KCET PYQ 2020
PHYSICS

Q1 The value of acceleration due to gravity at a height of 10 km from the surface of earth is x. At what depth inside the earth is the value of the acceleration due to gravity has the same value x ?

(A) 5 km (B) 20 km
(C) 10 km (D) 15 km

Q2 Young's modulus of a perfect rigid body is
(A) Zero
(B) unity
(C) infinity
(D) Between (a) and (b)

Q3 A wheel starting from rest gains an angular velocity of 10 rad/s after uniformly accelerated for 5s. The total angle through which it has turned is
(A) 25 rad
(B) 100 rad
(C) 25 π rad
(D) 50π rad and a vertical axis

Q4 Iceberg floats in water with part of it submerged. What is the fraction of the volume of iceberg submerged, if the density of ice is $\rho_i = 0.917\, g\, cm^{-3}$? [KCET 2020]

(A) 0.917 (B) 1
(C) 0.458 (D) 0

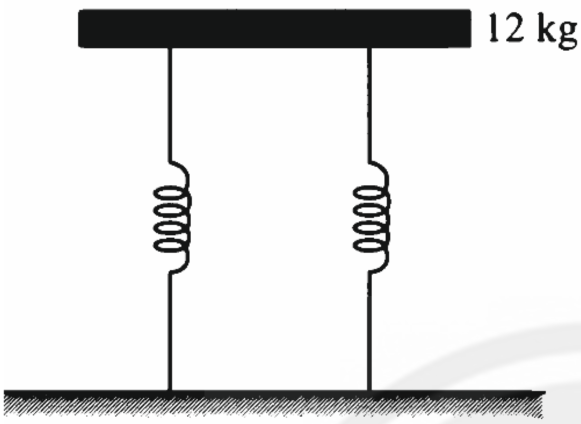
Q5 A sphere, a cube and a thin circular plate all of same material and same mass initially heated to same high temperature are allowed to cool down under similar conditions. Then, the
(A) Plate will cool the fastest and cube the slowest
(B) Sphere will cool the fastest and cube the slowest
(C) Plate will cool the fastest and sphere the slowest
(D) Cube will cool the fastest and plate the slowest

Q6 In an adiabatic expansion of an ideal gas the product of pressure and volume [KCET 2020]
(A) Decreases
(B) Increases
(C) Remians constant
(D) At first increase and then decreases

Q7 A certain amount of heat energy is supplied to a monoatomic ideal gas which expands at constant pressure. What fraction of the heat energy is converted into work? [KCET 2020]

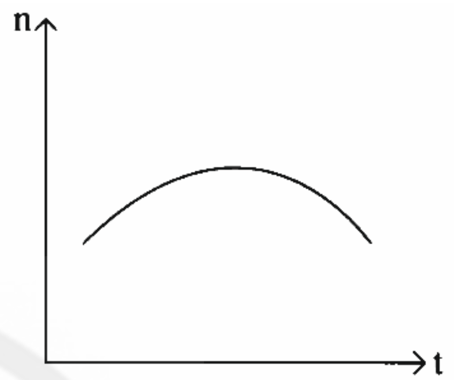
(A) 1 (B) 2/3
(C) 2/5 (D) 5/7

Q8 A tray of mass 12 kg is supported by two identical springs as shown in figure. When the tray is pressed down slightly and then released, it executes SHM with a time period of 1.5 kg. The spring constant of each spring is [KCET 2020]

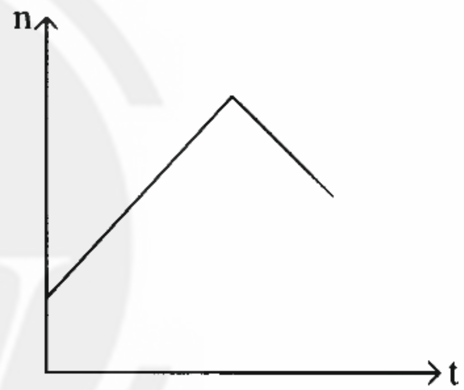


(A) 50 Nm^{-1}
(B) 0
(C) 105 Nm^{-1}
(D) ∞

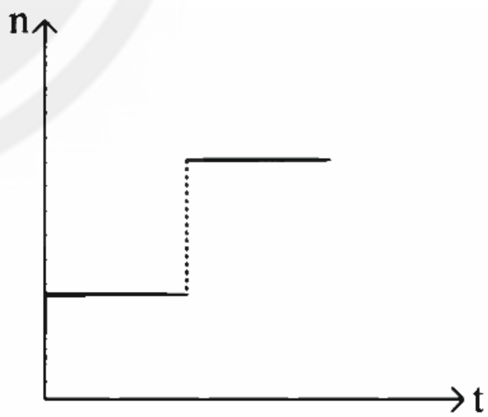
Q9 A train whistling at constant frequency n is moving towards a station at a constant speed n. The train goes past a stationary observer on the station. The frequency n of the sound as heard by the observer is plotted as a function of time t. Identify the correct curve. [KCET 2020]



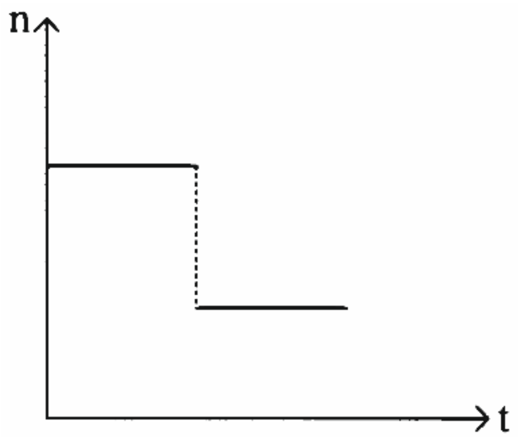
(A)



(B)

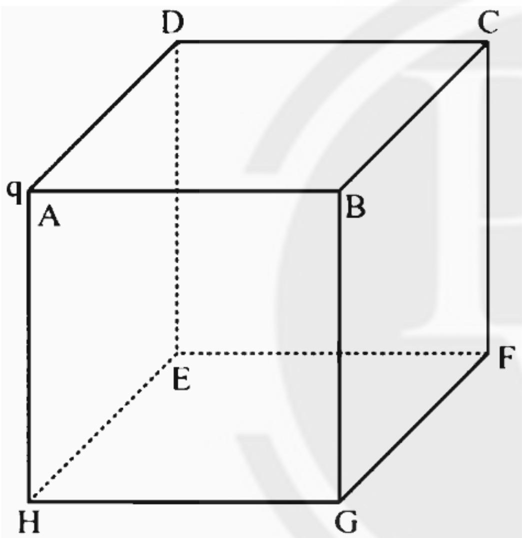


(C)



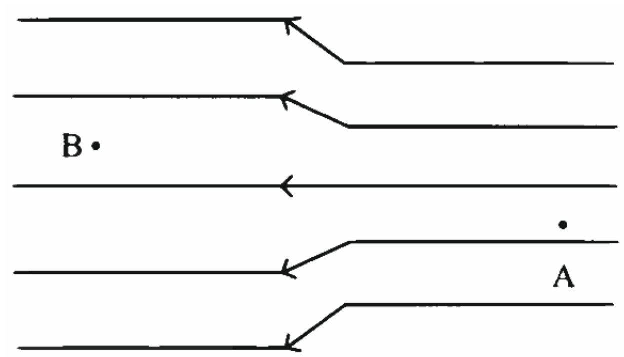
(D)

Q10 A point charge q is placed at the corner of a cube of side a as shown in the figure. What is the electric flux through the face $ABCD$? [KCET 2020]



(A) 0
(B) $\frac{q}{24\varepsilon_o}$
(C) $\frac{q}{6\varepsilon_o}$
(D) $\frac{q}{72\varepsilon_o}$

Q11 The electric field lines on the left have twice the separation on those on the right as shown in figure. If the magnitude of the field at A is $40 V m^{-1}$, what is the force on $20 \mu C$ charge kept at B ? [KCET 2020]



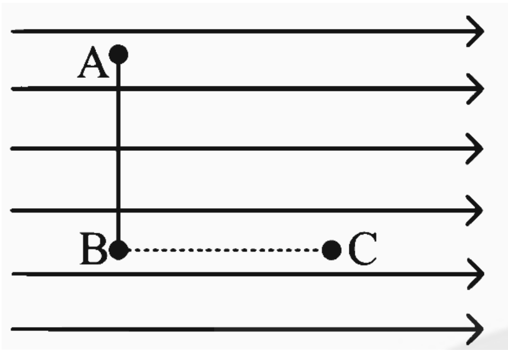
(A) $4 \times 10^{-4} N$
(B) $8 \times 10^{-4} N$
(C) $16 \times 10^{-4} N$
(D) $1 \times 10^{-4} N$

