AIPMT 2014

Physics

1. If force (F), velocity (V) and time (T) are taken as fundamental units, the dimensions of mass are
(1) $[FVT^{-1}]$ (2) $[FVT^{-2}]$
(3) $[FV^{-1}T^{-1}]$ (4) $[FV^{-1}T]$

Solution:
Force (F) = mass × acceleration

$$= \text{mass} \times \frac{\text{velocity (V)}}{\text{time (T)}}$$

$$\therefore \text{mass} = \frac{F \times T}{V}$$

Units of mass = $[FV^{-1}\,T]$
Hence, the correct option is (4).

2. A projectile is fired from the surface of the earth with a velocity of $5 ms^{-1}$ and angle θ with the horizontal. Another projectile fired from another planet with a velocity of $3 ms^{-1}$ at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is: (given, $g = 9.8\ ms^{-2}$)
(1) 3.5 (2) 5.9
(3) 16.3 (4) 110.8

Solution:
We know that

Range $= \dfrac{u^2 \sin 2\theta}{g}$ so, $g \propto u^2$

Therefore, $\dfrac{g_{\text{planet}}}{g} = \left(\dfrac{3}{5}\right)^2$

$$g_{\text{planet}} = \left(\frac{3}{5}\right)^2 \times 9.8\ \ ms^{-1}$$

$$= 3.528 \cong 3.5$$

Hence, the correct option is (1).

3. A particle is moving such that its position coordinates (x,y) are:
(2m, 3m) at time $t = 0$,
(6m,7m) at time $t = 2s$ and
(13m, 14m) at time $t = 5$ s,
Average velocity vector ($\overline{v}_{av}$) from $t = 0$ to $t = 5s$ is:
(1) $\frac{1}{5}(13\hat{i} + 14\hat{j})$ (2) $\frac{7}{3}(\hat{i} + \hat{j})$
(3) $2(\hat{i} + \hat{j})$ (4) $\frac{11}{5}(\hat{i} + \hat{j})$

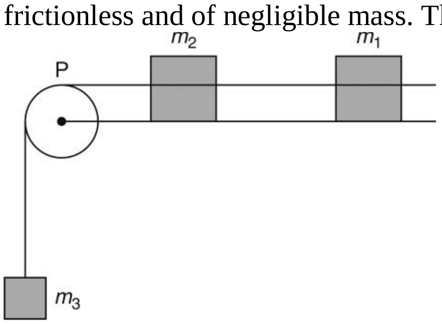
Solution:
We know that

$$\bar{v}_{av} = \frac{\Delta \vec{r}}{\Delta t} = \frac{(13-2)\hat{i} + (14-3)\hat{j}}{5-0}$$

$$= \frac{11\hat{i} + 11\hat{j}}{5} = \frac{11}{5}(\hat{i} + \hat{j})$$

Hence, the correct option is (4).

4. A system consists of three masses m_1, m_2 and m_3 connected by a string passing over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is: (Assume $m_1 = m_2 = m_3 = m$)



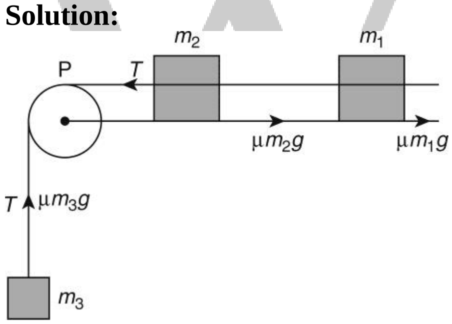
(1) $\dfrac{g(1-g\mu)}{g}$

(2) $\dfrac{2g\mu}{3}$

(3) $\dfrac{g(1-2\mu)}{3}$

(4) $\dfrac{g(1-2\mu)}{2}$

Solution:



$m_3\text{g} - T = m_3 a$ …(1)

$\Rightarrow\ T = m_3 g - m_3 a$ …(1)

$T - (\mu m_2 g + \mu m_1 g) = (m_1 + m_2)a$ …(2)

Putting (1) in (2)

$m_3 g - m_3 a - (\mu m_2 g + \mu m_1 g) = (m_1 + m_2)a$

$m_3 g - (\mu m_2 g + \mu m_1 g) = (m_1 + m_2 + m_2)a$

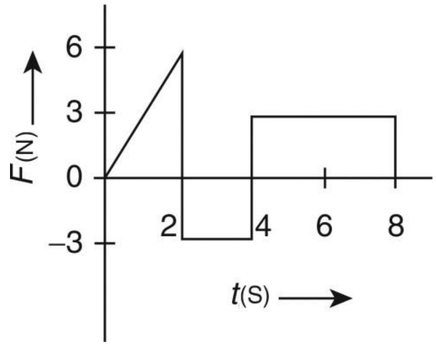
$m_3 g - (\mu m_2 g + \mu m_1 g)/\ (m_1 + m_2 + m_3) = a$

$$a = \frac{m}{m}\left[\frac{g - 2\mu g}{3}\right]$$ (as $m_1 = m_2 = m_3 = m$)

$$a = \frac{g}{3}[1 - 2\mu]$$

Hence, the correct option is (3).

5. The force 'F' acting on a particle of mass 'm' is indicated by the force-time graph shown below. The change in momentum of the particle over the time interval from zero to 8s is:



(1) 24 Ns
(2) 20 Ns
(3) 12 Ns
(4) 6 Ns

Solution:
Change in momentum
$\Delta P = \int F dt$
= Area of F-t graph
$= \left(\frac{1}{2}\times 2\times 6\right) - (3\times 2) + (4\times 3)$
= 12 Ns
Hence, the correct option is (3).

6. A balloon with mass 'm' is descending down with an acceleration 'a' (where $a <$ g). How much mass should be removed from it so that is starts moving up with an acceleration 'a'?

