# 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.

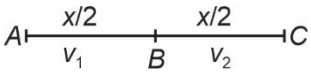
**Choose the correct answer:**

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.** 


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

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

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

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

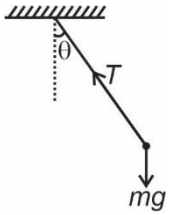
$$= \frac{2v_1v_2}{v_1+v_2}$$

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)

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

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

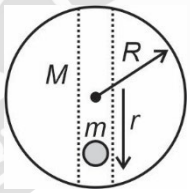
$\Rightarrow \theta = 37°$

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)

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

$\Rightarrow T' = 2T$

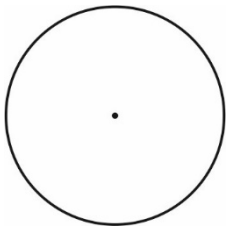
6. Let $I_{cm}$ be the moment of Inertia of disc passing through center and perpendicular to its plane. $I_{AB}$ be the moment of Inertia about axis $AB$ that is in the plane of disc and $\frac{2r}{3}$ distance from centre, Find $\frac{I_{cm}}{I_{AB}}$?

(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)

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

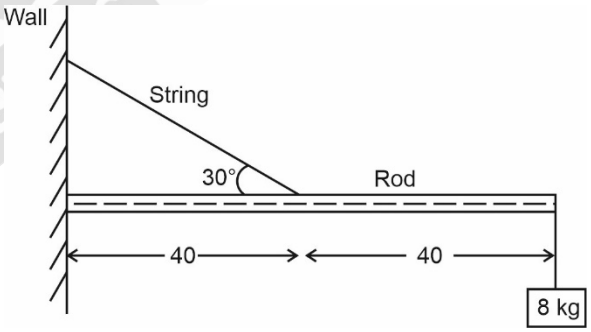
$I_{AB} = \frac{1}{4}MR^2 + M\left(\frac{2}{3}R\right)^2$

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

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

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

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

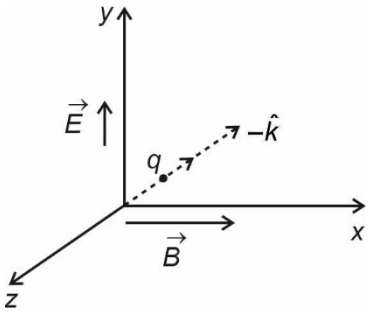
12. Electric field is applied along $+y$ direction. A charged particle is travelling along $-\hat{k}$, undeflected. Then magnetic field in the region will be along?

(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 $\lambda_0$. 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 $\lambda_0=\frac{h}{p}$

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

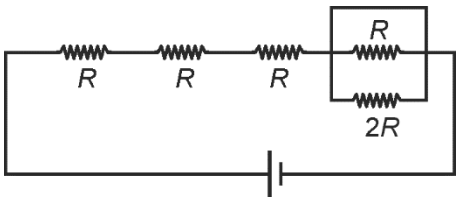
$=\frac{h}{\sqrt{2meV}}$

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.



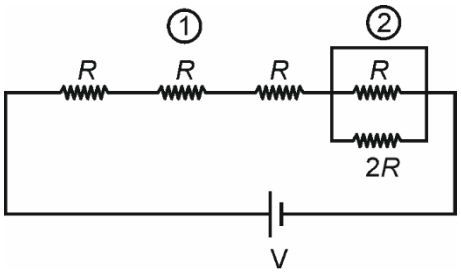

Find the equivalent resistance of the shown circuit across the terminals of ideal battery.

(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 $^4_2He$ and $^{40}_{20}Ca$ be $\rho_1$ and $\rho_2$ 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 $R=R_0A^{\frac{1}{3}}$

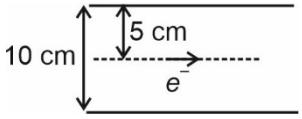
$\Rightarrow$ Density $=\frac{\text{Mass}}{\text{Volume}}=\frac{A}{\frac{4}{3}\pi\left(R_0A^{\frac{1}{3}}\right)^3}$

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

$\Rightarrow$ 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 $\vec{E}$.