Q12 An infinitely long thin straight wire has uniform charge density of $\frac{1}{4} \times 10^{-2} cm^{-1}$. What is the magnitude of electric field at a distance 20 cm from the axis of the wire? [KCET 2020]
(A) $1.12 \times 10^{8} NC^{-1}$
(B) $4.5 \times 10^{8} NC^{-1}$
(C) $2.25 \times 10^{10} NC^{-1}$
(D) $9 \times 10^{8} NC^{-1}$

Q13 A dipole moment p and moment of inertia I is placed in a uniform electric field E. If it is displaced slightly from its stable equilibrium position, the period of oscillation of dipole is [KCET 2020]
(A) $\sqrt{\frac{pE}{I}}$
(B) $2\pi\sqrt{\frac{I}{pE}}$
(C) $\frac{1}{2\pi}\sqrt{\frac{pE}{I}}$
(D) $\pi\sqrt{\frac{I}{pE}}$

Q14 The difference between equivalent capacitances of two identical capacitors connected in parallel to that in series is $6 \mu F$. The value of capacitance of each capacitor is [KCET 2020]
(A) $2 \mu F$
(B) $3 \mu F$
(C) $4 \mu F$
(D) $6 \mu F$

Q15 Figure shows three points A, B and C in a region of uniform electric field E. The line AB is perpendicular and BC is parallel to the field lines. Then, which of the following holds good? (V_A, V_B and Vc represent the electric potential at points A, B and C, respectively) [KCET 2020]



(A) $V_A = V_B = V_c$ (B) $V_A = V_B > V_c$
(C) $V_A = V_B < V_c$ (D) $V_A > V_B = V_c$

Q16 When a soap bubble is charged? [KCET 2020]
(A) Its radius increases
(B) Its radius decreases
(C) The radius remains the same
(D) Its radius may increase or decrease

Q17 A hot filament liberates an electron with zero initial velocity. The anode potential is 1200 V. The speed of the electron when it strikes the anode is
(A) 1.5×10^5 ms^{-1}
(B) 2.5×10^6 ms^{-1}
(C) 2.1×10^7 ms^{-1}
(D) 2.5×10^8 ms^{-1}

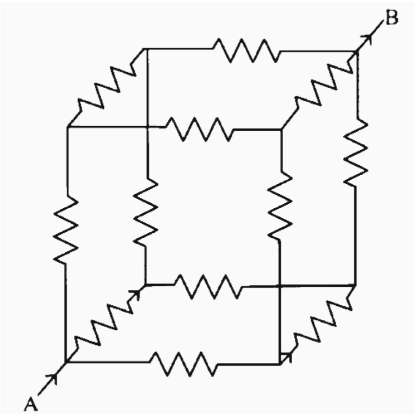
Q18 A metal rod of length 10 cmand a rectangular cross-section of $1\,cm \times \frac{1}{2}cm$ is connected to a battery across opposite faces. The resistance will be [KCET 2020]
(A) Maximum when the battery is connected across 1 cm × 1/2 cm faces
(B) Maximum when the battery is connected across 10 cm × 1/2 cm faces
(C) Maximum when the battery is connected across 10 cm × 1 cm faces
(D) Same irrespective of the three faces

Q19 A car has a fresh storage battery of emf 12 V and internal resistance 2 x $10^{-22}\Omega$. If the starter motor draws a current of 80 A. Then, the terminal voltage when the starter is On is [KCET 2020]
(A) 10.4 V (B) 8.5 V
(C) 8.4 V (D) 9.3 V

Q20 A potentiometer has a uniform wire of length 5m. A battery of emf 10 V and negligible internal resistance is connected between its ends. A secondary cell connected to the circuit gives balancing length at 200 cm. The emf of the secondary cell is [KCET 2020]
(A) 4 V (B) 6 V
(C) 2 V (D) 8 V

Q21 The colour code for a carbon resistor of resistance $0.2k\Omega \pm 10\%$ is [KCET 2020]
(A) Red, black,brown,silver
(B) Red, green, brown, silver
(C) Red, grey, silver, silver
(D) Red, green, silver

Q22 Each resistance in the given cubical network has resistance of $1\,\Omega$ and equivalent resistance between A and B is [KCET 2020]



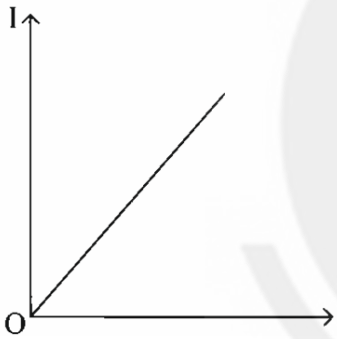
(A) $\frac{5}{6}\Omega$

(B) $\frac{6}{5}\Omega$

(C) $\frac{5}{12}\Omega$

(D) $\frac{12}{5}\Omega$

Q23 *I–V* characteristic of a copper wire of length *L* and area of cross-section *A* is shown in figure. The slope of the curve becomes [KCET 2020]



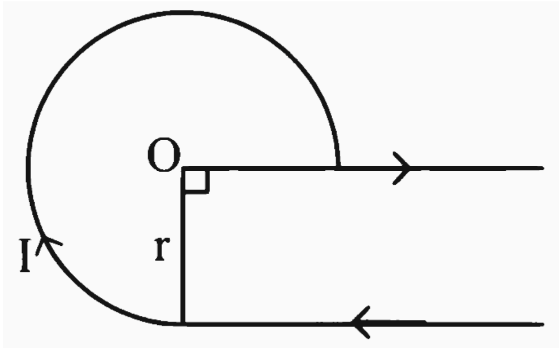
(A) More if experiment is performed at higher temperature

(B) More if a wire of steel of same dimension is used

(C) Less if the area of the wire is increased

(D) Less if the length of the wire is increased

Q24 In the given figure, the magnetic field at *O*. [KCET 2020]



(A) $\frac{3}{4}\frac{\mu_o I}{r} + \frac{\mu_o I}{4\pi r}$

(B) $\frac{3}{10}\frac{\mu_o I}{r} - \frac{\mu_o I}{4\pi r}$

(C) $\frac{3}{8}\frac{\mu_o I}{r} + \frac{\mu_o I}{4\pi r}$

(D) $\frac{3}{8}\frac{\mu_o I}{r} - \frac{\mu_o I}{4\pi r}$

Q25 The magnetic field at the origin due to a current element *idl* placed at a point with vector position *r* is [KCET 2020]

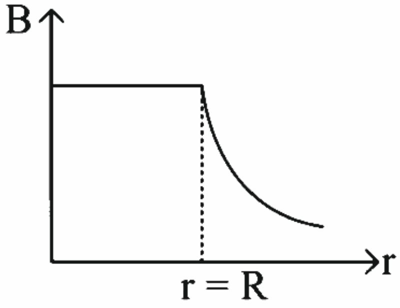
(A) $\frac{\mu_o i}{4\pi}\frac{dl\times r}{r^3}$

(B) $\frac{\mu_o i}{4\pi}\frac{r\times dl}{r^3}$

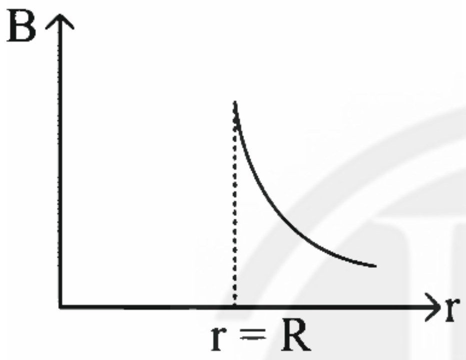
(C) $\frac{\mu_o i}{4\pi}\frac{dl\times r}{r^2}$

(D) $\frac{\mu_o i}{4\pi}\frac{r\times dl}{r^2}$

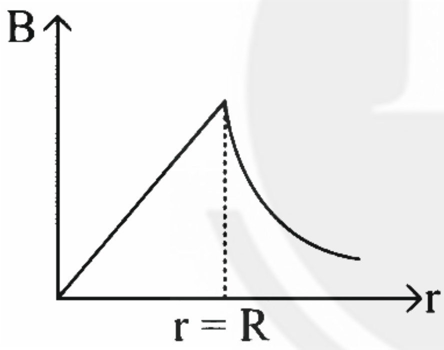
Q26 A long cylindrical wire of radius R carries a uniform current I flowing through it. The variation of magnetic field with distance r from the axis of the wire is shown by [KCET 2020]



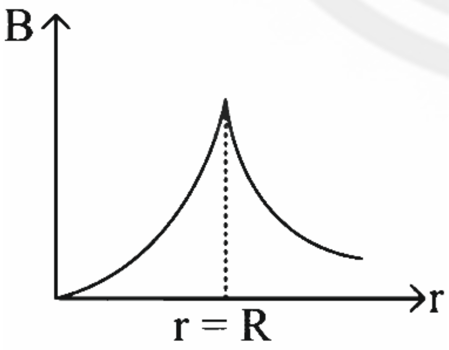
(A)



(B)



(C)



(D)

