PHYSICS SECTION A

1. 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) 5 : 3

(2) 2 : 5

(3) 5 : 2

(4) 3 : 5

Answer Key (4*)

Sol<u>n</u>. We know, Radius of gyration K= $\sqrt{\frac{I}{M}}$

Moment of Inertia of solid sphere about its own axis $I_S=\frac{2}{5}\ MR^2$

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

Similarly,

For hollow sphere, $I_H=\frac{2}{3}\,MR^2$

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

So, the required ratio $K_S:K_H=\sqrt{\frac{2}{5}} \times \sqrt{\frac{3}{2}} =\sqrt{3}:\sqrt{5}$

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

2. The work functions of Cesium (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) Both Na and K

(2) K only

(3) Na only

(4) Cs only

Answer Key (4)

Sol<u>n</u>. According to Einstein's

Photoelectric equation, $K_{max} = E - W$

So, for Photoelectric emission E > W

Now,

Energy of incident radiation E = 2.20 eV

Work function of Cs → 2.14 Ev

Work function of K → 2.30 eV

Work function of Na → 2.75 eV

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

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

(1) 5.06×10^{-4} J

(2) 3.01×10^{-4} J

(3) 50.1×10^{-4} J

(4) 30.16×10^{-4} J

Answer Key (2)

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

$\Rightarrow$ Energy required $= S \times (4\pi R^2 \times 2)$ [2-factor due to two surfaces of bubble]

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

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

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

(1) Green

(2) Orange

(3) Yellow

(4) Red

Answer Key (2)

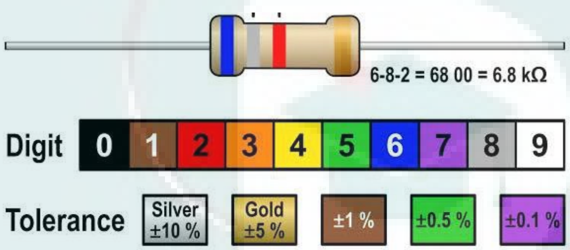
Soln. Resistance = $(22 \times 10^3)\ \Omega \pm 5\%$

Third band corresponds to decimal multiplier(i.e. power of 10)

So, third band corresponds to number ‘3’

Bb Roy of Great Britain has a very good wife which signifies the BBROYGBVGW alphabet.

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9
Gold	
Silver	



⇒Required colour → Orange

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) 15.9 kHz

(2) 1.59 rad/s

(3) 1.59 kHz

(4) 15.9 rad/s

Answer Key (3)

Soln

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. 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^{-8} T

(2) 1.6×10^{-7} T

(3) 1.6×10^{-6} T

1.6×10^{-9} T

Answer Key (2)

Sol. From the properties of electromagnetic wave

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

$E0$ ⇒ Amplitude of oscillating electric field

$B0$ ⇒ Amplitude of oscillating magnetic field

$\Rightarrow B_0 = \frac{48}{3\times10^8} = 1.6\times10^{-7}$ T

7. 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 Key from the options given below.

(1) Both Statement I and Statement II are incorrect

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

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

(4) Both Statement I and Statement II are correct

Answer Key (4)

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.

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

(1) Personal errors

(2) Least count errors

(3) Random errors

(4) Instrumental errors

Answer Key (3)

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.

9. If $\oint \boldsymbol{E} \cdot \boldsymbol{dS} = 0$ over a surface, then

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

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

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

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

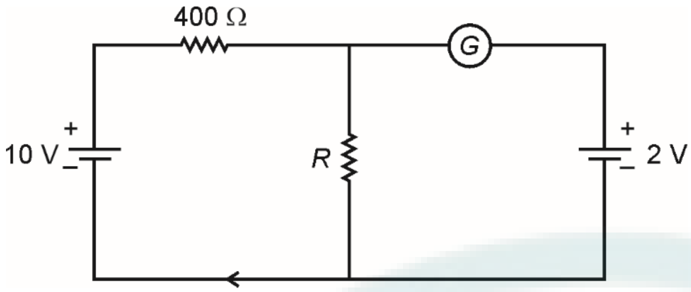
Answer Key (4)

Sol. $\Phi_{net} = \oint \boldsymbol{E} \cdot \boldsymbol{dS} = 0$

⇒ Net flux through surface is zero.

