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:

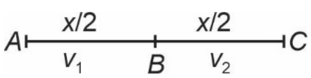
1. A car moving on a straight line travels in same direction half of the distance with uniform velocity v_1 and other half of the distance with uniform velocity v_2. Average velocity of the car is equal to

(1) $\frac{2v_1v_2}{v_1+v_2}$ (2) $\frac{v_1+v_2}{2}$

(3) $v_1 + v_2$ (4) $\sqrt{v_1v_2}$

Answer (1)

Sol.



$t_1 = \frac{x}{2v_1},\ t_2 = \frac{x}{2v_2}$

So $v_{av} = \frac{\text{Total distance}}{\text{Total time}}$

$= \frac{x}{t_1+t_2}$

$= \frac{x}{\frac{x}{2v_1}+\frac{x}{2v_2}}$

$= \frac{2v_1v_2}{v_1+v_2}$

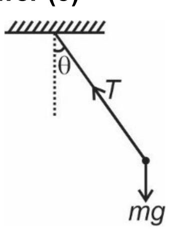
2. A car is moving with a constant speed of 2 m/s in circle having radius R. A pendulum is suspended from the ceiling of the car. Find the angle made by the pendulum with the vertical. Take $R = \frac{8}{15}$ m and $g = 10$ m/s^2

(1) 30° (2) 53°

(3) 37° (4) 60°

Answer (3)

Sol.



$T\cos\theta = mg$ ...(1)

$T\sin\theta = \frac{mv^2}{R}$ ...(2)

$\Rightarrow \tan\theta = \frac{v^2}{Rg}$

$= \frac{4}{\frac{8}{15}\times 10} = \frac{3}{4}$

$\Rightarrow \theta = 37°$

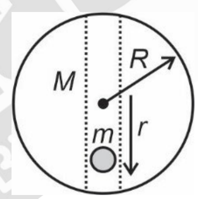
3. A particle is droped inside tunnel of earth about any diameter. Particle starts oscillating, with time period T. (R = radius of earth, g = acceleration due to gravity on earth's surface). Then find T.

(1) $T = 2\pi\sqrt{\frac{R}{g}}$ (2) $T = \pi\sqrt{\frac{R}{g}}$

(3) $T = 2\pi\sqrt{\frac{2R}{g}}$ (4) $T = 2\pi\sqrt{\frac{3R}{g}}$

Answer (1)

Sol.



$F = mg$ (towards centre)

$\frac{mdv}{dt} = -\left(\frac{GMm}{R^3}\right)r$

$\frac{dv}{dt} = -\left(\frac{GM}{R^3}\right)r$

$g = \frac{GM}{R^2}$

$\frac{dv}{dt} = -\left(\frac{g}{R}\right)r$

$\omega^2 = \left(\frac{g}{R}\right)$

$\omega = \sqrt{\frac{g}{R}}$

$$\boxed{T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{R}{g}}}$$

4. If T is the temperature of a gas then RMS velocity of the gas molecules is proportional to

(1) $T^{1/2}$ (2) $T^{-1/2}$

(3) T (4) T^2

Answer (1)

Sol. $v_{rms} = \sqrt{\frac{3RT}{M_0}}$

So $v_{rms} \propto \sqrt{T}$

5. Time period of a pendulum at earth's surface is T. Find the time period of the pendulum at distance (from centre) which is twice the radius of earth.

(1) $\frac{T}{4}$ (2) $4T$

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

Answer (4)

Sol. We know that $T = 2\pi\sqrt{\frac{l}{g}}$

$\Rightarrow T = 2\pi\sqrt{\frac{l}{\frac{GM}{R^2}}}$ ...(i)

Also, $T' = 2\pi\sqrt{\frac{l}{\frac{GM}{(2R)^2}}}$ ...(ii)

$\Rightarrow \frac{T'}{T} = \frac{2}{1}$

$\Rightarrow T' = 2T$

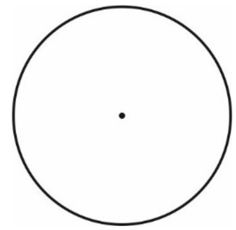
6. Let I_{cm} be the moment of Inertia of disc passing through center and perpendicular to its plane. I_{AB} be the moment of Inertia about axis AB that is in the plane of disc and $\frac{2r}{3}$ distance from centre, Find $\frac{I_{cm}}{I_{AB}}$?

