PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. A body of man 100 kg travelled 10 m before coming to rest. If $\mu = 0.4$, work done against friction is (motion is happening on horizontal surface, take $g = 10\ m/s^2$)

(1) 4500 J (2) 5000 J

(3) 4200 J (4) 4000 J

Answer (4)

Sol. $\frac{v^2}{2a} = s$ $(a = \mu g)$

$v^2 = 2 \times \mu g\, s$

$v^2 = 2 \times (.4) \times 10 \times 10$

$v^2 = 80$

$w_f = \Delta k$

$= -\frac{1}{2} \times 100 \times 80$

$w_f = -4000$

2. If an object is having same weight at same distance above and below the surface of earth, find its distance from surface of earth.

(1) $\frac{R}{2}$ (2) $\left(\sqrt{5}-1\right)\frac{R}{2}$

(3) $\left(\sqrt{3}-1\right)\frac{R}{2}$ (4) $\left(\sqrt{5}-1\right)R$

Answer (2)

Sol. $\frac{GMm}{(R+x)^2} = \frac{GMm\,(R-x)}{R^3}$

$\Rightarrow R^3 = (R + x)^2 (R - x)$

$\Rightarrow R^3 = (R^2 - x^2) (R + x)$

$\Rightarrow x^2 + Rx - R^2 = 0$

$\therefore x = \frac{-R \pm \sqrt{R + 4R^2}}{2}$

$\boxed{x = \frac{\left(\sqrt{5}-1\right)}{2}R}$

3. Consider the two statements :

Statement-1 : A capillary tube is first dipped in hot water and then dipped in cold water. The rise is higher in hot water.

Statement-2 : Capillary tube is first dipped in cold water and then dipped in hot water. The rise is higher in cold water.

(1) Statement-1 is true and statement-2 is false

(2) Statement-1 is false and statement-2 is true

(3) Both statements are true

(4) Both statements are false

Answer (2)

Sol. $h = \frac{2S\cos\theta}{\rho g\, R}$

as $T\uparrow$, $S\downarrow$

The correct answer is Option (2).

4. If a particle starting from rest having constant acceleration covers distance S_1 in first $(p-1)$ seconds and S_2 in first p seconds, then determine time for which displacement is $S_1 + S_2$

(1) $\sqrt{2p^2 + 1 - 2p}$

(2) $\sqrt{2p^2 + 1 + 2p}$

(3) $\sqrt{(p-1)^2 - p}$

(4) $2p$

Answer (1)

Sol. $S_1 = \frac{1}{2}a(p-1)^2$

$S_2 = \frac{1}{2}ap^2$

$S_1 + S_2 = \frac{1}{2}a\left[(p-1)^2 + p^2\right] = \frac{1}{2}at^2$

$t = \sqrt{2p^2 + 1 - 2p}$

5. de-Broglie wavelength of a proton and an electron is same. The ratio of kinetic energy of electron to that of proton is

(1) 1 (2) 1835

(3) $\frac{1}{1867}$ (4) 933.5

Answer (2)

Sol. $\frac{h}{p_1}=\frac{h}{p_2}$

$\Rightarrow \sqrt{2m_1k_1}=\sqrt{2m_2k_2}$

$\Rightarrow \frac{k_2}{k_1}=\frac{m_1}{m_2}=1835$

6. If ratio of centripetal acceleration of two particles moving on the same path is 3 : 4. Find the ratio of their tangential velocities.

(1) $2:\sqrt{3}$

(2) $\sqrt{3}:2$

(3) $\sqrt{3}:1$

(4) $\sqrt{2}:1$

Answer (2)

Sol. $a_c=\frac{v^2}{r},\ \frac{(a_c)_1}{(a_c)_2}=\left(\frac{v_1}{v_2}\right)^2$

$\frac{3}{4}=\left(\frac{v_1}{v_2}\right)^2 \rightarrow \frac{v_1}{v_2}=\sqrt{3}:2$

7. A capacitor having capacitance of 100 μF is charged with a potential difference of 12 V is connected to an inductor of inductance 10 mH. Find the maximum current through the inductor.

