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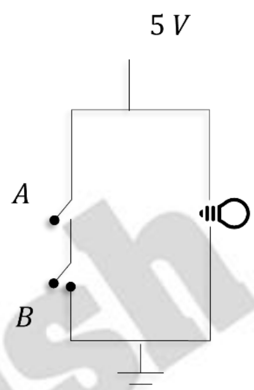
JEE Main 2023 (Memory based)

24 January 2023 - Shift 2

Answer & Solutions

PHYSICS

1. The corresponding gate for the given circuit diagram is



A. OR

B. AND

C. NAND

D. XOR

Answer (C)

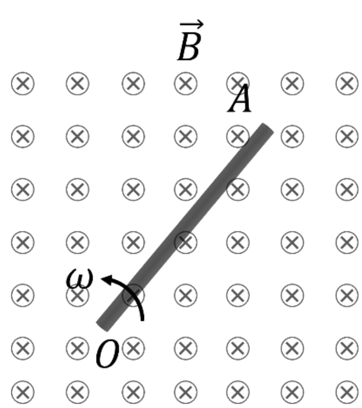
Sol.

When both A and B are open or any one of them is open, bulb will glow.
When both switches are closed, due to short circuit, bulb will not glow.

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

Output = $\overline{A.B}$

2. A rod $'OA'$ of length 'L' is rotating with constant angular speed 'ω' about an axis passing through point O in a perpendicular uniform magnetic field 'B'. Find the emf induced between points O and A of the rod.



A. $\frac{1}{2}B\omega L^2$

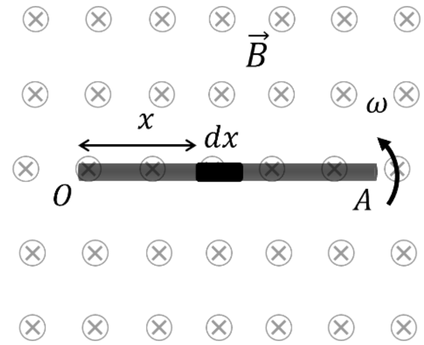
B. $B\omega L^2$

C. $\frac{3}{2}B\omega L^2$

D. $2\ B\omega L^2$

Answer (A)

Sol.



$$d\mathcal{E} = Bvdx = B\omega x dx$$

$$\int d\mathcal{E} = \int_0^L B\omega x\, dx$$

$$\mathcal{E} = \frac{B\omega L^2}{2}$$

3. Let γ_1 be the ratio of molar specific heat at constant pressure and constant volume for a monoatomic gas and let γ_2 be this ratio for a diatomic gas. Find $\frac{\gamma_1}{\gamma_2}$

A. $21/25$

B. $7/3$

C. $25/21$

D. $3/7$

Answer (C)

Sol.

We know that $\gamma_1 = \frac{5}{3}$ and $\gamma_2 = \frac{7}{5}$

$$\frac{\gamma_1}{\gamma_2} = \frac{25}{21}$$

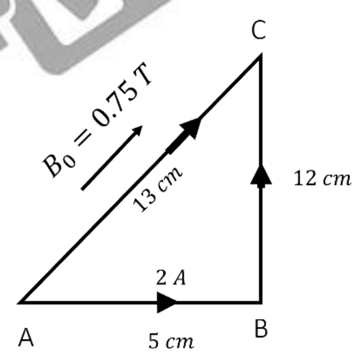
4. A right-angled triangle has current of $2\ A$. The edge length are shown in the diagram. Magnetic field is acting in the plane of the triangle. The magnetic force acting on wire AB is

A. $\frac{5}{130}\ N$

B. $\frac{15}{2}\ N$

C. $\frac{3}{40}\ N$

D. $\frac{9}{130}\ N$



Answer (D)

Sol.

$$B = 0.75\ T$$

$$\left|\vec{F}_{AB}\right| = i \times (l_{AB}) B \sin\theta$$

$$= 2 \times \left(\frac{5}{100}\right) \times 0.75 \times \frac{12}{13}$$

$$= \frac{9}{130}\ N$$

5. Assertion (A): Steel is used to build big structures.

Reason (R): Steel has more elastic modulus as compared to other materials.

A. Both A and R are true and R is the correct explanation of A.
B. Both A and R are true but R is not the correct explanation of A.
C. A is true but R is false.
D. Both A and R are false.

Answer (A)

Sol.

Large elastic modulus implies deformations will stay in elastic region and permanent deformations will not occur for small magnitude of force.

