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. Two disc having same moment of inertia about their axis. Thickness is t_1 and t_2 and they have same density. If $\frac{R_1}{R_2}=\frac{1}{2}$, then find $\frac{t_1}{t_2}$.

(1) $\frac{1}{16}$ (2) 16

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

Answer (2)

Sol. $\pi R^2 t\rho\frac{R^2}{2}=I$

So $\frac{I_1}{I_2}=\frac{t_1\rho R_1^4}{t_2\rho R_2^4}$

$\Rightarrow \frac{t_1}{t_2}=\left(\frac{R_2}{R_1}\right)^4=16$

2. In series R-L circuit, voltage of battery is 10 V. Resistance & inductance are 10 Ω and 10 mH respectively. Find energy stored in the inductor when current reaches $\frac{1}{e}$ times of maximum value

(1) 0.67 mJ (2) 1.33 mJ

(3) 0.33 mJ (4) 0.50 mJ

Answer (1)

Sol. $\varepsilon=\frac{L}{2}\frac{i_0^2}{e^2}$

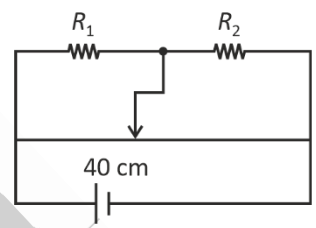
$I_0=\frac{\varepsilon}{R}=1\,A$

$=\frac{1}{2}\times10^{-2}\times\frac{1}{e^2}$

$=10^{-2}\times0.067$

= 0.67 mJ

3. In a potentiometer null point for two resistances R_1 and R_2 is at 40 cm as shown. If 16 Ω is connected in parallel to R_2 then null point is at 50 cm then R_1 and R_2 are respectively



(1) 16 Ω, 48 Ω (2) 32 Ω, $\frac{32}{3}$ Ω

(3) $\frac{16}{3}$ Ω, 16 Ω (4) $\frac{32}{5}$ Ω, 32 Ω

Answer (3)

Sol. $\frac{R_1}{R_2}=\frac{40}{60}=\frac{2}{3}$

$3R_1 = 2R_2$

$\frac{R_1(R_2+16)}{16R_2}=\frac{1}{1}$

$R_1=\frac{R_2 16}{R_2+16}=\frac{2R_2}{3}$

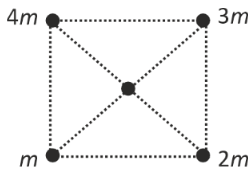
$48 = 2R_2 + 32$

$R_2 = 8$

$R_1=\frac{16}{3}$

4. In the given situation force at center on 1 kg mass is F_1. Now if $4m$ and $3m$ is interchanged the force is F_2.

Given : $\frac{F_1}{F_2} = \frac{2}{\sqrt{\alpha}}$. Find α.

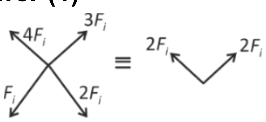


(1) $\alpha = 5$ (2) $\alpha = 3$

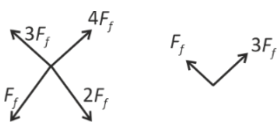
(3) $\alpha = 7$ (4) $\alpha = 1$

Answer (1)

Sol.



$$F_1 = \frac{2\sqrt{2}Gm}{a^2}$$



$$F_2 = \sqrt{10}F_f = \sqrt{10}\frac{Gm^2}{a^2}$$

$$\frac{F_2}{F_1} = \sqrt{\frac{10}{8}} = \frac{\sqrt{5}}{2}$$

5. Match the column

	Column-I		Column-II
(A)	Thermal Conductivity	(P)	$[ML^2T^{-2}K^{-1}]$
(B)	Boltzmann Constant	(Q)	$[M^1L^{-1}T^{-2}]$
(C)	Spring constant	(R)	$[M^1L^1T^{-3}K^{-1}]$
(D)	Surface tension	(S)	$[M^1L^0T^{-2}]$
		(T)	$[M^1L^2T^{-3}K^{-1}]$
		(U)	$[ML^2T^{-2}]$