⇒ Therefore, the number of field lines entering the surface must be equal to the number of field lines leaving it.

10. If the galvanometer G does not show any deflection in the circuit shown, the value of R is given by



(1) 50 Ω

(2) 100 Ω

(3) 400 Ω

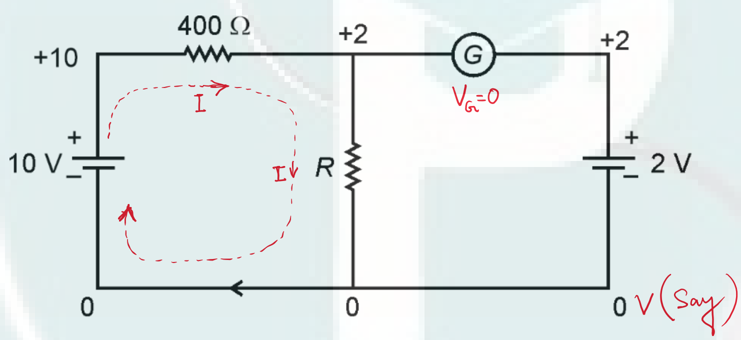
(4) 200 Ω

Answer Key (2)

Sol. Since galvanometer does not show any deflection

⇒ $i_g = 0$

Then current will flows only through the left loop of the circuit and **V_R=2 V**



$$\frac{10-2}{400} = \frac{2}{R}$$

⇒ $R = \frac{2 \times 400}{8}$

⇒ R = 100 Ω

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

(1) Displacement current increases

(2) Displacement current decreases

(3) Capacitive reactance remains constant

(4) Capacitive reactance decreases

Answer Key (2)

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

Since ω is decreasing, X_C will increases hence current will decreases

Again, conduction current = displacement current

Therefore displacement current will also decrease.

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

(1) $\frac{1}{V}$

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

(3) V^2

(4) $\sqrt{V}$

Answer Key (1)

Sol. $E = \frac{1}{2}mv^2 = eV$

Now, this K.E of electron converts into energy of a photon

So, $\frac{hc}{\lambda_{min}} = \frac{1}{2}mv^2 = eV$

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

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

13. The venturi-meter works on

(1) Bernoulli’s principle

(2) The principle of parallel axes

(3) The principle of perpendicular axes

(4) Huygens’s principle

Answer Key (1)

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

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) p-n junction diodes

(2) Capacitor

(3) Load resistance

(4) A centre-tapped transformer

Answer Key (2)

Sol. As we know, capacitor and inductors are used as filtering components.

So here, Capacitor removes the ac ripple from rectified output.

15. 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) 1.3%

(2) 1.6%

(3) 1.4%

(4) 1.2%

Answer Key (2)

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

Using the concept of errors we know,

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + \frac{2\Delta r}{r} + \frac{\Delta \ell}{\ell}$$

$$= \left(\frac{0.002}{0.4} + \frac{2 \times 0.001}{0.3} + \frac{0.02}{5}\right)$$

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

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

16. 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 Key from the options given below:

(1) Both Statement I and Statement II are false.

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

(3) Statement I is false but Statement II is true.

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

Answer Key (2)

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

It does not depend on the distance of screen from the slit(D), so statement I is correct. Angular fringe width $\alpha \propto \lambda$

If λ increases then, angular separation of fringes(i.e angular fringe width) also will increase.

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

17. 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) $4U$

(2) $8U$

(3) $16U$

(4) $2U$

Answer Key (3)

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

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

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

$U = 2K$ ....(i)

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

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

On dividing (i) by (ii)

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

$U' = 16U$

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

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

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

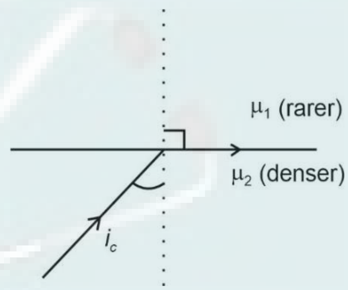
(4) $\sin^{-1}\left(\frac{t_2}{t_1}\right)$

Answer Key (3)

Sol.

