi x - 2\pi t)$$

$$A = 10cm, \omega = 2\pi$$

Maximum particle velocity

$$= A\omega = 2\pi\times10 = 63cm/s$$

44.Sol: Force between two charges does not depend upon the presence or absence of third charge.

45.Sol: The charged particle travels in circular path only when $B \neq 0$ and $E = 0$