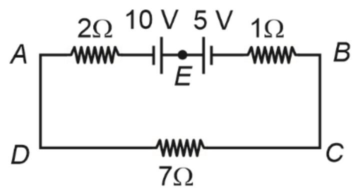
PHYSICS

SECTION-A

1. The magnitude and direction of the current in the following circuit is



(1) $\frac{5}{9}$ A from *A* to *B* through *E*

(2) 1.5 A from *B* to *A* through *E*

(3) 0.2 A from *B* to *A* through *E*

(4) 0.5 A from *A* to *B* through *E*

Answer (4)

Sol. Using Kirchhoff's law

$$i = \frac{10-5}{10} = \frac{5}{10}$$

i = 0.5 A

In clock-wise direction (from *A* to *B*)

2. The net magnetic flux through any closed surface is

(1) Infinity

(2) Negative

(3) Zero

(4) Positive

Answer (3)

Sol. $\oint \vec{B} \cdot \overrightarrow{ds} = \text{zero}$

Magnetic monopole doesn't exist.

Hence net magnetic flux through any closed surface is zero.

3. The amount of energy required to form a soap bubble of radius 2 cm from a soap solution is nearly (surface tension of soap solution = 0.03 N m^{-1})

(1) 3.01×10^{-4} J

(2) 50.1×10^{-4} J

(3) 30.16×10^{-4} J

(4) 5.06×10^{-4} J

Answer (1)

Sol. Amount of energy required = $[S \times \Delta A] \times 2$

$\Rightarrow$ Energy required = $[0.03 \times 4 \times \pi \times 4 \times 10^{-4}] \times 2$

$= 3.015 \times 10^{-4}$ J

4. A 12 V, 60 W lamp is connected to the secondary of a step-down transformer, whose primary is connected to ac mains of 220 V. Assuming the transformer to be ideal, what is the current in the primary winding?

(1) 3.7 A

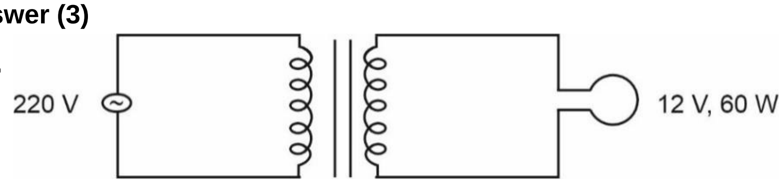
(2) 0.37 A

(3) 0.27 A

(4) 2.7 A

Answer (3)

Sol.



For ideal transformer

$P_{input} = P_{output}$

$(VI)_{in} = 60$

$220 \times I = 60$

$I = 0.27$ A

5. In a series LCR circuit, the inductance L is 10 mH, capacitance C is 1 μF and resistance R is 100 Ω. The frequency at which resonance occurs is

(1) 1.59 rad/s
(2) 1.59 kHz
(3) 15.9 rad/s
(4) 15.9 kHz

Answer (2)

Sol. For resonance frequency = $\frac{1}{2\pi\sqrt{LC}}$

$$\Rightarrow \quad f = \frac{1}{2\times\pi\times\sqrt{10\times10^{-3}\times1\times10^{-6}}} = \frac{10^4}{2\pi}$$

$= 1.591 \times 10^3$

$= 1.591$ kHz

6. Given below are two statements:

Statement I: Photovoltaic devices can convert optical radiation into electricity.

Statement II: Zener diode is designed to operate under reverse bias in breakdown region.

In the light of the above statements, choose the ***most appropriate*** answer from the options given below.

(1) Statement I is correct but Statement II is incorrect

(2) Statement I is incorrect but Statement II is correct

(3) Both Statement I and Statement II are correct

(4) Both Statement I and Statement II are incorrect

Answer (3)

Sol. Both Statements are correct.

I: Photovoltaic devices convert optical radiation into electricity.

II: Zener diode is designed to operate under reverse bias in breakdown region.

e.g., Zener diode as a voltage regulator.

7. The temperature of a gas is –50°C. To what temperature the gas should be heated so that the rms speed is increased by 3 times?

(1) 3097 K
(2) 223 K
(3) 669°C
(4) 3295°C

Answer (4)

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

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

v_{rms} is increased by 3 times

$T_1 = 273 - 50$

$= 223$ K

$T_2 = ?$

So, final rms speed = $v + 3v = 4v$

$$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{v}{4v} = \sqrt{\frac{223}{T_2}} \Rightarrow \frac{1}{16} = \frac{223}{T_2}$$

$T_2 = 3568$ K

$T_2 = 3568 - 273 = 3295°C$

8. The venturi-meter works on

(1) The principle of parallel axes

(2) The principle of perpendicular axes

(3) Huygen's principle

(4) Bernoulli's principle

Answer (4)

Sol. Venturi-meter works on the Bernoulli's principle.