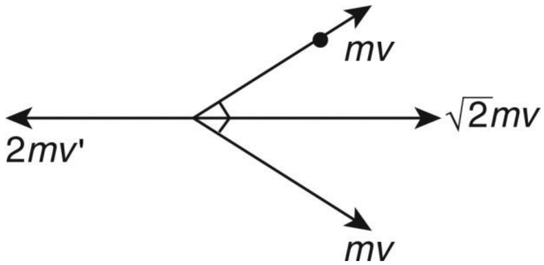
(1) $\frac{2ma}{g+a}$
(2) $\frac{2ma}{g-a}$
(3) $\frac{ma}{g+a}$
(4) $\frac{ma}{g-a}$

Solution:
Let upthrust of air be F_a then
$mg - F_a = ma$ …(1)
For upward motion
$F_a - (m - \Delta m)g = (m - \Delta m)a$
$F_a - mg + \Delta mg = ma - \Delta ma$
$-ma + \Delta mg = ma - \Delta ma$
$\Delta m\,(a + g) = 2ma$
$\Delta m = \frac{2ma}{a+g}$
Hence, the correct option is (1).

7. A body of mass ($4m$) is lying in x-y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is:

(1) mv^2
(2) $\frac{3}{2}mv^2$
(3) $2mv^2$
(4) $4mv^2$

Solution:



$2mv' = \sqrt{2}mv$

$v' = \dfrac{v}{\sqrt{2}}$ ….(1)

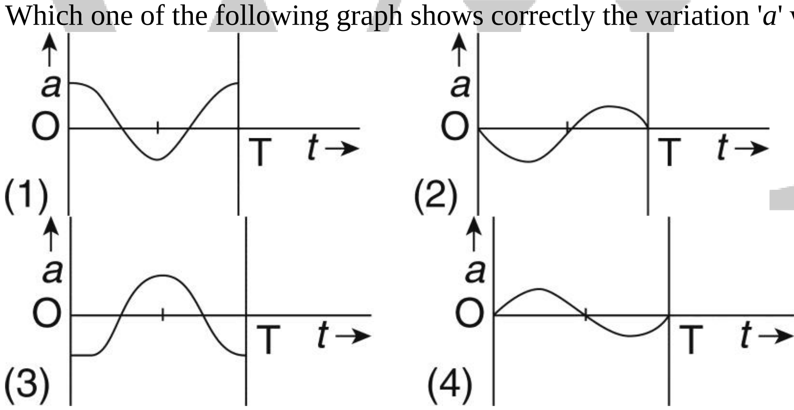
Total K.E. $= \dfrac{1}{2}mv^2 + \dfrac{1}{2}mv^2 + \dfrac{1}{2}(2m)v'^2$

$= mv^2 + \dfrac{mv^2}{2}$ {On putting value of *v*' from (1)}

$= \dfrac{3}{2}mv^2$

Hence, the correct option is (2).

8. The oscillation of a body on a smooth horizontal surface is represented by the equation,
x = A cos (ωt)
where x= displacement at time t
ω =frequency of oscillation
Which one of the following graph shows correctly the variation 'a' with 't'?



Solution:
$x = A$ cos (ωt)

$$v = \frac{dx}{dt} = -A\sin\omega t \times \omega$$

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = -A\omega^2\cos\omega t$$

Hence, the correct option is (3).

9. A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions s^{-2}

(1) 25 N (2) 50 N
(3) 78.5 N (4) 157 N

Solution:

$Z = I\alpha$

$TR = I\alpha$

$\alpha = 2$ revolutions/s^2 = $2 \times 2\pi$ rad/s^2

= 4π rad/s^2

$T = I\alpha/R$

$$= \frac{1}{2}\frac{MR^2\alpha}{R} = \frac{1}{2}MR\alpha = \frac{1}{2}\times 50\times 0.5\times 4\times 3.14 \ = \ 157 \text{ N}$$

Hence, the correct option is (4).

10. The ratio of the acceleration for a solid sphere (mass '*m*' and radius '*R*') rolling down an incline of angle 'θ' without slipping and slipping down the incline without rolling is:

(1) 5 : 7
(2) 2 : 3
(3) 2 : 5
(4) 7 : 5

Solution:

We know that,

For rolling motion without slipping on inclined plane,

$$a_1 = g\sin\theta/1 + \frac{k^2}{R^2}$$

For slipping motion on inclined plane,

$a_2 = g \sin\theta$

$$\text{Ratio} = \frac{a_1}{a_2} = \frac{g\sin\theta / 1 + \frac{k^2}{R^2}}{g\sin\theta} = \frac{1}{1+\frac{k^2}{R^2}} = \frac{1}{1+\frac{(2/5R)^2}{R^2}} = \frac{5}{7}$$

Hence, the correct option is (1).

11. A black hole is an object whose gravitational field is so strong that even light cannot escape from it. To what approximate radius would earth (mass= 5.98x1 0^{24} kg) have to be compressed to be a black hole?

(1) 10^{-9} m
(2) 10^{-6} m
(3) 10^{-2} m
(4) 100 m

Solution:

