Head Office: 2nd Floor, Grand Plaza, Fraser Road, Dak Bunglow, Patna - 01

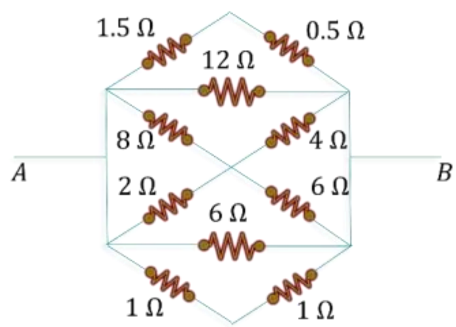
JEE Main 2023 (Memory based)

30 January 2023 - Shift 2

Answer & Solutions

PHYSICS

1. In the given circuit the resistance between terminals A and B is equal to

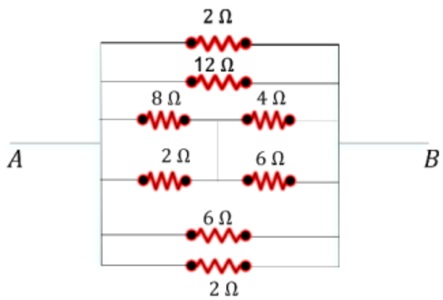


A. $2\,\Omega$
B. $\frac{3}{2}\,\Omega$
C. $\frac{2}{3}\,\Omega$
D. $6\,\Omega$

Answer (C)

Solution:

The circuit can be redrawn as:



So, the net resistance across A and B is:

$$\frac{1}{R_{net}} = \frac{1}{2} + \frac{1}{12} + \frac{1}{4} + \frac{1}{6} + \frac{1}{2}$$
$$\frac{1}{R_{net}} = \frac{18}{12}$$
$$R_{net} = \frac{2}{3}\,\Omega$$

2. A car travels $4\ km$ distance with a speed of $3\ km/hr$ and next $4\ km$ with a speed of $5\ km/h$. Find average speed of car.

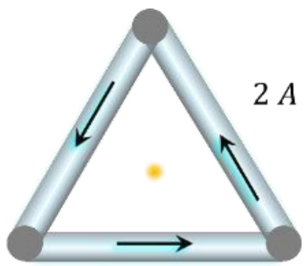
A. $\frac{15}{2}\ km/hr$
B. $\frac{15}{4}\ km/hr$
C. $15\ km/hr$
D. $10\ km/hr$

Answer (B)

Solution:

$$\text{Velocity} = \frac{\text{Total Distance}}{\text{Total time}}$$
$$v = \frac{4+4}{\frac{4}{3}+\frac{4}{5}}\ km/h$$
$$v = \frac{15}{4}\ km/h$$

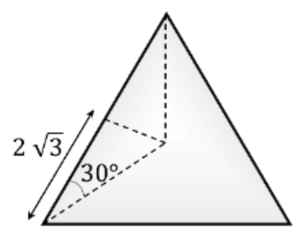
3. A current $2\ A$ if flowing through the sides of an equilateral triangular loop of side $4\sqrt{3}\ m$ as shown. Find the magnetic field induction at the centroid of the triangle.



A. $3\sqrt{3} \times 10^{-7}\ T$
B. $\sqrt{3} \times 10^{-7}\ T$
C. $2\sqrt{3} \times 10^{-7}\ T$
D. $5\sqrt{3} \times 10^{-7}\ T$

Answer (A)

Solution:

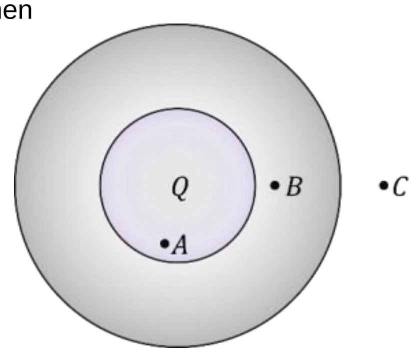


$$\frac{r}{2\sqrt{3}} = \tan 30°$$
$$r = 2\ m$$

Magnetic field at centroid

$$B = 3 \times \frac{\mu_0 I}{4\pi r}(\sin 60° + \sin 60°)$$
$$= 3 \times \frac{\mu_0 \times 2}{4\pi \times 2}\left(\frac{\sqrt{3}}{2} + \frac{\sqrt{3}}{2}\right) = 3\sqrt{3} \times 10^{-7}\ T$$