Q27 A cyclotron is used to accelerate protons $\left({}^{1}_{1}H\right)$ deuterons $\left({}^{2}_{1}H\right)$ and α-particles $\left({}^{4}_{2}He\right)$. While exiting under similar conditions, the minimum KE is gained by [KCET 2020]

(A) $\alpha-$ Particles

(B) Protons

(C) deuterons

(D) same for all

Q28 A paramagnetic sample shows a net magnetisation of 8 Am^{-1} when placed in an external magnetic field of 0.6 T at a temperature of 4K. When the same sample is placed in an external magnetic field of 0.2 T at a temperature of 16 K, the magnetisation will be [KCET 2020]

(A) $\frac{32}{3}Am^{-1}$ (B) $\frac{2}{3}Am^{-1}$

(C) $6Am^{-1}$ (D) $2.4Am^{-1}$

Q29 The ratio of magnetic field at the centre of a current carrying circular coil to its magnetic moment is x, if the current and the radius both are doubled. The new ratio will become [KCET 2020]

(A) $2x$ (B) 4x

(C) x/4 (D) x/8

Q30 In a permanent magnet at room temperature [KCET 2020]

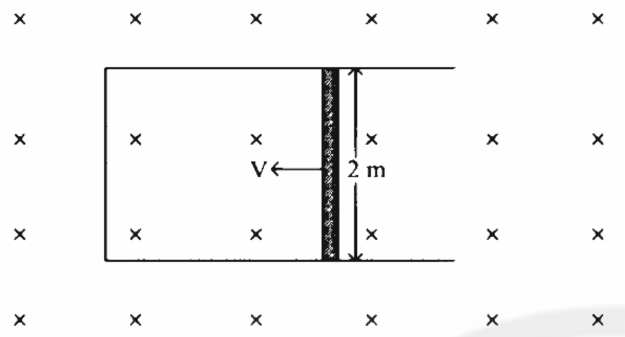
(A) Magnetic moment of each molecule is zero

(B) The individual molecules have non-zero magnetic moment which are all perfectly aligned

(C) Domains are partially aligned

(D) Domains are all perfectly aligned

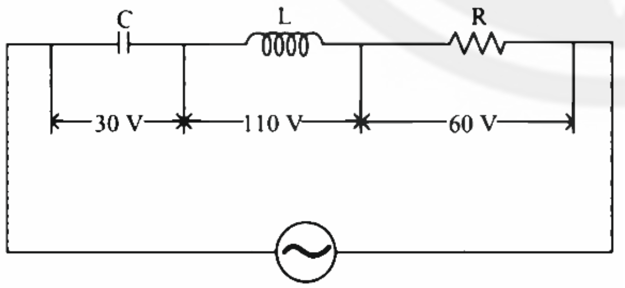
Q31 A rod of length 2*m* slides with a speed of 5 ms^{-1} on a rectangular conducting frame as shown in figure. There exists a uniform magnetic filed of 0.04 *T* perpendicular to the plane of the figure. If the resistance of the rod is 3Ω. The current through the rod is [KCET 2020]



(A) 75 mA (B) 133 mA
(C) 0.75 A (D) 1.33 A

Q32 The current in a coil of inductance 0.2 H changes from 5 A to 2 A in 0.5 s. The magnitude of the average induced emf in the coil is [KCET 2020]
(A) 0.6 V (B) 1.2 V
(C) 30 V (D) 0.3 V

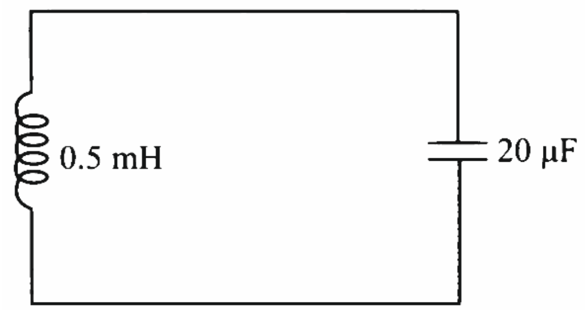
Q33 In the given circuit the peak voltage across C, L and Rare 30 V, 110 V and 60 V, respectively. The rms value of the applied voltage is [KCET 2020]



(A) 100 V (B) 200 V
(C) 70.7 V (D) 141 V

Q34 The power factor of *R* – *L* circuit is $\frac{1}{\sqrt{3}}$. If the inductive reactance is 2Ω. The value of resistance is [KCET 2020]
(A) 2Ω (B) $\sqrt{2}\Omega$
(C) 0.5Ω (D) $\frac{1}{\sqrt{2}}\Omega$

Q35 In the given circuit, the resonant frequency is [KCET 2020]



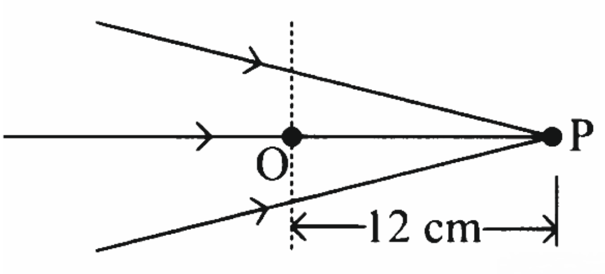
(A) 15. 92 Hz (B) 159.2 Hz
(C) 1592 Hz (D) 15910 Hz

Q36 A light beam of intensity 20 W/cm^2 is incident normally on a perfectly reflecting surface of sides 25 cm × 15 cm. The momentum imparted to the surface by the light per second is [KCET 2020]
(A) $2 \times 10^{-5} kg - ms^{-1}$
(B) $1 \times 10^{-5} kg - ms^{-1}$
(C) $5 \times 10^{-5} kg - ms^{-1}$
(D) $1.2 \times 10^{-5} kg - ms^{-1}$

Q37 An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus, the image [KCET 2020]
(A) Moves away from the lens with an uniform speed 5 m/s
(B) Moves away from the lens with an uniform acceleration
(C) Moves away from the lens with a non-uniform acceleration
(D) Moves towards the lens with a non-uniform acceleration

Q38 The refracting angle of prism is *A* and refractive index of material of prism is $\cot\frac{A}{2}$. The angle of minimum deviation is *A* [KCET 2020]
(A) 180° – 3A
(B) 180° + 2A
(C) 90° – A
(D) 180° – 2A

Q39 The following figure shows a beam of light converging at point *P*. When a concave lens of focal length 16 cm is introduced in the path of the beam at a place shown by dotted line such that *OP* becomes the axis of the lens, the beam converges at a distance x from the lens. The value of *x* will be equal to [KCET 2020]



(A) 12 cm (B) 24 cm
(C) 36 cm (D) 48 cm

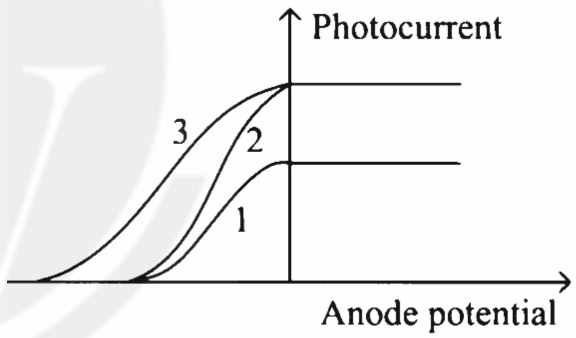
Q40 Three polaroid sheets P_1, P_2 and P_3 are kept parallel to each other such that the angle between pass axes of P_1 and P_2 is 45° and that between P_2 and P_3 is 45°. If unpolarised beam of light of intensity 128 Wm is incident on P_1. What is the intensity of light oming out of P_3? [KCET 2020]
(A) $128\ Wm^{-2}$
(B) Zero
(C) $16\ Wm^{-2}$
(D) $64\ Wm^{-2}$

Q41 Two poles are separated by a distance of 3.14m. The resolving power of human eye is 1 mm of an arc. The maximum distance from which he can identify the two poles distinctly is
(A) 10.8 km (B) 5.4 km
(C) 188 km (D) 376 km

Q42 In Young's double slit experiment, the distance between the slits and the screen is 1.2 m and the distance between the two slits is 2.4 mm. If a thin transparent mica sheet of thickness $1\ \mu m$ and RI 1.5 is introduced between one of the interfering beams, the shift in the position of central bright fringe is [KCET 2020]
(A) 2 mm (B) 0.5 mm
(C) 0.125 mm (D) 0.25 mm

Q43 The de-Broglie wavelength associated with electron of hydrogen atom in this ground state is [KCET 2020]
(A) 0.3 Å (B) 3.3 Å
(C) 6.26 Å (D) 10 Å

Q44 The following graph represents the variation of photocurrent with anode potential for a metal surface. Here I_1, I_2 *and* I_3 represents intensities and ν_1, ν_2, ν_3 represent frequency for curves 1, 2 and 3 respectively, then