9. A vehicle travels half the distance with speed v and the remaining distance with speed $2v$. Its average speed is

(1) $\frac{4v}{3}$

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

(3) $\frac{v}{3}$

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

Answer (1)

Sol. $v_{avg} = \frac{2v_1v_2}{v_1 + v_2}$

$$= \frac{2 \times v \times 2v}{v + 2v}$$

$$= \frac{4v}{3}$$

10. An ac source is connected to a capacitor C. Due to decrease in its operating frequency

(1) Displacement current decreases

(2) Capacitive reactance remains constant

(3) Capacitive reactance decreases

(4) Displacement current increases

Answer (1)

Sol. $X_C = \frac{1}{\omega C}$

Since ω decreasing X_C will increases hence current will decreases also

conduction current = displacement current

Therefore displacement current will decrease.

11. Light travels a distance x in time t_1 in air and $10x$ in time t_2 in another denser medium. What is the critical angle for this medium?

(1) $\sin^{-1}\left(\frac{t_1}{10\,t_2}\right)$

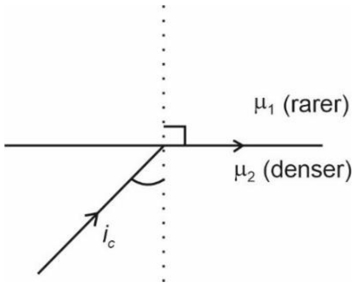
(2) $\sin^{-1}\left(\frac{10\,t_1}{t_2}\right)$

(3) $\sin^{-1}\left(\frac{t_2}{t_1}\right)$

(4) $\sin^{-1}\left(\frac{10t_2}{t_1}\right)$

Answer (2)

Sol.



$\mu_2 \sin i_c = \mu_1$

$\sin i_c = \dfrac{\mu_1}{\mu_2}$

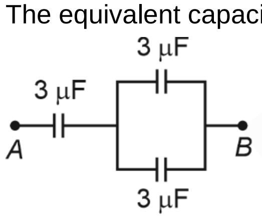
$\mu = \dfrac{c}{V}$

So $\sin i_c = \dfrac{\mu_1}{\mu_2} = \dfrac{V_2}{V_1}$

$\sin i_c = \dfrac{10xt_1}{t_2x}$

$i_c = \sin^{-1}\left(\dfrac{10t_1}{t_2}\right)$

12. The equivalent capacitance of the system shown in the following circuit is



(1) 6 μF
(2) 9 μF
(3) 2 μF
(4) 3 μF

Answer (3)

Sol. For parallel grouping, $C_1 = 3 + 3 = 6$ μF

For series grouping

$$C_{eq} = \frac{C_1C_2}{C_1 + C_2} = \frac{3\times 6}{3+6} = \frac{18}{9}$$

$C_{eq} = 2$ μF

13. The magnetic energy stored in an inductor of inductance 4 μH carrying a current of 2 A is

(1) 8 mJ

(2) 8 μJ

(3) 4 μJ

(4) 4 mJ

Answer (2)

Sol. Magnetic energy stored in an inductor

$$U = \frac{1}{2}Li^2 = \frac{1}{2}\times 4\times 10^{-6}\times (2)^2 = 8\times 10^{-6}\ \text{J}$$

$U = 8$ μJ

14. A full wave rectifier circuit consists of two p-n junction diodes, a centre-tapped transformer, capacitor and a load resistance. Which of these components remove the ac ripple from the rectified output?

(1) Capacitor
(2) Load resistance
(3) A centre-tapped transformer
(4) p-n junction diodes

Answer (1)

Sol. Capacitor removes the ac ripple from rectified output.

15. In a plane electromagnetic wave travelling in free space, the electric field component oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 V m^{-1}. Then the amplitude of oscillating magnetic field is

(Speed of light in free space = 3×10^8 m s^{-1})

(1) 1.6×10^{-7} T
(2) 1.6×10^{-6} T
(3) 1.6×10^{-9} T
(4) 1.6×10^{-8} T

Answer (1)

Sol. From the properties of electromagnetic wave

we know that, $C = \frac{E_0}{B_0}$

$E_0 \Rightarrow$ Amplitude of oscillating electric field

$B_0 \Rightarrow$ Amplitude of oscillating magnetic field

$$\Rightarrow B_0 = \frac{48}{3 \times 10^8} = 1.6 \times 10^{-7} \text{ T}$$

16. The errors in the measurement which arise due to unpredictable fluctuations in temperature and voltage supply are

(1) Least count errors
(2) Random errors
(3) Instrumental errors
(4) Personal errors

Answer (2)

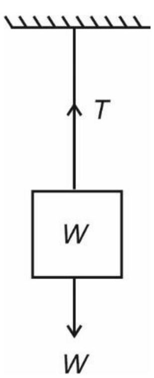
Sol. The errors which cannot be associated with any systematic or constant cause are called random errors. These errors can arise due to unpredictable fluctuations in experimental conditions. *e.g.,* random change in pressure, temperature, voltage supply etc.