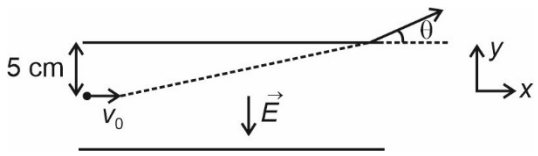



(1) $\theta = 45°$ (2) $\theta = 60°$

(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

$$v_y^2 = 2a_y S_y$$

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

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

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

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

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

$= \sqrt{1}$

$\tan\theta = 1$

$\theta = 45°$

18. ??

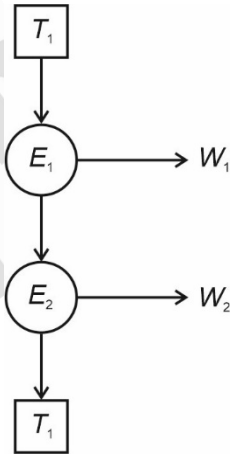
19. ??

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

$$\eta_1 = \eta_2$$

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

$$\Rightarrow T = \sqrt{180000}$$

$$= 300\sqrt{2}\ \text{K}.$$

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 $N\pi\times10^{-5}$ 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

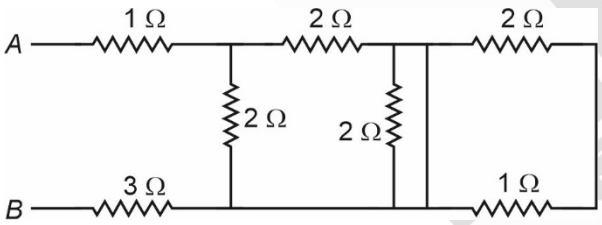
$$= \frac{1200}{2} = 600$$

$i$ = current in a turn = 2 A

$B = 4\pi\times10^{-7}\times600\times2$

$= 48\pi\times10^{-5}$ T

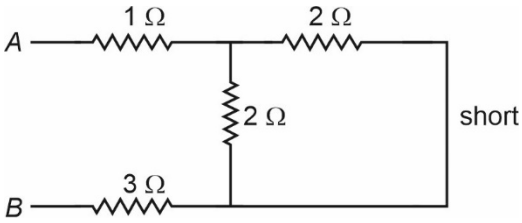
23. Consider a network of resistors as shown:




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

**Answer (05.00)**

**Sol.** Effectively, the network is:




$$\Rightarrow R_{AB} = 1\Omega + \frac{2\times2}{2+2}\Omega + 3\Omega$$

$= 5\ \Omega$

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

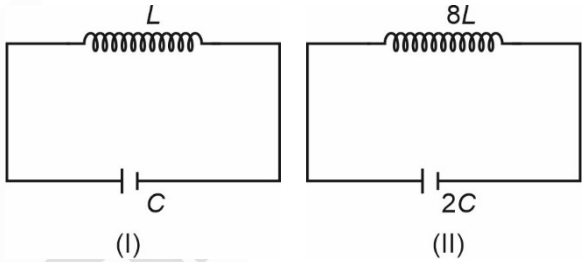
**Answer (08.00)**

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

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

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

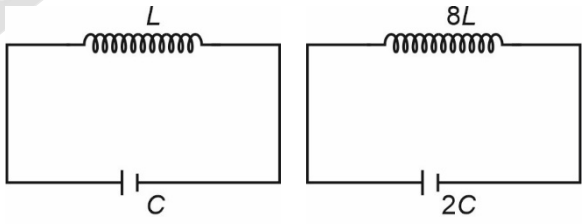
25. Consider the following two LC circuits.




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

**Answer (04.00)**

**Sol.**




$$\omega_1 = \frac{1}{\sqrt{LC}}\ ,\ \omega_2 = \frac{1}{\sqrt{(8L\times2C)}} = \frac{1}{4\sqrt{LC}}$$

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

26. ??

27. ??

28. ??

29. ??

30. ??