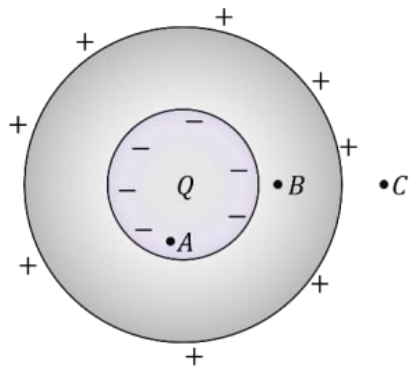
4. A point charge Q is placed inside the cavity made in uniform conducting solid sphere as shown. E_A, E_B *and* E_C are electric field magnitudes at points A, B and C respectively. Then



A. $E_A = 0$, $E_B = 0$ and $E_C \neq 0$
B. $E_A \neq 0$, $E_B = 0$ and $E_C \neq 0$
C. $E_A \neq 0$, $E_B = 0$ and $E_C = 0$
D. $E_A \neq 0$, $E_B \neq 0$ and $E_C = 0$

Answer (B)

Solution:



$E_A \neq 0$ (Electric field due to both Q and induced charges on the inner surface of cavity)

$E_B = 0$ (No field line inside conductor)

$E_C \neq 0$ (Electric field due to charge induced on outer surface of conductor)

5. In the shown mass-spring system, when it is set into oscillations along the spring, it has angular frequency ω_1 if $m = 1\,kg$ and ω_2 if $m = 2\,kg$. Then value of ω_1/ω_2 is equal to

A. 1
B. $\sqrt{2}$
C. $1/\sqrt{2}$
D. 2

Answer (B)

Solution:

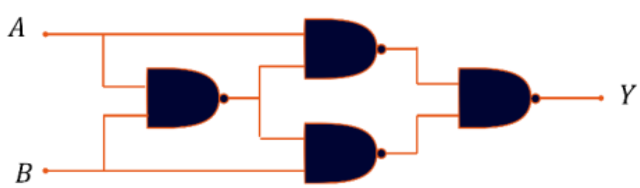
$$\omega_1 = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{1}}$$

$$\omega_2 = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{2}}$$

So,

$$\frac{\omega_1}{\omega_2} = \sqrt{2}$$

6. For the given logic circuit, which of the following truth table is correct?



A.

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

B.

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

C.

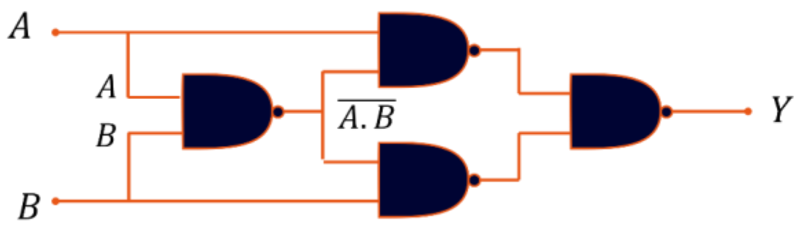
A	B	Y
0	0	1
0	1	1
1	0	1
1	0	0

D.

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Answer (A)

Solution:



$$X_1 = \overline{\left(\overline{A.(\overline{A.B})}.\overline{B.(\overline{A.B})}\right)}$$

$$= A.(\overline{A.B}) + B.(\overline{A.B})$$

$$= A.\bar{B} + B.A$$

$$= XOR\ gate$$

7. A particle of mass m is moving under a force whose delivered power P is constant. Initial velocity of particle is $zero$. Find the position of particle at $t = 4\ s$