$\mu_2 \sin i_c = \mu_1$

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



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

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

$\sin i_c = \frac{10xt_1}{t_2 x}$

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

19. 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) 2.7 A

(2) 3.7 A

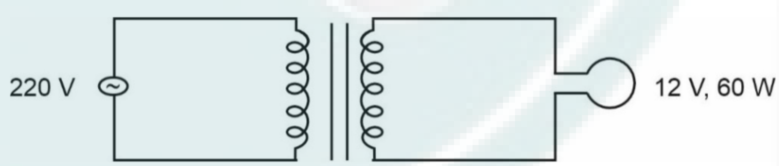
(3) 0.37 A

(4) 0.27 A

Answer

Key (4)

Sol.



For ideal transformer

Pinput = Poutput

$V_{in} I_{in} = 60$

$220 \times I_{in} = 60$

$I_{in} = 0.27$ A

20. 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 northward

(2) Along north-east

(3) Along south-west

(4) Along eastward

Answer

Key: (2)

Sol. $\Delta \boldsymbol{P}$ =

$\boldsymbol{Pf} - \boldsymbol{Pi}$

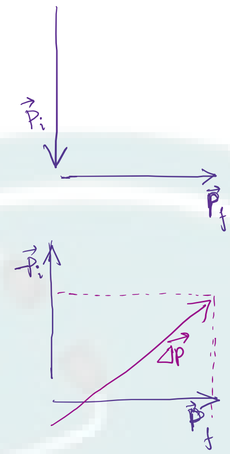
Pf = $mu\hat{i}$

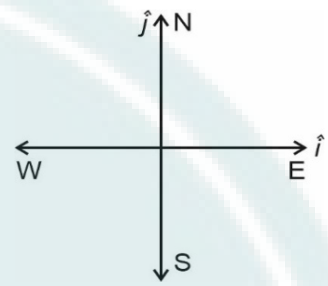
$Pi = mu(-\hat{j})$

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

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

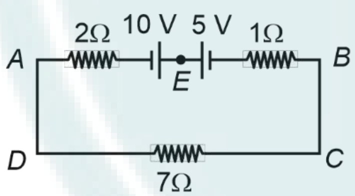
now, F = $\frac{\Delta P}{\Delta t}$





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

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



(1) 0.5 A from *A* to *B* through *E*

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

(3) 1.5 A from *B* to *A* through *E*

(4) 0.2 A from *B* to *A* through *E*

Answer Key (1)

Sol. Using Kirchhoff's law

I = $\frac{10-5}{1+2+7} = \frac{5}{10}$ = 0.2 A

As, polarity of 10 V battery is opposite to that of the 5 V battery

So, 10 V battery will dominate over the 5 V battery

Hence, the direction of current will be according to the polarity of 10 V battery, i.e, clockwise direction in the circuit(A to B through E).

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

(1) Along the radius towards the centre

(2) Along the tangent to its position

(3) Along the axis of rotation

(4) Along the radius, away from centre

Answer Key (3)

Sol. The direction of any angular vector quantity is along the axis of the circular path

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

23. 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) 2000 m

(2) 1000 m

(3) 3000 m

(4) 2800 m

Answer Key (2)

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

$= \dfrac{[280 \times \sin 30°]^2}{2 \times 9.8}$

$H = 1000$ m

24. The net magnetic flux through any closed surface is

(1) Positive

(2) Infinity

(3) Negative

(4) Zero

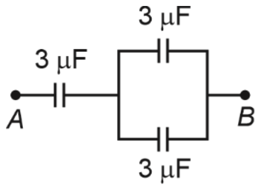
Answer Key (4)

Sol. $\oint B \cdot ds$ = zero

Magnetic monopole doesn't exist.