(1) A → R ; B → P ; C → S ; D → S

(2) A → T ; B → P ; C → U ; D → S

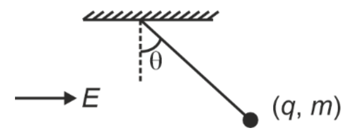
(3) A → R ; B → T ; C → Q ; D → Q

(4) A → T ; B → U ; C → S ; D → Q

Answer (1)

Sol. Theoretical

6. A simple pendulum with bob (mass m & charge q) is in equilibrium in presence of horizontal electric field E then tension in thread is



(1) $mg + qE$ (2) $\sqrt{m^2g^2 + q^2E^2}$

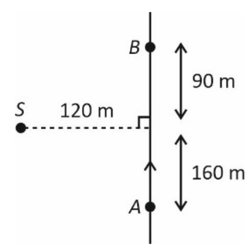
(3) $\sqrt{mg + qE}$ (4) $mg + qE\tan\theta$

Answer (2)

Sol. $\vec{T} + \overrightarrow{mg} + \overrightarrow{qE} = \vec{0}$

$T = \left(\overrightarrow{mg} + \overrightarrow{qE}\right) = \sqrt{m^2g^2 + q^1E^2}$

7. Detector D moves from A to B and observe the frequencies are differing by 10 Hz. Source is emitting frequency f_0 as shown: Speed of detector is 35 times less than speed of sound. Then f_0 is

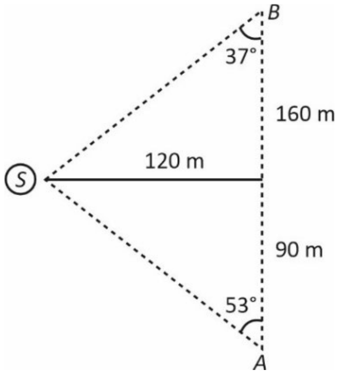


(1) 400 Hz (2) 350 Hz

(3) 250 Hz (4) 150 Hz

Answer (3)

Sol.

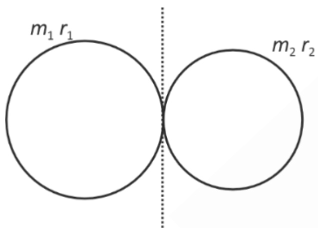


$$f_0\left\{\frac{C+V\cos°53}{C}-\frac{C-V\cos 37°}{C}\right\}=10$$

$$f_0\left\{\frac{V}{C}\right\}\left\{\frac{7}{5}\right\}=10$$

$$f_0=\frac{50}{7}\times\frac{C}{V}=250\,\text{Hz}$$

8. Disk m_1 = 5 kg & radius r_1 = 10 cm and disk m_2 = 10 kg & radius r_2 = 50 cm are arranged as shown in figure. Find moment of inertia about an axis through common tangent and parallel to the plane of the disk.



(1) $\frac{31}{8}$ kg m^2 (2) $\frac{57}{64}$ kg m^2

(3) $\frac{41}{8}$ kg m^2 (4) $\frac{51}{16}$ kg m^2

Answer (4)

Sol. $\left(\frac{m_1r_1^2}{4}+m_1r_1^2\right)+\left(\frac{m_2r_2^2}{4}+m_2r_2^2\right)=I$

$$\Rightarrow \left(\frac{1}{100}\times\frac{5}{4}\times 5\right)+\frac{1}{4}\left(\frac{5}{4}\times 10\right)=I$$

$$\Rightarrow \frac{1}{16}+\frac{50}{16}=\frac{51}{16}\text{ kg m}^2$$

9. In adiabatic process the temperature reduces to $\frac{1}{4}$th and volume increases to 8 times. Find adiabatic constant of the gas.

