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. Electric flux ϕ is related with linear charge density λ and surface charge density σ as $\phi = \alpha\lambda + \beta\sigma$ where α and β are of appropriate dimensions of $\left(\frac{\beta}{\alpha}\right)$ is

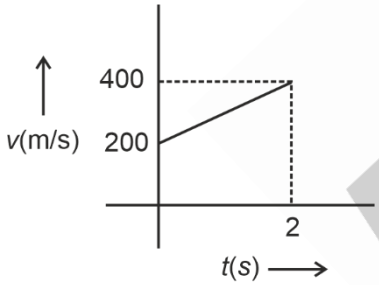
(1) Displacement (2) Area

(3) Electric field (4) Velocity

Answer (1)

Sol. $\alpha\lambda \equiv \beta\sigma \Rightarrow \frac{\beta}{\alpha} = \frac{\lambda}{\sigma} = \frac{Q/L}{Q/L^2} \equiv L$

2. For given velocity-time (v – t) graph, find distance travelled at 0.5 sec.



(1) 125 m (2) 112.5 m

(3) 137.5 m (4) 150 m

Answer (2)

Sol. $a = \frac{400-200}{2} = 100\ \text{m/s}^2$

$$S = ut + \frac{1}{2}at^2 = 200\times 0.5 + \frac{1}{2}\times 100\times\frac{1}{2}\times\frac{1}{2}$$

$$= 100 + 12.5 = 112.5\ \text{m}$$

3. The displacement of a particle as function of time is $x(t) = A\sin(t) + B\cos^2(t) + Ct^2 + D$. Find dimension of $\left[\frac{ABC}{D}\right]$

(1) L^2 (2) L^2T^{-2}

(3) LT^{-2} (4) L^3T

Answer (2)

Sol. $x(t) = A\sin(t) + B\cos^2(t) + Ct^2 + D$

We can say

$[D] = [L]$

$[C] = [LT^{-2}]$

$[B] = [L]$

$[A] = [L]$

So $\left[\frac{ABC}{D}\right] = \frac{L^3T^{-2}}{L} = [L^2T^{-2}]$

4. The ratio of electric force to gravitational force between two particles having charges q_1, q_2 and masses m_1 and m_2 respectively is (where symbols have their usual meanings)

(1) $\frac{4\pi\varepsilon_0 m_1 m_2 G}{q_1 q_2}$ (2) $\frac{4\pi\varepsilon_0 G m_1 m_2}{q_1 q_2 r^4}$

(3) $\frac{q_1 q_2 r^4}{4\pi\varepsilon_0 G m_1 m_2}$ (4) $\frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$

Answer (4)

Sol. $F_g = \frac{G m_1 m_2}{r^2}$

$$F_e = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$$

$$\frac{F_e}{F_g} = \frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$$

5. Match the column appropriately regarding thermodynamic process.

Column-I		Column-II	
(P)	When volume change is zero	(i)	$\Delta W = 0$
(Q)	When pressure is constant	(ii)	$\Delta Q = 0$
(R)	When no heat is exchanged	(iii)	Isobaric
(S)	Work done by the gas is equal to heat given to the gas	(iv)	Isothermal

(1) P(iv), Q(iii), R(i), S(ii)

(2) P(i), Q(iii), R(ii), S(iv)

(3) P(ii), Q(iii), R(iv), S(i)

(4) P(ii), Q(iii), R(i), S(iv)

Answer (2)

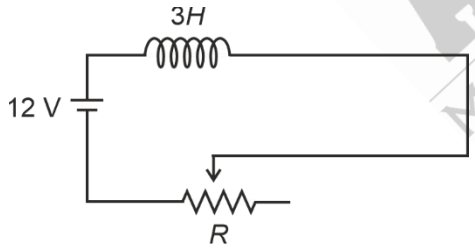
Sol. Volume change is zero $\rightarrow$ isochoric $\rightarrow \Delta W = 0$

Isobaric $\Rightarrow \Delta P = 0$

No heat exchange (adiabatic) $\Rightarrow \Delta Q = 0$

Heat given = $\Delta W \Rightarrow \Delta u = 0 \Rightarrow \Delta T = 0$

6. In given DC circuit, find current for R = 12 Ω in steady state.



(1) 2 A (2) 1 A

(3) 3 A (4) 4 A

Answer (2)

Sol. $i = \frac{V}{R} = \frac{12}{12} = 1\text{ A}$

7. **Statement-I :** Hot water is less viscous than of cold water.

Statement-II : Surface tension of soap bubble is more than that of a drop of water.