17. Let a wire be suspended from the ceiling (rigid support) and stretched by a weight W attached at its free end. The longitudinal stress at any point of cross-sectional area A of the wire is

(1) $W/2A$
(2) Zero
(3) $2W/A$
(4) W/A

Answer (4)

Sol.



Longitudinal stress $= \frac{\text{Internal restoring force}}{\text{Area}} = \frac{F_{ext}}{\text{Area}}$

Stress $= \frac{W}{A}$

18. Resistance of a carbon resistor determined from colour codes is (22000 ± 5%) Ω. The colour of third band must be

(1) Orange (2) Yellow

(3) Red (4) Green

Answer (1)

Sol. Resistance = (22×10^3) Ω ± 5%

Third band corresponds to decimal multiplier.

Decimal multiplier = 10^3

$\Rightarrow$ Colour $\rightarrow$ Orange

19. The work functions of Caesium (Cs), Potassium (K) and Sodium (Na) are 2.14 eV, 2.30 eV and 2.75 eV respectively. If incident electromagnetic radiation has an incident energy of 2.20 eV, which of these photosensitive surfaces may emit photoelectrons?

(1) K only (2) Na only

(3) Cs only (4) Both Na and K

Answer (3)

Sol. Energy of incident radiation = 2.20 eV

Work function of Cs $\rightarrow$ 2.14 eV

Work function of K $\rightarrow$ 2.30 eV

Work function of Na $\rightarrow$ 2.75 eV

Since the work function of potassium and sodium are more than energy of incident radiation hence photons may be emitted from caesium.

20. For Young's double slit experiment, two statements are given below:

Statement I : If screen is moved away from the plane of slits, angular separation of the fringes remains constant.

Statement II : If the monochromatic source is replaced by another monochromatic source of larger wavelength, the angular separation of fringes decreases.

In the light of the above statements, choose the *correct* answer from the options given below:

(1) Statement I is true but Statement II is false. (2) Statement I is false but Statement II is true.

(3) Both Statement I and Statement II are true. (4) Both Statement I and Statement II are false.

Answer (1)

Sol. For YDSE, angular fringe width is given by $\alpha = \frac{\lambda}{d}$

It does not depend on the distance of screen from the slit, so statement I is correct.

Angular fringe width $\propto \lambda$

If $\lambda \uparrow \rightarrow$ angular separation of fringes increases

So, statement I is true and statement II is false.

21. The half life of a radioactive substance is 20 minutes. In how much time, the activity of substance drops to $\left(\frac{1}{16}\right)^{th}$ of its initial value?

(1) 60 minutes
(2) 80 minutes
(3) 20 minutes
(4) 40 minutes

Answer (2)

Sol. $A = \frac{A_0}{2^n}$

$\frac{A}{A_0} = \frac{1}{2^n}$

$\frac{1}{16} = \frac{1}{2^n}$

$\frac{1}{2^4} = \frac{1}{2^n}$

$n = 4$

$n = \frac{t}{T_{\frac{1}{2}}}$, $t = 4 \times T_{\frac{1}{2}} = 4 \times 20$

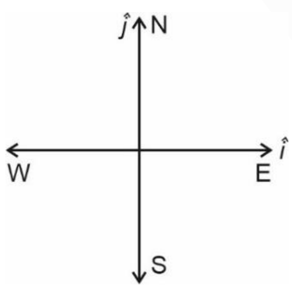
$= 80$ minutes

22. A football player is moving southward and suddenly turns eastward with the same speed to avoid an opponent. The force that acts on the player while turning is

(1) Along north-east
(2) Along south-west
(3) Along eastward
(4) Along northward

Answer (1)

Sol.



$\Delta\vec{P} = \vec{P}_f - \vec{P}_i$

$\vec{P}_f = mu\hat{i}$

$\vec{P}_i = mu(-\hat{j})$

$\Delta\vec{P} = mu\hat{i} - mu(-\hat{j})$

$\Delta\vec{P} = mu(\hat{i} + \hat{j})$

$\vec{F} = \frac{\Delta\vec{P}}{\Delta t}$

Direction of change of momentum and direction of force acting on the player will be same, so correct answer is North east direction

23. In hydrogen spectrum, the shortest wavelength in the Balmer series is λ. The shortest wavelength in the Bracket series is

(1) 9λ (2) 16λ

(3) 2λ (4) 4λ

Answer (4)

Sol. $\frac{1}{\lambda} = R\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$

