

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 mass 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 $g = 10 \text{ m/s}^2$)

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

Answer (2)

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

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

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

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

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

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

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

$$S_2 = \frac{1}{2} a p^2$$

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

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

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. $\frac{h}{\lambda_1} = \frac{h}{\lambda_2}$

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

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

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 $100 \mu\text{F}$ 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)

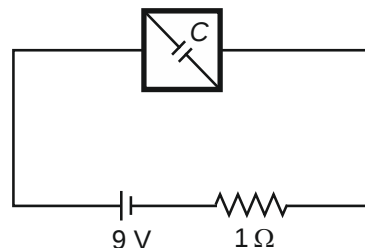
Sol. $I = Q_0 \omega$

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

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

$$= 1.2 \text{ A}$$

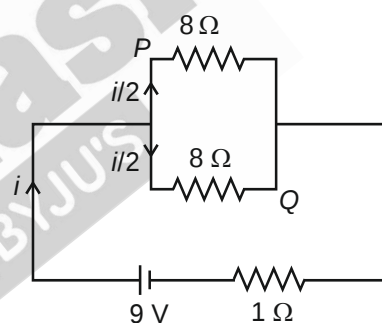
8. A square loop of resistance 16Ω is connected with battery of 9 V and internal resistance of 1Ω . In steady state, find energy stored in capacitor of capacity $C = 4 \mu\text{F}$ as shown (at steady state current divides symmetrically)



- (1) $51.84 \mu\text{J}$
(2) $12.96 \mu\text{J}$
(3) $25.92 \mu\text{J}$
(4) $103.68 \mu\text{J}$

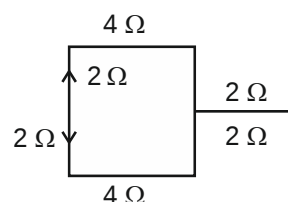
Answer (3)

Sol. Equivalent circuit



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

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



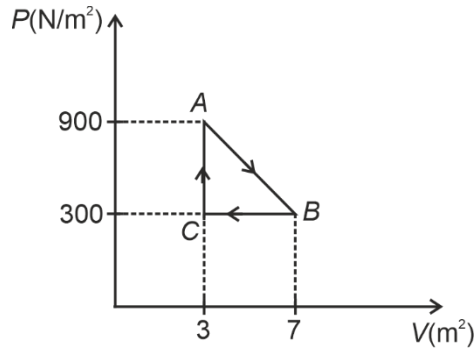
$$(V_P - V_Q) = 0.9 \times 6 - 0.9 \times 2$$

$$V_C = 3.6 \text{ V}$$

$$U = \frac{1}{2} CV^2 = \frac{1}{2} \times 4 \times 3.6 \times 3.6 \mu\text{J}$$

$$= 25.92 \mu\text{J}$$

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



- (1) 1800 J
(2) 1200 J
(3) 3600 J
(4) 600 J

Answer (2)

Sol. Work = Area

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

$$= 1200 \text{ J}$$

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

$$R = 20 \text{ cm}$$

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

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

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

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

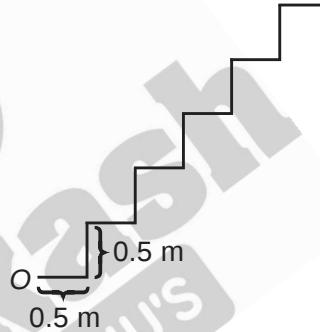
- (1) 400 C (2) 500 C
(3) 200 C (4) 350 C

Answer (4)

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

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

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) $5(\sqrt{2} + 1) \text{ m/s}$ (2) $5\sqrt{2} \text{ m/s}$
(3) $5\sqrt{\sqrt{2} + 1} \text{ m/s}$ (4) $6\sqrt{\sqrt{3} + 1} \text{ m/s}$

Answer (3)

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

(2.5, 2.5) must lie on this

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

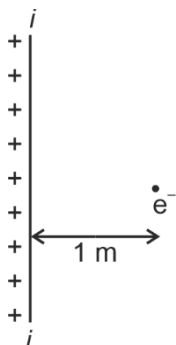
$$\Rightarrow \frac{25}{2v^2 \cos^2 \theta} = \tan \theta - 1$$

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

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

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

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/m². Find maximum value of σ such that electron hit the sheet after 1 sec.