We know that

Escape velocity, $v = \sqrt{\frac{2GM}{R}}$

Here, R = Radius of earth

M = Mass of earth

G = Gravitational constant

Here, $v = c$

$$\therefore c = \sqrt{\frac{2GM}{R}}$$

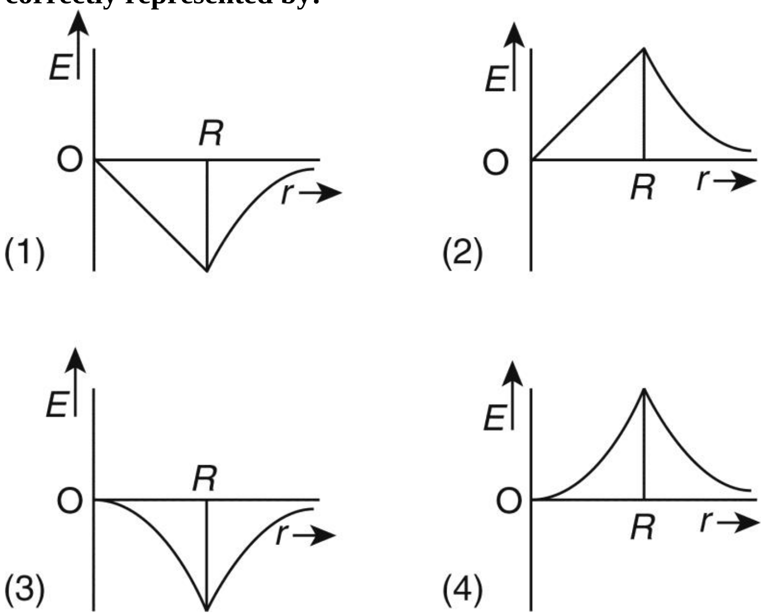
$RC^2 = 2GM$

$$R = \frac{2GM}{C^2}$$

$$= \frac{2 \ \times \ 6.6 \ \times \ 10^{-11} \times \ 5.98 \ \times \ 10^{24}}{(3 \ \times \ 10^8)^2} = 8.77\times 10^{-3} \cong 10^{-2}$$

Hence, the correct option is (3).

12. Dependence of intensity of gravitational field (E) of earth with distance (r) from centre of earth is correctly represented by:



Solution:

$$E = -\frac{GM}{R^3} \times \vec{r} \text{ (if } r < R)$$

$$E = -\frac{GM}{r^3} \times \vec{r} \text{ (if } r \geq R)$$

Hence, the correct option is (1).

13. Copper of fixed volume 'V' is drawn into wire of length'l'. When this wire is subjected to a constant force 'F', the extension produced in the wire is 'Δl'. Which of the following graph is a straight line?

(1) Δl versus $1/l$

(2) Δl versus l^2

(3) Δl versus $1/l^2$

(4) Δl versus l

Solution:

$$\mathrm{Y} = \frac{\mathrm{F}/A}{\Delta l/l} \Rightarrow \Delta l = \frac{Fl}{A\mathrm{Y}}$$

But, $V = Al$, so $A = V/l$

$$\therefore \ \Delta l = \frac{Fl^2}{V\mathrm{Y}}$$

$$\Delta l \propto l^2$$

Hence, the correct option is (2).

14. A certain number of spherical drops of a liquid of radius 'r' coalesce to form a single drop of radius 'R' and volume 'V'. If 'T' is the surface tension of the liquid then:

(1) Energy = $4VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released.

(2) Energy = $3VT\left(\frac{1}{r} + \frac{1}{R}\right)$ is released.

(3) Energy = $3VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released.

(4) Energy is neither released nor absorbed.

Solution:

$\Delta U = (ST)(\Delta A)$ ...(1)

$A_{\text{initial}} = (4\pi r^2)n$

$A_{\text{final}} = 4\pi R^2$

$\Delta A = (4\pi r^2)n - 4\pi R^2$

$\left(\frac{4}{3}\pi r^3\right)n = \frac{4}{3}\pi R^3$

$n = \frac{R^3}{r^3}$

$\Delta A = 4\pi\left[\frac{R^3}{r^3}.r^2 - R^2\right] = 4\pi\left[\frac{R^3}{r} - \frac{R^3}{R}\right] = 4\pi R^3\left[\frac{1}{r} - \frac{1}{R}\right]$

$\Delta A = \left(\frac{4\pi R^3}{3}\right)3\left[\frac{1}{r} - \frac{1}{R}\right] = 3V\left[\frac{1}{r} - \frac{1}{R}\right]$

$\Delta U = 3VT\left[\frac{1}{r} - \frac{1}{R}\right]$ Putting in (1)

Hence, the correct option is (3).

15. Steam at 100°C is passed into 20g of water at 10°C. When water acquires a temperature of 80°C, the mass of water present will be:
[Take specific heat of water= 1 cal g^{-1} $°C^{-1}$ and latent heat of steam = 540 cal g^{-1}]

(1) 24 g (2) 31.5 g
(3) 42.5 g (4) 22.5 g

Solution:
Heat lost = Heat gained
$mL + mS_w\Delta\theta = m_w S_w\Delta\theta$
Given
L = 540 cal/g
S_w = 1 cal/g/°C
$\Delta\theta$ = 100 – 80 = 20°C
m_w = 20g
In order to determine 'm'

$\Rightarrow m\times 540 + m\times 1\times(100 - 80) = 20 \times 1 \times (80 - 10)$

$\Rightarrow m = 2.5\text{g}$

Total mass of water = (20 + 2.5)g = 22.5g
Hence, the correct option is (4).

16. Certain quantity of water cools from 70°C to 60°C in the first 5 minutes and to 54°C in the next 5 minutes. The temperature of the surroundings is:

(1) 45°C (2) 20°C
(3) 42 °C (4) 10°C

Solution:
By Newton's law of cooling, we know that

$\frac{\theta_1 - \theta_2}{t} = k\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$

$\Rightarrow \frac{60 - 70}{5} = k\left[\frac{70 + 60}{2} - \theta_0\right]$

$\Rightarrow -2 = k[65 - \theta_0]$ ...(1)

Also, $\frac{54-60}{5} = k\left[\frac{60+54}{2} - \theta_0\right]$

$-\frac{6}{5} = k[57 - \theta_0]$ ...(2)

On dividing (1) by (2) we get:

$\frac{10}{6} = \frac{k[65-\theta_0]}{k[57-\theta_0]}$

$570 - 10\theta_0 = 390 - 6\theta_0$

$570 - 390 = 4\theta_0$

$\frac{180}{4} = \theta_0$

$\theta_0 = 45°C$

Hence, the correct option is (1).

