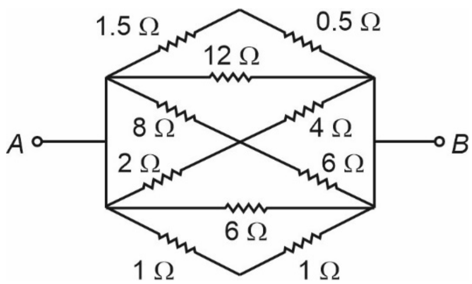
PHYSICS

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

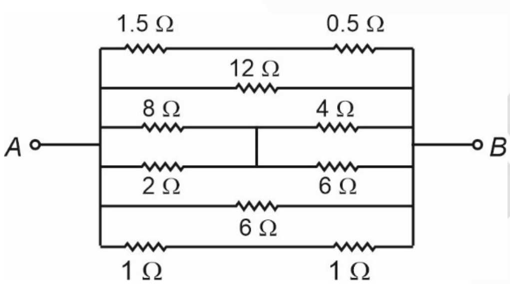


(1) $2\ \Omega$ (2) $\frac{3}{2}\ \Omega$

(3) $\frac{2}{3}\ \Omega$ (4) $6\ \Omega$

Answer (3)

Sol. The circuit can be redrawn as



So the net resistance across A and B is

$$\frac{1}{R_{\text{net}}}=\frac{1}{2}+\frac{1}{12}+\frac{1}{4}+\frac{1}{6}+\frac{1}{2}$$

$$\frac{1}{R_{\text{net}}}=\frac{6+1+3+2+6}{12}$$

$$R_{net}=\left(\frac{2}{3}\right)\Omega$$

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

(1) $\frac{15}{2}$ km/h (2) $\frac{15}{4}$ km/h

(3) 15 km/h (4) 10 km/h

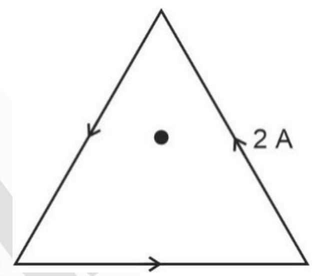
Answer (2)

Sol. $v_{\text{avg}}=\frac{\text{Distance}}{\text{Time}}$

$$=\frac{4+4}{\frac{4}{3}+\frac{4}{5}}\text{ km/h}$$

$$=\frac{15}{4}\text{ km/h}$$

3. A current 2 A is 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.

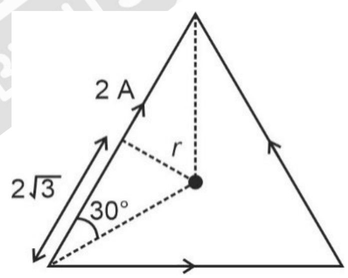


(1) $3\sqrt{3}\times10^{-7}$ T (2) $\sqrt{3}\times10^{-7}$ T

(3) $2\sqrt{3}\times10^{-7}$ T (4) $5\sqrt{3}\times10^{-7}$ T

Answer (1)

Sol.



$$\frac{r}{2\sqrt{3}}=\tan30^\circ$$

r = 2 m

Magnetic field at centroid

$$=3\times\frac{\mu_0 I}{4\pi r}(\sin60^\circ+\sin60^\circ)$$

$$=3\times\frac{\mu_0}{4\pi}\times\frac{2}{2}\left[\frac{\sqrt{3}}{2}+\frac{\sqrt{3}}{2}\right]$$

$$=3\sqrt{3}\times\frac{\mu_0}{4\pi}\text{ T}$$

$$=3\sqrt{3}\times10^{-7}\text{ T}$$

4. A particle is released at a height equal to radius of the 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)

(1) $v=\sqrt{\frac{2GM_e}{R_e}}$ (2) $v=\sqrt{\frac{GM_e}{2R_e}}$

(3) $v=\sqrt{\frac{GM_e}{R_e}}$ (4) $v=\sqrt{\frac{2GM_e}{3R_e}}$

Answer (3)

Sol. Using energy conservation.

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

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

5. 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.

(1) 40°C (2) 41°C

(3) 36°C (4) 45°C

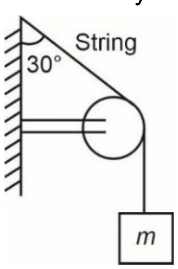
Answer (1)

Sol. $\frac{41-5}{95-5}=\frac{x-0}{100-0}$

$\Rightarrow$ $9x = 360$

$\Rightarrow$ $x = 40$

6. A block stays in equilibrium as shown:



Find the tension in the string if $m=\sqrt{3}$ kg

(1) $\sqrt{3}g$ N (2) $3g$ N

(3) $\frac{g}{2}$ N (4) $\frac{g}{\sqrt{3}}$ N

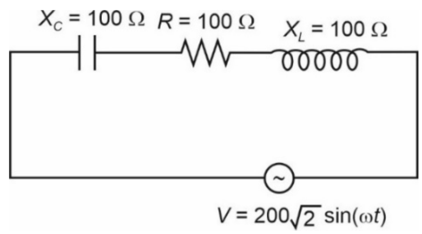
Answer (1)