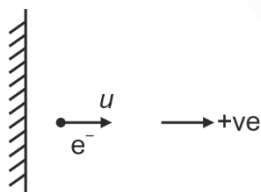


(mass of electron 9×10^{-31} kg, permittivity of free space $\epsilon_0 = 9 \times 10^{-12}$ C²/Nm²)

- (1) 4.05×10^{-22} C/m²
- (2) 8.10×10^{-22} C/m²
- (3) 4.05×10^{24} C/m²
- (4) 2.02×10^{-20} C/m²

Answer (1)

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



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

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

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

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

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

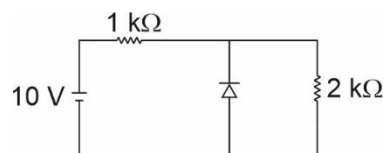
$$\frac{q\sigma}{2\epsilon_0 m} = 4$$

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

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

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

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)

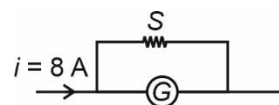
Sol. $i_{\text{battery}} = \frac{10-3}{1000} = 7 \text{ mA}$

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

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

$$= 5.5 \text{ mA}$$

15. Consider the circuit shown. Galvanometer resistance is 10Ω 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. $KE = \frac{1}{2} m \omega^2 (A^2 - n^2)$

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

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

17.

18.

19.

20.

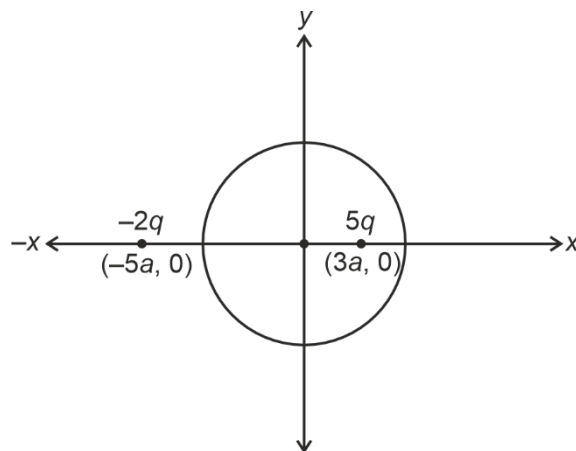
SECTION - B

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 $\frac{xq}{\epsilon_0}$. Find x

Answer (5)

Sol.



From Gauss law

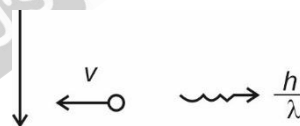
$$\phi = \frac{q_{\text{enclosed}}}{\epsilon_0} = \frac{5q}{\epsilon_0}$$

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

$$|\Delta E| = 10.2 \text{ eV}$$



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

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

$$\therefore mv = \frac{h}{\lambda}$$

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

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

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

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

$$\approx 3 \text{ m/s}$$

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. $PV = nRT$

$$\Rightarrow P \propto n$$

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

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. $f = 15$

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

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

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

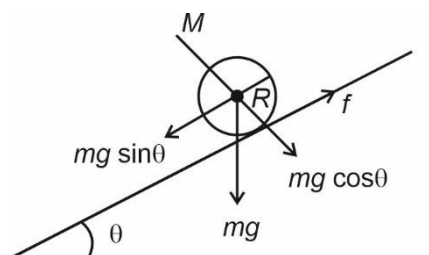
$$\frac{2}{-u} + \frac{1}{u} = \frac{1}{f}$$

$$u = -f = -15 \text{ cm}$$

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 $g = 10 \text{ m/s}^2$)

Answer (3)

Sol.



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

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

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

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

Answer (35)

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

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

$$= 3.5$$

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 $p\text{N}$. The value of p upto its nearest integral value is

Answer (20)

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

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

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

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

$$= \sqrt{385}$$

$$= 19.62 \text{ N}$$

28.

29.

30.