(1) Statement-I is true and statement-II true

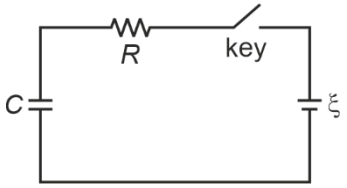
(2) Statement-I is true and statement-II false

(3) Statement-I is false and statement-II true

(4) Statement-I is false and statement-II false

Answer (2)

8. The key shown in the circuit is closed at t = 0.



Choose the incorrect option regarding the conditions at t = 0.

(1) Current in the circuit is zero

(2) Voltage across the capacitor is minimum

(3) Current in the circuit is maximum

(4) Voltage across resistance is maximum

Answer (1)

Sol. Immediately after closing the key the capacitor acts as a short circuit *i.e.* path of zero resistance. Hence, current is maximum at t = 0.

9. A uniform solid sphere of mass m rolls down from rest to achieve speed v_1 on an inclined plane of 30°. Sphere achieves speed v_2 on an inclined plane of 45° when released from same height then $\frac{v_1^2}{v_2^2}$ is

(assume no slipping)

(1) 1 (2) $\frac{5}{2}$

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

Answer (1)

Sol. $|\Delta U| = |\Delta K|$

$\Rightarrow \quad mgh = \frac{1}{2}(\gamma+1)mv^2$ where $\gamma = \frac{2}{5}$

Here v doesn't depend on θ so $\frac{v_1^2}{v_2^2} = 1$ for solid sphere

10. Find the equation of magnetic field for the give equation of electric field (for EM wave).

$E = E_0\left(4\hat{i} - 3\hat{j}\right)\cos(\omega t - kz)$

(1) $\vec{B} = \frac{E_0}{C}\left(3\hat{i} + 4\hat{j}\right)\cos\left(\omega t - kz\right)$

(2) $\vec{B} = \frac{E_0}{C}\left(-3\hat{i} - 4\hat{j}\right)\cos\left(\omega t - kz\right)$

(3) $\vec{B} = \frac{E_0}{C}\left(3\hat{i} - 4\hat{j}\right)\sin\left(\omega t - kz\right)$

(4) $\vec{B} = \frac{E_0}{C}\left(-3\hat{i} - 4\hat{j}\right)\sin\left(\omega t - kz\right)$

Answer (1)

Sol. Phase difference of magnetic field with electric field is zero.

Also $\left|\vec{B}\right| = \frac{\left|\vec{E}_0\right|}{C}$

$\Rightarrow \quad \left|\vec{B}\right| = \frac{\left|\vec{E}_0\right|5}{C}$

And propagation direction is along $\left(\vec{E}\times\vec{B}\right)$

So unit vector along $\vec{B}$ is $\left(\frac{3\hat{i}+4\hat{j}}{5}\right)$

So finally.

$\vec{B} = \frac{5\left|\vec{E}_0\right|}{C}\frac{\left(3\hat{i}+4\hat{j}\right)}{5}\cos(\omega t - kz)$

$\Rightarrow \quad \vec{B} = \frac{E_0}{C}(3\hat{i}+4\hat{j})\cos(\omega t - kz)$

11. Self-inductance depends on :

(1) Only on geometry

(2) Only on medium property

(3) Geometry and medium property

(4) Value of current through inductor

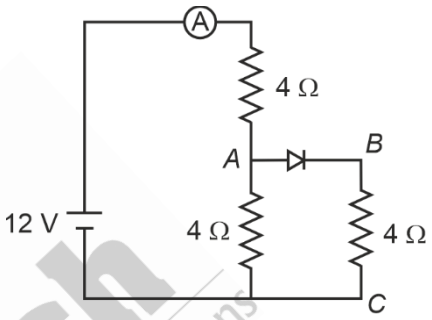
Answer (3)

Sol. $L = \mu_r\mu_0 n^2 V$

μ_r = relative permeability (medium)

V = Volume (geometry)

12. For the circuit shown below



(A) Current in ammeter is 2 A

(B) Net resistance is 8 Ω

(C) Voltage across BC is 4 V

(D) Current through diode is 1 A

Choose the correct option.