(1) $\frac{1}{4}$ (2) $\frac{18}{25}$

(3) $\frac{9}{17}$ (4) $\frac{1}{2}$

Answer (2)

Sol.



$I_{cm} = \frac{1}{2}MR^2$ (Perpendicular to plane)

$I_{cm}(\text{in plane}) = \frac{1}{4}MR^2$

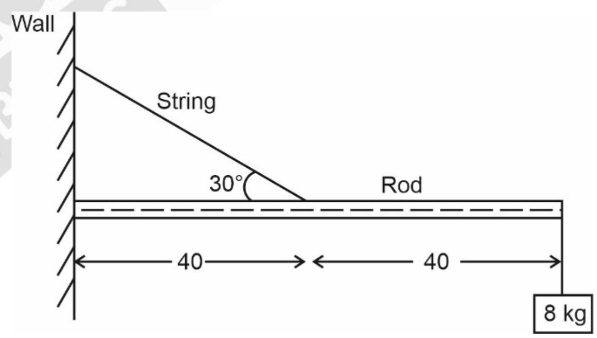
$I_{AB} = \frac{1}{4}MR^2 + M\left(\frac{2}{3}R\right)^2$

$= \frac{1}{4}MR^2 + \frac{4}{9}MR^2$

$= \frac{(9+16)MR^2}{36} = \frac{25}{36}MR^2$

$\frac{I_{cm}(\text{Perpendiular})}{I_{AB}} = \frac{\frac{1}{2}MR^2}{\frac{25}{36}MR^2} = \left(\frac{18}{25}\right)$

7. A massless rod is arranged as shown:



Find the tension in the string

(1) 320 N

(2) 640 N

(3) 160 N

(4) 480 N

Answer (1)

Sol. Balancing the torque on the rod about the point of contact with the wall:

$(T\sin 30°) \times 40 = (mg) \times (40 + 40)$

$\Rightarrow T = 320$ N

8. A carnot engine working between a source and sink at 200 K has efficiency of 50%. Another carnot engine working between the same source and another sink with unknown temperature *T* has efficiency of 75%. The value of *T* is equal to

(1) 400 K (2) 300 K

(3) 200 K (4) 100 K

Answer (4)

Sol. $\frac{50}{100} = 1 - \frac{200}{T}$

$\Rightarrow$ $T = 400$ K

$T' = 100$ K

9. Mark the option correctly matching the following columns with appropriate dimensions

Column-I	Column-II
(A) Surface tension	(P) $[ML^{-1}T^{-2}]$
(B) Pressure	(Q) $[MT^{-2}]$
(C) Viscosity	(R) $[MLT^{-1}]$
(D) Impulse	(S) ML–1T^{-1}

(1) A(Q), B(P), C(R), D(S)

(2) A(Q), B(P), C(S), D(R)

(3) A(S), B(Q), C(P), D(R)

(4) A(R), B(P), C(Q), D(S)

Answer (2)

Sol. For surface tension

$F = SL$

$[S] = \frac{[F]}{[L]} = [MT^{-2}]$

For pressure

$P = \frac{F}{A}$

$[P] = \frac{[F]}{[A]} = [ML^{-1}T^{-2}]$

For viscosity coefficient

$F = A\left(\frac{\Delta v}{\Delta z}\right)\eta$

$[\eta] = \frac{[F]}{[A]\left[\frac{\Delta v}{\Delta z}\right]} = [ML^{-1}T^{-1}]$

For Impulse

$I = \Delta p$

$[I] = [\Delta p] = [MLT^{-1}]$

10. Assertion (A): Reverse biased diode is used in photodiode.

Reason (R): Forward biased current is more than reverse bias current.