For Balmer [$n_2 = 2$, $n_1 = \infty$]

$\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{\infty}\right]$

$\lambda = \frac{4}{R}$ ...(1)

For Bracket, ($n_2 = 4$, $n_1 = \infty$)

$\frac{1}{\lambda'} = R\left[\frac{1}{16} - \frac{1}{\infty}\right]$

$\lambda' = \frac{16}{R}$ ...(2)

$\frac{\text{Eq}^n(1)}{\text{Eq}^n(2)}$

$\lambda' = 4\lambda$

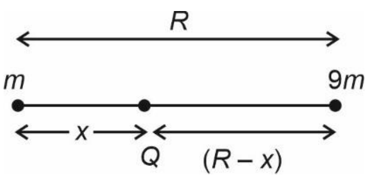
24. Two bodies of mass m and $9m$ are placed at a distance R. The gravitational potential on the line joining the bodies where the gravitational field equals zero, will be (G = gravitational constant)

(1) $-\frac{16Gm}{R}$ (2) $-\frac{20Gm}{R}$

(3) $-\frac{8Gm}{R}$ (4) $-\frac{12Gm}{R}$

Answer (1)

Sol.



Let electric field at point Q be zero

So,

$\frac{Gm}{x^2} = \frac{G(9m)}{(R-x)^2}$

$\frac{(R-x)^2}{x^2} = 9$

$x = \frac{R}{4}$

$$V_P = \frac{-Gm}{x} - \frac{G(9m)}{R-x}$$

$$V_P = \frac{-Gm}{\frac{R}{4}} - \frac{G(9m)}{\frac{3R}{4}} = \frac{-4Gm}{R} - \frac{12Gm}{R} = \frac{-16Gm}{R}$$

25. The minimum wavelength of *X*-rays produced by an electron accelerated through a potential difference of *V* volts is proportional to

(1) $\frac{1}{\sqrt{V}}$ (2) V^2

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

Answer (4)

Sol. $eV = \frac{hc}{\lambda_{min}}$

$$\lambda_{min} = \frac{hc}{eV}$$

$$\lambda_{min} \propto \frac{1}{V}$$

26. The ratio of radius of gyration of a solid sphere of mass *M* and radius *R* about its own axis to the radius of gyration of the thin hollow sphere of same mass and radius about its axis is

(1) 2 : 5 (2) 5 : 2

(3) 3 : 5 (4) 5 : 3

Answer (3*)

Sol. Radius of gyration of solid sphere about its own axis = $\sqrt{\frac{2}{5}}R$

Radius of gyration of hollow sphere about its own axis = $\sqrt{\frac{2}{3}}R$

$\Rightarrow$ Required ratio = $\sqrt{\frac{2}{5}} \times \sqrt{\frac{3}{2}} = \sqrt{\frac{3}{5}}$

* None of the option is correct (correct answer is $\sqrt{\frac{3}{5}}$)

27. A metal wire has mass (0.4 ± 0.002) g, radius (0.3 ± 0.001) mm and length (5 ± 0.02) cm. The maximum possible percentage error in the measurement of density will nearly be

(1) 1.6% (2) 1.4%

(3) 1.2% (4) 1.3%

Answer (1)

Sol. We know, $\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{\pi r^2 \ell}$

Using the concept of errors we know,

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + \frac{2\Delta r}{r} + \frac{\Delta \ell}{\ell} = \left(\frac{0.002}{0.4} + \frac{2 \times 0.001}{0.3} + \frac{0.02}{5}\right)$$

$$\frac{\Delta\rho}{\rho} = 0.0156$$

$$\frac{\Delta\rho}{\rho}\% = 1.56\% \approx 1.6\%$$

28. If $\oint_s \vec{E} \cdot \overrightarrow{dS} = 0$ over a surface, then

(1) All the charges must necessarily be inside the surface

(2) The electric field inside the surface is necessarily uniform

(3) The number of flux lines entering the surface must be equal to the number of flux lines leaving it

(4) The magnitude of electric field on the surface is constant

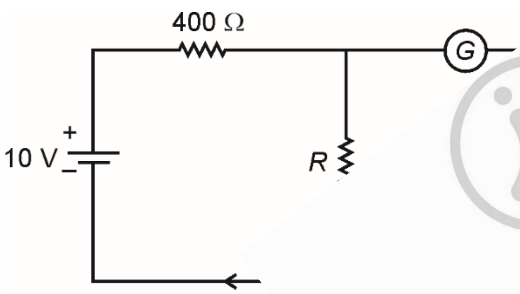
Answer (3)

Sol. $\phi_{\text{net}} = \oint_s \vec{E} \cdot \overrightarrow{dS} = 0$

$\Rightarrow$ Net flux through surface is zero.

$\Rightarrow$ Therefore, the number of flux lines entering the surface must be equal to the number of flux lines leaving it.