(1) 2 A (2) 1.6 A

(3) 2.4 A (4) 1.2 A

Answer (4)

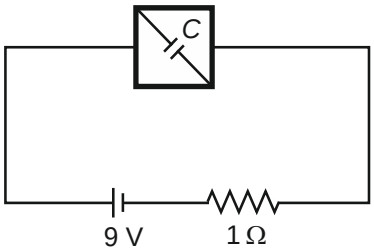
Sol. $I = Q_0.\omega$

$=\frac{CV}{\sqrt{LC}}=V\sqrt{\frac{C}{L}}$

$=12\sqrt{\frac{100\times10^{-6}}{10\times10^{-3}}}$

= 1.2 A

8. A square loop of resistance 16 Ω is connected with battery of 9 V and internal resistance of 1 Ω. In steady state, find energy stored in capacitor of capacity $C = 4$ μF as shown (at steady state current divides symmetrically)



(1) 51.84 μJ

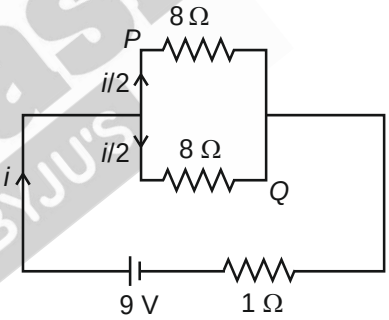
(2) 12.96 μJ

(3) 25.92 μJ

(4) 103.68 μJ

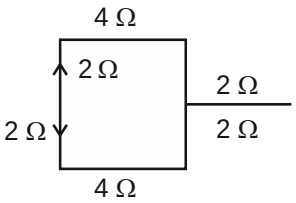
Answer (3)

Sol. Equivalent circuit



$i=\frac{9}{4+1}=1.8$ A

$\Rightarrow \frac{i}{2}=0.9$ A



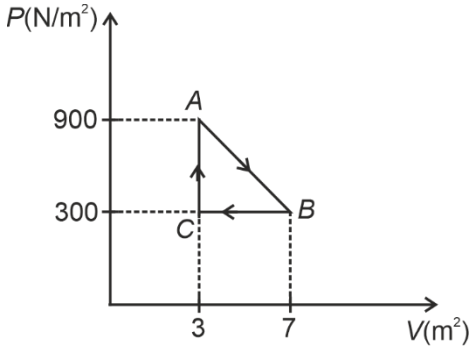
$(V_P - V_Q) = 0.9 \times 6 - 0.9 \times 2$

$V_C = 3.6$ V

$U=\frac{1}{2}CV^2=\frac{1}{2}\times4\times3.6\times3.6$ μJ

= 25.92 μJ

9. A gas undergoes a cyclic process *ABCA* as shown. Find the work done by the gas for $A \longrightarrow B \longrightarrow C$.



(1) 1800 J

(2) 1200 J

(3) 3600 J

(4) 600 J

Answer (2)

Sol. Work = Area

$\Rightarrow W = \frac{1}{2} \times 600 \times 4$

$= 1200$ J

10. If a biconvex lens of material of refractive index 1.5 has focal length 20 cm in air, then its focal length when it is submerged in a medium of refractive index 1.6 is

(1) –160 cm

(2) 160 cm

(3) 1.6 cm

(4) – 16 cm

Answer (1)

Sol. $\frac{1}{20} = (1.5-1)\left(\frac{2}{R}\right)$

$R = 20$ cm

$\frac{1}{f'} = \left(\frac{1.5}{1.6}-1\right)\left(\frac{2}{R}\right)$

$= \frac{-1}{16} \times \frac{2}{20}$

$\boxed{f' = -160 \text{ cm}}$

11. If electric current passing through a conductor varies with time as $I = I_0 + \beta t$, where $I_0 = 20$ A, $\beta = 3$ A/s, then find charge flow through conductor in first 10 sec.

(1) 400 C

(2) 500 C

(3) 200 C

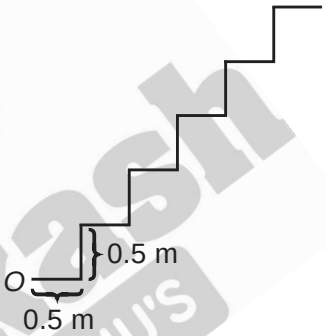
(4) 350 C

Answer (4)

Sol. $\Rightarrow d = \int I.dt = \int_0^{10} (20+3t)dt$

$= (20t)_0^{10} + 3\left(\frac{t^2}{2}\right)_0^{10} = 350$ C

12. Consider a series of steps as shown. A ball is thrown from *O*. Find the minimum speed of directly jump to 5th step.



(1) $5\left(\sqrt{2}+1\right)$ m/s

(2) $5\sqrt{2}$ m/s

(3) $5\sqrt{\sqrt{2}+1}$ m/s

(4) $6\sqrt{\sqrt{3}+1}$ m/s

Answer (3)

Sol. $y = x\tan\theta - \frac{gx^2}{2v^2\cos^2\theta}$

(2.5, 2.5) must lie on this

$\Rightarrow 1 = \tan\theta - \frac{g \times 2.5}{2v^2\cos^2\theta}$

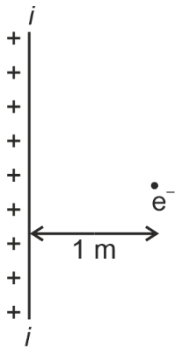
$\Rightarrow \frac{25}{2v^2\cos^2\theta} = \tan\theta - 1$

$\Rightarrow v^2 = \frac{25}{2}\left\{\frac{1+\tan^2\theta}{\tan\theta-1}\right\}$

$\Rightarrow v_{min} = 5\sqrt{\sqrt{2}+1}$

$\left[\text{Happens when } \tan\theta = \sqrt{2}+1\right]$

13. An electron is moving with speed of 1 m/s at distance of 1 m from a large sheet of charge with density σ C/m^2. Find maximum value of σ such that electron hit the sheet after 1 sec.