A. $x = \frac{16}{3}\sqrt{\left[\frac{2P}{m}\right]}$

B. $x = \frac{4}{3}\sqrt{\left[\frac{2P}{m}\right]}$

C. $x = \frac{2}{3}\sqrt{\left[\frac{P}{m}\right]}$

D. $x = \frac{3}{10}\sqrt{\left[\frac{P}{m}\right]}$

Answer (A)

Solution:

We know that:

$$P = \frac{W}{t}$$

$$\frac{1}{2}mv^2 = P \times t$$

$$v = \sqrt{\frac{2Pt}{m}} = \frac{dx}{dt}$$

$$x = \frac{16}{3}\sqrt{\frac{2P}{m}}$$

8. Column-I list few physical quantities and column-II lists their dimensions. Choose the correct option matching two lists correctly.

column I	column II
(P) Pressure gradient	(A) $[M^1L^2T^{-2}]$
(Q) Energy density	(B) $[M^1L^1T^{-1}]$
(R) Torque	(C) $[M^1L^{-2}T^{-2}]$
(S) Impulse	(D) $[M^1L^{-1}T^{-2}]$

A. $P-C,\ Q-A,\ R-B,\ S-D$
B. $P-C,\ Q-D,\ R-A,\ S-B$
C. $P-A,\ Q-D,\ R-B,\ S-C$
D. $P-A,\ Q-C,\ R-B,\ S-D$

Answer (B)

Solution:

$$[Pressure\ gradient] \Rightarrow \left[\frac{dP}{dz}\right] = \left[\frac{ML^{-1}T^{-2}}{L}\right] = [ML^{-2}T^{-2}]$$

$$[Energy\ density] \Rightarrow \left[\frac{dU}{dV}\right] = \left[\frac{ML^2T^{-2}}{L^3}\right] = [ML^{-1}T^{-2}]$$

$$[Torque] \Rightarrow [F]\times[r] = [MLT^{-2}]\times[L] = [ML^2T^{-2}]$$

$$[Impulse] \Rightarrow [F][t] = [MLT^{-2}][T] = [MLT^{-1}]$$

So, $P-C,\ Q-D,\ R-A,\ S-B$ is the correct match.

9. Consider the following assertion and reason:
Assertion (A): At sink temperature of $-273°C$, the efficiency of a Carnot engine will be 1.
Reason (R): Efficiency of a Carnot engine is given by $\eta = 1 - \frac{T_{sink}}{T_{source}}$

A. A is correct. R is correct and correctly explains A.
B. A is not correct. R is correct.
C. Both A and R *are* incorrect.
D. Both A and R *are* correct. R doesn't explain A.

Answer (A)

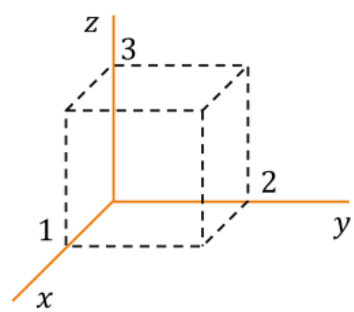
Solution:

We know that Carnot efficiency is:

$$\eta = 1 - \frac{T_{Sink}}{T_{Source}}$$

For $T_{sink} = -273°\ C = 0\ K \Rightarrow \eta = 1$

10. Electric field in a region is $\vec{E} = 2x^2\hat{\imath} - 4y\hat{\jmath} + 6z\hat{k}$
Find the charge inside the cuboid shown:



A. $-8\varepsilon_o$
B. $36\varepsilon_o$
C. $12\varepsilon_o$
D. $24\varepsilon_o$

Answer (D)

Solution:

Total flux can be calculated as:

$$\phi_{total} = 2(1)^2[2\times 3] - 4(2)[1\times 3] + 6(3)[1\times 2]$$
$$\phi_{total} = 12 - 24 + 36$$
$$\phi_{total} = 24$$

From Gauss's Law:

$\Rightarrow \frac{q}{\varepsilon_o} = 24$

$\Rightarrow q = 24\varepsilon_o$

11. Find the ratio of de-Broglie wavelength of proton when it is accelerated across V and $3V$ potential difference.

A. $3:1$
B. $1:\sqrt{3}$
C. $1:3$
D. $\sqrt{3}:1$

Answer (D)

