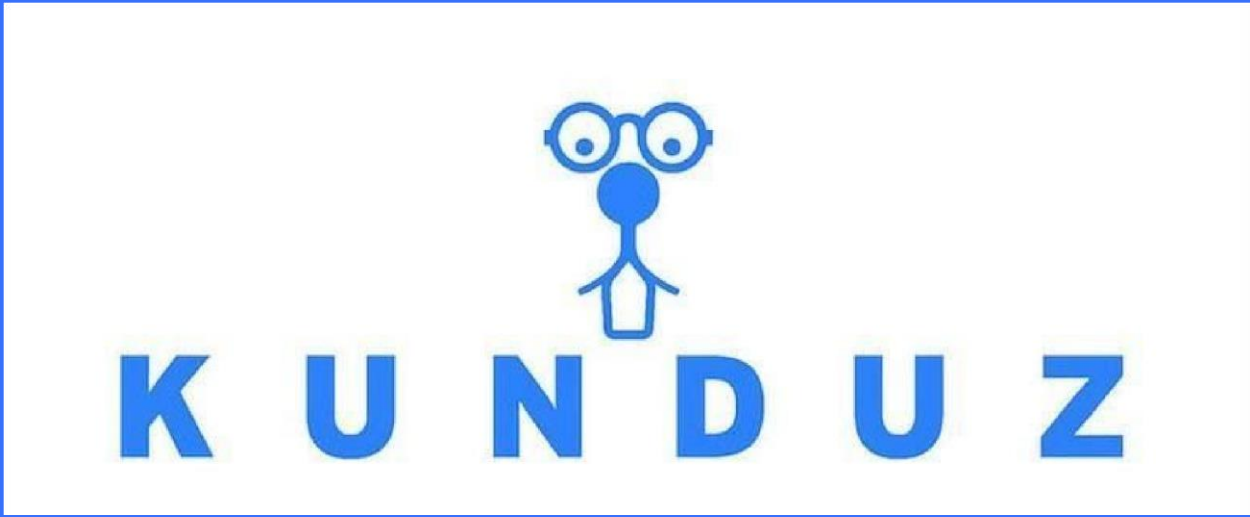


JEE Mains 3rd September 2020 shift 2 Physics solutions prepared by KUNDUZ tutors

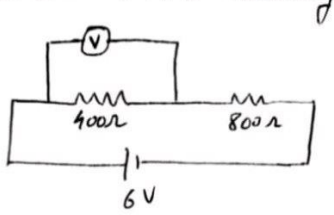
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Question number

Question and Answers

1

1 In the given diagram, resistance of voltmeter is 10kΩ, Find reading of voltmeter.



1) 4V 2) 3.23V
3) 1.95V 4) 1.26V

Sol) $R_{eq} = 800 + \left(\frac{1}{400} + \frac{1}{V}\right)^{-1}$

$V = 10000\,\Omega$

$\Rightarrow R_{eq} = 800 + \left(\frac{1}{400} + \frac{1}{10000}\right)^{-1}$

$\Rightarrow R_{eq} = \frac{15400}{13}\,\Omega$

$\Rightarrow$ current $= \frac{V}{R_{eq}} = \frac{6 \times 13}{15400} = \frac{39}{7700}$ A

R of voltmeter an 400Ω $= \left(\frac{1}{400} + \frac{1}{V}\right)^{-1}$

$= \frac{5000}{13}\,\Omega$

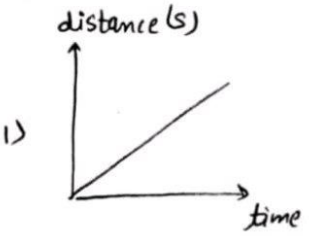
$\Rightarrow$ voltmeter reading $= I \times R$

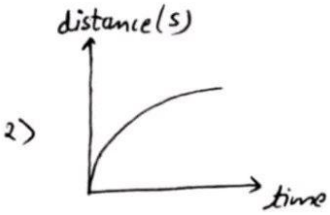
$= \frac{39}{7700} \times \frac{5000}{13} = \boxed{1.95\text{V}}$

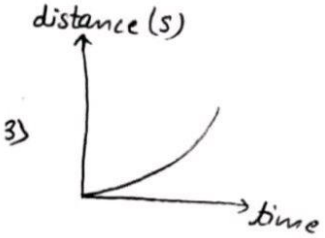
Thus, option 3 is correct.