17. A monoatomic gas at a pressure P, having a volume V expands isothermally to a volume $2V$ and then adiabatically to a volume $16V$. The final pressure of the gas is: (take $\gamma = 5/3$)

(1) $64P$
(2) $32P$
(3) $P/64$
(4) $16P$

Solution:

For isothermal expansion, $P_1V_1 = P_2V_2$ [$\because$ T = constant]

$\Rightarrow PV = P_2(2V)$

$\Rightarrow P_2 = P/2$

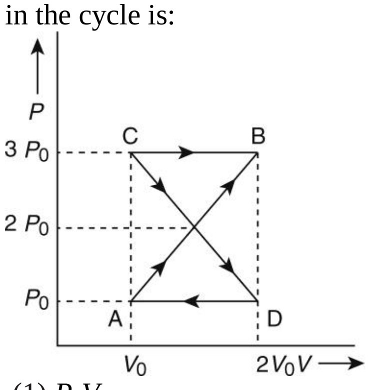
For adiabatic process $P_2V_2^\gamma = P_3V_3^\gamma$

$\Rightarrow \left(\frac{P}{2}\right)(2V)^\gamma = P_3(16)^\gamma$

$\Rightarrow P_3 = \frac{3}{2}\left(\frac{1}{8}\right)^{5/3} = \frac{P}{64}$

Hence, the correct option is (3).

18. A thermodynamics system undergoes cyclic process ABCDA as shown in Fig. The work done by the system in the cycle is:



(1) P_0V_0
(2) $2P_0V_0$
(3) $P_0V_0/2$
(4) Zero

Solution:

Work done under cyclic process ABCDA = Area of the graph

We know that

If $V_2 > V_1$ then $W > 0$ (When clock wise, Work done > 0) …(1)
If $V_2 < V_1$ then $W < 0$ (When anticlockwise, Work done < 0) …(2)
From the figure, by using (1) and (2)

$$=\frac{1}{2}(V_0-2V_0)(2P_0-P_0)+\frac{1}{2}(V_0-2V_0)(3P_0-2P_0)$$

$$=-\frac{1}{2}P_0V_0+\frac{1}{2}P_0V_0$$

= 0

Hence, the correct option is (4).

19. The mean free path of molecules of a gas (radius 'r') is inversely proportional to:

(1) r^3 (2) r^2
(3) r (4) $\sqrt{r}$

Solution:
We know that

Mean free path, $\lambda_m = \dfrac{1}{\sqrt{2}\pi d^2 n}$

$$d = 2r$$

$$\lambda_m = \frac{1}{\sqrt{2}\pi 4r^2 m}$$

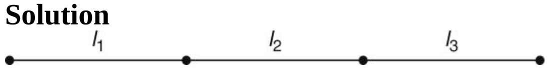
$$\lambda_m \propto \frac{1}{r^2}$$

Hence, the correct option is (2).

20. If n_1, n_2 and n_3 are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency n of the string is given by:

(1) $\frac{1}{n}=\frac{1}{n_1}+\frac{1}{n_2}+\frac{1}{n_3}$ (2) $\frac{1}{\sqrt{n}}=\frac{1}{\sqrt{n_1}}+\frac{1}{\sqrt{n_2}}+\frac{1}{\sqrt{n_3}}$
(3) $\sqrt{n}=\sqrt{n_1}+\sqrt{n_2}+\sqrt{n_3}$ (4) $n=n_1+n_2+n_3$

Solution



$$n_1=\frac{1}{2l_1}\sqrt{\frac{T}{\mu}}$$

$$n_2=\frac{1}{2l_2}\sqrt{\frac{T}{\mu}}$$

$$n_3=\frac{1}{2l_3}\sqrt{\frac{T}{\mu}}$$

$$l=l_1+l_2+l_3$$

Thus, $\dfrac{1}{n}=\dfrac{1}{n_1}+\dfrac{1}{n_2}+\dfrac{1}{n_3}$

Hence, the correct option is (1).

21. The number of possible natural oscillations of air column in a pipe closed at one end of length 85 cm whose frequencies lies below 1250Hz are: (velocity of sound = 340 ms^{-1})

(1) 4 (2) 5

(3) 7 (4) 6

Solution:

The fundamental frequency of a closed organ pipe is $f = \frac{V}{4l} = \frac{340}{4 \times 0.85} = 100\text{Hz}$

The natural frequencies of the organ pipe will be f = 100Hz, 300 Hz, 500 Hz, 700 Hz, 900 Hz and 1100Hz. Thus, there are 6 possible natural oscillations which are below 1250 Hz.

Hence, the correct option is (4).

22. A speeding motorcyclist sees traffic jam ahead of him. He slows down to 36 km/hour. He finds that traffic has eased and a car moving ahead of him at 18 km/hour is honking at a frequency of 1392 Hz. If the speed of sound is 343 m/s, the frequency of the honk as heard by him will be:

(1) 1332 Hz (2) 1372 Hz

(3) 1412 Hz (4) 1454 Hz

Solution:

Both source and observer are moving in the same direction

$$f = f_0\left[\frac{v + v_0}{v + v_s}\right]$$

Here v_s = 18 km/hr

v_0 = 36 km/hr

f_0 = 1392 Hz

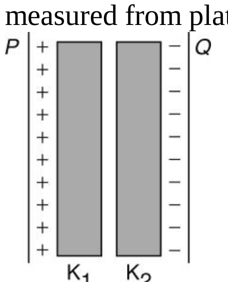
$$f = 1392\left[\frac{343 + 10}{343 + 5}\right]$$

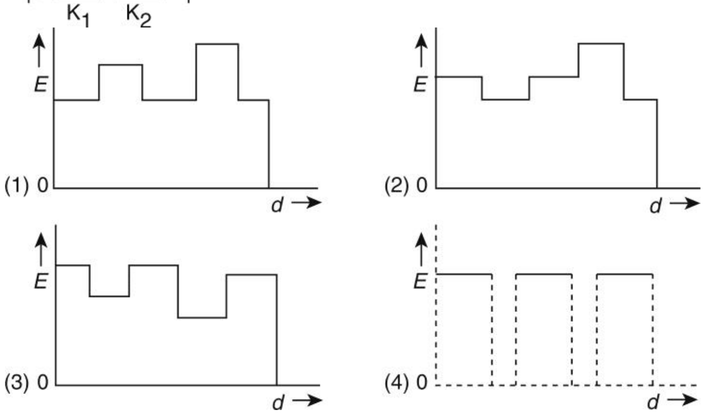
$$= 1392 \times \frac{353}{348}$$

= 1412 Hz

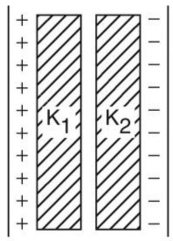
Hence, the correct option is (3).