(mass of electron 9×10^{-31} kg, permittivity of free space $\varepsilon_0 = 9 \times 10^{-12}$ C^2/Nm^2)

(1) 4.05×10^{-22} C/m^2

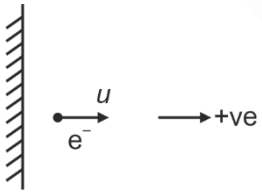
(2) 8.10×10^{-22} C/m^2

(3) 4.05×10^{24} C/m^2

(4) 2.02×10^{-20} C/m^2

Answer (1)

Sol. For maximum value of σ, initially, electron must move away from plate.



$$ut + \frac{1}{2}at^2 = s$$

$$t = 1 \quad u = 1\ \text{m/s} \quad s = -1\ \text{m}$$

$$1 \times 1 - \frac{1}{2}a \times 1^2 = -1$$

$$\Rightarrow \quad a = 4\ \text{m/s}^2$$

$$\frac{qE}{m} = 4$$

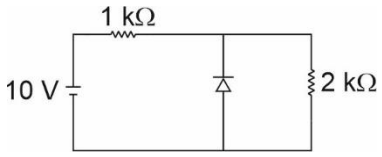
$$\frac{q\sigma}{2\varepsilon_0 m} = 4$$

$$\sigma = \frac{4 \times 2 \times 9 \times 10^{-12} \times 9 \times 10^{-31}}{1.6 \times 10^{-19}}$$

$$= \frac{8 \times 81}{1.6} \times 10^{-24}$$

$$= 4.05 \times 10^{-22}\ \text{C/m}^2$$

14. In the voltage regulator circuit shown below, the reverse breakdown voltage of zener diode is 3 V. Find the current through zener diode.



(1) 7 mA

(2) 1.5 mA

(3) 5.5 mA

(4) 10 mA

Answer (3)

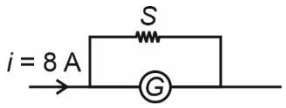
Sol. $i_{\text{battery}} = \frac{10-3}{1000} = 7\ \text{mA}$

$i_{2k\Omega} = \frac{3}{2000} = 1.5\ \text{mA}$

$i_z = (7 - 1.5)\ \text{mA}$

$= 5.5\ \text{mA}$

15. Consider the circuit shown. Galvanometer resistance is 10 Ω and current through galvanometer is 3 mA. Find the resistance of shunt.



(1) $10^{-3}\ \Omega$

(2) $7.5 \times 10^{-3}\ \Omega$

(3) $6.75 \times 10^{-3}\ \Omega$

(4) $3.75 \times 10^{-3}\ \Omega$

Answer (4)

Sol. Since G and S are in parallel

$\Rightarrow V_G = V_S$

$\Rightarrow 3\text{ mA} \times 10 = 8\text{ A} \times R_S$

$\Rightarrow R_S = 3.75\text{ m}\Omega$

16. A particle executing simple harmonic motion along x-axis, with amplitude A, about origin. If ratio of kinetic energy and total energy at $x = \frac{A}{3}$ is

(1) $\frac{8}{9}$

(2) $\frac{7}{8}$

(3) $\frac{1}{9}$

(4) $\frac{1}{8}$

Answer (1)

Sol. $KE = \frac{1}{2}m\omega^2(A^2 - n^2)$

$TE = \frac{1}{2}m\omega^2A^2$

$\frac{KE}{TE} = \frac{A^2 - n^2}{A^2} = \frac{1-\frac{1}{9}}{1} = \frac{8}{9}$

17.

18.

19.

20.