Hence net magnetic flux through any closed surface is zero.

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



(1) 3 μF

(2) 6 μF

(3) 9 μF

(4) 2 μF

Answer Key (4)

Sol. For parallel grouping

$C1 = 3 + 3 = 6\ \mu F$

For series grouping

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

$C_{eq} = 2\ \mu F$

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

(1) 2V/3

(2) 4V/3

(3) 3V/4

(4) V/3

Answer Key

(2)

Sol.
$$v_{avg} = \frac{2v_1v_2}{v_1 + v_2}$$
$$= \frac{2 \times v \times 2v}{v + 2v}$$
$$= \frac{4v}{3}$$

27. The half life of a radioactive substance is 20 minutes. In how much time, the activity of substance drops to $(1/16)_{th}$ of its initial value?

(1) 40 minutes

(2) 60 minutes

(3) 80 minutes

(4) 20 minutes

Answer Key (3)

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

28. 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) 3295°C

(2) 3097 K

(3) 223 K

(4) 669°C

Answer Key (1)

Sol.

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

Efficiency of Carnot engine

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

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

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

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

$T_2 = 300 - 273 = 27°C$

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

(1) 15°C

(2) 100°C

(3) 200°C

(4) 27°C

Answer Key (4)

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

Efficiency of Carnot engine

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

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

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

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

$T_2 = 300 - 273 = 27°C$

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

(1) 4 mJ

(2) 8 mJ

(3) 8 μJ

(4) 4 μJ

Answer Key (3)

Sol. Magnetic energy stored in an inductor

$$U = \frac{1}{2} L i^2$$

$$= \frac{1}{2} \times 4 \times 10^{-6} \times (2)^2$$

$$= 8 \times 10^{-6}\ \text{J}$$

$$U = 8\ \mu\text{J}$$

31. 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/A

(2) $W/2A$

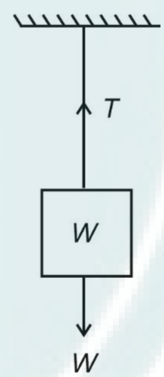
(3) Zero

(4) $2W/A$

Answer Key (1)

Sol.

Longitudinal stress= $\frac{\text{Elastic restoring force developed}}{\text{Area of crossection}} = \frac{\text{Applied external force}}{\text{Area}} = \frac{F}{A} = \frac{W}{A}$



32. 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) 6 mC

(2) 4 mC

(3) 2 mC

(4) 8 mC

Answer Key (3)

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

$L = 2l = 2$ cm

$\tau = 4$ Nm

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

$4 = pE\sin\theta$

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

$p = 4 \times 10^{-5}$ C.m

q. L=4×10^{-5} C.m

q×0.02=4×10^{-5} C.m

⇒q= 2×10^{-3} C = 2 mC

33.

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

(1) 4λ

(2) 9λ

(3) 16λ

(4) 2λ

Answer Key (1)

Sol.

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

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

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

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

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

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

$$\lambda' = \frac{16}{R}$$

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

$\lambda' = 4\lambda$

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

(1) 2 : 1

(2) 1 : 3

(3) 3 : 1

(4) 1 : 2

Answer Key (1)
Sol.

$$f_0 = f_{\text{open pipe}} = \frac{v}{2l}$$

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

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

$$f_0 : f_c = 2 : 1$$

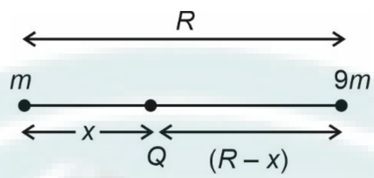
35. Two bodies of mass m and $9m$ are placed at a distance R. The gravitational potential on the line joining the bodies where the gravitational field equals zero, will be (G = gravitational constant)

(1) $-\frac{12Gm}{R}$

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

(3) $-\frac{20Gm}{R}$

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



Answer

Key (2)

Sol.