(1) A & R are correct and R is correct explanation of A

(2) A & R are correct, R is not correct explanation of A

(3) A is incorrect and R is correct

(4) A is correct and R is incorrect

Answer (??)

Sol. (NCERT) It is easier to observe small changes in current due to intensity, when diode is in reverse bias.

11. Temperature of hot soup in a bowl goes from 98°C to 86°C in 2 minutes. The temperature of surroundings is 22°C. Find the time taken for the temperature of soup to go from 75°C to 69°C. [Assume Newton's law of cooling is valid]

(1) 1 minute

(2) 1.4 minute

(3) 2 minute

(4) 3.2 minute

Answer (2)

Sol. By Newton's law of cooling:

Rate of cooling (R) $\propto$ temperature difference

$\Rightarrow$ $R_1 = kx$ (92°C – 22°C) …(i)

and $R_2 = kx$ (72°C – 22°C) …(ii)

$\Rightarrow$ $\frac{R_1}{R_2} = \frac{70}{50} = \frac{7}{5}$

$\Rightarrow$ $\Delta t_2 = 1.4$ minute

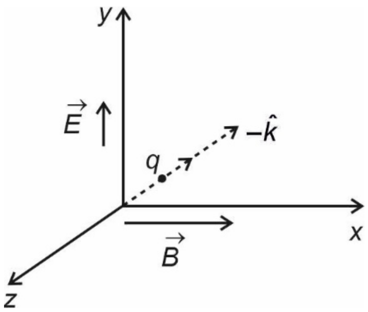
12. Electric field is applied along $+y$ direction. A charged particle is travelling along $-\hat{k}$, undeflected. Then magnetic field in the region will be along?

(1) $\hat{i}$ (2) $-\hat{i}$

(3) $\hat{j}$ (4) $-\hat{k}$

Answer (1)

Sol.



$q(\vec{E}+\vec{V}\times\vec{B})=0$

$\vec{V}\times\vec{B}=-\vec{E}$

$\Rightarrow \quad V_0(-\hat{k})\times\vec{B}=-E_0\hat{j}$

$\vec{B}$ should be in $\hat{i}$ direction to balance the electrostatic force on the charge particle.

13. When an electron is accelerated by 20 kV, its de-Broglie wavelength is λ_0. If the electron is accelerated by 40 kV, find its de-Broglie wavelength.

(1) $2\lambda_0$ (2) $\frac{\lambda_0}{2}$

(3) $\sqrt{2}\lambda_0$ (4) $\frac{\lambda_0}{\sqrt{2}}$

Answer (4)

Sol. We know $\lambda_0=\frac{h}{p}$

$\Rightarrow \quad \lambda_0=\frac{h}{\sqrt{2mK}}$

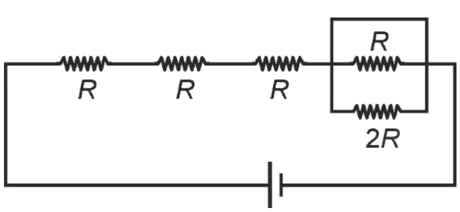
$=\frac{h}{\sqrt{2meV}}$

Since V doubles

$\Rightarrow \quad \frac{\lambda'}{\lambda_0}=\sqrt{\frac{V}{2V}}=\frac{1}{\sqrt{2}}$

$\Rightarrow \quad \lambda'=\frac{\lambda_0}{\sqrt{2}}$

14.



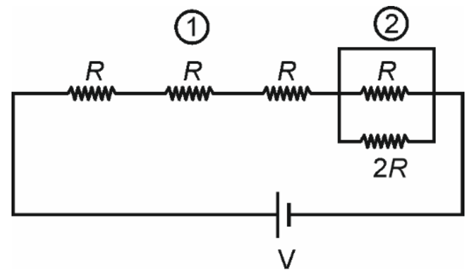
Find the equivalent resistance of the shown circuit across the terminals of ideal battery.