Solution:

When proton is accelerated by potential difference V, then linear momentum of proton

$$\frac{P^2}{2m} = eV$$

$$P = \sqrt{2meV} \Rightarrow \lambda_1 = \frac{h}{\sqrt{2meV}}$$

When proton is accelerated by potential difference $3\,V$, then linear momentum of proton

$$\frac{P^2}{2m} = 3eV$$

$$P = \sqrt{6meV} \Rightarrow \lambda_2 = \frac{h}{\sqrt{6meV}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{3}$$

12. A faulty scale reads $5°C$ at melting point and $95°C$ at steam point. Find original temperature if this faulty scale reads $41°C$.

A. $40°C$
B. $41°C$
C. $36°C$
D. $45°C$

Answer (A)

Solution:

Suppose X is the original temperature.
So,

$$\frac{41-5}{95-5} = \frac{X-0}{100-0}$$

$$9X = 360$$

$$X = 40$$

13. A particle is released at a height equal to radius of earth above the surface of the earth. Its velocity when it hits the surface of earth is equal to
M_e=mass of earth, R_e= radius of earth

A. $v = \sqrt{\left[\frac{2GM_e}{R_e}\right]}$
B. $v = \sqrt{\left[\frac{GM_e}{2R_e}\right]}$
C. $v = \sqrt{\left[\frac{GM_e}{R_e}\right]}$
D. $v = \sqrt{\left[\frac{2GM_e}{3R_e}\right]}$

Answer (C)

Solution:

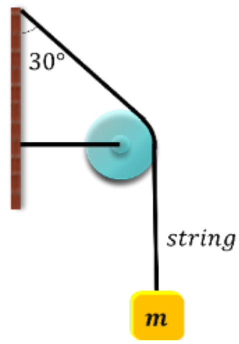
Applying law of conservation of mechanical energy,

$$-\frac{GM_e m}{2R_e} = -\frac{GM_e m}{R_e} + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{GM_e}{R_e}}$$

14. A block stays in equilibrium as shown. Find the tension in the string if $m = \sqrt{3}\,kg$.

A. $\sqrt{3}g\ N$
B. $3g\ N$
C. $g/2\ \ N$
D. $g/\sqrt{3}\ \ N$



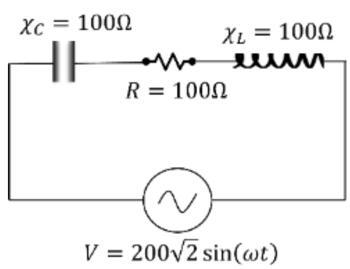
Answer (A)

Solution:

Since block is in equilibrium,
$\Rightarrow T = mg$
$\Rightarrow T = \sqrt{3}\ g$

15. In the AC circuit shown in the figure, the value of I_{rms} is equal to

A. $2A$
B. $2\sqrt{2}A$
C. $4A$
D. $\sqrt{2}A$



Answer (A)

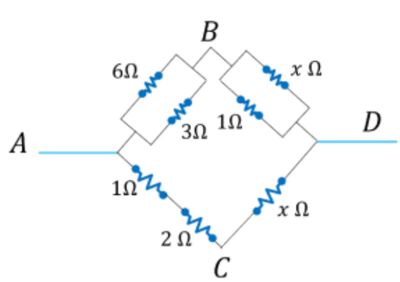
Solution

$$Z = \sqrt{R^2 + (\chi_L - \chi_C)^2}$$
$$Z = \sqrt{100^2 + (100 - 100)^2} = 100\Omega$$

So,

$$i_o = \frac{V_o}{Z} = \frac{200\sqrt{2}}{100} = 2\sqrt{2}$$
$$i_{rms} = \frac{i_o}{\sqrt{2}} = 2\ A$$

16. For the given electrical circuit, the potential difference between point B and C is zero. The value of $2x$ is __________.