Let electric field at point Q be zero

So,

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

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

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

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

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

$$= \frac{-4Gm}{R} - \frac{12Gm}{R}$$

$$= \frac{-16Gm}{R}$$

SECTION – B PHYSICS

36. 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 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) 24 cm

(2) 28 cm

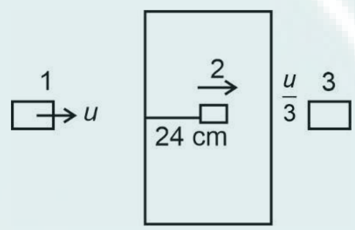
(3) 30 cm

(4) 27 cm

Answer Key (4)

Sol.

between 1 to 2



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

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

between 2 to 3

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

From equation (I) and (II)

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

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

Length of wooden block is 24 + 3 = 27 cm

37. 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) 1.06 Å

(2) 1.59 Å

(3) 4.77 Å

(4) 0.53 Å

Answer Key (3)

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

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

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

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

$$= 4.77\ \text{Å}$$

38. 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) 150 m s^{-2}

(2) 1.5 m s^{-2}

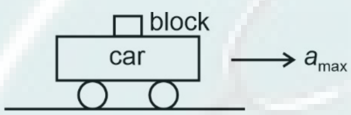
(3) 50 m s^{-2}

(4) 1.2 m s^{-2}

Answer

Key (2)

Sol.



w.r.t. car

$ab = 0$

mamax = μs mg

$a$max = μs g = 0.15 × 10 = 1.5 m/s^2

39. 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) 100

(2) 1

(3) 1000

(4) 10

Answer Key (1)

Sol.

In series combination

$R_{eq} = 10R$

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

In parallel combination

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

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

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

$\boxed{n = 100}$

40. 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) 60 m

(2) 64 m

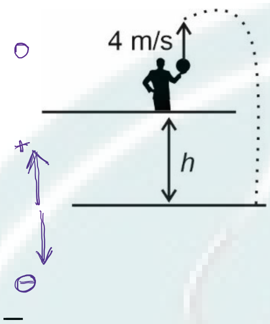
(3) 68 m

(4) 56 m

Answer

Key (2)

Sol.



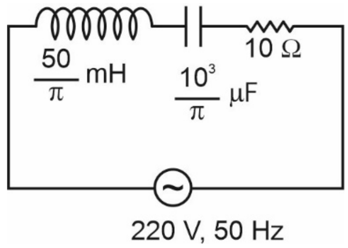
Displacement, $s = ut - (1/2)gt^2$

$= 16 - 5 \times 16$

$= -64$ m

Height of bridge above water surface = 64 m

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



(1) 15 Ω

(2) 5√5 Ω

(3) 25 Ω

(4) 10√2 Ω

Answer Key (2)

Sol.

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

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

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

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

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

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

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

Answer Key (1)

Sol. Time period of satellite above earth surface

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

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

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

43. 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) f/4
(2) f/2
(3) Infinite
(4) Zero

Answer Key (3)

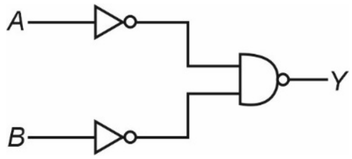
Sol. Convex lens $f1 > 0$, concave lens $f2 < 0$

We know, $\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$

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

f_{eq} = infinity

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



(1)

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

(2)

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

(3)

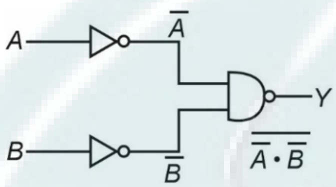
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(4)

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

Answer Key (1)

Sol.



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

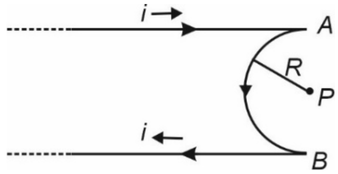
It is OR gate.

