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. The dimensions of a physical quantity $\varepsilon_0 \frac{d\phi_E}{dt}$ are similar to [Symbols have their usual meanings]

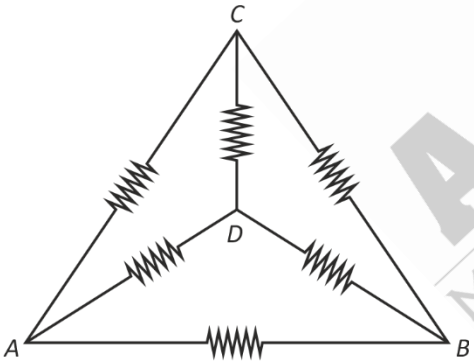
(1) Electric current (2) Electric field

(3) Electric flux (4) Electric charge

Answer (1)

Sol. $\varepsilon_0 \frac{d\phi_E}{dt}$ represents displacement current hence, dimensions are same as electric current.

2. Six resistors of resistance R each are connected as shown in the figure. Find equivalent resistance across points A and B.

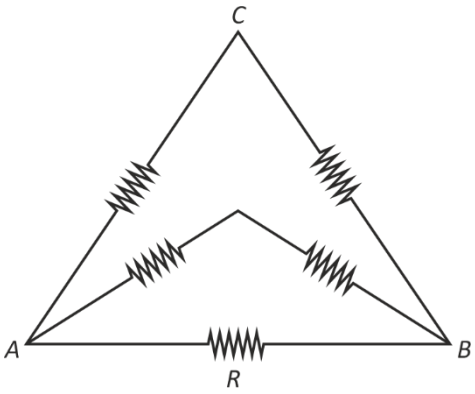


(1) $\frac{R}{2}$ (2) $\frac{R}{3}$

(3) $\frac{2R}{3}$ (4) $\frac{3R}{2}$

Answer (1)

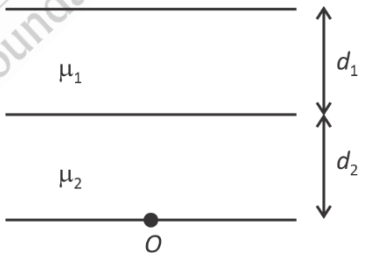
Sol.



$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{2R} + \frac{1}{2R}$$

$$R_{eq} = \frac{R}{2}$$

3. An object is placed below two parallel layers of thickness d_1, d_2 are refractive index μ_1, μ_2 respectively. Find apparent depth of the object.



(1) $\frac{d_1\mu_2 - d_2\mu_1}{\mu_1\mu_2}$ (2) $\frac{d_1\mu_2 + d_2\mu_1}{\mu_1\mu_2}$

(3) $\frac{d_1\mu_1 + d_2\mu_2}{\mu_1\mu_2}$ (4) $\frac{d_1\mu_1 - d_2\mu_2}{\mu_1\mu_2}$

Answer (2)

Sol. $\mu = \frac{d_1}{\mu_1} + \frac{d_2}{\mu_2}$

4. A lens of focal length 20 cm in air is made of glass with refractive index 1.6. What is its focal length when it is immersed in a liquid of refractive index 1.8.

(1) –36 cm (2) –72 cm

(3) – 60 cm (4) –108 cm

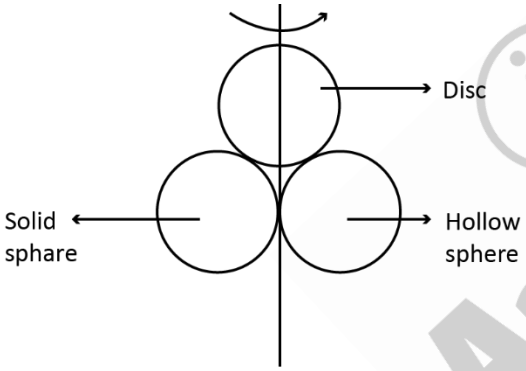
Answer (4)

Sol. $\left(\frac{\mu_g}{\mu_{air}}-1\right)F_{air}=\left(\frac{\mu_g}{\mu_{liq}}-1\right)F_{liq}$

$F_{liq}=\frac{0.6\times 20}{-0.2}\times 1.8$

$=-108$ cm

5. MOI of disc about central axis perpendicular to surface is I then moment of inertia of given assembly is, where each round object is of same mass and same radius. (Given centre of round bodies and axis are planar.)