(1) $\frac{3}{4}$ (2) $\frac{5}{7}$

(3) $\frac{5}{3}$ (4) $\frac{8}{5}$

Answer (3)

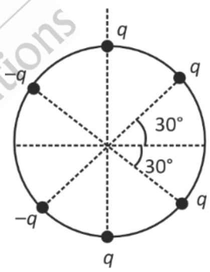
Sol. $TV^{\gamma-1}$ = Constant

$$\Rightarrow TV^{y-1}=\frac{T}{4}(8V)^{y-1}$$

$$\Rightarrow TV^{y-}=\frac{T.V^{y-1}}{4}(8)^{y-1}$$

$$\Rightarrow (2)^2=(2)^{3y-3}\Rightarrow y=\frac{5}{3}$$

10. Six charges (four + q, two – q) are present at circle of radius r and centred at origin as shown. Electric field at origin is

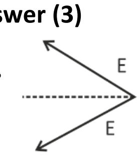


(1) $\frac{\sqrt{3}q}{4\pi\in_0 r^2}\hat{i}$ (2) $\frac{\sqrt{3}q}{4\pi\in_0 r^2}(-\hat{i})$

(3) $\frac{\sqrt{3}\,q}{2\pi\in_0 r^2}(-\hat{i})$ (4) $\frac{\sqrt{3}\,q}{\pi\in_0 r^2}(\hat{i})$

Answer (3)

Sol.



$E=\frac{2kq}{r^2}\Rightarrow E_{net}=E\sqrt{3}$

11. An α-particle with KE 7.9 MeV is projected towards a stationary target nucleus of $Z = 79$. Find the distance of closest approach.

(1) 1.44×10^{-14} (2) 2.88×10^{-14}

(3) 1.44×10^{-15} (4) 2.88×10^{-15}

Answer (2)

Sol. $KE = \dfrac{KZe \times 2e}{d} = 7.9 \times 10^6$

$$d = \frac{9 \times 10^9 \times 2 \times 1.6 \times 10^{-19}}{10^5} = 2.88 \times 10^{-14}$$

12. A planet '*A*' having density ρ and radius R has escape velocity = 10 km/sec. Find the escape velocity of a plant B having density and radius both 10% that of plant A.

(1) $\dfrac{1}{\sqrt{10}}$ (2) $\dfrac{1}{\sqrt{20}}$

(3) $\dfrac{1}{\sqrt{30}}$ (4) $\dfrac{1}{\sqrt{50}}$

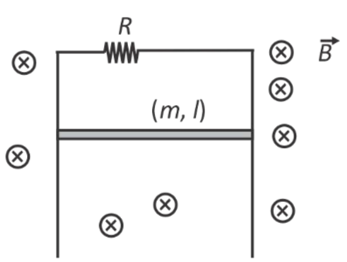
Answer (1)

Sol. $v_e = \sqrt{\dfrac{Gm \times 2}{R}} = \sqrt{G\rho \dfrac{8}{3}\pi R^2}$

$$\frac{v_A}{v_B} = \sqrt{\frac{\rho_A}{\rho_B}}\left(\frac{R_A}{R_B}\right) = \sqrt{10} \times 10$$

$$v_B = \frac{v_A}{10\sqrt{10}} = \frac{1}{\sqrt{10}}$$

13. A conducting rod of mass m and length l is moving on a infinite pair of conducting rails as shown. Conducting rails are connected to a resistance R at one end. Motion is in vertical plane and horizontal magnetic field in the region is B. Find terminal speed of rod.