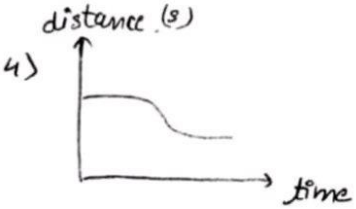
2

2 Constant power P is supplied to a particle having mass m, initially at rest. Choose correct graph :

1) 

2) 

3) 

4) 

sol) we know $P = \frac{\text{work done}}{t}$

$\Rightarrow P = \frac{WD}{t} \quad \Rightarrow WD = Pt$

By work energy theorem, $WD = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$u = 0$ {start from rest}

$\Rightarrow WD = \frac{1}{2}mv^2 \quad \Rightarrow Pt = \frac{1}{2}mv^2$

$\Rightarrow v = \sqrt{\frac{2Pt}{m}} \quad \Rightarrow \frac{ds}{dt} = \sqrt{\frac{2Pt}{m}}$

$\Rightarrow \int_0^s ds = \sqrt{\frac{2P}{m}} \int_0^t \sqrt{t}\, dt \quad \Rightarrow s = \sqrt{\frac{2P}{m}} \left[\frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1} \right]_0^t$

$\Rightarrow \boxed{s = \frac{2}{3}\sqrt{\frac{2P}{m}}\, t^{3/2}}$

Thus, option 3 is correct.

3

3

Two light ray having the same wavelength λ in vaccum are in phase initially. Then the first ray travels a path L_1 through a medium of refractive index n_1 while the second ray travels a path of length L_2 through a medium of refractive index n_2. The two waves are then combined to produce interference. The phase difference between the two waves at the point of interference is:

(1) $\frac{2\pi}{\lambda}(L_2 - L_1)$ (2) $\frac{2\pi}{\lambda}(n_1L_1 - n_2L_2)$

(3) $\frac{2\pi}{\lambda}(n_2L_1 - n_1L_2)$ (4) $\frac{2\pi}{\lambda}\left[\frac{L_1}{n_1} - \frac{L_2}{n_2}\right]$

Sol) For ray ①:

Path travelled $= x_1 = L_1$

$\Rightarrow$ optical path $= OPD_1 = n_1L_1$

For ray ②

Path travelled $= x_2 = L_2$

$\Rightarrow$ optical path $= OPD_2 = n_2L_2$

$\Rightarrow \Delta x = L_2 - L_1$

$\Rightarrow OPD = |OPD_2 - OPD_1| = |n_2L_2 - n_1L_1|$

We know that, phase difference $= K \times OPD$

K is wave number.

$\Rightarrow K = \frac{2\pi}{\lambda}$

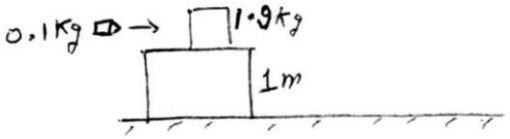
$\Rightarrow$ phase difference $= \boxed{\frac{2\pi}{\lambda}|n_2L_2 - n_1L_1|}$

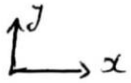
Thus, option 2 is correct.

4

4 In the given diagram a 0.1 kg bullet moving with speed 20 m/s strikes 1.9 kg mass and get embeded in it. Find the Kinetic energy of mass with which it strikes the ground.

1) 11 J 2) 21 J
3) 25 J 4) 30 J





Sol> By conservation of linear momentum:

$0.1 \times 20 = (0.1 + 1.9)\, V_x \Rightarrow V_x = 1\ m/s$

$d_y = 1m$ (given)

$V_y^2 = U_y^2 + 2g\, d_y \quad \{ U_y = 0 \}$

$\Rightarrow V_y^2 = 0 + 2 \times 10 \times 1 = 20\ (m/s)^2$

$\Rightarrow$ Total KE $= \frac{1}{2} m (V_x^2 + V_y^2) = \frac{1}{2} \times 2 \times (20 + 1) =$ **21 J**

Thus, option 2 is correct.