(1) $2R$ (2) $3R$

(3) $4R$ (4) $5R$

Answer (2)

Sol. In 2nd part of diagram a connecting wire is nullifying the resistance of parallel resistance thus their net resistance is zero. So net resistance of circuit is $3R$.



15. For an AM signal, it is given that

$f_{carrier}$ = 10 MHz

f_{signal} = 5 kHz

Find the bandwidth of the transmitted signal.

(1) 5 kHz

(2) 10 kHz

(3) 2.5 kHz

(4) 20 MHz

Answer (2)

Sol. We know bandwidth = 2 fm

$\Rightarrow$ bandwidth = 10 kHz

16. Let nuclear densities of ${}^{4}_{2}He$ and ${}^{40}_{20}Ca$ be ρ_1 and ρ_2 respectively. Find the ratio $\frac{\rho_1}{\rho_2}$.

(1) 1 : 10

(2) 10 : 1

(3) 1 : 1

(4) 1 : 2

Answer (3)

Sol. We know radius $R=R_0A^{\frac{1}{3}}$

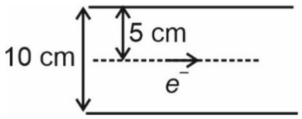
$\Rightarrow$ Density $=\frac{\text{Mass}}{\text{Volume}}=\frac{A}{\frac{4}{3}\pi\left(R_0A^{\frac{1}{3}}\right)^3}$

$=\frac{1}{\frac{4}{3}\pi R_0^3}$

$\Rightarrow$ Density is independent of A.

$\Rightarrow \quad \frac{\rho_1}{\rho_2}=1$

17. A particle is projected with 0.5 eV kinetic energy in an uniform electric field $\vec{E} = -10\ \text{N/C}\ \hat{j}$, as shown in the figure. Find the angle made by the particle from the x-axis when it leaves $\vec{E}$.

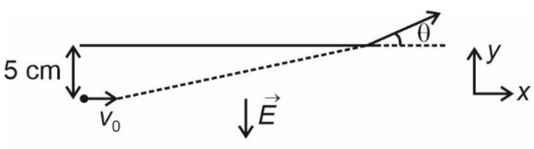


(1) $\theta = 45°$ (2) $\theta = 60°$

(3) $\theta = 30°$ (4) $\theta = 37°$

Answer (1)

Sol.



$v_x = v_0$

$a_y = \left(\frac{eE}{m_e}\right)$

$S_y = 5 \times 10^{-2}$ m

$v_y^2 = 2a_yS_y$

$v_y = \sqrt{\frac{2eE}{m_e}S_y}$

$\tan\theta = \left(\frac{v_y}{v_x}\right)$

$K_i = 0.5\ \text{eV} = \frac{1}{2}\frac{m_e v_x^2}{e}$

$v_x = \sqrt{\frac{0.5 \times 2e}{m_e}} = \sqrt{\frac{e}{m_e}}$

$\tan\theta = \frac{\sqrt{\frac{2eE}{m_e} \times S_y}}{\sqrt{\frac{e}{m_e}}} = \sqrt{2ES_y} = \sqrt{2 \times 10 \times 5 \times 10^{-2}}$

$= \sqrt{1}$

$\tan\theta = 1$

$\theta = 45°$

18. ??

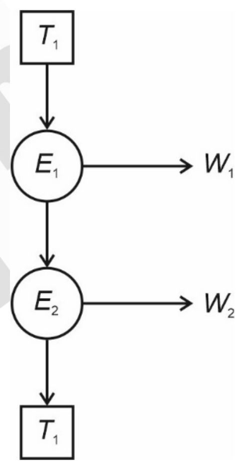
19. ??

20. ??

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. In the series sequence of two engines E_1 and E_2 as shown $T_1 = 600$ K and $T_2 = 300$ K. It is given that both the engines working on carnot principle have same efficiency, then temperature T at which exhaust of E_1 is fed into E_2 is equal to $300\sqrt{n}$ K. Value of n is equal to



Answer (02.00)

Sol. $\eta_1 = 1 - \frac{T}{600}$

$\eta_2 = 1 - \frac{300}{T}$

As efficiency is same

$\eta_1 = \eta_2$

$\frac{T}{600} = \frac{300}{T}$

$\Rightarrow T = \sqrt{180000}$

$= 300\sqrt{2}$ K.