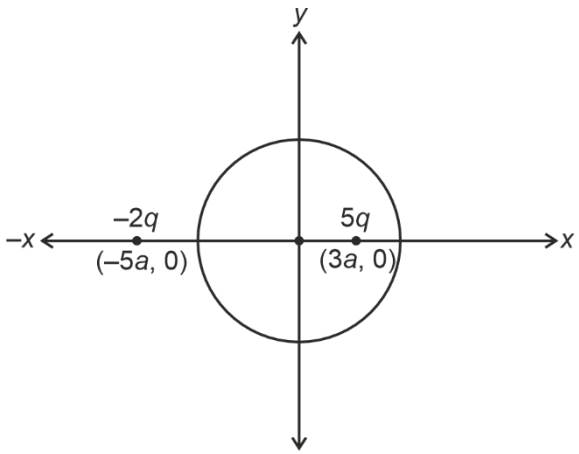
SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A solid sphere of radius $4a$ with centre at origin. Two charge, $-2q$ at $(-5a, 0)$ and $5q$ at $(3a, 0)$ is placed. Flux through sphere is $\frac{xq}{\varepsilon_0}$. Find x

Answer (5)

Sol.



From Gauss law

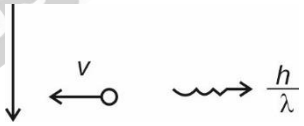
$\phi = \frac{q_{enclosed}}{\varepsilon_0} = \frac{5q}{\varepsilon_0}$

22. A stationary hydrogen atom de excites from first excited state to ground state. Find recoil speed of hydrogen atom up to nearest integral value. (mass of hydrogen atom = 1.8×10^{-27} kg)

Answer (3)

Sol. $|\Delta E_0| = \left(-13.6\left\{1 - \frac{1}{4}\right\}\right)$ ev

$|\Delta E| = 10.2$ ev



$\lambda = \frac{12400}{10.2} \times 10^{-10}$ m

$\rho = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34} \times 10.2}{12400 \times 10^{-10}}$

$\because \quad mv = \frac{h}{\lambda}$

$\therefore \quad 1.8 \times 10^{-27}$

$v = \frac{6.63 \times 10.2 \times 10^{-34}}{12400 \times 10^{-10}}$

$v = \frac{6.63 \times 10.2}{12400 \times 1.8} \times 10^3$

$= \frac{6.63 \times 102}{124 \times 1.8} = 3.02$

$\approx$ 3 m/s

23. In a container, 1 g of hydrogen and 1 g of oxygen are taken. Find the ratio of hydrogen pressure to oxygen pressure.

Answer (16)

Sol. $PV = nRT$

$\Rightarrow P \propto n$

$\Rightarrow$ Ratio = $\frac{32}{2} = 16$

24. In a convex mirror having radius of curvature 30 cm the height of image is half the object height. What will be the object (in cm) distance?

Answer (15)

Sol. $f = 15$

$$m = -\frac{v}{u} = +\frac{1}{2}$$

$$v = -\frac{u}{2}$$

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

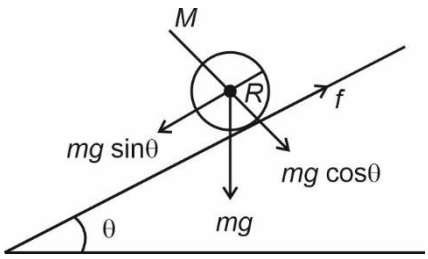
$$\frac{2}{-u} + \frac{1}{u} = \frac{1}{f}$$

$u = -f = -15$ cm

25. A solid cylinder is placed gently over an incline plane of inclination 60°. The acceleration of cylinder when it start rolling without slipping is $\frac{g}{\sqrt{x}}$, where μ is coefficient of friction. (Take g = 10 m/s^2)

Answer (3)

Sol.



Since $a = \frac{g\sin\theta}{1+\frac{I}{MR^2}}$

$$\Rightarrow a = \frac{g \times \frac{\sqrt{3}}{2}}{1+\frac{1}{2}} = \frac{g\frac{\sqrt{3}}{2}}{\frac{3}{2}}$$

$$\Rightarrow a = \frac{g}{\sqrt{3}}$$

26. Voltage and resistance for a resistor are measured as V = 200 ± 5 volts and R = 20 ± 0.2 Ω. The percentage error in current $I = \frac{V}{R}$ is x. Find the value of 10x

Answer (35)

Sol. % error $= \left(\frac{dV}{V} + \frac{dR}{R}\right) \times 100$

$$= \left(\frac{5}{200} + \frac{0.2}{20}\right) \times 100$$

= 3.5

27. Potential energy function corresponding to a conservative force is given as $U(x,y,z) = \frac{3x^2}{2} + 5y + 6z$, then the force at x = 6 is pN. The value of p upto its nearest integral value is

Answer (20)

Sol. $F_x = \frac{-dv}{dx}$

$\vec{F} = -3x\hat{i} - 5\hat{j} - 6\hat{k}$

$\left|\vec{F}\right|_{x=6} = \sqrt{18^2 + 5^2 + 6^2}$

$= \sqrt{324 + 25 + 36}$

$= \sqrt{385}$

= 19.62 N

28.

29.

30.