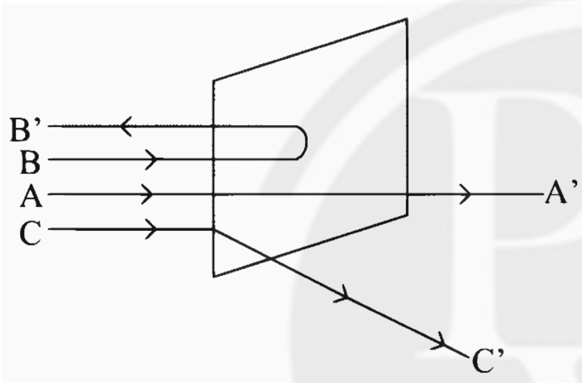
(A) $\nu_1 = \nu_2$ *and* $I_1 \neq I_2$
(B) $\nu_1 = \nu_3$ *and* $I_1 \neq I_3$
(C) $\nu_1 = \nu_2$ *and* $I_1 = I_2$
(D) $\nu_2 = \nu_3$ *and* $I_1 = I_3$

Q45 The period of revolution of an electron revolving in nth orbit of H–atom is proportional to
(A) n^2
(B) $\frac{1}{n}$
(C) n^3
(D) independent of n

Q46 Angular momentum of an electron in hydrogen atom is $\frac{3h}{2\pi}$(h is the Planck's constant). The KE of the electron is [KCET 2020]

(A) 4.35 eV
(B) 1.51 eV
(C) 3.4 eV
(D) 6.8 eV

Q47 A beam of fast moving alpha particles were directed towards a thin film of gold. The parts A, B and C of the transmitted and reflected beams corresponding to the incident parts A, B and C of the beam are shown in the adjoining diagram. The number of alpha particles in [KCET 2020]



(A) B' will be minimum and in C' maximum
(B) A' will be maximum and in B' minimum
(C) A' will be minimum and in B' maximum
(D) C' will be minimum and in B' maximum

Q48 Two protons are kept at a separation of 10 nm. Let F_n and F_e the nuclear force and the electromagnetic force between them [KCET 2020]

(A) $F_e = F_n$
(B) $F_e >> F_n$
(C) $F_e << F_n$
(D) F_e and F_n differ only slightly

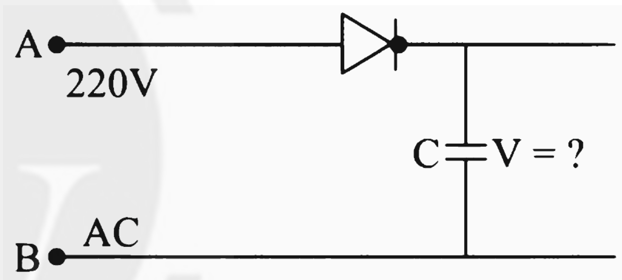
Q49 During a β^- decay [KCET 2020]

(A) An atomic electron is ejected
(B) An electron which is already present within the nucleus is ejected
(C) A neutron in the nucleus decays emitting an electron
(D) A proton in the nucleus decays emitting an electron

Q50 A radio-active elements has half-life of 15 years. What is the fraction that will decay in 30 years? [KCET 2020)

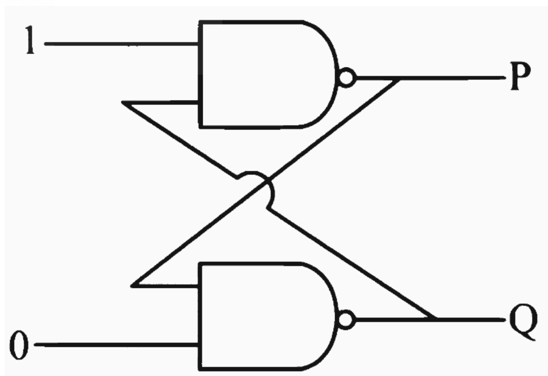
(A) 0.25
(B) 0.5
(C) 0.75
(D) 0.85

Q51 A 220 V AC supply is connected between points A and B as shown in figure, what will be the potential difference V across the capacitor? [KCET 2020]



(A) 220 V
(B) 110 V
(C) Zero
(D) $220\sqrt{2}v$

Q52 In the following circuit what are P and Q [KCET 2020]



(A) $P = 1, Q = 0$
(B) $P = 0, Q = 1$
(C) $P = 0, Q = 0$
(D) $P = 1, Q = 1$

Q53 A positive hole in a semiconductor is

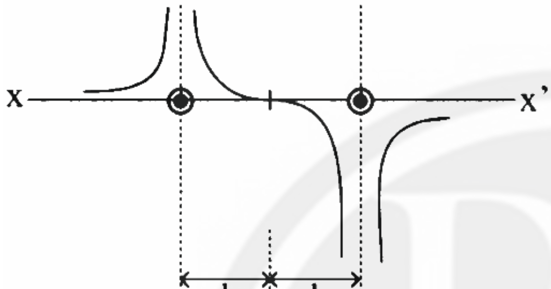
(A) An anti-particle of electron

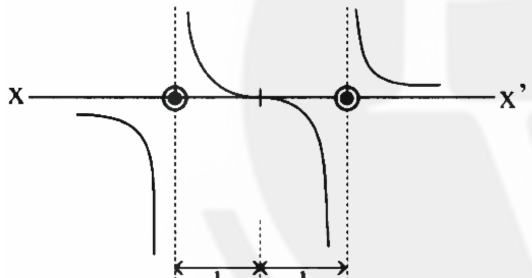
(B) A vacancy created when an electron leaves a covalent bond

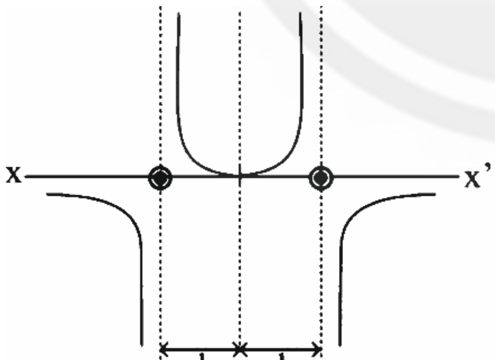
(C) Absence of free electrons

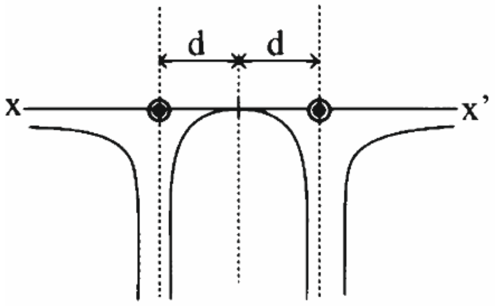
(D) An artificially created particle

Q54 Two long straight parallel wires are a distance *d* part. They carry steady equal currents flowing out of the plane of the paper. The variation of magnetic field *B* along the line *xx*' is given by [KCET 2020]

(A)


(B)


(C)


(D)


Q55 A cylindrical wire has a mass $(0.3 \pm 0.003)g$, radius $(0.5 \pm 0.005)mm$ and length $(0.6 \pm 0.06)mm$. The maximum percentage error in the measurement of its density is [KCET 2020]

(A) 1 (B) 2

(C) 3 (D) 4

Q56 At a metro station, a girl walks up a stationary escalator in 20 s. If she remains stationary on the escalator, then the escalator take her up in 30 s. The time taken by her to walk up on the moving escalator will be [KCET 2020]

(A) 25 s (B) 60 s

(C) 12 s (D) 10 s

Q57 Rain is falling vertically with a speed of $12\ ms^{-1}$. A woman rides a bicycles with a speed of $12\ ms^{-1}$ in east to west direction. What is the direction in which she should hold her umbrella? [KCET 2020]

(A) 30°, Towards east

(B) 45°, Towards east

(C) 30°, Towards west

(D) 45°, Towards west

Q58 One end of a string of length *l* is connected to a particle of mass *m* and the other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed *v*, the net force on the particle (directed towards the centre) is (*T* is the tension in the string) [KCET 2020]

(A) T (B) $T - \frac{mv^2}{l}$

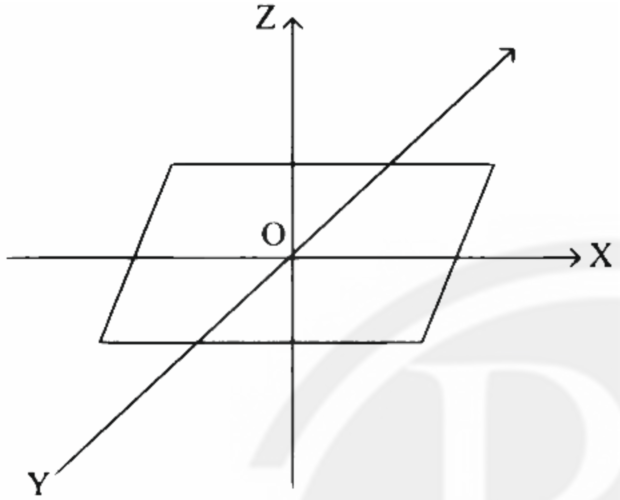
(C) $T + \frac{mv^2}{l}$ (D) Zero

Q59 A body is initially at rest. It undergoes one-dimensional motion with constant acceleration. The power delivered to it at time *t* is proportional to [KCET 2020]