(1) $\frac{89}{15}I$

(2) $\frac{79}{17}I$

(3) $\frac{199}{30}I$

(4) $\frac{209}{32}I$

Answer (3)

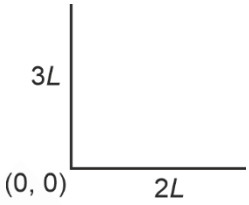
Sol. $I_{disc}=\frac{MR^2}{2}$

I(of assembly) = $I_1 + I_2 + I_3$

$=\frac{MR^2}{4}+\left(\frac{2}{5}MR^2+MR^2\right)+\frac{2}{3}MR^2+MR^2$

$=\frac{199}{60}MR^2=\frac{199}{30}I$

6. A rod of length 5 L is converted in L-shape as shown.



Find the position of its center of mass w.r.t origin.

(1) $\left(L,\frac{3L}{2}\right)$ (2) $\left(\frac{9L}{12},\frac{5L}{12}\right)$

(3) $\left(\frac{2L}{5},\frac{9L}{10}\right)$ (4) $\left(\frac{9L}{10},\frac{4L}{5}\right)$

Answer (3)

Sol. $x_m=\frac{2m\times L+0}{5m}=\frac{2L}{5}$

$y_m=\frac{0+3m\times\frac{3L}{2}}{5m}=\frac{9L}{10}$

7. A block of mass m slides on inclined plane of inclination 60° with an acceleration of $g/2$ then friction coefficient between block and plane is

(1) $\frac{\sqrt{3}}{2}$ (2) $\frac{1}{\sqrt{3}+1}$

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

Answer (3)

Sol. $a = g(\sin\theta - \mu\cos\theta) = \frac{g}{2}$

$\sin 60 - \mu\cos 60 = \frac{1}{2}$

$\frac{\sqrt{3}}{2} - \frac{\mu}{2} = \frac{1}{2}$

$\Rightarrow \quad \mu = \sqrt{3} - 1$

8. A composite sound wave is represented by $y = A\cos\omega t \cdot \cos\omega' t$. The observed beat frequency is

(1) $\frac{\omega - \omega'}{2\pi}$

(2) $\frac{\omega - \omega'}{\pi}$

(3) $\frac{\omega'}{2\pi}$

(4) $\frac{\omega'}{\pi}$

Answer (4)

Sol. The given wave can be represented as

$$y = \frac{A}{2}\cos(\omega + \omega')t + \cos(\omega - \omega')t$$

$$\Rightarrow \text{ beat frequency } = \frac{1}{2\pi}(\omega + \omega') - (\omega - \omega') = \frac{\omega'}{\pi}$$

9. Two convex lenses of focal length 30 cm and 10 cm are kept 10 cm apart. Principal axis of the lenses is common. Find equivalent power of the lens system.

(1) 5 D

(2) 10 D

(3) 6 D

(4) 13.33 D

Answer (2)

Sol. $P = P_1 + P_2 - dP_1P_2$

10. Two rods whose lengths are in ratio of 1 : 3 and diameter are in ratio of 2 : 1, then ratio of elongations of rod if force applied and material of rods are same

(1) 1 : 12

(2) 1 : 3

(3) 4 : 1

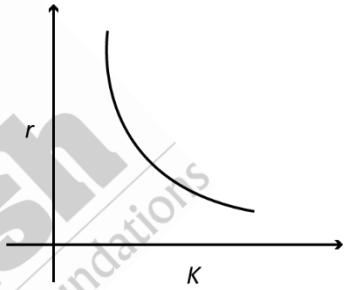
(4) 1 : 1

Answer (1)

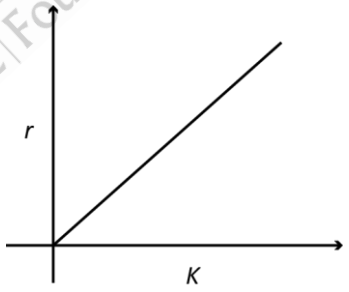
Sol. $\Delta l = \frac{Fl}{YA} \Rightarrow \frac{\Delta l_1}{\Delta l_2} = \frac{l_1 / l_2}{A_1 / A_2} = \frac{1/3}{4/1} = \frac{1}{3} \times \frac{1}{4} = \frac{1}{12}$

11. A charge particle moves in circular path in uniform magnetic field. Then graph of radius of circular path *vs* its kinetic energy is best represented by