5

Q5. A calorimeter of water equivalent 20g contains 180g of water at 25°C. 'm' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to (Latent heat of water = 540 cal/g, Specific heat of water = $1\ cal\ g^{-1}\ °C^{-1}$)

(1) 2 (2) 4 (3) 3.2 (4) 2.6

Sol) mass of water = 180 + 20
= 200 g.

$\Rightarrow$ heat gained = $200 \times 1 \times (31-25)$
= 1200 cal.

Heat lost = $m \times 540 + m \times 1 \times (100-31)$
= $609m$ cal

$\Rightarrow 1200 = 609m$

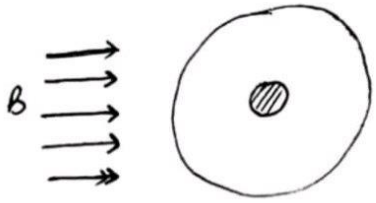
$\Rightarrow m = \frac{1200}{609} \approx \boxed{2}$

Thus, option 1 is correct.

6

6 In a diamagnetic sphere is a cavity at its centre and now paramagnetic material is inserted in the cavity. The sphere is kept in an external magnetic field. Magnetic field at its centre?

1) 0 2) B 3) $B_0 > B$ 4) $B_0 < B$.



sol) It is given that magnetic field exists in space.

That means magnetic field will be there in both diamagnetic and paramagnetic materials.

Since dia-magnetic material creates a magnetic field opposing the external magnetic field, thus, net magnetic field in diamagnetic material is zero.

In paramagnetic material, it will create a small magnetic field (B_{01}) in direction of $\vec{B}$.

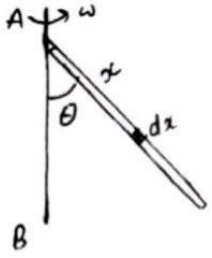
$\Rightarrow B_0 = B_{01} + B$

$\Rightarrow B_0 > B$ { B_0 is magnetic field in Paramagnetic material }

Thus, option 3 is correct.

7

7



A rod is rotating with angular velocity ω about axis AB. Find $\cos(\theta)$.

1) $\frac{g}{2l\omega^2}$ 2) $g/l\omega^2$

3) $2g/l\omega^2$ 4) $3g/2l\omega^2$

Sol) Let us solve question from rod frame of reference.

From here we will experience centrifugal force.

$\Rightarrow F_c$ = centrifugal force = $dm\, r\omega^2$

$dm = \frac{M\,dx}{l}$ { M is mass of rod (say). l is length of rod.

Let r be the perpendicular distance of dx from AB axis.

$\Rightarrow r = x\sin(\theta)$

$\Rightarrow F_c = dm\, x\sin(\theta)\,\omega^2$

$\Rightarrow F_c = \frac{M}{l}\sin(\theta)\omega^2 x\,dx$

Torque of Mg = Torque of F_c, about A.

$\Rightarrow$ Torque of $F_c = \int_0^l \frac{M}{l}\sin(\theta)\,\omega^2 x\,dx \times x\cos(\theta)$

$= \frac{M\sin(\theta)\omega^2\cos(\theta)}{l}\left[\frac{l^3}{3}\right]_0^l$

$\Rightarrow$ Torque of $Mg = Mg\frac{l}{2}\sin(\theta)$

$\Rightarrow Mg\frac{l}{2}\sin(\theta) = \frac{M\sin(\theta)\omega^2\cos(\theta)\,l^2}{3} = \boxed{\frac{3g}{2l\omega^2}}$

Thus, option 4 is correct

8

88. A uniform magnetic field B exists in a direction perpendicular to the plane of a square loop made of a metal wire. The wire has a diameter of 4mm and a total length of 30cm. The magnetic field changes with time at a steady rate $dB/dt = 0.032\ Ts^{-1}$. The induced current in the loop is close to (Resistivity of the metal wire is $1.23 \times 10^{-8}\ \Omega m$)

(1) 0.61A (2) 0.34A (3) 0.43A (4) 0.53A

Sol) Area of loop $= a^2 = \left[0.3/4\right]^2$

$= \frac{0.09}{16}\ m^2 = 5.625 \times 10^{-3}\ m^2$

$\Rightarrow emf = A\frac{dB}{dt} = 0.032 \times 5.625 \times 10^{-3}$

$\Rightarrow emf = 1.8 \times 10^{-4} V$

$\Rightarrow R = \rho\frac{l}{A} = \frac{1.23 \times 10^{-8} \times (30/100)}{\pi \times (2 \times 10^{-3})^2}$

$\Rightarrow R = 2.94 \times 10^{-4}\ \Omega$

$\Rightarrow i = emf/R = \frac{1.8 \times 10^{-4}}{2.94 \times 10^{-4}} = \boxed{0.61A}$

Thus, option 1 is correct.