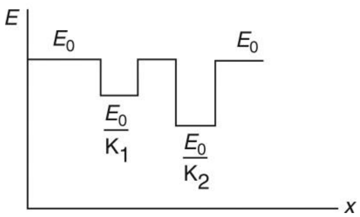
23. Two thin dielectric slabs of dielectric constants K_1 and K_2 ($K_1 < K_2$) are inserted between plates of a parallel plate capacitor, as shown in the figure. The variation of electric field 'E' between the plates with distance 'd' as measured from plate P is correctly shown by:





Solution:





Hence, the correct option is (3).

24. A conducting sphere of radius *R* is given a charge *Q*. The electric potential and the electric field at the center of the sphere respectively are:

(1) Zero and $\dfrac{Q}{4\pi\varepsilon_0 R^2}$

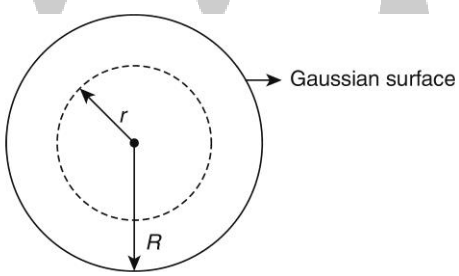
(2) $\dfrac{Q}{4\pi\varepsilon_0 R}$ and zero

(3) $\dfrac{Q}{4\pi\varepsilon_0 R}$ and $\dfrac{Q}{4\pi\varepsilon_0 R^2}$

(4) Both are zero

Solution:

Electric field inside the shell (or conducting sphere)



According to Gauss Law:

$$\oint E.ds = \frac{q_{\text{in}}}{\varepsilon_0}$$

$$E\oint ds = \frac{q_{in}}{\varepsilon_0}$$

$$E(4\pi r^2) = \frac{0}{\varepsilon_0}$$ [$\because$ Charge enclosed by the Gaussian surface will be zero].

$E = 0$

So, electric field inside the conducting sphere will be zero.

Potential inside the shell

Using $dV = \vec{E}.d\vec{r}$, we have

d$V = 0 \Rightarrow V$ = constant [$\because$ $E = 0$ inside the shell]

Thus, the potential at any point inside the uniformly charged shell is same. This will be equal to potential of surface. So, $V = \dfrac{q}{4\pi\varepsilon_0 R}$

Hence, the correct option is (2).

25. In a region the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in meters. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is:

(1) $6\sqrt{5}$ N	(2) 30 N
(3) 24 N	(4) $4\sqrt{35}$ N

Solution:

$V(x, y, z) = 6x - 8xy - 8y + 6xyz$

We know that

$$E_x = -\frac{\partial V}{\partial x}, E_y = -\frac{\partial V}{\partial y} \text{ and } E_z = -\frac{\partial V}{\partial z},$$

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

$$= -[(6-8y)\hat{i} + (-8x - 8 + 6z)\hat{j} + (6y)\hat{k}]$$

At (1, 1, 1) $\vec{E} = 2\hat{i} + 10\hat{j} - 6\hat{k}$

$\Rightarrow \vec{E} = \sqrt{2^2 + 10^2 + 6^2} = \sqrt{140} = 2\sqrt{35}$

q = 2 coulomb

$F = qE$

$= 2 \times 2\sqrt{35} = 4\sqrt{35}$ N

Hence, the correct option is (4).

26. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is 0.5 Ω. The power loss in the wire is:

(1) 19.2 W	(2) 19.2 kW
(3) 19.2 J	(4) 12.2 kW

Solution:

For 1 km,

$P = VI$

$$P = \frac{V^2}{R} = \frac{8 \times 8}{0.5}$$

For 150 km,

$$P = \frac{100 \times 8 \times 8}{0.5} = \frac{150 \times 640}{5}$$

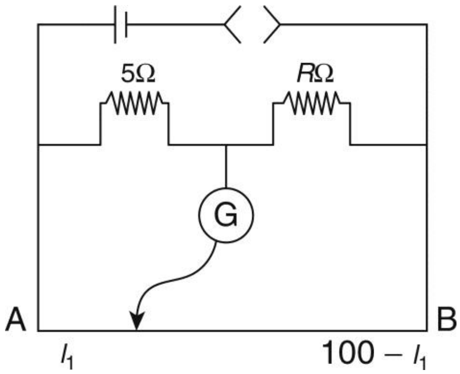
$= 30 \times 640$

$= 19200$ W

$= 19.2$ kW

Hence, the correct option is (2).

27. The resistance in the two arms of the meter bridge are 5Ω and RΩ, respectively. When the resistance R is shunted with an equal resistance, the new balance point is at 1.6 l_1. The resistance 'R' is:



(1) 10 Ω (2) 15 Ω
(3) 20 Ω (4) 25 Ω

Solution:

Before applying shunt resistance

$$\frac{5}{R} = \frac{l_1}{100 - l_1} \Rightarrow R = \frac{5(100 - l_1)}{l_1} \qquad \ldots(1)$$

After applying shunt resistance in R of equal value:

$$\frac{5}{R/2} = \frac{1.6l_1}{100 - 1.6l_1} \Rightarrow R = \frac{10(100 - 1.6l_1)}{1.6l_1} \qquad \ldots(2)$$

From (1) by (2) we get:

$$\frac{5(100 - l_1)}{l_1} = \frac{10(100 - 1.6l_1)}{1.6l_1}$$

$$8(100 - l_1) = 10(100 - 1.6l_1)$$

$800 - 8l_1 = 1000 - 16l_0$

$8l_1 = 200$

$l_1 = 25$

Putting l_1 in (1) we get:

$R = 15\ \Omega$

Hence, the correct option is (2).