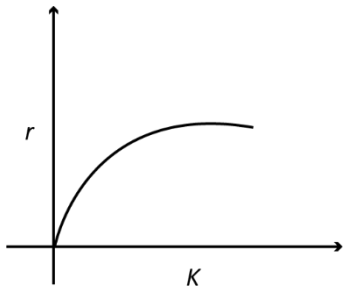
(1)



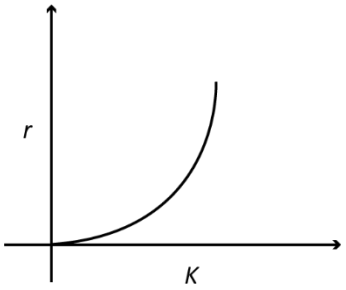
(2)



(3)



(4)



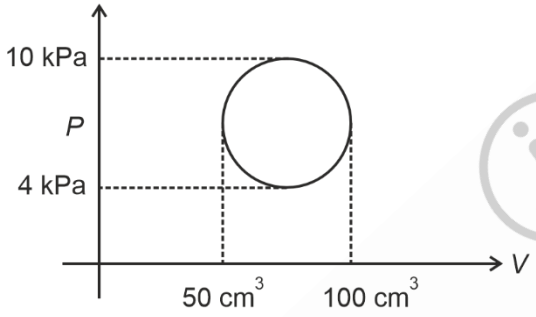
Answer (3)

Sol. $r = \frac{mv}{qB} = \frac{\sqrt{2mk}}{qB}$

$\Rightarrow \quad r = c\sqrt{k}$

$\Rightarrow \quad k \propto r^2$

12. Find the work done for the process shown in figure.



(1) $\frac{3\pi}{40}$ J (2) $\frac{\pi}{20}$ J

(3) $\frac{\pi}{10}$ J (4) $\frac{3\pi}{20}$ J

Answer (1)

Sol. Work done = Area = $\pi(\Delta P)(\Delta V) \times \frac{1}{4}$

$= \pi \times 6 \times 10^3 \text{ Pa} \times 50 \times 10^{-6} \text{ m}^3 \times \frac{1}{4}$

$= \frac{0.3\pi}{4} \text{ J} = \frac{3\pi}{40} \text{ J}$

13. Match the two columns.

	Column-I		Column-II
a.	Monoatomic gas	(i)	$\gamma = 7/5$
b.	Diatomic rigid gas	(ii)	$\gamma = 4/3$
c.	Diatomic non-rigid	(iii)	$\gamma = 5/3$
d.	Triatomic non-linear rigid	(iv)	$\gamma = 9/7$

(1) a(i), b(iii), c(ii), d(iv) (2) a(iii), b(i), c(iv), d(ii)

(3) a(ii), b(iv), c(i), d(ii) (4) a(iii), b(iv), c(i), d(ii)

Answer (2)

Sol. $f_{\text{mono}} = 3$

$f_{\text{atomic rigid}} = 5$

$f_{\text{diatomic non-rigid}} = 7$

$f_{\text{triatomic}} = 6$

$\gamma = 1 + \frac{2}{f}$

14. Let λ_1 be largest wavelength of Lyman series for hydrogen atom and λ_2 be largest wavelength of Balmer series then $\frac{\lambda_1}{\lambda_2}$ is

(1) $\frac{5}{27}$ (2) $\frac{1}{4}$

(3) $\frac{3}{4}$ (4) $\frac{4}{9}$

Answer (1)

Sol. $\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{1} - \frac{1}{4}\right)$

$\frac{1}{\lambda_2} = Rz^2\left(\frac{1}{4} - \frac{1}{9}\right)$

$\frac{\lambda_1}{\lambda_2} = \frac{5}{27}$

15. Two particles *A* and *B* are projected from a point on ground with same speed at angles 45° + θ and 45° – θ with horizontal. If the times of flight are T_A and T_B respectively, then $\frac{T_A}{T_B}$ is equal to

(1) $\frac{1+\tan\theta}{1-\tan\theta}$

(2) $2\tan\theta$

(3) $\tan 2\theta$

(4) $\frac{1-\tan\theta}{1+\tan\theta}$

Answer (1)

Sol. $T = \frac{2u\sin\theta}{g}$

$\frac{T_A}{T_B} = \frac{\sin(45°+\theta)}{\sin(45°-\theta)}$

$= \frac{\cos\theta+\sin\theta}{\cos\theta-\sin\theta}$

$= \frac{1-\tan\theta}{1+\tan\theta}$

16. Two plane polarised light combine at certain point whose electric field components are

$\vec{E_1} = E_0 \sin\omega t\,\hat{i}$

$\vec{E_2} = E_0 \sin\left(\omega t + \frac{\pi}{3}\right)\hat{i}$

Find the amplitude of electric field of resultant wave.