So n = 2

22. A solenoid of length 2 m, has 1200 turns. The magnetic field inside the solenoid when 2 A current is passed through it is $N\pi \times 10^{-5}$ T. Find the value of *N*. (Diameter of solenoid is 0.5 m)

Answer (48.00)

Sol. 

$B_{inside} = \mu_0 \, n \, i$

N = Number of turns per unit length

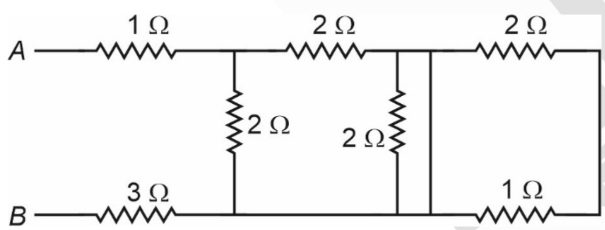
$= \frac{1200}{2} = 600$

i = current in a turn = 2 A

$B = 4\pi \times 10^{-7} \times 600 \times 2$

$= 48\pi \times 10^{-5}$ T

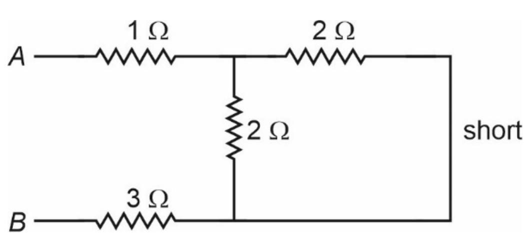
23. Consider a network of resistors as shown:



Find the effective resistance (in Ω) across *A* and *B*.

Answer (05.00)

Sol. Effectively, the network is:



$\Rightarrow R_{AB} = 1\Omega + \frac{2 \times 2}{2+2}\Omega + 3\Omega$

= 5 Ω

24. Find the ratio of density of oxygen $\left({}^{16}_{8}O\right)$ to the density of Helium $\left({}^{4}_{2}He\right)$ at STP.

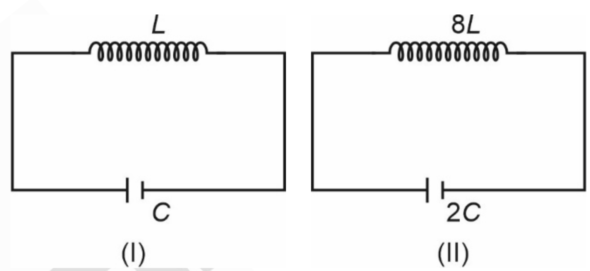
Answer (08.00)

Sol. $\frac{P}{\rho} = \frac{RT}{M_0}$

$\Rightarrow \frac{\rho_1}{\rho_2} = \frac{M_1}{M_2}$

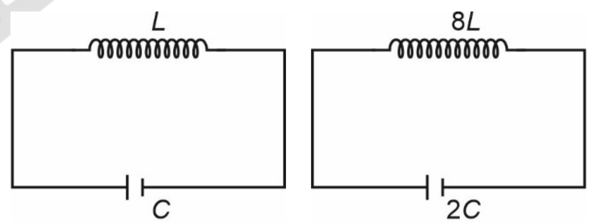
$\frac{\rho_1}{\rho_2} = \frac{32}{4} = 8$

25. Consider the following two LC circuits.



Then find $\frac{\omega_I}{\omega_{II}}$, where ω_I and ω_{II} are resonance frequencies of the Circuit I and Circuit II respectively.

Answer (04.00)

Sol. 

$\omega_1 = \frac{1}{\sqrt{LC}}$, $\omega_2 = \frac{1}{\sqrt{(8L \times 2C)}} = \frac{1}{4\sqrt{LC}}$

$\frac{\omega_1}{\omega_2} = \frac{4}{1}$

26. ??

27. ??

28. ??

29. ??

30. ??