A	B	Y
0	0	0
0	1	1

1 0 1

1 1 1

45. 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



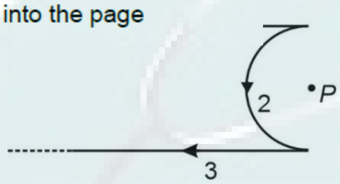
(1) $\frac{\mu_0 i}{4R}$ pointed away from the page

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

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

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

Answer



Key (2)

Sol.

B_P due to wire 1 $=(\mu_0 i/4\pi R)\otimes$

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

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

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

46. 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) $3 \times 10^{-3}\ °C^{-1}$

(2) $3 \times 10^{-2}\ °C^{-1}$

(3) $3 \times 10^{-1}\ °C^{-1}$

(4) $3 \times 10^{-4}\ °C^{-1}$

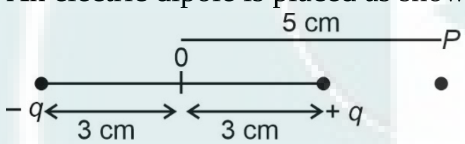
Answer Key (2)

Sol. Using $R = R0(1 + \alpha\Delta T)$ [where α is the thermal coefficient of resistance]

then, 6.8 = 2(1+α×80)

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

47. 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 $k=\frac{1}{4\pi\varepsilon\epsilon_0}$)

(1) $(\frac{5}{8})kq$

(2) $(\frac{8}{5})kq$

(3) $(\frac{8}{3})kq$

(4) $(\frac{3}{8})kq$

Answer Key (4)

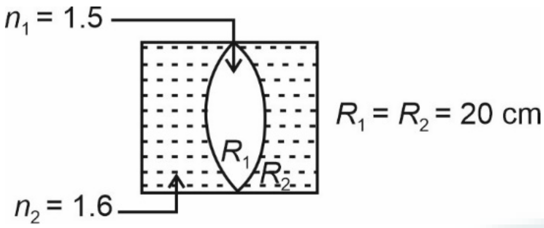
Sol. Electrostatic potential due to a point charge is given by V=kq/r

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

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

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

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



(1) –40 cm

(2) –100 cm

(3) –50 cm

(4) 40 cm

Answer Key (2)

Sol. Effective focal length ⇒ *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

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

(1) $\sqrt{5}\, lL$

(2) $5\, lL$

(3) $\sqrt{3}\, lL$

(4) $3\, lL$

Answer Key (2)

Sol. Magnetic force acting on a current carrying wire is

$\mathbf{F} = I(\mathbf{l} \times \mathbf{B})$

$IL\mathbf{i} \times (2\boldsymbol{i} + 3\boldsymbol{j} - 4\boldsymbol{k})$

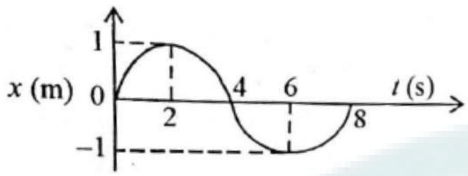
$= 3IL\,\mathbf{k} + 4IL\,\mathbf{j}$

Magnitude of force,

$F = \sqrt{(3IL)^2 + (4IL)^2}$

$F = 5IL$

50. 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) $-\frac{\pi^2}{8}$ m s^{-2}

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

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

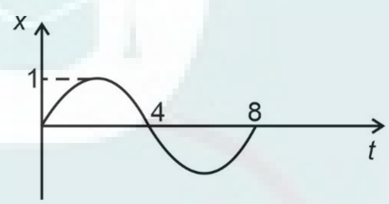
(4) $\frac{\pi^2}{8}$ m s^{-2}

Answer Key (3)

Sol. Position of particle as function of time

$x = A\sin\omega t$

From figure,



$A = 1$

$\omega = \frac{2\pi}{8}$

$x = \sin\frac{\pi}{4}t$

$v = \frac{dx}{dt}$

$v = \frac{\pi}{4}\cos\frac{\pi}{4}t$

$a = \frac{dv}{dt}$

$a = -\frac{\pi^2}{16}\sin\frac{\pi}{4}t$

at $t = 2$ s

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