Sol. Since block in equilibrium

$\Rightarrow$ $T = mg$

$\Rightarrow$ $T=\sqrt{3}g$

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



(1) 2A (2) $2\sqrt{2}$A

(3) 4A (4) $\sqrt{2}$A

Answer (1)

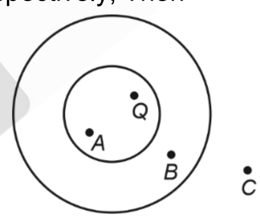
Sol. $Z=\sqrt{R^2+(X_L-X_C)^2}$

$=\sqrt{100^2+(100-100)^2}=100\ \Omega$

So, $i_0=\frac{200\sqrt{2}}{100}=2\sqrt{2}$

So, $i_{rms}=\frac{i_0}{\sqrt{2}}=2$A

8. 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



(1) $E_A = 0$, $E_B = 0$ and $E_C \neq 0$

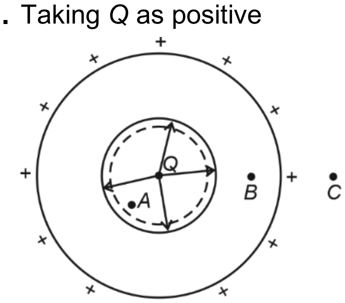
(2) $E_A \neq 0$, $E_B = 0$ and $E_C \neq 0$

(3) $E_A \neq 0$, $E_B = 0$ and $E_C = 0$

(4) $E_A \neq 0$, $E_B \neq 0$ and $E_C \neq 0$

Answer (2)

Sol. Taking Q as positive

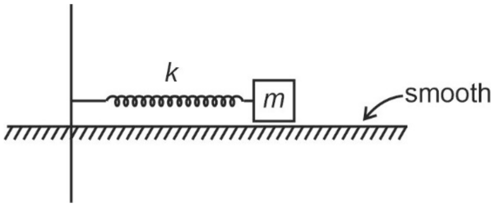


$E_A \neq 0$ (electric field due to both Q and induced charge on the inner surface of cavity)

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

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

9. In the shown mass-spring system when it is set into oscillations along the spring, it has angular frequency ω_1, when m = 1 kg and ω_2 if m = 2 kg. Then value of $\frac{\omega_1}{\omega_2}$ is equal to



(1) 1 (2) $\sqrt{2}$

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

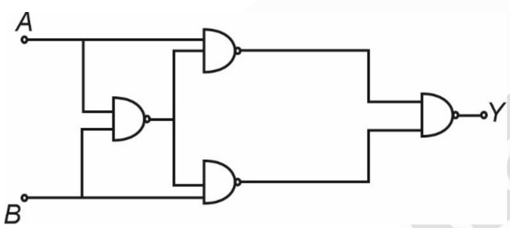
Answer (2)

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

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

So $\frac{\omega_1}{\omega_2} = \sqrt{\frac{k}{k/2}} = \sqrt{2}$

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



(1)

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

(2)

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

(3)

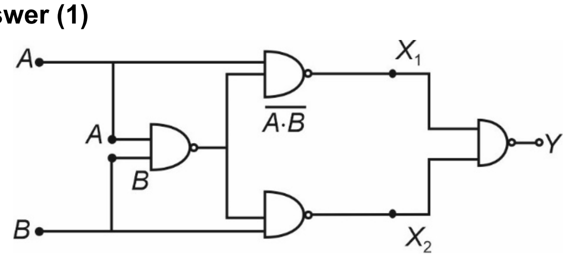
A	B	Y
0	0	1
0	1	1
1	0	1
1	0	0

(4)

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

Answer (1)

Sol.



$X_1 = \overline{\overline{A \cdot (\overline{A \cdot B})} \cdot \overline{B \cdot (\overline{A \cdot B})}}$

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

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

$= A\overline{B} + B\overline{A}$

= XOR gate

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

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

(1) $x = \frac{16}{3}\sqrt{\frac{2P}{m}}$ (2) $x = \frac{4}{3}\sqrt{\frac{2P}{m}}$

(3) $x = \frac{2}{3}\sqrt{\frac{P}{m}}$ (4) $x = \frac{3}{10}\sqrt{\frac{P}{m}}$

Answer (1)

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

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

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

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

12. Column-I list few physical quantities and column-II lists their dimensions. Choose the correct option matching the 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)	$[M^1L^{-1}T^{-2}]$

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

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

Answer (2)

Sol. [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

13. Consider the following assertion & 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 $\eta = 1 - \frac{T_{sink}}{T_{Source}}$.