28. A potentiometer circuit has been set up for finding the internal resistance of a given cell. The main battery, used across the potentiometer wire, has an emf of 2.0 V and a negligible internal resistance. The potentiometer wire itself is 4 m long. When the resistance R is connected across the given cell, has values of.

(i) infinity (ii) 9.5 Ω

The balancing lengths, on the potentiometer wire are found to be 3m and 2.85 m, respectively. The value of internal resistance of the cell is:

(1) 0.25 Ω (2) 0.95 Ω
(3) 0.5 Ω (4) 0.75 Ω

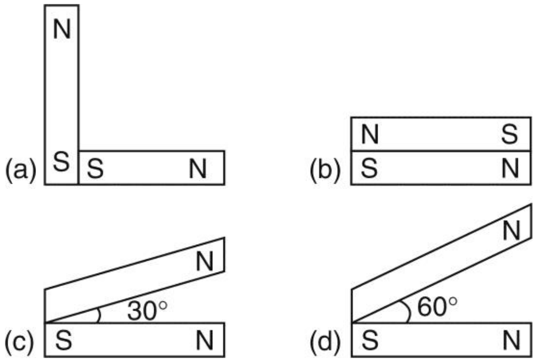
Solution:

For determination of internal resistance of a cell:

$$r = R\left(\frac{l_1}{l_2} - 1\right) = 9.5\left(\frac{3}{2.85} - 1\right) = 0.5\Omega$$

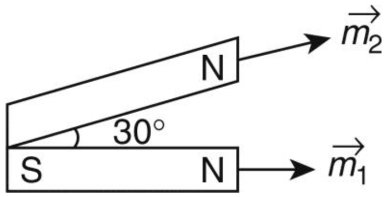
Hence, the correct option is (3).

29. Following figures show the arrangement of bar magnets in different configurations. Each magnet has magnetic dipole $\vec{m}$. Which configuration has highest net magnetic dipole moment?



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

Solution:
$m = IA\cos\theta$



$\vec{m}_{\text{net}} = \sqrt{m_1^2 + m_2^2 + 2m_1m_2\cos\theta}$

But $\vec{m}_1 = \vec{m}_2 = m$

$\vec{m}_{\text{net}} = \sqrt{2m^2 + 2m^2\cos\theta} = \sqrt{2m^2(1+\cos\theta)} = \sqrt{2m^2 \times 2\cos\theta/2} = 2M\cos\theta/2$

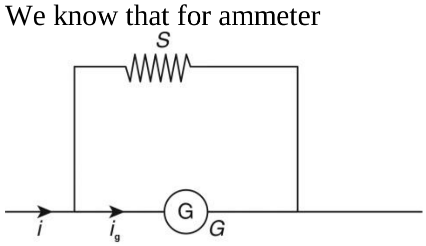
The value of m is maximum for $\theta = 30°$.

Hence, the correct option is (3).

30. In an ammeter 0.2% of main current passes through the galvanometer. If resistance of galvanometer is G, the resistance of ammeter will be:

(1) $\frac{1}{499}G$
(2) $\frac{499}{500}G$
(3) $\frac{1}{500}G$
(4) $\frac{500}{499}G$

Solution:
We know that for ammeter



$i_g = \frac{i \times s}{G + S}$ …..(1)

Given $i_g = \frac{0.2}{100}i$. Putting its value in (1)

$$\frac{0.2}{100} i = \frac{i \times s}{G + S}$$

$\Rightarrow 2G + 2S = 1000\,S$

$$\Rightarrow S = \frac{1}{499} G$$

Total Resistance = $\dfrac{SG}{S+G} = \dfrac{\frac{1}{499}G^2}{\frac{1}{499}G + G} = \dfrac{\frac{1}{499}}{\frac{900}{499}} G = \dfrac{1}{500} G$

Hence, the correct option is (3).

31. Two identical long conducting wires AOB and COD are placed at right angle to each other, with one above other such that 'O' is their common point for the two. The wires carry I_1 and I_2 currents, respectively. Point 'I' is lying at distance 'd' from 'O' along a direction perpendicular to the plane containing the wires. The magnetic field at the point 'P' will be:

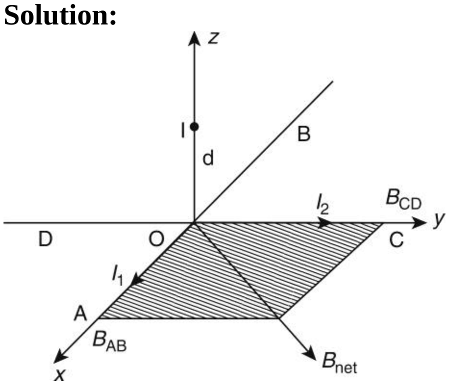
(1) $\dfrac{\mu_0}{2\pi d} \dfrac{I_1}{I_2}$

(2) $\dfrac{\mu_0}{2\pi d} (I_1 + I_2)$

(3) $\dfrac{\mu_0}{2\pi d} (I_1^2 - I_2^2)$

(4) $\dfrac{\mu_0}{2\pi d} \sqrt{I_1^2 + I_2^2}$

Solution:



$$B_{AB} = \frac{\mu_0 I_1}{2\pi d}$$

$$B_{CD} = \frac{\mu_0 I_2}{2\pi d}$$

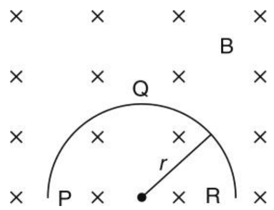
Net magnetic field $B_{net} = \sqrt{B_1^2 + B_2^2}$

$$= \sqrt{\left(\frac{\mu_o I_1}{2\pi d}\right)^2 + \left(\frac{\mu_0 I_2}{2\pi d}\right)^2}$$

Net magnetic field $= \dfrac{\mu_0}{2\pi d} \sqrt{I_1^2 + I_2^2}$

Hence, the correct option is (4).