9

9 A mass m is moving in SHM on a line with amplitude A and frequency f in a spring mass system. Suddenly half of the mass comes to rest just at the moment, when it crosses mean position, then new Amplitude becomes λA, then λ will be.

1) $\frac{1}{2}$ 2) $\frac{1}{\sqrt{2}}$ 3) $\sqrt{2}$ 4) 1

Sol) Since no external force is present:

At mean position.

$mv = m'v'$, $m' = \frac{m}{2}$

$\Rightarrow mv = \frac{m}{2}v' \Rightarrow v' = 2v$

Also $v = A\omega$, $\omega = \sqrt{\frac{k}{m}}$

$\Rightarrow v = A\sqrt{\frac{k}{m}}$, $v' = A'\sqrt{\frac{k}{m'}}$

$\Rightarrow A'\sqrt{\frac{k}{m'}} = 2A\sqrt{\frac{k}{m}} \Rightarrow A' = A \times 2 \times \sqrt{\frac{m'}{m}}$

$\Rightarrow A' = 2A \times \sqrt{\frac{m}{2m}} = \sqrt{2}A$

$\Rightarrow \boxed{\lambda = \sqrt{2}}$

Thus, option 3 is correct.

10

Q10 The radius R of a nucleus of mass number A can be estimated by the formula $R=(1.3\times10^{-15})A^{1/3}$ m. It follows that the mass density of a nucleus is of the order of: ($m_{prot.} \cong m_{neut} \approx 1.67\times10^{-27}$ kg)

(1) 10^{10} kg m^{-3}
(2) 10^{24} kg m^{-3}
(3) 10^{3} kg m^{-3}
(4) 10^{17} kg m^{-3}

Sol>

$$R = 1.3\times10^{-15}\times A^{1/3}\ m$$

$$\Rightarrow \text{volume} = V = \frac{4}{3}\pi R^3 = \frac{4\pi A}{3}(1.3\times10^{-15})^3$$

$$\Rightarrow V = A\times 9.2\times10^{-45}\ m^3$$

$$\text{mass} = 1.67\times10^{-27}\times A$$

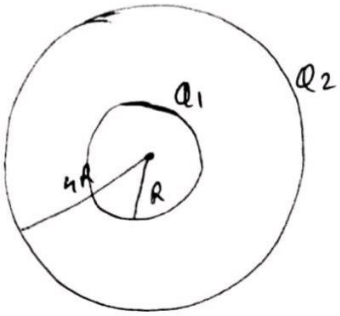
$$\Rightarrow \rho = \frac{\text{mass}}{V}$$

$$= \frac{A\times1.67\times10^{-27}}{A\times9.2\times10^{-45}} = \boxed{1.815\times10^{17}\ kg/m^3}$$

Thus, option 4 is correct.

11

11 In the given figure, there are two concentric spherical shells, find potential difference between the spheres:



1) $\frac{3}{8\pi\varepsilon_0}\cdot\frac{Q_1}{R}$ 2) $\frac{3}{16\pi\varepsilon_0}\cdot\frac{Q_2}{R}$

3) $\frac{3}{4\pi\varepsilon_0}\cdot\frac{Q_1}{R}$ 4) $\frac{3}{16\pi\varepsilon_0}\cdot\frac{Q_1}{R}$

Sol) Potential of inner sphere = V_{in}

$$\Rightarrow V_{in} = \frac{kQ_1}{R} + \frac{kQ_2}{4R}$$

Potential of outer sphere = V_{out}

$$\Rightarrow V_{out} = \frac{kQ_1}{4R} + \frac{kQ_2}{4R}$$

$$\Rightarrow \Delta V = V_{in} - V_{out} = \frac{kQ_1}{R} + \frac{kQ_2}{4R} - \frac{kQ_1}{4R} + \left[-\frac{kQ_2}{4R}\right]$$

$$= \frac{kQ_1}{R}\left(1-\frac{1}{4}\right) = \frac{3kQ_1}{4R}$$

$$\Rightarrow \Delta V = \frac{3Q_1}{4R}\times\frac{1}{4\pi\varepsilon_0} = \boxed{\frac{3}{16\pi\varepsilon_0}\cdot\frac{Q_1}{R}}$$

Thus, option 4 is correct.