6. If $\vec{a} = \hat{\imath} + 2\hat{\jmath} + m\hat{k}$ and $\vec{b} = \hat{\imath} - 2\hat{\jmath} + m\hat{k}$ are perpendicular to each other, then $m = \sqrt{x}$. Find x.

Answer (3)

Sol.

$\vec{a} = \hat{\imath} + 2\hat{\jmath} + m\hat{k}$ and $\vec{b} = \hat{\imath} - 2\hat{\jmath} + m\hat{k}$

$\vec{a} \perp \vec{b} \Rightarrow \vec{a} \, . \, \vec{b} = 0$

$1 - 4 + m^2 = 0$

$m = \sqrt{3}$

$x = 3.00$

7. The distance of earth from the sun is $1.5 \times 10^8\ km$. If the time period of an imaginary planet is $2.83\ years$, then its distance from the sun comes out to be $n \times 10^8\ km$. Find n.

Answer (3)

Sol.

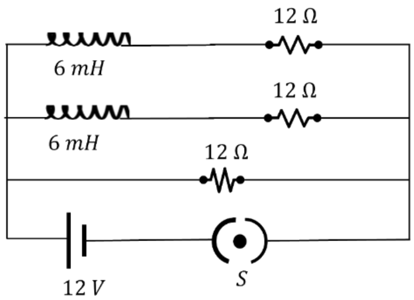
$T^2 \propto \ a^3$

$$\left[\frac{T^2}{a^3}\right]_{earth} = \left[\frac{T^2}{a^3}\right]_{any\ planet}$$

$$\frac{1}{(1.5 \times 10^8)^3} = \frac{2.83^2}{(x)^3}$$

$x = 3 \times 10^8$
$n = 3$

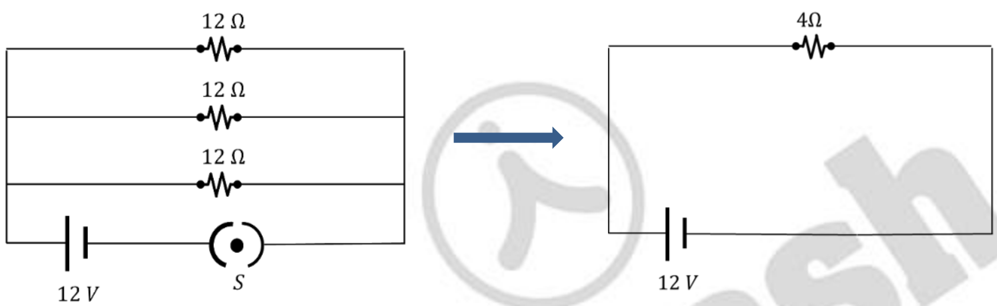
8. For the given electrical circuit, the switch 's' is closed at $t = 0$. Find the current $(in\ A)$ drawn through the battery at steady state.



Answer (3)

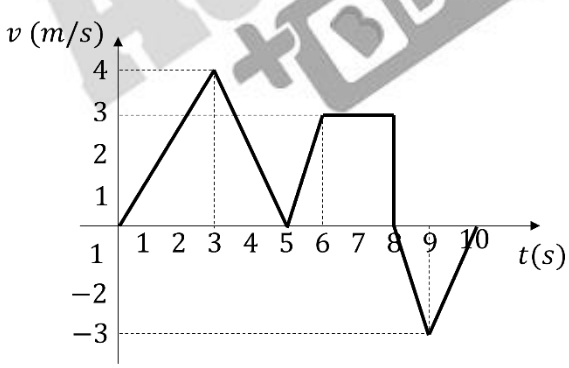
Sol.

At steady state, inductors behave as shorted.



$$i = \frac{12}{4} = 3A$$

9. The velocity-time $(v - t)$ graph for a particle moving along a straight path is shown. Find the time taken (in seconds) by the particle to cover the first $10\ m$ of distance.



Answer (5)

Sol.

Distance = Area under $v - t$ graph

Area in first 5 seconds,

$$A = \frac{1}{2} \times t \times 4 = 10\ m$$

$$t = 5\ s$$

10. An electron jumps from 3^{rd} excited state to the ground state in a hydrogen atom. The wavelength of photon emitted in nm to the nearest integer is _____ $(hc = 1240\ eV - nm)$

Answer (97)

Sol.