32. A thin semicircular conducting the ring (PQR) of radius 'r' is falling with its plane vertical in a horizontal magnetic field B, as shown in figure. The potential difference developed across the ring when its speed is v, is:



(1) Zero
(2) $Bv\pi r^2/2$ and P is at higher potential
(3) $Bv\pi r/2$ and R is at higher potential
(4) $2Bvr$ and R is at higher potential

Solution:
For motion of conductor in magnetic field,
$E = B\, l_{\text{eff}}\, v$
$\because\ l_{\text{eff}} = 2r$
$\therefore\ E = B(2r)v = 2Brv$
R is at higher potential and P is at lower potential.
Hence, the correct option is (4).

33. A transformer having efficiency of 90% is working on 200V and 3kW power supply. If the current in the secondary coil is 6A, the voltage across the secondary coil and the current in the primary coil respectively are:
(1) 300V, 15A
(2) 450V, 15A
(3) 450V, 13.5A
(4) 600V, 15A

Solution:
$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}} = \frac{V_s I_s}{V_P I_p}$$
$$\frac{90}{100} = \frac{V_S \times 6}{3\times10^3}$$
$$V_S = \frac{0.9\times3\times10^3}{6} = 0.45 \times 10^3 = 450\text{V}$$
$P_{in} = V_P I_P$
$3000 = 200 \times I_P$
$I_P = 15\text{A}$
Hence, the correct option is (2).

34. Light with an energy flux of 25×10^4 Wm^{-2} falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm^2, the average force exerted on the surface is:
(1) 1.25×10^{-6} N
(2) 2.50×10^{-6} N
(3) 1.20×10^{-6} N
(4) 3.0×10^{-6} N

Solution:
For complete reflection
$\Delta p = 2h/\lambda$ ….(1)
$\therefore$ Momentum transfer per unit time i.e. force (F) exerted on the surface,
$F = n\Delta p$ (where n is no. of photons per second)
$$F = \frac{2nh}{\lambda} = \frac{2IA}{c}$$ {Putting value of Δp from (1)}
$$F_{av} = \frac{2IA}{c} = \frac{2\times25\times10^4\times15\times10^{-4}}{3\times10^8} = 2.5 \times 10^{-6}\text{ N}$$
Hence, the correct option is (2).

35. A beam of light of λ = 600 nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2m away. The distance between first dark fringes on either side of the central bright fringe is:

(1) 1.2 cm (2) 1.2 mm
(3) 2.4 cm (4) 2.4 mm

Solution:

Width of central bright fringe $= \frac{2\lambda D}{d} = \frac{2\times 600\times 10^{-6}\times 2}{10^{-3}}$ = 2.4 × 10^{-3} m = 2.4 mm

Hence, the correct option is (4).

36. In the Young's double slit experiment, the intensity of light at a point on the screen where the path difference is λ is K, (λ being the wavelength of light used). The intensity at a point where the path difference is $\lambda/4$ will be:

(1) K (2) K/4
(3) K/2 (4) Zero

Solution:

We know that

$$I = I_0 \cos^2 \frac{\phi}{2} \qquad \text{.....(1)}$$

Given, I_0 = K,

$$\phi = \frac{2\pi}{\lambda}\times \text{Path difference}$$

When path difference = λ

$$\phi = \frac{2\pi}{\lambda}\times\lambda = 2\pi$$

On putting these values in (1)

$$I = \mathrm{K}\cos^2\frac{2\pi}{2} = \mathrm{K}\cos^2\pi = \mathrm{K}$$

When path difference = $\lambda/4$

$$\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{4} = \frac{\pi}{2}$$

On putting these values in (1)

$$I = \mathrm{K}\cos^2\left[\frac{\pi}{4}\right] = \mathrm{K}\left[\frac{1}{\sqrt{2}}\right]^2 = \frac{\mathrm{K}}{2}$$

Hence, the correct option is (3).

37. If the focal length of objective lens is increased, then magnifying power of:

(1) microscope will increase but that of telescope decrease.
(2) microscope and telescope both will increase.
(3) microscope and telescope both will decrease.
(4) microscope will decrease but that of telescope will increase.

Solution:

Magnifying power of microscope $= \frac{LD}{f_0 f_e}$

Thus, magnifying power of microscope $\propto \frac{1}{f_0}$

Magnifying power of telescope $= \frac{-f_0}{f_e}$

Thus, magnifying power of telescope $\propto f_0$

Hence, the correct option is (4).

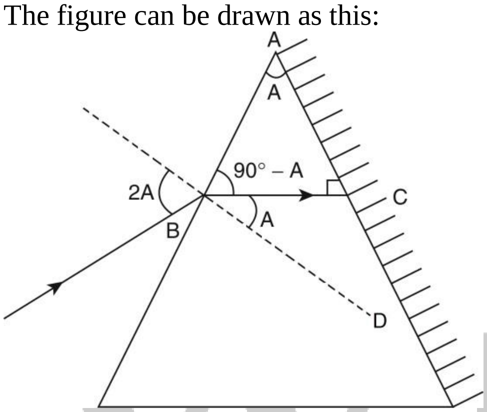
38. The angle of a prism is 'A'. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence 2A on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ of the prism is:

(1) 2 sinA (2) 2 cosA

(3) $\frac{1}{2}\cos A$ (4) tanA

Solution:

The figure can be drawn as this:



In ΔABC

$\angle A + \angle B + \angle C = 180°$

$\angle A + \angle B + 90° = 180°$

$\angle B = 90° - \angle A$

$\angle ABD = 90°$

$\angle ABC + \angle CBD = 90°$

$(90° - \angle A) + \angle CBD = 90°$

$\angle CBD = \angle A$

By Snell's law

sin 2A = μ sinA

μ = 2 cosA

Hence, the correct option is (2).