(1) 0.9 E_0

(2) E_0

(3) 1.7 E_0

(4) 3.7 E_0

Answer (3)

Sol. $E_R = \sqrt{E_0^2 + E_0^2 + 2E_0^2\cos\phi}$

$\phi = \frac{\pi}{3}$

$= \sqrt{3}E_0 = 1.7E_0$

17. A variable force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$ acts on a particles of mass 1 kg, which is at rest at t = 0. Find the power supplied as a function of time.

(1) $2t^3 + 3t^5$

(2) $t^3 + 4t^5$

(3) $t^3 + 4t^3$

(4) $t^3 + 5t^4$

Answer (1)

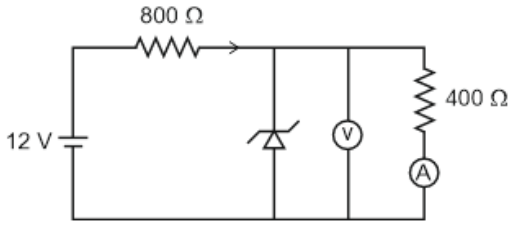
Sol. $\vec{V} = \frac{1}{m}\int_d^t \vec{F}dt$

$t^2\hat{i} + t^3\hat{j}$

Power $= \vec{F}\cdot\vec{V}$

$= 2t^3 + 3t^5$

18. Find the current through the ammeter for the circuit shown in figure. (Reading of voltmeter = 4 V)



(1) 1 mA

(2) 7 mA

(3) 10 mA

(4) 3 mA

Answer (3)

Sol. Voltage across 800 Ω = 12 V – 4 V

$$i = \frac{8}{800} = 10 \text{ mA}$$

i = i (current through Zener diode) + i (current through 400 Ω resister)

$$10 \text{ mA} = i_z + \frac{4}{400} \Rightarrow 10 \text{ mA} = I_z + 10 \text{ mA}$$

$I_Z = 0$

19. Find the dimensions of the physical quantity $\frac{2B^2\mu_0}{\varepsilon_0}$.

(Symbols have their usual meanings)

(1) $M^4 L^{-2} T^{-4} A^{-1}$

(2) $M^4 L^4 T^{-10} A^{-6}$

(3) $M^{-1} L^{-2} T^{-3} A^{-1}$

(4) $M^{-1} L^{-4} A^{-1}$

Answer (2)

Sol. $[B] = M T^{-2} A^{-1}$

$[\mu_0] = M L T^{-2} A^{-2}$

$[\varepsilon_0] = M^{-1} L^{-3} T^4 A^2$

$$\left[\frac{2B^2\mu_0}{\varepsilon_0}\right] = M^4 L^4 T^{-10} A^{-6}$$

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. Current in circuit varies with time as $i = 5\sqrt{2} + 10\cos\left(\omega t + \frac{\pi}{6}\right)$, then rms current in the circuit shall be ____ A.

Answer (10)

Sol. $i = i_1 + i_2 \sin\theta$

$$\Rightarrow i^2 = i_1^2 + i_2^2 \sin^2\theta + 2i_1 i_2 \sin\theta$$

Taking average both side

$$< i^2 > = i_1^2 + \frac{i_2^2}{2}$$

$$\Rightarrow i_{rms} = \sqrt{i_1^2 + \frac{i_2^2}{2}}$$

$$= \sqrt{50 + \frac{1}{2} \times 100} = 10$$

22. Resonance tube closed at one end. Two consecutive resonances were obtained at lengths L_1 = – 120 cm and L_2 = 200 cm if velocity of sound = 340 m/s.

The frequency of sound is $\frac{100\alpha}{8}$ Hz then α =

Answer (17)

Sol. $f = \frac{v}{\lambda}$ $L_2 - L_1 = \frac{\lambda}{2}$

$$f = \frac{340}{2(80 \text{ cm})} = \frac{340 \times 100}{2 \times 80}$$

$$= \frac{1700}{8} \text{ Hz} = \frac{100}{8} \times 17 \text{ Hz}$$

$a = 17$ Hz

23.

24.

25.