(A) $t^{1/2}$ (B) t

(C) $t^{3/2}$ (D) t^2

Q60 A thin uniform rectangular plate of mass 2kg is placed in *xy*–plane as shown in figure. The moment of inertial about *x*-axis is $I_x = 0.2\ kgm^2$ and the moment of inertia about *Y*-axis is $I_y = 0.3\ kgm^2$. The radius of gyration of the plate about the axis passing through *O* and perpendicular to the plane of the plate is



(A) 50 cm (B) 5 cm
(C) 38.7 cm (D) 31.6 cm

Answer Key

Q1	B
Q2	C
Q3	A
Q4	A
Q5	C
Q6	A
Q7	C
Q8	C
Q9	D
Q10	B
Q11	A
Q12	C
Q13	B
Q14	C
Q15	B
Q16	A
Q17	C
Q18	A
Q19	A
Q20	A
Q21	A
Q22	A
Q23	D
Q24	C
Q25	A
Q26	C
Q27	C
Q28	B
Q29	D
Q30	A
Q31	B
Q32	B
Q33	C
Q34	B
Q35	C
Q36	C
Q37	C
Q38	D
Q39	D
Q40	C
Q41	A
Q42	D
Q43	B
Q44	A
Q45	C
Q46	B
Q47	B
Q48	B
Q49	C
Q50	C
Q51	D
Q52	B
Q53	B
Q54	B
Q55	D
Q56	C
Q57	B
Q58	A
Q59	B
Q60	A

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

The value of acceleration due to gravity at height (h = 10 km) is x.

i.e., $g_h = x$

$$\Rightarrow \frac{g}{\left(1+\frac{h}{R_e}\right)^2} = x$$

$$\Rightarrow g\left(1 - \frac{2h}{R_e}\right) = x$$

The value of acceleration due to gravity at depth d below the surface of earth,

$$g_d = x$$

$$\Rightarrow \quad g\left(1 - \frac{d}{R_e}\right) = x$$

From Eqs. (i) and (ii), we have

$$\Rightarrow \quad g\left(1 - \frac{2h}{R_e}\right) = g\left(1 - \frac{d}{R_e}\right)$$

$$\Rightarrow \quad 1 - \frac{2h}{R_e} = 1 - \frac{d}{R_e} \Rightarrow \frac{2h}{R_e} = \frac{d}{R_e}$$

$$\Rightarrow \quad d = 2h = 2 \times 10 = 20\,\text{km}$$

Q2 Text Solution:

For a perfect rigid body, strain is always zero, for all values of stress.

As, Young's modulus, $\mathrm{Y} = \frac{\text{Normal stress}}{\text{Longitudenal strain}}$

So, its Young's modulus would be infinity.

Q3 Text Solution:

Initial angular velocity of wheel, $\omega_o = 0$

Final angular velocity, ω = (10 rad) / s

t = 5 s

By first equation of rotational motion,

$$\omega = \omega_0 + \alpha t$$

$$\Rightarrow 10 = 0 + \alpha \times 5$$

$$\Rightarrow \alpha = \frac{10}{5} = 2\,\text{rad/s}^2$$

If θ be the total angle through which wheel has turned, then from,

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$= 0 \times 5 + \frac{1}{2} \times 2 \times 5^2 = 0 + 25$$

$$\Rightarrow \quad \theta = 25\text{rad}$$

Q4 Text Solution:

Density of ice, $\rho_i = 0.917\,g\,cm^{-3}$

Fraction of the volume of iceberg submerged in water is given as

$$\frac{\text{Volume of iceberg submerged in water}}{\text{Volume of iceberg}}$$

$$= \frac{\text{density of ice}}{\text{density of water}} = \frac{0.917\ \text{gcm}^{-3}}{1\ \text{gcm}^{-3}} = 0.917$$

Q5 Text Solution:

The rate of heat transfer is directly proportional to the surface area of body. Since, circular plate has greatest surface area and sphere has least surface area amongst the given three bodies. Hence, when a sphere, a cube and a thin circular plate are allowed to cool down under similar conditions, then the plate will cool the fastest and sphere the slowest.

Q6 Text Solution:

In an adiabatic expansion, internal energy decreases and hence temperature also decreases. Hence, from ideal gas equation,

$pV = nRT$

Since, T decreases.

Hence, pV also decreases

Q7 Text Solution:

Suppose Q amount of heat is supplied to monoatomic gas which expands at constant pressure. This heat is then converted into the internal energy and work. According to the first law of thermodynamics,

$$Q = U + W$$

$$\text{or}\, nC_p \Delta T$$

$$= nC_V \Delta T + W$$

where, Cp and Cv are the specific heat capacity at constant pressure and volume, respectively.

$\therefore$ The fraction of heat converted to work is given as

$$\frac{W}{Q}=\frac{nC_p\Delta T-nC_V\Delta T}{nC_p\Delta T}$$

For monoatomic gas, $n=1$

$$\Rightarrow \quad \frac{W}{Q}=\frac{C_p-C_V}{C_p}=\frac{\frac{5}{2}R-\frac{3}{2}R}{\frac{5}{2}R}$$

$$=\frac{R}{\frac{5}{2}R}=\frac{2}{5}$$

Q8 Text Solution:

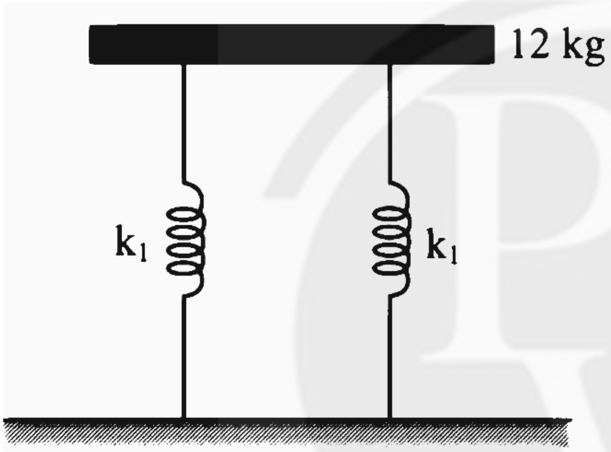
Mass of tray, m = 12kg

Time period, T = 1.5 s

If k be the spring constant of each spring, then

$k_1 = k_2 = k$

Since, springs are connected in parallel, hence



$k_{\text{baA}}=k+k$

$$T=2\pi\sqrt{\frac{m}{k_{\text{net}}}}=2\pi\sqrt{\frac{m}{k_1+k_2}}$$

$$\Rightarrow \quad 1.5=2\pi\sqrt{\frac{12}{k+k}}\Rightarrow 1.5=2\pi\sqrt{\frac{12}{2k}}$$

$$\Rightarrow \quad 1.5=2\pi\sqrt{\frac{6}{k}}$$

Squaring both side, we have

$$2.25=4\pi^2\cdot\frac{6}{k}$$

$$\Rightarrow \quad k=\frac{4\pi^2\times 6}{2.25}$$

$=105.17\,\text{Nm}^{-1}\approx 105\,\text{Nm}^{-1}$

Q9 Text Solution:

Since, the observer is stationary, so when train is approaching towards the observer or moving towards the observer, apparent frequency is given as,

$n'=n\left(\frac{v}{v-c_s}\right)$

where, v_s is the speed of sound.

It is clear from the above expression that

$n'>n$

However, when the train is going away from the observer, then apparent frequency,

$n'=n\left(\frac{v}{v+v_s}\right)$

$n'<n$

Hence, graph represented in option (*d*) is correct.

Q10 Text Solution:

If charge is placed at the one corner of a cube, then it can be shared further by 8 cubes.

Charge on one cube $=\frac{q}{8}$

Now, in any given cube this charge will be touching 3 out of 9 of cube faces. So, the area vector of that side and the electric field vector will be perpendicular. So, flux through those 3 sides will be zero. However, equal amount of flux will flow from other 3 sides.

So, flux through one side $=\left(\frac{q/8}{3}\right)\cdot\frac{1}{\varepsilon_o}=\frac{q}{24\varepsilon_o}$

Hence, flux through one face $(ABCD)=\frac{q}{24\varepsilon_o}$

Q11 Text Solution:

According to given figure,

Electric field at point $A, E_A=40\,Vm^{-1}$

Since, electric field lines on the left have twice the separation on those on the right (at point *B*), hence electric field at point *B*.