Answer (1)

Solution:

Since, $V_B = V_C$
Then,

$$\frac{2}{3} = \frac{\frac{x}{x+1}}{x}$$

$$x + 1 = \frac{3}{2} \Rightarrow x = \frac{1}{2}\ \Omega$$

17. Two waves of same intensity from sources in phase are made to superimpose at a point. If path difference between these two coherent waves is zero, then resultant intensity is I_o. If this path difference is $\frac{\lambda}{2}$ where λ is wavelength of these waves, then resultant intensity is I_1 and if the difference is $\frac{\lambda}{4}$ then resultant Intensity is I_2. Value of $\frac{I_1+I_2}{I_o}$ is equal to.

Answer (0.5)

Solution:

Let individual intensity from source is I thus,

$$I_0 = I + I + 2\sqrt{I \times I}\cos\left(0 \times \frac{2\pi}{\lambda}\right) \Rightarrow I_0 = 4I$$

$$I_1 = I + I + 2\sqrt{I \times I}\cos\left(\frac{\lambda}{2} \times \frac{2\pi}{\lambda}\right) \Rightarrow I_1 = 0$$

$$I_2 = I + I + 2\sqrt{I \times I}\cos\left(\frac{\lambda}{4} \times \frac{2\pi}{\lambda}\right) \Rightarrow I_2 = 2I$$

So,

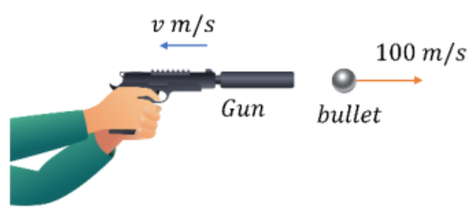
$$\frac{I_1 + I_2}{I_0} = \frac{1}{2}\ or\ 0.5$$

18. A bullet of mass $10\ grams$ is fired from a gun (mass of $10\ kg$ without bullet) with a speed of $100\ m/s$. The recoil speed of gun is $\frac{x}{10}\ m/s$. Find x.

Answer (1)

Solution:

Applying Conservation of linear momentum



$$10 \times 10^{-3} \times v = 10 \times 100$$

$$v = \frac{1}{10}\ m/s$$

19. The relation between velocity (v) and position (x) of a particle moving along x-axis is given by $4v^2 = 50 - x^2$. The time period of oscillatory motion of the particle is $\frac{88}{n}\ seconds$. Find n . Use $\pi = \frac{22}{7}$

Answer (7)

Solution:

$$4v^2 = 50 - x^2$$

$$v^2 = \frac{1}{4}(50 - x^2)$$

$$v = \frac{1}{2}\sqrt{[(50 - x^2)]}$$

comparing with equation of SHM

$$v = \omega\sqrt{A^2 - x^2}$$

$A^2 = 50 \Rightarrow A = 5\sqrt{2}$
$\omega = \frac{1}{2} = 0.5\ rad/s$
$T = \frac{2\pi}{\omega} = \frac{2\pi}{0.5} = 4\pi\ second$
$T = 4\left(\frac{22}{7}\right) = \frac{88}{7}\ \ second$
$So,\ n = 7$

20. The ratio of temperature in K of hydrogen and oxygen is $2:1$. The ratio of their average kinetic energy per molecule is

Answer (2)

Solution:

$\text{Average kinetic energy} = \frac{f}{2} K_B T$
As f $(both\ are\ diatomic)$ and K_B are same for hydrogen and oxygen.

$$\frac{(\text{Average kinetic energy per molecule})_{\mathrm{H_2}}}{(\text{Average kinetic energy per molecule})_{\mathrm{O_2}}} = \frac{T_{H_2}}{T_{O_2}} = \frac{2}{1}$$

21. Prism A has angle of prism equal to 6^0 and its material has refractive index 1.5. It is used in combination with prism B of refractive index 1.8 to produce dispersion without deviation. Angle of prism B is equal to _____degrees.

Answer (3.75)

Solution:

For dispersion without deviation
$A(\mu - 1) + A'(\mu' - 1) = 0$
$6°(1.5 - 1) + A'(1.8 - 1) = 0$
$A' = -3.75°$
Negative sign indicate that prison are inverted with respect to each other
$|A'| = 3.75°$