(1) (A) is correct, (R) is correct and correctly explains A

(2) (A) is not correct, (R) is correct

(3) Both (A) & (R) are incorrect

(4) Both (A) & (R) are correct, (R) does not explain (A)

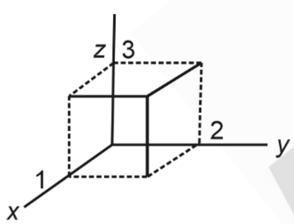
Answer (1)

Sol. $\eta = 1 - \frac{T_{sink}}{T_{Source}}$

If $T_{sink} = 0$ K $\Rightarrow \eta = 1$

14. Electric field in a region is

$\vec{E} = 2x^2\hat{i} - 4y\hat{j} + 6z\hat{k}$



Find the charge inside the cuboid shown:

(1) $-8\varepsilon_0$ (2) $36\varepsilon_0$

(3) $12\varepsilon_0$ (4) $24\varepsilon_0$

Answer (4)

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

$= 12 - 24 + 36$

$= 24$

$\Rightarrow \frac{q}{\varepsilon_0} = 24$

$\Rightarrow q = 24\varepsilon_0$

15. Find the ratio of de Broglie wavelength of proton, when it is accelerated across v and $3v$ potential difference.

(1) 3 : 1 (2) $1 : \sqrt{3}$

(3) 1 : 3 (4) $\sqrt{3} : 1$]

Answer (4)

Sol. When proton is accelerated by potential difference V, the linear momentum of proton

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

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

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

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

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

$\frac{\lambda_1}{\lambda_2} = \sqrt{3}$

16.

17.

18.

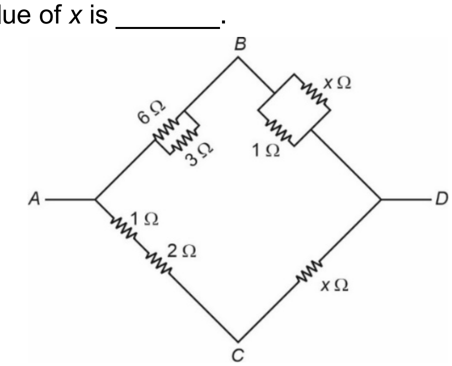
19.

20.

SECTION - B

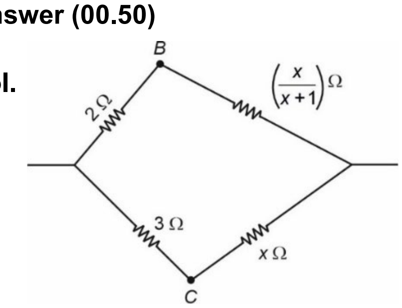
Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 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. For the given electrical circuit, the potential difference between points B and C is zero. The value of x is ________.



Answer (00.50)

Sol.



$V_B = V_C$

then $\frac{2}{3} = \frac{\left(\frac{x}{x+1}\right)}{x}$

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

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

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

22. 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_0. If this path difference is $\frac{\lambda}{2}$ where λ is wavelength of these waves, then resultant intensity is I, and if the path difference is $\frac{\lambda}{4}$ then resultant intensity is I_2. Value of $\frac{I_1 + I_2}{I_0}$ is equal to

Answer (00.50)

Sol. 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

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

Answer (1)

Sol. Conserving momentum

$10 \times V = \frac{10}{1000} \times 100$

$\Rightarrow \quad V = \frac{1}{10}$ m/s

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

Answer (02.00)

Sol. Average kinetic energy = $\frac{f}{2}K_B T$

$\frac{(\text{Average kinetic energy})_{H_2}}{(\text{Average kinetic energy})_{O_2}} = \frac{T_{H_2}}{T_{O_2}} = \left(\frac{2}{1}\right)$

25. 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 the oscillatory motion of the particle is $\frac{88}{n}$ seconds.

Find n $\left[\text{use } \pi = \frac{22}{7}\right]$

Answer (07.00)

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

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

$v = \frac{1}{2}\sqrt{50 - x^2}$

Comparing equation of S.H.M.

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

$A^2 = 50$

$A = \sqrt{50} = 5\sqrt{2}$

$w = \frac{1}{2} = 0.5$ rad/sec

$T = \frac{2\pi}{w} = \frac{2\pi}{0.5} = 4\pi$ second

$\pi = \left(\frac{22}{7}\right)$

$T = \frac{88}{7} = \frac{88}{n}$

So, $n = 7$

26. Prism A has angle of prism equal to 6° 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. Prism angle of prism B is equal to _____ degrees.

Answer (03.75°)

Sol. For dispersion without deviation

$A_A(\mu_A - 1) + A_B(\mu_B - 1) = 0$

$6(1.5 - 1) + A(1.8 - 1) = 0$

$A = -\frac{3}{0.8} = -3.75°$

27.

28.

29.

30.