12

12 Electric field of an electromagnetic wave is $\vec{E} = E_0 \cos(\omega t - kx)\hat{j}$. The equation of corresponding magnetic field at $t = 0$ should be:

1) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}$

2) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)\hat{k}$

3) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)(-\hat{k})$

4) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)(-\hat{k})$

Sol) We know that $B = \frac{E}{c}$

And $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$\Rightarrow B_0 = \frac{E_0}{1/\sqrt{\mu_0\varepsilon_0}} = E_0\sqrt{\mu_0\varepsilon_0}$

Also $\hat{c} = \hat{E} \times \hat{B}$

$\hat{E} = \hat{j}$, $\hat{c} = \hat{i}$

For $\hat{c} = \hat{E} \times \hat{B}$, $\hat{B}$ should be $\hat{k}$

$\Rightarrow \boxed{\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}}$

Thus, option 1 is correct.

13

813. Hydrogen ion and singly ionized helium atom are accelerated, from rest, through the same potential difference. The ratio of final speeds of hydrogen and helium ions is close to:

(1) 1:2 (2) 2:1 (3) 5:7 (4) 10:7

Sol) we know that, energy $= qV$

By work energy theorem, $qV = \frac{1}{2} m V_e^2$

V_e is velocilocity and V is voltage.

$$\Rightarrow \quad V_e = \sqrt{\frac{2qV}{m}}$$

$$\Rightarrow \quad V_e \propto \frac{1}{\sqrt{m}}$$

$m_H = m, \Rightarrow m_{He} = 4m$

$$\Rightarrow \frac{V_{eH}}{V_{eHe}} = \sqrt{\frac{m_{He}}{m_H}} = \sqrt{\frac{4}{1}} = 2$$

$$\Rightarrow \boxed{V_{eH} : V_{eHe} = 2:1}$$

Thus, option 2 is correct.

14

14 A p-n junction becomes active as photons of wavelength $\lambda = 400$ nm falls on it. Find the energy band gap.

1) 3.09 eV 2) 4.51 eV 3) 2.45 eV 4) 5.34 eV

Sol) Since photon of 400 nm just makes p-n junction active,

$\Rightarrow$ energy band gap = energy supplied by photons

$$\Rightarrow E_0 = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{400 \times 10^{-9}}$$

$$\Rightarrow \boxed{E_0 = 3.1 \text{ eV}}$$

Thus, option 1 is correct.

15

15 Dimension of solar constant:

1) $M^1L^0T^{-3}$ 2) $M^1L^1T^{-3}$ 3) $M^0L^0T^3$ 4) $M^1L^2T^{-3}$

Sol) Solar constant is energy by sun per unit area per unit time :

$\Rightarrow$ Solar constant = $\frac{\text{Energy}}{\text{Area} \times \text{time}}$

$\Rightarrow$ Dimension of energy = ML^2T^{-2}

Dimension of time = T

Dimension of Area = L^2

$\Rightarrow$ Dimension of solar constant = $\frac{ML^2T^{-2}}{TL^2}$

$= ML^0T^{-3}$

Thus, option 1 is correct.

16

16 Given, two point sources having same power of 200w. One source is emitting photons of $\lambda_1 = 500nm$ and other emitting photons of $\lambda_2 = 1nm$. Find the ratio of photon density of both the sources?

1) 200 2) 500 3) 250 4) 0.4

Sol) We know that $P = \frac{n hc}{\lambda t}$

where n is photon density, t is time.

$\Rightarrow P_1 = \frac{n_1 hc}{\lambda_1 t}$, $P_2 = \frac{n_2 hc}{\lambda_2 t}$

Given $P_1 = P_2 = 200\,w$

$\Rightarrow \frac{n_1}{\lambda_1} = \frac{n_2}{\lambda_2} \Rightarrow \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{500}{1} \Rightarrow \boxed{\frac{n_1}{n_2} = 500}$

Thus, option 2 is correct.