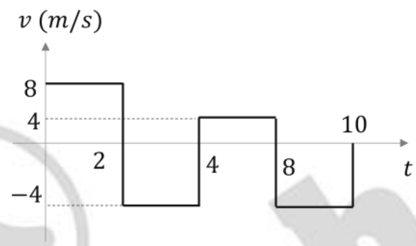
$n_i = 4,\ n_f = 1$

$\Delta E = 13.6(1 - \frac{1}{16}) = \frac{13.6 \times 15}{16} = 12.75\ eV$

$\lambda(nm) = \frac{1240}{12.75} \approx 97.25\ nm$

$\lambda(nm) = 97\ nm$

11. The velocity-Time graph of a body moving along straight line is given as shown. The ratio of displacement and distance is:



A. $1:1$
B. $1:2$
C. $1:3$
D. $1:4$

Answer (C)

Sol.

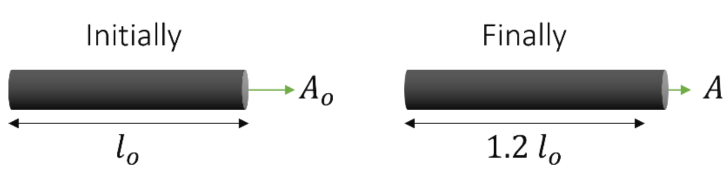
Distance = $8 \times 2 + 4 \times 2 + 4 \times 4 + 4 \times 2 = 48\ m$
Displacement = $8 \times 2 - 4 \times 2 + 4 \times 4 - 4 \times 2 = 16\ m$
Ratio = $1:3$

12. A copper wire is elongated such that its length is increased by $20\ \%$. Then the percentage increase in the resistance is

A. 20%
B. 30%
C. 44%
D. 50%

Answer (C)

Sol.



Before Heating

$R_o = \left(\frac{\rho l_o}{A_o}\right)$

After Heating

Volume = Constant

$$A_o l_o = 1.2\, l_o A$$

$$A = \left(\frac{A_o}{1.2}\right)$$

So,

$$R = \frac{\rho l}{A} = \frac{\rho \times (1.2\, l_o)}{\left(\frac{A_o}{1.2}\right)} = \frac{\rho l_o}{A_o} \times 1.44 = 1.44\, R_o$$

Percentage increase in $= \frac{R-R_o}{R_o} \times 100 = 44\%$

13. **Assertion** $(\mathbf{A})$: Acceleration due to gravity decreases with both height and depth from earth surface.

Reason $(\mathbf{R})$: If height and depth are equal for two points from surface of the earth, then acceleration due to gravity will be same at those points.

A. Both A and R are true and R is the correct explanation of A

B. Both A and R are true and R is not the correct explanation of A

C. A is true but R is false.

D. Both A and R are false

Answer (C)

Sol.

Acceleration due to gravity is maximum on the surface.

It increases linearly from centre to surface and then decreases by inverse square law.

So, Assertion is true, and Reason is false.

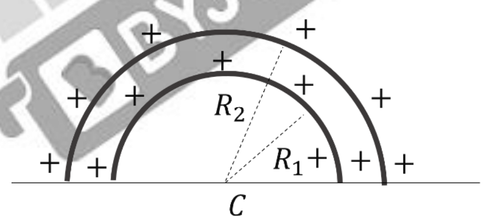
14. Two concentric semi-circular rings (radii R_1 and R_2) have equal linear charge density (λ each) as shown: Find the potential at center C.

A. $\frac{\lambda}{\epsilon_0}$

B. $\frac{2\lambda}{\epsilon_0}$

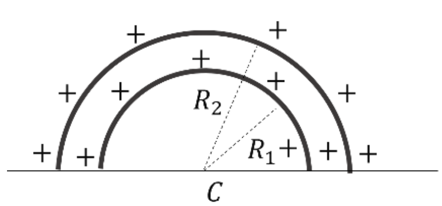
C. $\frac{\lambda}{4\epsilon_0}$

D. $\lambda/2\epsilon_0$



Answer (D)

Sol.



At point C:

$$V_c = V_1 + V_2$$

$$V_c = \frac{1}{4\pi\epsilon_0} \times \frac{\lambda_1(\pi R_1)}{R_1} + \frac{1}{4\pi\epsilon_0} \times \frac{\lambda_1(\pi R_2)}{R_2} = \frac{\lambda_1\ (or\ \lambda)}{2\epsilon_0}$$

15. Electric field vector and magnetic field vector of an electromagnetic wave is given as $\vec{E} = E_0 \sin(\omega t - kx)\hat{j}$ and $\vec{B} = B_0 \sin(\omega t - kx)\hat{k}$, then choose the correct option.