(1) $V_0 = \dfrac{3mgR}{2B^2l^2}$ (2) $V_0 = \dfrac{mgR}{2B^2l^2}$

(3) $V_0 = \dfrac{mgR}{B^2l^2}$ (4) $V_0 = \dfrac{2mgR}{B^2l^2}$

Answer (3)

Sol. Let V_0 is the terminal speed then power dissipated is

$$\left(\frac{V_0Bl}{R}\right)^2 \cdot R = \frac{V_0^2B^2l^2}{R}$$

and power delivered gravity is mgv_0

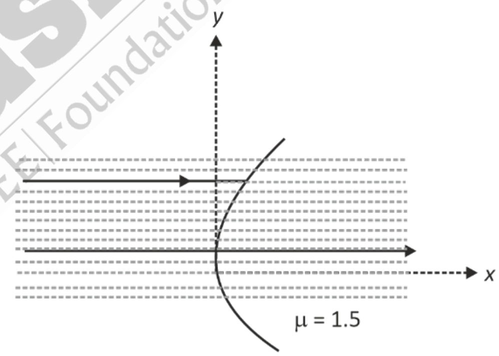
So, $mgV_0 = \dfrac{B^2l^2}{R} \cdot V_0^2$

$$\Rightarrow \frac{mgR}{B^2l^2} = V_0$$

14. A ray parallel to x axis (principal axis of curved surface.

The x co-ordinate where ray cuts x-axis (in m) is :

(The radius of curvature is 50 cm)



(1) 1.5 (2) 0.5

(3) 1 (4) 2

Answer (1)

Sol. $\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{\mu_2 - \mu_1}{R} \Rightarrow \dfrac{1.5}{v} = \dfrac{0.5}{0.5}$

$V = 1.5$

15. A sinusoidal EMW is given by $\vec{E} = 20\sin\left(\frac{2}{300}x - 10^6 t\right)$ propagating in a non-magnetic material. Dielectric constant of material is

(1) 9×10^4 (2) 3×10^2
(3) 4 (4) 2

Answer (3)

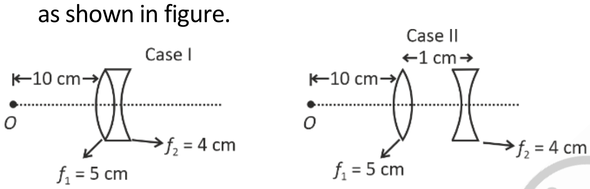
Sol. $K = \frac{\omega}{V} \Rightarrow \frac{2}{300} = \frac{10^6}{V}$

$V = \frac{3\times10^8}{2}$

$\mu = \frac{C}{V} \Rightarrow \mu = 2$

$\frac{C}{V} = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}} \Rightarrow \sqrt{\mu} = 2$

16. Combination of lenses are arranged in case I and case II as shown in figure.



Magnification in two cases are m_1 and m_2. Find $\left|\frac{m_1}{m_2}\right|$.

(1) $\frac{5}{6}$ (2) $\frac{4}{3}$
(3) $\frac{3}{4}$ (4) $\frac{6}{5}$

Answer (1)

Sol. For Case I

$\frac{1}{f_a} = \frac{1}{5} - \frac{1}{4} = \frac{-1}{20}$

So $\frac{1}{v} + \frac{1}{10} = -\frac{1}{20} \Rightarrow \frac{1}{v} = -\frac{1}{20} - \frac{1}{10} = -\frac{3}{20}$

So $|m_1| = \frac{20}{3\times10} = \frac{2}{3}$

For case II

For 1st lens $\frac{1}{v_1} + \frac{1}{f_0} = \frac{1}{5}$

$\Rightarrow v_1 = 10$ so, $m'_2 = \frac{10}{-10} = -1$

So 2nd lens

$\frac{1}{v_2} - \frac{1}{9} = -\frac{1}{4} \Rightarrow \frac{1}{v_2} = \frac{1}{9} - \frac{1}{4} = \frac{-5}{36}$