29. If the galvanometer G does not show any deflection [illegible] shown, the value of R is given by



(1) 100 Ω

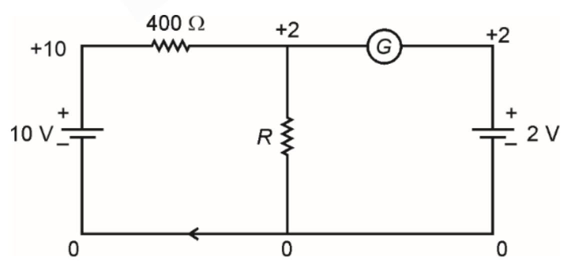
(3) 200 Ω

[illegible]

Answer (1)

Sol. Since galvanometer does not s[illegible]on

$\Rightarrow i_g = 0$



$$\frac{10-2}{400} = \frac{2}{R} \Rightarrow R = \frac{2 \times 400}{8} = 100\ \Omega$$

30. The potential energy of a long spring when stretched by 2 cm is U. If the spring is stretched by 8 cm, potential energy stored in it will be

(1) 8 U

(2) 16 U

(3) 2 U

(4) 4 U

Answer (2)

Sol. Potential energy stored in spring $U = \frac{1}{2}Kx^2$

$$U = \frac{1}{2}K(2)^2 \text{ where } x = 2 \text{ cm}$$

$$U = \frac{1}{2}(K)\cdot(4)$$

$$U = 2K \quad \text{....(i)}$$

$$U' = \frac{1}{2}K(8)^2$$

$$U' = \frac{1}{2}K \times 64 = 32K \quad \text{....(ii)}$$

On dividing (i) by (ii)

$$\frac{U}{U'} = \frac{2K}{32K} = \frac{1}{16}$$

$U' = 16\,U$

31. A Carnot engine has an efficiency of 50% when its source is at a temperature 327°C. The temperature of the sink is

(1) 100°C
(2) 200°C
(3) 27°C
(4) 15°C

Answer (3)

Sol. Efficiency $\eta = \frac{50}{100} = \frac{1}{2}$

Efficiency of Carnot engine

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = 1 - \frac{T_2}{600}$$

$$\frac{1}{2} = 1 - \frac{T_2}{600}$$

$$\frac{T_2}{600} = \frac{1}{2} \Rightarrow T_2 = 300 \text{ K}$$

$T_2 = 300 - 273 = 27°C$

32. The angular acceleration of a body, moving along the circumference of a circle, is

(1) Along the tangent to its position
(2) Along the axis of rotation
(3) Along the radius, away from centre
(4) Along the radius towards the centre

Answer (2)

Sol. Angular acceleration of a body, moving along the circumference of a circle is along the axis of rotation.

33. The ratio of frequencies of fundamental harmonic produced by an open pipe to that of closed pipe having the same length is

(1) 1 : 3
(2) 3 : 1
(3) 1 : 2
(4) 2 : 1

Answer (4)

Sol. $f_0 = f_{\text{open pipe}} = \dfrac{v}{2l}$

$f_c = f_{\text{closed pipe}} = \dfrac{v}{4l}$

$\dfrac{f_0}{f_c} = \dfrac{v}{2l} \times \dfrac{4l}{v}$

$f_0 : f_c = 2 : 1$

34. A bullet is fired from a gun at the speed of 280 m s^{-1} in the direction 30° above the horizontal. The maximum height attained by the bullet is (g = 9.8 m s^{-2}, sin30° = 0.5)

(1) 1000 m
(2) 3000 m
(3) 2800 m
(4) 2000 m

Answer (1)

Sol. $H = \dfrac{u^2 \sin^2\theta}{2g}$

$H = \dfrac{(280)^2(\sin^2 30)}{2\times 9.8}$

$= \dfrac{280\times 280\times 0.5\times 0.5}{2\times 9.8}$

H = 1000 m

35. An electric dipole is placed at an angle of 30° with an electric field of intensity 2 × 10^5 N C^{-1}. It experiences a torque equal to 4 N m. Calculate the magnitude of charge on the dipole, if the dipole length is 2 cm.