$E_B=\frac{E_A}{2}=\frac{40}{2}$

$E_B=20Vm^{-1}$

Force on charge q kept at B is

$F=qE_B$

Given, $q=20\mu\text{C}=20\times10^{-6}\text{C}$

$\Rightarrow \quad F=20\times10^{-6}\times20=4\times10^{-4}\text{N}$

Q12 Text Solution:

Given, charge density of uniformly long thin wire,

$\lambda = \frac{1}{4} \times 10^{-2}\ \mathrm{cm}^{-1}$

$= \frac{1}{4} \times 10^{-2} \times 10^{2}\mathrm{m}^{-1} = \frac{1}{4}\mathrm{m}^{-1}$

$r = 20\mathrm{cm} = 0.2\mathrm{m}$

Electric field at a distance *r* from the axis of wire is given as

$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{2\lambda}{4\pi\varepsilon_0 r}$

$= \frac{9\times10^{9}\times2\times\frac{1}{4}}{0.2}$

$= 2.25 \times 10^{10}\ \mathrm{NC}^{-1}$

option C

Q13 Text Solution:

Torque on electric dipole placed in uniform electric field *E*,

$\tau = pE\sin\theta.....(i)$

Where, *p* = electric dipole moment,

For small angle θ $\sin\theta \approx \theta$

From Eq. (i), we have

$\tau = pe\theta = (ii)$

$but\ \tau = I \times \alpha.....(iiii)$

where α is angular acceleration.

From Eqs. (ii) and (iii), we have

$I\alpha = pE\theta$

$\alpha = \frac{pE}{I} \cdot \theta \Rightarrow \frac{\theta}{\alpha} = \frac{I}{pE}$

Time period for the oscillation of dipole

$T = 2\pi\sqrt{\frac{\theta}{\alpha}} = 2\pi\sqrt{\frac{I}{pE}}$

Q14 Text Solution:

Given, $C_1 = C_2 = C$ (identical capacitors)

When both capacitors are connected in parallel, then equivalent capacitance

$C_p = C_1 + C_2 = C + C$

$C_p = 2C.......(i)$

When both capacitors are connected in series, then equivalent capacitance,

$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C} + \frac{1}{C}$

$\Rightarrow \quad \frac{1}{C_s} = \frac{2}{C} \Rightarrow C_s = \frac{C}{2}$

According to question,

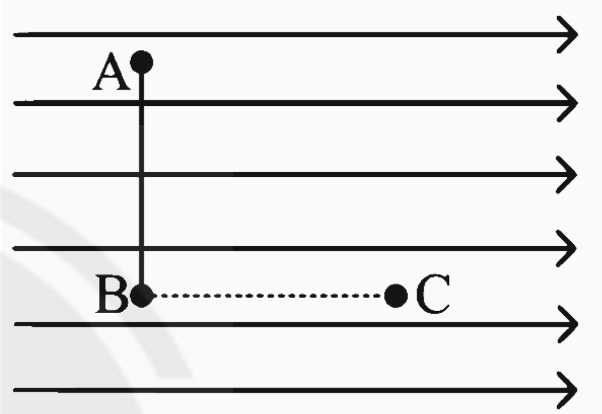
$C_p - C_s = 6\mu F$

$\Rightarrow 2C - \frac{C}{2} = 6\mu F \Rightarrow \frac{3C}{2} = 6\mu F$

$\Rightarrow C = 4\mu F$

Q15 Text Solution:

According to given figure, line *AB* is perpendicular to direction of electric field lines. Hence, surface passing through line *AB* and perpendicular to electric field lines behaves like a equipotential surface, therefore



$V_B > V_B.....(i)$

Electric field and electric potential are related as

$E = -\frac{dV}{dx} \Rightarrow v = -\int Edx$

Which indicates that electric potential decreases in the direction of electric field, i.e.

$V_B > V_C....(iii)$

From Eqs. (i) and (ii), we have

$V_A = V_B > V_C$

Q16 Text Solution:

When a soap bubble is charged, then the bubble expands because the charged particles uniformly distributed on it causes them to repel each other due to the electrostatic force. Hence, radius of soap bubble increases.

Q17 Text Solution:

Given, anode potential, *V* = 1200 *V*

Electron will accelerate with the effect of anode potential.

Hence $\frac{1}{2}mv^2 = eV$

$$v=\sqrt{\frac{2\,eV}{m}}=\sqrt{\frac{2\times1.6\times10^{-19}\times1200}{9.1\times10^{-31}}}$$
$$=\sqrt{421.98\times10^{12}}=20.5\times10^{6}\ ms^{-1}$$
$$=2.05\times10^{7}\ ms^{-1}\simeq2.1\times10^{7}\ ms^{-1}$$

Q18 Text Solution:

Given, length, l = 10 cm

Resistance of metal rod.

$$R=\rho.\frac{l}{A}$$

$$i.e,\ R\propto\frac{1}{A}$$

Since, among given faces in the options, area is minimum corresponding to face $1\,cm\ \times\frac{1}{2}cm$

Hence, resistance will be maximum when the battery is connected across the face of dimension

$$1\,cm\times\frac{1}{2}cm$$

Q19 Text Solution:

Given, emf of battery, E = 12V

Internal resistance, $r = 2\times10^{-2}\ \Omega$

Current, I = 80A

Terminal voltage when starter is ON is given as

$V = E - Ir$

$= 12 - 80\times2\times10^{-2}$

$= 12 - 1.6 = 10.4$V

Q20 Text Solution:

Given, length of potentiometer wire

l = 5m mf of battery, $E = 10\ V$

Potential gradient across the potentiometer wire,

$$K=\frac{E}{l}=\frac{10}{5}=2Vm^{-1}$$

When secondary cell is connected to the circuit of potentiometer, then balancing length,

$$l_1=200cm=2m$$

emf of the secondary cell,

$$E_s=kl_1=2\times2=4V$$

Q21 Text Solution:

Resistance of carbon resistor,

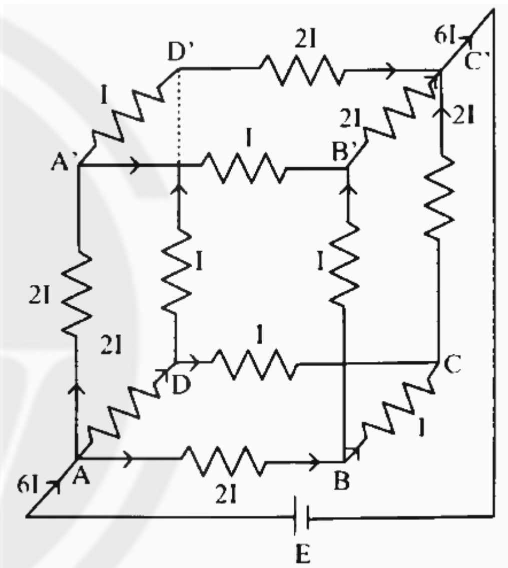
$$R=0.2k\Omega\pm10\%$$
$$=200\Omega\pm10\%$$
$$=20\times10^{1}\Omega\pm10\%$$

According to the colour code for carbon resistor, the colour assigned to number 2, 0 and 1 are red, black and brown. For colour used for tolerance of 10 % is silver.

∴ colour code are red, black, brown and silver.

Q22 Text Solution:

The given network of resistances can be shown as follows,



Let 6I be the current through the cell, which is distributed as shown in the figure.

Applying Kirchhoff's law to the loop $ABCC'EA$, we have

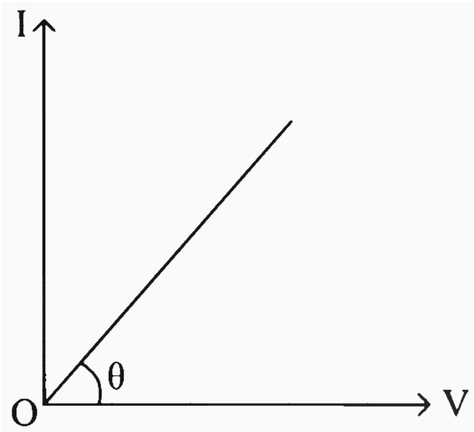
$$-2Ir-Ir-2Ir+E=0$$
$$\Rightarrow\quad E=5Ir$$
$$\text{but}\ r=1\Omega\ \text{given},$$
$$\therefore E=5I$$

If R' be the equivalent resistance of the network, then

$$R'=\frac{\text{total emf}}{\text{total current}}=\frac{5I}{6I}=\frac{5}{6}\Omega$$

Q23 Text Solution:

I – *V* characteristics of copper wire of length *L* and area of cross-section *A* is shown in the figure.



Since, I - V characteristic is a straight line, hence it obeys Ohm's law. According to which resistance of copper wire

$R=\frac{V}{I}=\cot\theta$

$\Rightarrow \quad R=\cot\theta$

$\Rightarrow \quad \rho\cdot\frac{l}{A}=\cot\theta$

or $\quad \tan\theta\propto\left(\frac{A}{\rho l}\right)$

Hence, slope ($\tan\theta$) of the curve becomes

(i) less if the length of the wire is increased.