17

Q17. Which of the following will NOT be observed when a multimeter (operating in resistance measuring mode) probes connected across a component, are just reversed?

(1) Multimeter shows a deflection, accompained by a splash of light out of connected component in one direction and NO deflection on reversing the probes if the chosen component is LED.

(2) Multimeter shows NO deflection in both cases i.e. before and after reversing in the probes is the chosen component is metal wire.

(3) Multimeter show NO deflection in both cases i.e. before and after reversing the probes if the chosen component is cahacitor.

(4) Multimeter shows an equal deflection in both cases i.e., before and after reversing the probes if the chosen component is resistor.

Sol> In case of metal wire multimeter show no deflection, where as in case of LED it shows deflection only before reversing the probes.

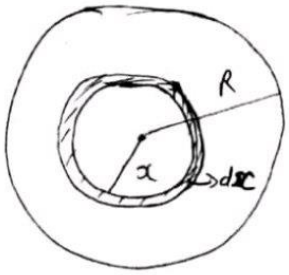
In case of pure resistor multimeter show deflection before and after reversing the probes.

Thus, correct option is (3).

18

18 Mass density of a sphere having radius R varies as $\rho = \rho_0\left[1-\frac{r^2}{R^2}\right]$ Find maximum magnitude of gravitational field.

Sol)



Let us take a differential element of radius x and thickness dx.

$$\Rightarrow dm = 4\pi x^2 dx\,\rho$$

$$\Rightarrow dm = 4\pi x^2 dx\,\rho_0\left(1-\frac{x^2}{R^2}\right)$$

$$\Rightarrow m = \int_0^t 4\pi x^2 dx\,\rho_0\left(1-\frac{x^2}{R^2}\right) = 4\pi\rho_0\int_0^t\left(x^2-\frac{x^4}{R^2}\right)dx$$

$$\Rightarrow m = 4\pi\rho_0\left(\frac{t^3}{3}-\frac{t^5}{5R^2}\right)$$

Also $E = \frac{Gm}{t^2} \Rightarrow E = G4\pi\rho_0\left(\frac{t}{3}-\frac{t^3}{5R^2}\right)$

For maxima: $\frac{dE}{dt}=0$

$$\Rightarrow \frac{dE}{dt} = G4\pi\rho_0\left[\frac{d}{dt}\left(\frac{t}{3}\right)-\frac{d}{dt}\left(\frac{t^3}{5R^2}\right)\right]=0$$

$$\Rightarrow \frac{1}{3}-\frac{3t^2}{5R^2}=0 \Rightarrow \frac{3t^2}{5R^2}=\frac{1}{3}$$

$$\Rightarrow t = \frac{\sqrt{5}R}{3}$$

$$\Rightarrow E_{max} = 4\pi G\rho_0\times\left[\frac{\sqrt{5}R}{3\times 3}-\left(\frac{\sqrt{5}}{3}\right)^3\times\frac{R}{5}\right] = \boxed{\frac{8\sqrt{5}}{27}\pi G\rho_0 R}$$

19

19 An ideal gas is heated by 160 J at constant pressure, its temperature rises by 50°c and if 240 J of heat is supplied at constant volume, temperature rises by 100°c. Then its degree of freedom is:

1) 3 2) 5 3) 6 4) 7

Sol) At constant pressure:

$\Delta Q = n C_p \Delta T$

$\Delta Q = 160\,J$, $\Delta T = 50$

$\Rightarrow C_p = \frac{\Delta Q}{\Delta T\, n} = \frac{160}{50n} = \frac{16}{5n}$ — (1)

At constant volume:

$\Delta Q = n C_v \Delta T$

$\Delta Q = 240\,J$, $\Delta T = 100$

$\Rightarrow 240 = n C_v \times 100 \Rightarrow C_v = \frac{240}{100n} = \frac{12}{5n}$ — (2)

we know that $\frac{C_p}{C_v} = \gamma$

$\Rightarrow \frac{16}{5n} \times \frac{5n}{12} = \gamma \Rightarrow \gamma = \frac{4}{3}$

Also $\gamma = 1 + \frac{2}{f} \Rightarrow \frac{4}{3} = 1 + \frac{2}{f}$

$\Rightarrow \boxed{f = 6}$

Thus, option 3 is correct.