(1) Only ABC are correct

(2) Only ACD are correct

(3) Only ABD are correct

(4) Only AD are correct

Answer (2)

Sol. $R_{eq} = 6\ \Omega$

$i = \frac{12\text{ V}}{6\ \Omega} = 2\text{ A}$

$i_{AB} = 1$ A

$V_{BC} = 4$ V

13. Find the time period of a cube of side length 10 cm and mass 10 g oscillating in water. (density of water = 10^3 kg/m^3 and g = 10 m/s^2)

(1) $\frac{\pi}{25}$ second

(2) $\frac{\pi}{50}$ second

(3) $\frac{\pi}{100}$ second

(4) $\frac{2\pi}{25}$ second

Answer (2)

Sol. $a = -\frac{F}{m} = -\omega^2 x = \frac{-\Delta B}{m}$

$$= -\frac{(10\text{ cm})^2 x (10^3\text{ kg/m}^3)(10\text{ m/s}^2)}{(10\text{ g})} = -\frac{10^{-2}\times 10^3 \times 10}{10^{-2}} x$$

$a = -10^4 x$

$\Rightarrow \omega = 100$ rad/s

$T = \frac{2\pi}{\omega} = \frac{\pi}{50}$ s

14. Adiabatic constant of a gas is $\frac{3}{2}$. If volume of gas initially at 0°C is reduced to one fourth of the original volume then new temperature is

(1) 0 K

(2) 273 K

(3) 546°C

(4) 546 K

Answer (4)

Sol. $TV^{\gamma-1}$ = constant

$$273V^{\gamma-1} = T\left(\frac{V}{4}\right)^{\gamma-1}$$

$$273V^{1/2} = T\frac{V^{1/2}}{4^{1/2}}$$

$\Rightarrow T = 2 \times 273 = 546$ K

15. Two objects are equal distances from sphere of radius R & refractive index μ such that the image of one object forms on other object. Find the object distance from the surface of sphere.

(1) $\frac{R}{\mu}$

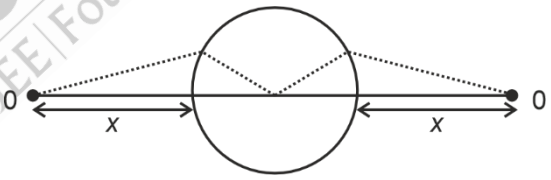
(2) $\frac{R}{\mu-1}$

(3) R

(4) $\frac{R}{\mu+1}$

Answer (2)

Sol.



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

After first refraction the ray must become parallel to the line joining two objects.

So $v = \infty$

$\Rightarrow 0 - \frac{1}{u} = \frac{(\mu-1)}{R}$

$\Rightarrow |u| = \frac{R}{\mu-1}$

16. There is force field $\vec{F} = x^3y\hat{i} + y^2\hat{j}$ in which a particle moves along the line $x = y$. Find work done by the force as the particle moves from (0, 0) to (2, 2)

(1) $\frac{173}{15}$ (2) $\frac{136}{15}$

(3) $\frac{139}{17}$ (4) $\frac{171}{17}$

Answer (2)

Sol. $w = \int_0^2 x^4dx + \int_0^2 y^2dy = \frac{2^5}{5} + \frac{2^3}{3} = \frac{136}{15}$

17. In a radioactive decay, decay constant of element A_2 is 3 times that of element A_1. Find the ratio of nuclei of element 1 to element 2 after one half life of A_2

(Assume initial number of nuclei are same for both elements)

(1) $2^{1/3}$

(2) $2^{2/3}$

(3) 2

(4) $2^{5/3}$

Answer (2)

Sol. $N_1 = N_0e^{-\lambda_1 t}$

$N_2 = N_0e^{-\lambda_2 t}$

$\frac{N_1}{N_2} = e^{-(\lambda_1-\lambda_2)t}$

$e^{-(\lambda-3\lambda)\frac{\ln 2}{3\lambda}}$

$= e^{\frac{2}{3}\ln 2}$

$= 2^{2/3}$

18.

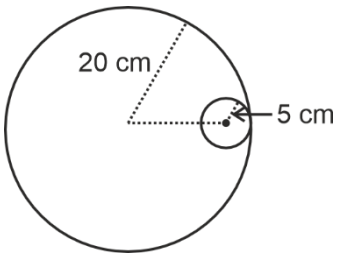
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. From a uniform circular disc of radius 20 cm a circular portion of radius 5 cm is removed. The shift in the position of centre of mass (in cm).



Answer (1)

Sol. $X_{com} = \frac{-\frac{M}{16} \times 15 \text{ cm}}{M - \frac{M}{16}}$

$= \frac{-\frac{M}{16}}{15\frac{M}{16}} \times 15 \text{ cm}$

$= -1 \text{ cm}$

22. A bullet of kinetic energy of 125 J strikes a lead block where temperature rises by 50°C. If specific heat of lead is 0.1 J/g-°C then mass of lead block is (Assume half of kinetic energy of bullet is converted to heat) m gram then $2m$ is

Answer (25)

Sol. $Q = ms\Delta T \Rightarrow \frac{125}{2} = m \times 0.1 \times 50$

$m = \frac{125}{10} = 12.5 \text{ gm}$

23.

24.

25.