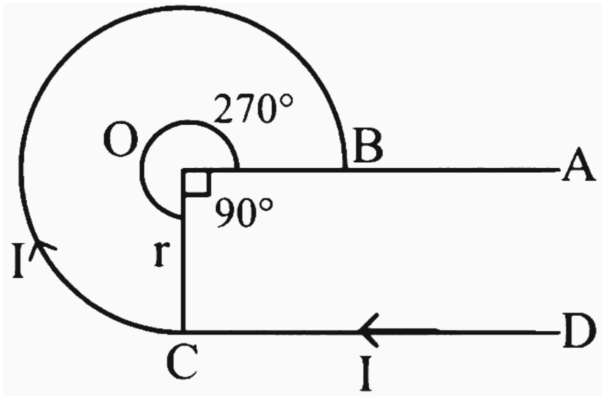
(ii) more if the area of the wire is increased.

(iii) less if a wire of steel of same dimensions is used as $\rho_{steel}>\rho_{copper}$

(iv) less if experiment is performed at higher temperature.

Q24 Text Solution:

According to the figure, magnetic field at point is given as



B_{net} = magnetic field due to straight wire *AB*+ magnetic field due to straight wire *CD*+ magnetic field due circular wire BC Since, point O is along the length of the wire *BA*. So, B_{AB} = 0

$$\begin{aligned}B_{\text{net}}&=0+\frac{\mu_0}{4\pi}\cdot\frac{I}{r}+\frac{270}{360}\left(\frac{\mu_0 I}{2r}\right)\\&=\frac{\mu_0 I}{4\pi r}+\frac{3}{4}\cdot\frac{\mu_0 I}{2r}\\&=\frac{\mu_0 I}{4\pi r}+\frac{3\mu_0 I}{8r}(\text{downward})\end{aligned}$$

Q25 Text Solution:

According to Biot-Savart's law, magnetic field at the origin due to a current element *idl* placed at a point with position vector *r* is given as.

$B=\frac{\mu_o i}{4\pi}\cdot\frac{dl\times r}{r^3}$

Q26 **Text Solution:**

Magnetic field due to long cylindrical wire of radius *R* inside the cylinder at a distance *r*

$$B_{\text{in}} = \frac{\mu_0}{2\pi} \cdot \frac{Ir}{R^2} \quad [\text{where}, I = \text{current}]$$

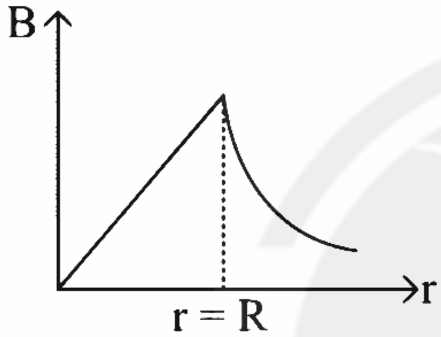
$$\therefore \quad B_{\text{in}} \propto r \quad \ldots \text{(i)}$$

Magnetic field outside the current carrying cylindrical wire of radius *R* at a distance *r* > *R* is given as

$$B_{\text{out}} = \frac{\mu_0 I}{2\pi r}$$

$$\text{i.e.} B_{\text{out}} \propto \frac{1}{r}$$

From Eqs. (i) and (ii), graph between *B* and *r* drawn as



Q27 **Text Solution:**

When a charged particle is accelerated by a potential difference *V* volts, then the radius of the trajectory of the path of the particle is given as,

$$r = \frac{\sqrt{2Km}}{Bq} = \frac{\sqrt{2qVm}}{Bq}$$

$$\Rightarrow \quad K = \frac{1}{2}\frac{B^2q^2r^2}{m} \text{or} K \propto \frac{q^2}{m} \text{ .....(i)}$$

For protons $\left({}_1^1\text{H}\right)$, deutrons $\left({}_1^2\text{H}\right)$ and α–particles $\left({}_2^4\text{He}\right)$

$$q_p : q_d : q_\alpha = 1 : 1 : 2$$

$$m_p : m_d : m_\alpha = 1 : 2 : 4$$

$$\Rightarrow \quad K_p : K_d : K_\alpha = 1 : \frac{1}{4} : 1$$

Thus, minimum kinetic energy is gained by deuterons.

Q28 **Text Solution:**

Given

$$M_1 = 8Am^{-1}, B_1 = 0.6T, T_1 = 4K, B_2 = 0.2\ T\ and\ T_2 = 16k$$

According to Curie's law, for paramagnetic materials,

$$M = \frac{CB}{T}$$

$$\Rightarrow \quad M_1 = \frac{CB_1}{T_1}$$

$$\text{and} \quad M_2 = \frac{CB_2}{T_2}$$

$$\therefore \quad \frac{M_2}{M_1} = \frac{\frac{CB_2}{T_2}}{\frac{CB_1}{T_1}} = \frac{B_2}{B_1} \times \frac{T_1}{T_2}$$

$$= \frac{0.2}{0.6} \times \frac{4\text{K}}{16\text{K}} = \frac{1}{3} \times \frac{1}{4}$$

$$\Rightarrow \quad \frac{M_2}{M_1} = \frac{1}{12} \Rightarrow M_2 = \frac{M_1}{12} = \frac{8}{12}$$

$$\Rightarrow M_2 = \frac{2}{3}\text{Am}^{-1}$$

Q29 **Text Solution:**

Magnetic field at the centre of current carrying circular coil

$$B = \frac{\mu_o I}{2r}$$

where, *I* = current and *r* = radius.

Magnetic dipole moment,

$$m = IA = I \cdot \pi r^2$$

$$\text{Given}, \frac{B}{m} = x$$

$$\Rightarrow \frac{\frac{\mu_0 I}{2r}}{\pi I r^2} = x$$

$$\Rightarrow \frac{\mu_0}{2\pi r^3} = x$$

When current and radius, both are doubled, then

$$\frac{B'}{m'} = \frac{\frac{\mu_0 2I}{2\cdot 2r}}{\pi(2I)(2r)^2}$$

$$= \frac{\frac{\mu_0 I}{2r}}{8\pi r^2 I} = \frac{\mu_0}{16\pi r^3}$$

$$= \frac{1}{8} \cdot \frac{\mu_0}{2\pi r^3} = \frac{x}{8} \quad [\text{from Eq. (i)}]$$

Q30 **Text Solution:**

At room temperature, all domains of permanent magnet are perfectly aligned like ferromagnetic material.

Q31 **Text Solution:**

Given,

$$l = 2m, v = 5m/s, B = 0.04T\ and\ R = 3\Omega$$

The current induced in a conducting coil, when moved in a uniform magnetic field is

$$I = \frac{Blv}{R} = \frac{0.04 \times 2 \times 5}{3} = 0.133\text{A} = 133\,\text{mA}$$

Q32 Text Solution:

Given

$L = 0.2H, I_1 = 5A, I_2 = 2A \text{ and } \Delta t = 0.5s$

The magnitude of induced emf, $|e| = L\frac{dI}{dt}$

$= L\frac{\Delta I}{\Delta t} = \frac{0.2\times(5-2)}{0.5} = 1.2\text{V}$

Q33 Text Solution:

Given $V_C = 30\text{V}, V_L = 110\text{V}$ and $V_R = 60\text{V}$

The peack voltage across series L – C – R Circtuit is given by

$$V_O = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$= \sqrt{(60)^2 + (110-30)^2}$$

$$= \sqrt{(60)^2 + (80)^2} = 100\text{V}$$

Rms value of voltage, $V_{\text{rms}} = \frac{V_0}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.7\text{V}$

Q34 Text Solution:

Given, power factor $= \frac{1}{\sqrt{3}}$

Inductive reactance, $X_L = 2\Omega$

The power factor in a *R-L* circuit is given by

power factor $= \frac{\text{Resistance}}{\text{Impedance}} = \frac{R}{\sqrt{R^2+X_L^2}}$

$\Rightarrow \frac{1}{\sqrt{3}} = \frac{R}{\sqrt{R^2+4}}$

Squaring both sides, we get

$$\frac{1}{3} = \frac{R^2}{R^2+4}$$

$\Rightarrow \quad R^2 + 4 = 3R^2 \Rightarrow R = \sqrt{2}\Omega$

Q35 Text Solution:

Given $L = 0.5\text{mH} = 0.5\times10^{-3}\text{H}$

and $C = 20\mu\text{F} = 20\times10^{-6}\text{F}$

The resonant frequency of $L - C$ circuit is

$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.5\times10^{-3}\times20\times10^{-6}}}$

$= \frac{1}{2\pi\times\sqrt{10\times10^{-9}}} = \frac{10^4}{2\pi} = 1592.3 \simeq 1592\text{ Hz}$

Q36 Text Solution:

Given, intensity, $I = 20W/cm^2$

Area of surface, $A = (25\times15)cm^2$

and time, t = 1 s

The intensity of light of energy E is given by

$$I = \frac{E}{At} \Rightarrow 20 = \frac{E}{25\times15\times1}$$

$\Rightarrow \quad = 20\times25\times15\text{J}$

The momentum imparted to a perfectly reflecting surface is given by

$p = \frac{2E}{c} = \frac{2\times20\times25\times15}{3\times10^8} = 5\times10^{-5}\text{ kgms}^{-1}$

Q37 Text Solution:

To understand the behavior of the image as an object approaches a converging lens, we begin with the lens formula:

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

where f is the focal length, v is the image distance, and u is the object distance.