(1) 4 mC
(2) 2 mC
(3) 8 mC
(4) 6 mC

Answer (2)

Sol. $E = 2 \times 10^5$ N/C

l = 2 cm

τ = 4 Nm

$\vec{\tau} = \vec{p} \times \vec{E}$

$4 = pE\sin\theta$

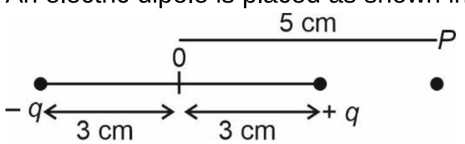
$4 = p \times 2 \times 10^5 \times \sin 30°$

$p = 4 \times 10^{-5}$ cm

$q = \dfrac{p}{l} = \dfrac{4\times 10^{-5}}{0.02} = 2\text{ mC}$

SECTION-B

36. An electric dipole is placed as shown in the figure.



The electric potential (in 10^2 V) at point P due to the dipole is ($\in_0$ = permittivity of free space and $\frac{1}{4\pi \in_0} = K$)

(1) $\left(\frac{8}{5}\right)qK$

(2) $\left(\frac{8}{3}\right)qK$

(3) $\left(\frac{3}{8}\right)qK$

(4) $\left(\frac{5}{8}\right)qK$

Answer (3)

Sol. Electrostatic potential due to a point charge is given by $\frac{Kq}{r}$

$$V_{\text{net at point } P} = \frac{Kq}{2\times10^{-2}} - \frac{Kq}{8\times10^{-2}}$$

$$= \frac{Kq\times10^{2}}{2}\left(1-\frac{1}{4}\right)$$

$$= \left(\frac{3}{8}Kq\right)\times10^{2}\text{ V} = \frac{3}{8}qK$$

37. Two thin lenses are of same focal lengths (f), but one is convex and the other one is concave. When they are placed in contact with each other, the equivalent focal length of the combination will be

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

(2) Infinite

(3) Zero

(4) $\frac{f}{4}$

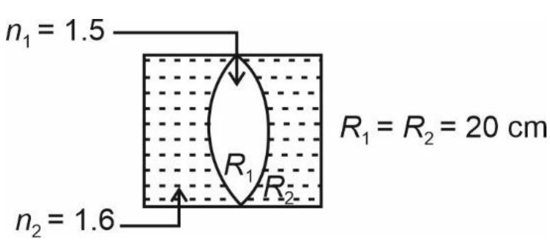
Answer (2)

Sol. Convex lens $f_1 > 0$, concave lens $f_2 < 0$

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f} - \frac{1}{f} = 0$$

$$\boxed{f_{eq} = \infty}$$

38. In the figure shown here, what is the equivalent focal length of the combination of lenses (Assume that all layers are thin)?



(1) –100 cm

(2) –50 cm

(3) 40 cm

(4) –40 cm

Answer (1)

Sol. Effective focal length $\Rightarrow f_{eff}$

$$\frac{1}{f_{eff}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

Also, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\frac{1}{f_1} = (1.6 - 1)\left(\frac{1}{\infty} - \frac{1}{20}\right) = \frac{-0.6}{20}$$

$$\frac{1}{f_2} = (1.5 - 1)\left(\frac{1}{20} - \frac{1}{-20}\right) = \frac{0.5}{10}$$

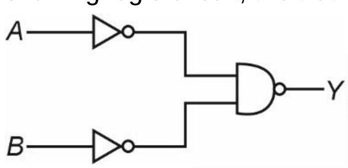
$$\frac{1}{f_3} = (1.6 - 1)\left(\frac{1}{-20} - \frac{1}{\infty}\right) = \frac{-0.6}{20}$$

$$\frac{1}{f_{eff}} = \frac{-0.6}{20} + \frac{0.5}{10} - \frac{0.6}{20}$$

$$\frac{1}{f_{eff}} = \frac{-0.6}{10} + \frac{0.5}{10} = \frac{-0.1}{10} = \frac{-1}{100}$$

$\therefore \; f_{eff} = -100$ cm

39. For the following logic circuit, the truth table is



(1)

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

(2)

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

(3)

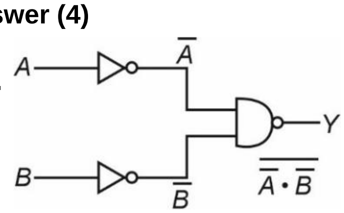
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(4)

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

Answer (4)

Sol.



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

It is OR gate.

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

40. The resistance of platinum wire at 0°C is 2 Ω and 6.8 Ω at 80°C. The temperature coefficient of resistance of the wire is

(1) 3×10^{-2} °C^{-1}
(2) 3×10^{-1} °C^{-1}
(3) 3×10^{-4} °C^{-1}
(4) 3×10^{-3} °C^{-1}

Answer (1)

Sol. Using $R = R_0(1 + \alpha\Delta T)$

where α is the thermal coefficient of resistance

$6.8 = 2\{1 + \alpha(80 - 0)\}$

$$\frac{6.8}{2} - 1 = \alpha \times 80$$

$$\alpha = \frac{3.4 - 1}{80} = \frac{2.4}{80} = 0.03$$

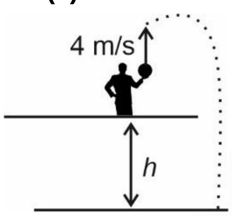
$\therefore\ \alpha = 3 \times 10^{-2}$ °C^{-1}