20

20 A body cools from 50°c to 40°c in 5 min in surrounding temperature of 20°c. Find the temperature of body after next 5 min.

1) 13.3°c 2) 23.3°c 3) 43.3°c 4) 33.3°c

Sol) By Newton's law of cooling:

$$\frac{\theta_1 - \theta_2}{\Delta t} = K\left(\frac{\theta_1 + \theta_2}{2} - \theta_0\right)$$

here θ_0 = Atmospheric temperature = 20°c

$\theta_1 = 50°c$, $\theta_2 = 40°c$, $\Delta t = 5 min$

$$\Rightarrow \frac{50-40}{5} = K\left(\frac{50+40}{2} - 20\right) \quad \text{— (1)}$$

Let the temperature of body after 5 min be θ.

$$\Rightarrow \frac{40-\theta}{5} = K\left(\left(\frac{\theta+40}{2}\right) - 20\right) \quad \text{— (2)}$$

$$\frac{(1)}{(2)} \Rightarrow \frac{50-40}{40-\theta} = \frac{25}{\left(\frac{\theta+40}{2} - 20\right)} \Rightarrow 10\left(\frac{\theta+40}{2} - 20\right) = 25(40-\theta)$$

$$\Rightarrow 5\theta + 200 - 200 = 1000 - 25\theta$$

$$\Rightarrow 30\theta = 1000 \Rightarrow \theta = \frac{1000}{30} = \frac{100}{3} = 33.3°c$$

$$\Rightarrow \boxed{\theta = 33.3°c}$$

Thus, option 4 is correct.

21

821. A galvanometer coil has 500 turns and each turn has an average area of $3\times10^{-4}\,m^2$. If a torque of 1.5 Nm is required to keep this coil parallel to the magnetic field when a current of 0.5A is flowing through it, the strength of the field (in T) is

Sol>

Given, $n = 500$, $A = 3\times10^{-4}\,m^2$

$\tau = 1.5\,Nm$, $I = 0.5A$

we know that $\vec{\tau} = ni(\vec{A}\times\vec{B})$

$\Rightarrow \tau = iAB\sin(\theta)\, n$

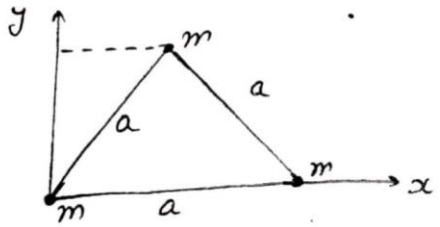
Since, coil is parallel to magnetic field, $\theta = 90^\circ$

$\Rightarrow \tau = niAB \Rightarrow 1.5 = 0.5\times 3\times10^{-4}\times B\times 500$

$\Rightarrow B = \frac{100}{5} = \boxed{20\ T}$

22

22 In the diagram three point masses 'm' each are fixed at the corners of an equilateral triangle. Moment of inertia of the system about y axis is $\frac{N}{20}ma^2$, N is:



1) 25 2) 50
3) 75 4) 100

sol) Perpendicular distances of three mass from y axis is $0, a, \frac{a}{2}$

$$\Rightarrow I = m(0^2) + ma^2 + m\left(\frac{a}{2}\right)^2$$

$$\Rightarrow I = 0 + ma^2 + \frac{ma^2}{4} = \frac{5ma^2}{4}$$

$$\Rightarrow \frac{N}{20}ma^2 = \frac{5ma^2}{4} \Rightarrow \boxed{N = 25}$$

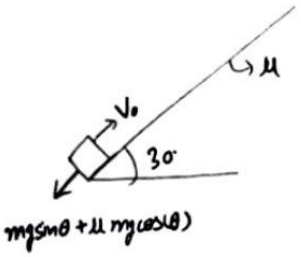
Thus, option 1 is correct.