A. $\omega E_0 = kB_0$
B. $kE_0 = \omega B_0$
C. $k\omega = E_0 B_0$
D. None of these

Answer (B)

Sol.

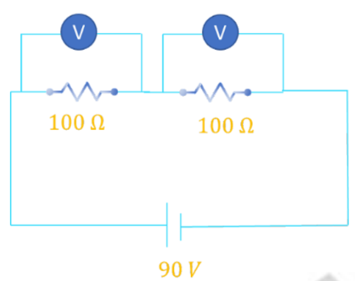
Given: $\vec{E} = E_0 \sin(\omega t - kx)\hat{j}$ and $\vec{B} = B_0 \sin(\omega t - kx)\hat{k}$

$E_0 = vB_0$

$v = \frac{\omega}{k}$

$E_0 = \frac{\omega}{k} B_0 \Rightarrow kE_0 = \omega B_0$

16. Consider the circuit shown:
Resistance of each voltmeter is $400\ \Omega$. Find the reading of any one voltmeter.



A. $60\ V$
B. $45\ V$
C. $80\ V$
D. $30\ V$

Answer (B)

Sol.

By symmetry, voltage would be divided equally.

$\Rightarrow$ Voltage across a voltmeter$= \frac{90}{2}\ V = 45\ V$

17. A long solenoid has 70 turns per cm and carries current $2\ A$. The magnetic field inside the solenoid is____ $(\mu_o = 4\pi \times 10^{-7}\ in\ SI\ units)$

A. $125.2 \times 10^{-4}\ T$
B. $835.2 \times 10^{-4}\ T$
C. $176.0 \times 10^{-4}\ T$
D. $880 \times 10^{-4}\ T$

Answer (C)

Sol.

Magnetic field inside solenoid $= \mu_o ni$

where $n =$ Number of turns per unit length

$n = 7000\ turns/m$

$$B_{solenoid} = \mu_o ni = (4\pi \times 10^{-7} \times 7000 \times 2)\ T$$
$$= 8 \times \frac{22}{7} \times 10^{-7} \times 7000\ \ T$$
$$= 176 \times 10^{-4}\ \ T$$

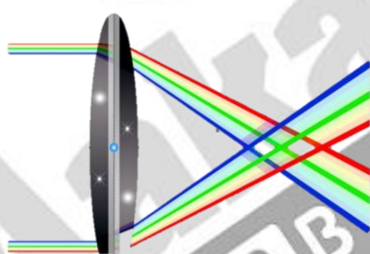
18. A ray of parallel white light incidence on convex lens and colour gets separated, this phenomenon is called

A. Chromatic aberration
B. Polarization
C. Scattering
D. Spherical aberration

Answer (A)

Sol.

This phenomenon is known as chromatic aberration.



19. **Assertion** $(\mathbf{A})$: The weight of an object at Mount Everest is lesser than its weight at sea level.
Reason $(\mathbf{R})$: The value of g decreases as height increases.

A. Assertion and Reason both are correct, and Reason is the correct explanation of Assertion.
B. Assertion and Reason both are correct, but Reason is not the correct explanation.
C. Assertion is correct reason is incorrect.
D. Assertion is incorrect reason is correct.

Answer (A)

Sol.

As we know that:

$$g = \frac{GM}{(R+h)^2}, \text{Weight} = mg$$

As height from surface of earth increases g decreases, so weight on Mount Everest is less than the weight on the surface of earth.

20. A convex lens of refractive index 1.5 has focal length $20\ cm$ in air. When this lens is immersed in water (refractive index $= 4/3$), the new focal length $(in\ cm)$ is _______.

Answer (80)

Sol.

$$f_{air} = 20\ cm,\ \mu_{water} = \frac{4}{3},\ \mu = 1.5$$

When convex lens is in air,

$$\frac{1}{f_{air}} = (\mu - 1)\left(\frac{2}{R}\right) = 0.5\left(\frac{2}{R}\right) \qquad \text{-----------(1)}$$

When lens is immersed in water,

$$\frac{1}{f} = \left(\frac{\mu}{\mu_{water}} - 1\right)\left(\frac{2}{R}\right) = 0.125\left(\frac{2}{R}\right) \qquad \text{----------(2)}$$

From (1) and (2),

$$\frac{f}{f_{air}} = \frac{0.5}{0.125}$$

$$f = 0.5 \times \frac{20}{0.125} = 80\ cm$$