41. A horizontal bridge is built across a river. A student standing on the bridge throws a small ball vertically upwards with a velocity 4 m s^{-1}. The ball strikes the water surface after 4 s. The height of bridge above water surface is (Take g = 10 m s^{-2})

(1) 64 m
(2) 68 m
(3) 56 m
(4) 60 m

Answer (1)

Sol.



$$s = ut - \frac{1}{2}gt^2$$

$$= 16 - \frac{1}{2} \times 10 \times 16$$

$= -64$ m

Height of bridge above water surface = 64 m

42. A satellite is orbiting just above the surface of the earth with period T. If d is the density of the earth and G is the universal constant of gravitation, the quantity $\frac{3\pi}{Gd}$ represents

(1) T^3
(2) $\sqrt{T}$
(3) T
(4) T^2

Answer (4)

Sol. Time period of satellite above earth surface

$$T = 2\pi\sqrt{\frac{R^3}{GM}} = 2\pi\sqrt{\frac{R^3}{Gd\frac{4}{3}\pi R^3}}$$

$$T = 2\pi\sqrt{\frac{3}{4\pi Gd}}$$

$$\boxed{T = \sqrt{\frac{3\pi}{Gd}}} \qquad \boxed{T^2 = \frac{3\pi}{Gd}}$$

43. The radius of inner most orbit of hydrogen atom is 5.3×10^{-11} m. What is the radius of third allowed orbit of hydrogen atom?

(1) 1.59 Å (2) 4.77 Å

(3) 0.53 Å (4) 1.06 Å

Answer (2)

Sol. $r_n = \frac{n^2}{Z}$

$$\frac{r_1}{r_2} = \left(\frac{1}{3}\right)^2$$

$$r_2 = 9r_1 = 5.3 \times 10^{-11} \times 9$$

$= 47.7 \times 10^{-11}$

$= 4.77$ Å

44. A wire carrying a current I along the positive x-axis has length L. It is kept in a magnetic field $\vec{B} = (2\hat{i} + 3\hat{j} - 4\hat{k})$ T. The magnitude of the magnetic force acting on the wire is

(1) 5 IL (2) $\sqrt{3}\, IL$

(3) 3 IL (4) $\sqrt{5}\, IL$

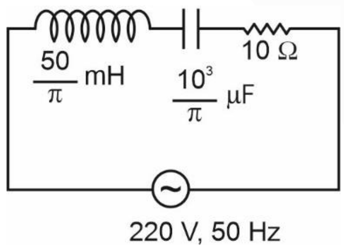
Answer (1)

Sol. Magnetic force acting on a current carrying wire is

$$\vec{F} = I\vec{\ell} \times \vec{B} = IL\hat{i} \times \left(2\hat{i} + 3\hat{j} - 4\hat{k}\right) = 3IL\hat{k} + 4IL\hat{j}$$

Magnitude of force, $|\vec{F}| = \sqrt{(3IL)^2 + (4IL)^2} = 5IL$

45. The net impedance of circuit (as shown in figure) will be



(1) $5\sqrt{5}\ \Omega$ (2) 25 Ω

(3) $10\sqrt{2}\ \Omega$ (4) 15 Ω

Answer (1)

Sol. $L = \frac{50}{\pi}$ mH

$$X_L = 2\pi \times 50 \times \frac{50}{\pi} \times 10^{-3} = 5\ \Omega$$

$$C = \frac{10^3}{\pi} \times 10^{-6}$$

$$X_C = \frac{1 \times \pi}{2\pi \times 50 \times 10^3 \times 10^{-6}} = \frac{10^3}{100} = 10\ \Omega$$

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

$$Z = \sqrt{(10-5)^2 + 10^2} = \sqrt{125} = 5\sqrt{5}\ \Omega$$

46. 10 resistors, each of resistance R are connected in series to a battery of emf E and negligible internal resistance. Then those are connected in parallel to the same battery, the current is increased n times. The value of n is

(1) 1 (2) 1000

(3) 10 (4) 100

Answer (4)

Sol. In series combination

$R_{eq} = 10R$

$$i = \frac{E}{10R}$$

In parallel combination

$$R_{eq} = \frac{R}{10}$$

$$i' = \frac{E}{\frac{R}{10}} = \frac{10\,E}{R}$$

$i' = 10 \times 10\,i = 100\,i$

$\boxed{n = 100}$

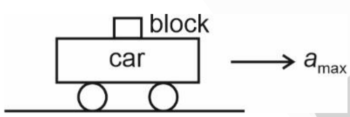
47. Calculate the maximum acceleration of a moving car so that a body lying on the floor of the car remains stationary. The coefficient of static friction between the body and the floor is 0.15 (g = 10 m s^{-2}).