23

23 A block starts going up a rough inclined plane with speed V_0 as shown in figure. After some time it reaches to starting point again with a speed $\frac{V_0}{2}$. Find coefficient of friction 'μ'. Given $g = 10 m/s^2$

1) 0.15 2) 0.35 3) 0.75 4) 0.80

Sol) Correct option 2.



$$\Rightarrow a_{net} = g\sin(\theta) + \mu g\cos(\theta)$$

$$\Rightarrow V^2 = u^2 - 2a_{net}S \quad , V = 0$$

$$\Rightarrow V_0^2 = 2g(\sin\theta + \mu\cos\theta)S$$

$$\Rightarrow S = \frac{V_0^2}{2g\left(\frac{1}{2} + \frac{\mu\sqrt{3}}{2}\right)} = \frac{V_0^2}{g(1+\sqrt{3}\mu)}$$

$$\Rightarrow \text{WD by friction} = \mu mg\cos\theta \times (2S)$$

$$= 2\mu mg\frac{\sqrt{3}}{2} \times \frac{V_0^2}{g(1+\sqrt{3}\mu)}$$

$$= \frac{\mu m V_0^2\sqrt{3}}{(1+\sqrt{3}\mu)}$$

$$\Delta KE = \frac{1}{2}mV_0^2 - \frac{1}{2}m\left(\frac{V_0}{2}\right)^2 = \frac{m}{2}\cdot\frac{3V_0^2}{4}$$

$$= \frac{3mV_0^2}{8}$$

$$\Rightarrow \Delta KE = WD \Rightarrow \frac{3mV_0^2}{8} = \frac{\mu m V_0^2\sqrt{3}}{1+\mu\sqrt{3}}$$

$$\Rightarrow \frac{3}{8} = \frac{\mu\sqrt{3}}{1+(\mu\sqrt{3})} \quad = 3+3\sqrt{3}\mu = 8\mu\sqrt{3}$$

$$\Rightarrow \mu = \frac{3}{5\sqrt{3}} = 0.346$$

24

24 A spherical mirror forms image of a point object, placed at principle axis at a distance 10 cm, at a distance 30 cm from mirror. If object start moving at velocity 9 cm/s. Fing the initial velocity of image.

1) -9 cm/s 2) -4 cm/s 3) -1 cm/s 4) -3 cm/s

Sol) We know that $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ for spherical mirror.

Differentiating both the sides with respect to time.

$$\Rightarrow 0 = \frac{d}{dt}\left(\frac{1}{v}\right) + \frac{d}{dt}\left(\frac{1}{u}\right)$$

$$\Rightarrow 0 = -\frac{1}{v^2}\frac{dv}{dt} + \left[-\frac{1}{u^2}\frac{du}{dt}\right]$$

$\frac{dv}{dt}$ = velocity of image = V_o

$\frac{du}{dt}$ = velocity of object = V_o'

$$\Rightarrow 0 = -\frac{1}{30^2} \times V_o' - \frac{1}{10^2} V_o$$

$$\Rightarrow -\frac{V_o'}{900} = \frac{V_o}{100}$$

$$\Rightarrow V_o = -\frac{V_o'}{9}, \quad V_o' = 9 \text{ cm/s (given)}$$

$$\Rightarrow V_o = -\frac{9}{9} = \boxed{-1 \text{ cm/s}}$$

Thus, option 3 is correct.

25

Q25. If minimum possible work is done by a refrigerator in converting 100g of water at 0°C to ice, how much heat (in calories) is released to the surroundings at temperature 27°C (Latent heat of ice = 80 cal/g) to the nearest integer?

Sol)

Heat given by water = 100 × 80 cal

= 8000 cal.

We know that, efficiency $= \frac{Q_1}{Q_2} - 1 = \eta$

Also $\eta = \frac{T_1 - T_2}{T_2}$

$\Rightarrow \frac{Q_1}{Q_2} - 1 = \frac{T_1 - T_2}{T_2}$

Q_1 is heat given to surroundings

Q_2 is heat taken

T_1 is temp. of surrounding

T_2 is temperature inside refrigerator

$\Rightarrow \frac{Q_1}{8000} - 1 = \frac{300 - 273}{273}$ $\Rightarrow Q_1 = 8000\left(1 + \frac{27}{273}\right)$

$\Rightarrow Q_1 = \frac{8000 \times 300}{273} = \boxed{8791.2 \text{ cal}}$

$\Rightarrow \boxed{Q_1 \approx 8791 \text{ cal}}$

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