39. When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from emitted 0.5 eV to 0.8eV. The work function of the metal is

(1) 0.65 eV (2) 1.0 eV

(3) 1.3 eV (4) 1.5 eV

Solution:

According to Einstein's photoelectric equation:

$h\nu = \phi_0 + K_{max}$

When K.E. = 0.5 eV

$h\nu = \phi_0 + 0.5$ …(1)

When K.E. = 0.8 eV

Then, frequency is increased by 20% $\Rightarrow$ $\nu' = \nu + \frac{20}{100}\nu = \frac{6}{5}\nu = 1.2\nu$

$1.2h\nu = \phi_0 + 0.8$ …(2)

On dividing (1) by (2) we get:

$$\frac{h\nu}{1.2\,h\nu} = \frac{\phi_0 + 0.5}{\phi_0 + 0.8}$$

$\phi_0 + 0.8 = 1.2\phi_0 + 0.5 \times 1.2$

$0.8 - 0.6 = 0.2\,\phi_0$

$\phi_0 = 1$

Hence, the correct option is (2).

40. If the kinetic energy of the particle is increased to 16 times its previous value, the percentage change in the de-Broglie wavelength of the particle is:

(1) 25 (2) 75

(3) 60 (4) 50

Solution:

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{\frac{1}{2} \times 2mv \times mv}} = \frac{h}{\sqrt{\frac{1}{2}mv^2 \times 2m}} = \frac{h}{\sqrt{2m\,\mathrm{KE}}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{\mathrm{KE}_2}{\mathrm{KE}_1}}$$

Given, $\mathrm{KE}_2 = 16\mathrm{KE}_1$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{16\,\mathrm{KE}_1}{\mathrm{KE}_1}}$$

$$\frac{\lambda_1}{\lambda_2} = 4$$

$$-\frac{\lambda_2}{\lambda_1} = \frac{-1}{4}$$

$$1 - \frac{\lambda_2}{\lambda_1} = 1 - \frac{1}{4}$$

$$\frac{\lambda_1 - \lambda_2}{\lambda_1} = \frac{3}{4}$$

$$\frac{\lambda_1 - \lambda_2}{\lambda_1} \times 100 = \frac{3}{4} \times 100 = 75\%$$

Hence, the correct option is (2).

41. Hydrogen atom in ground state is excited by a monochromatic radiation of λ = 975 Å. Number of spectral lines in the resulting spectrum emitted will be:

(1) 3 (2) 2

(3) 6 (4) 10

Solution:

Energy of the photons, $E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{975 \times 10^{-10}} = 2.03 \times 10^{-16}\,\mathrm{J} = 12.75\ \mathrm{eV}$

This energy equals the energy gap between n = 1 (-13.6) and n = 4(-0.85). Thus, by the gain of this energy, the electron will excite from n = 1 to n = 4.
When the electron will fall back to its original state,

Numbers of spectral lines emitted = $\frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$

Hence, the correct option is (3).

42. The Binding energy per nucleon of $^{7}_{3}\text{Li}$ and $^{4}_{2}\text{He}$ nucleon are 5.60 MeV and 7.06 MeV, respectively. In the nuclear reaction $^{7}_{3}\text{Li} + ^{1}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + ^{4}_{2}\text{He} + Q$, the value of energy Q released is:

(1) 19.6 MeV
(2) -2.4 MeV
(3) 8.4 MeV
(4) 17.3 MeV

Solution:

Binding energy per nucleon of $^{7}_{3}\text{Li} = 5.60\ \text{MeV}$

Total binding energy of $^{7}_{3}\text{Li}$ = 7 × 5.6 = 39.2 MeV

Binding energy per nucleon of $^{4}_{2}\text{He}$ = 7.06

Total binding energy of $^{4}_{2}\text{He}$ = 4 × 7.06 = 28.24 MeV

$^{7}_{3}\text{Li} + ^{1}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + ^{4}_{2}\text{He} + Q$

39.20 28.24 × 2

Q = 56.48 – 39.20 = 17.28 MeV

Hence, the correct option is (4).

43. A radio isotope 'X' with a half-life 1.4×10^9 years decays to 'Y' which is stable. A sample of the rock from a cave was found to contain 'X' and 'Y' in the ratio 1 : 7. The age of the rock is:

(1) 1.96×10^9 years
(2) 3.92×10^9 years
(3) 4.20×10^9 years
(4) 8.40×10^9 years

Solution:

We know that

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$ and $t = n\, t_{1/2}$

$\frac{N_X}{N_Y} = \frac{1}{7} \Rightarrow \frac{N_Y}{N_X} = 7$

$\frac{N_Y}{N_X} + 1 = 8$

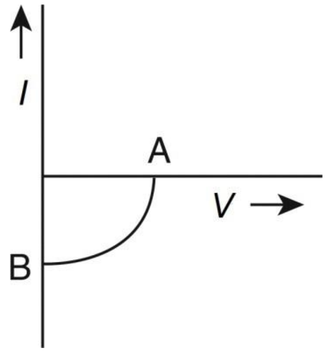
$\frac{N_X}{N_X + N_Y} = \frac{1}{8} = \left(\frac{1}{2}\right)^3$

n = 3

$t = 3 \times 1.4 \times 10^8$ yrs. $= 4.2 \times 10^9$ yrs.

Hence, the correct option is (3).

44. The given graph represents V-I characteristic for a semiconductor device.



(1) It is *V-I* characteristic for solar cell where, point A represents open circuit voltage and point B short circuit current.
(2) It is for a solar cell and points A and B represent open circuit voltage and current, respectively.
(3) It is for a photodiode and points A and B represent open circuit voltage and current respectively.
(4) It is for a LED and points A and B represent open circuit voltage and short circuit current, respectively.

Solution:
It is *V- I* characteristic curve for a solar cell, where A represent open circuit voltage of solar cell and B represent short circuit current.
Hence, the correct option is (1).

45. The barrier potential of a *p-n* junction depends on:
(a) type of semiconductor material
(b) amount of doping
(c) temperature
Which one of the following is correct?

(1) (a) and (b) only
(2) (b) only
(3) (b) and (c) only
(4) (a), (b) and (c)

Solution:
The barrier potential depends on type of semiconductor (for Si V_b = 0.7 volt and for Ge V_b = 0.3 volt), amount of doping and also on the temperature.
Hence, the correct option is (4).