So $m''_2 = \left(\frac{36}{-5}\right)\frac{}{9} = \frac{-4}{5}$

So $m_2 = m'_2 . m''_2 = \left(\frac{4}{5}\right)\times(1) = \frac{4}{5}$

So $\left|\frac{m_1}{m_2}\right| = \frac{2\times5}{3\times4} = \frac{5}{6}$

17. Match the column-I with the correct numerical values of energy/heat in column-II (R is universal gas constant)

	Column-I		Column-II
(A)	1 mole of monoatomic ideal gas undergoes polytopic process $PV^{-1/2}$ with ΔT = 320 K find ΔU	(P)	650 R
(B)	Find heat supplied to 2 moles of gas having heat capacity as $\frac{5}{2}R$ and ΔT = 130K	(Q)	800 R
(C)	Find the ΔU for 1 mole diatomic gas for ΔT = 230K	(R)	480 R

(1) $A\to R$; $B\to P$; $C\to Q$
(2) $A\to P$; $B\to R$; $C\to Q$
(3) $A\to R$; $B\to Q$; $C\to P$
(4) $A\to Q$; $B\to P$; $C\to R$

Answer (1)

Sol. ΔU for any process ${}^nC_V\Delta T$

(A) $\Delta U = 1\times\frac{3R}{2}\times320 = 480R$

(B) $\Delta Q -{}^{n}C_{process}\Delta T = 2\times\frac{5R}{2}\times130 = 650R$

(C) $\Delta U = 1\times\frac{5}{2}R\times320 = 800R$

18. Statement-I : Fluid exerts pressure on the surface of a solid in contact with it.

Statement-II : The excess potential energy of molecules at the surface of a liquid leads to surface tension.

(1) Both are true and statement-II B correct explanation of Statement-I

(2) Both are true but statement-II is not correct explanation of Statement-I

(3) Statement-I is true but Statement-II is false

(4) Statement-II is true but statement-I is false

Answer (2)

Sol. Theoretical

19. For an object revolving around a planet of mass M and radius R_0 at a distance r from the center of the planet. If area velocity of the object is 10 km^2/sec. Now if density of the planet increases by +10% and radius of planet increases by +10% then find new area velocity at same orbital radius.

(1) 12.1 km^2/sec (2) 10 km^2/sec

(3) 15.5 km^2/sec (4) 8.5 km^2/sec

Answer (1)

Sol. $T^2 = \dfrac{4\pi^2 r^3}{GM}$

So $V_{\text{Area}}^2 = \dfrac{\pi r^2 \cdot \pi r^2 GM}{4\pi^2 r^3} = \dfrac{GMr}{4}$

So $V_{\text{Area}}^2 = \dfrac{G}{4} \cdot r \cdot \dfrac{4}{3}\pi R^3 \rho = \dfrac{\pi}{3} R^3 \rho G r$

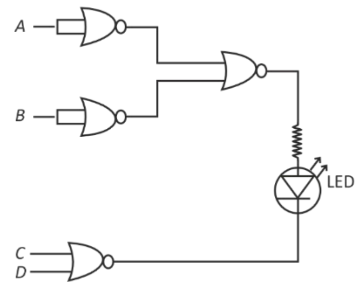
Since r is constant so

$$\frac{V_{2(\text{Area})}^2}{V_{1(\text{Area})}^2} = \frac{\frac{110\rho}{100}\left(\frac{11}{10}\right)^3 \cdot R^3}{\rho R^3}$$

$\Rightarrow$ $V_{2(\text{Area})}^2 = \left(\dfrac{11}{10}\right)^4 \times 100$

$\Rightarrow$ $V_{2(\text{Area})}$ = 12.1 km^2/sec

20. In the given logic circuit shown in the figure, inputs A, B, C, and D are applied as shown. An LED is connected at the output. In which of the following combinations will the LED glow.



(1) $A = 1, B = 1, C = 0, D = 0$

(2) $A = 1, B = 0, C = 0, D = 0$

(3) $A = 0, B = 1, C = 1, D = 0$

(4) $A = 1, B = 1, C = 1, D = 1$

Answer (4)

Sol. $\overline{\overline{A}+\overline{B}}$ $\overline{C+D}$ are two terminals

AB $\overline{C+D}$ LED glows when forward bias

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.

22.

23.

24.

25.