(1) 1.5 m s^{-2} (2) 50 m s^{-2}

(3) 1.2 m s^{-2} (4) 150 m s^{-2}

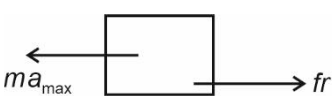
Answer (1)

Sol.



w.r.t. car

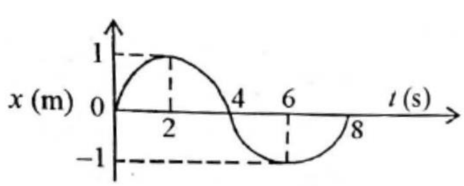
$a_b = 0$



$ma_{max} = \mu_s\, mg$

$a_{max} = \mu_s\, g = 0.15 \times 10 = 1.5$ m/s^2

48. The x-t graph of a particle performing simple harmonic motion is shown in the figure. The acceleration of the particle at t = 2 s is



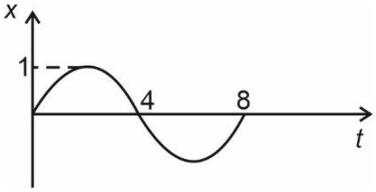
(1) $\frac{\pi^2}{16}$ m s^{-2} (2) $-\frac{\pi^2}{16}$ m s^{-2}

(3) $\frac{\pi^2}{8}$ m s^{-2} (4) $-\frac{\pi^2}{8}$ m s^{-2}

Answer (2)

Sol. Position of particle as function of time

$x = A\sin\omega t$



From figure,

$$T = 8\,s$$

$$\omega = \frac{2\pi}{T} = \frac{\pi}{4}\frac{rad}{s}$$

$$a = -\omega^2 A$$

$$a = -\left[\frac{\pi}{4}\right]^2 \times 1$$

$$a = -\frac{\pi^2}{16}\,m/s^2$$

49. A bullet from a gun is fired on a rectangular wooden block with velocity *u*. When bullet travels 24 cm through the block along its length horizontally, velocity of bullet becomes $\frac{u}{3}$. Then it further penetrates into the block in the same direction before coming to rest exactly at the other end of the block. The total length of the block is

(1) 28 cm

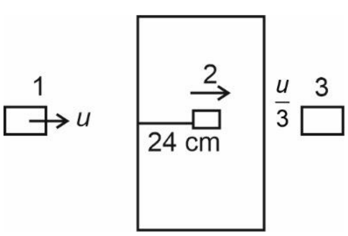
(2) 30 cm

(3) 27 cm

(4) 24 cm

Answer (3)

Sol.



between 1 to 2

$$\left(\frac{u}{3}\right)^2 = u^2 - 2a \times 24$$

$$\Rightarrow 2a(24) = \frac{8u^2}{9} \qquad ...(I)$$

between 2 to 3

$$0 = \left(\frac{u}{3}\right)^2 - 2as \quad ...(II)$$

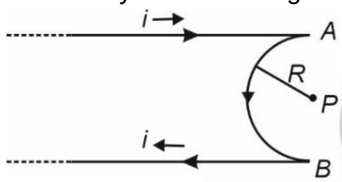
From equation (I) and (II)

$$2as = \frac{2a(24)}{8}$$

$$\boxed{s = 3\text{ cm}}$$

Length of wooden block is 24 + 3 = 27 cm

50. A very long conducting wire is bent in a semi-circular shape from *A* to *B* as shown in figure. The magnetic field at point *P* for steady current configuration is given by



(1) $\frac{\mu_0 i}{4R}\left[1-\frac{2}{\pi}\right]$ pointed away from page

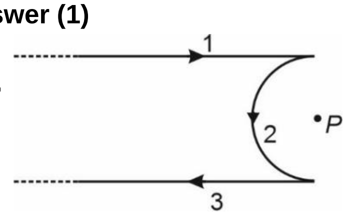
(2) $\frac{\mu_0 i}{4R}\left[1-\frac{2}{\pi}\right]$ pointed into the page

(3) $\frac{\mu_0 i}{4R}$ pointed into the page

(4) $\frac{\mu_0 i}{4R}$ pointed away from the page

Answer (1)

Sol.



B_P due to wire 1 $= \frac{\mu_0 i}{4\pi R} \otimes$

B_P due to wire 3 $= \frac{\mu_0 i}{4\pi R} \otimes$

B_P due to wire 2 $= \frac{\mu_0 i}{4R} \odot$

$$B_{net} = -\frac{\mu_0 i}{2\pi R} + \frac{\mu_0 i}{4R} = \frac{\mu_0 i}{4R}\left[-\frac{2}{\pi}+1\right] = \frac{\mu_0 i}{4R}\left[1-\frac{2}{\pi}\right]$$

Pointed away from page.