By differentiating this equation with respect to time, we obtain:

$0 = \frac{1}{v^2}\frac{dv}{dt} + \frac{1}{u^2}\frac{du}{dt}$

This implies:

$\frac{dv}{dt} = \left(\frac{v^2}{u^2}\right)\frac{du}{dt}$

Here, $\frac{dv}{dt}$ is the speed of the image (v_i), and $\frac{du}{dt}$ is the speed of the object $(v_o 5m/s)$. Additionally, *m* represents the magnification. So, we derive:

$v_i = m^2 v_o .....(i)$

For acceleration, we differentiate with respect to time again:

$\frac{d^2 v_i}{dt^2} = v_o.2m.\frac{dm}{dt}$

This gives:

$a_i = 2mv_o\frac{dm}{dt} .....(ii)$

where a_i is the acceleration of the image.

When the object approaches the lens with a constant speed of 2 m/s and stops at the focus, equations (i) and (ii) indicate that the image will move away from the lens with a non-uniform acceleration. The variability in acceleration arises because $\frac{dm}{dt}$ changes as the object moves, resulting in non-uniform motion of the image.

Q38 Text Solution:

Given:

Angle of the prism A

Refractive index of the prism material $\mu = \cot\frac{A}{2}$

We know that the refractive index μ is related to the angle of minimum deviation δ_m as follows:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Substitute the given refractive index:

$$\cot\frac{A}{2} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

This simplifies to:

$$\frac{\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Therefore:

$$\sin\left(90^\circ - \frac{A}{2}\right) = \sin\left(\frac{A+\delta_m}{2}\right)$$

Equating the angles, we get:

$$\frac{180^\circ - A}{2} = \frac{A+\delta_m}{2}$$

Solving for δ_m gives

$$\delta_m = 180^\circ - 2A$$

Q39 Text Solution:

When the beam of light converges at point P, it acts as a virtual object for the concave lens.

To determine the convergence distance x from the lens:

The object distance u is given as 12 cm.

The focal length f of the concave lens is -16 cm (negative because it's a concave lens).

Using the lens formula:

$$\frac{1}{v} = \frac{1}{u} = \frac{1}{f}$$

Substitute the known values into the formula

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = -\frac{1}{16} + \frac{1}{12} = \frac{-3+4}{48} = \frac{1}{48}$$

Solving for v:

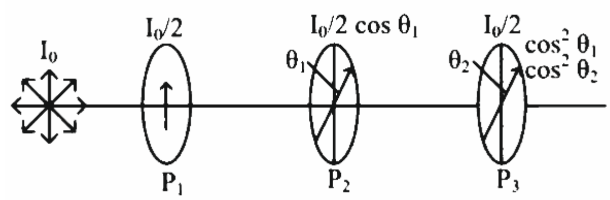
v = 48 cm

Given that v = x, we find

x = 48 cm

Q40 Text Solution:

The situation given in question can be shown as



Here,

$$I_o = 128 W m^{-2}, \theta_1 = 45^\circ \text{ and } \theta_2 = 45^\circ$$

According to Malus's law, intensity of the light coming out of P_2

$$I = \frac{I_0}{2}\cos^2\theta_1$$

Similarly, intensity of light coming out of P_3

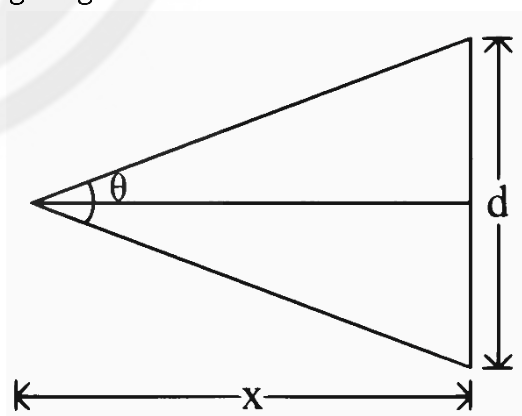
$$I' = \frac{I_0}{2}\cos^2\theta_1\cos^2\theta_2$$
$$= \frac{128}{2} \times \cos^2 45^\circ \times \cos^2 45^\circ$$
$$= 64 \times \frac{1}{2} \times \frac{1}{2} = 16\,\mathrm{Wm^{-2}}$$

Q41 Text Solution:

Given, distance between poles (d) = 3.14 m

Resolving power = 1 min or l'

Let maximum distance of two poles from eye to be resolved distinctly be x. Then, angle on eye in minute for two poles can be found using figure given below



$$\theta = \frac{d}{x} \times \frac{180}{\pi} \times 60$$

$$\Rightarrow \quad 1 = \frac{3.14}{x} \times \frac{180}{\pi} \times 60$$

$$\Rightarrow \quad x = \frac{3.14 \times 180 \times 60}{\pi} = 10794.5$$

$$\simeq 10.8\,\mathrm{km}$$

Q42 Text Solution:

Given

$D = 1.2\text{m}, d = 2.4\text{mm} = 2.4 \times 10^{-3}\text{m}$

$t = 1\mu\text{m} = 1 \times 10^{-6}\text{m} \text{and} \mu = 1.5$

When a transparent sheet is introduced in the path of one of the interfering beam, the shift in the position of central bright fringe is

$y = (\mu - 1)t\frac{D}{d}$

$= (1.5 - 1)1 \times 10^{-6} \times \frac{1.2}{2.4 \times 10^{-3}}$

$= \frac{0.5 \times 10^{-6} \times 1.2}{2.4 \times 10^{-3}}$

$= 0.25 \times 10^{-3} \text{or} 0.25\ \text{mm}$

Q43 Text Solution:

The angular momentum of electron in an orbit of radius *r* is,

$mvr = \frac{nh}{2\pi}$

So, Momentum in ground state,

$p = mv = \frac{h}{2\pi r} .....(i)$

The de-Broglie wavelength associated with an electron is

$\lambda = \frac{h}{mv} = \frac{h}{p} 2\pi r \ [from\ eq.(i)]$

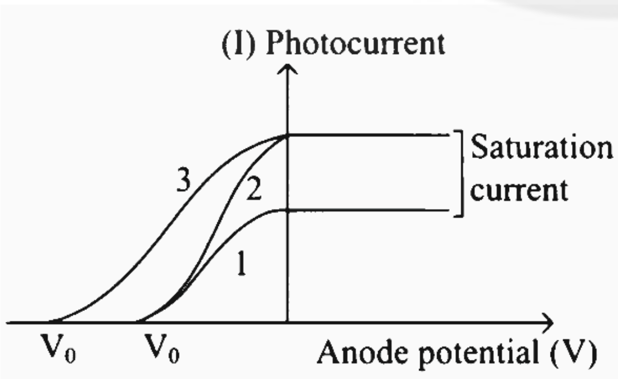
As we know, in ground state of hydrogen atom,

$r = 0.53\text{Å}$

$\Rightarrow \lambda = 2\pi \times 0.53\text{Å} = 3.3\text{Å}$

Q44 Text Solution:

The given figure can be shown as



From figure, we can see that the stopping potential (V_0) is same for curve 1 and 2. But for curve 3, it is greater than that for land 2.

As, we know that, $eV_0 = E_{\max} = h\gamma - \phi_0$

where, ϕ_0 is the work function.

Since, V_0 is same for 1 and 2, so from above equation, we have $r_1 = r_2$

Thus, for 1, 2 and 3

$\gamma_1 = \gamma_2 \neq \gamma_3$

Also, the saturation current of curve 2 is greater than of curve 1. But for curve 2 and 3 it is equal, so,

$I_1 \neq I_2 = I_3$

Q45 Text Solution:

The time period of revolution of an electron revolving in *n*th orbit of H-atom is given by

$T_n = \frac{2\pi r_n}{v_n} = \left(\frac{4\varepsilon_0^2 h^2}{meh4}\right)\frac{n^3}{z^2}$

$= T_n \propto n^3$

Q46 Text Solution:

Given, angular momentum of electron in H-atom $= \frac{3h}{2\pi}$ ....(i)

From Bohr's postulate,

Angular momentum $= \frac{nh}{2\pi}$..........(ii)

Comparing Eqs. (i) and (ii), we get

$n = 3$

The kinetic energy of an electron in hydrogen is given by

$\text{KE} = \frac{13.6 \times Z^2}{n^2}\text{eV}$

$= \frac{13.6 \times 1}{3^2} \quad (\text{for H}, \text{Z} = 1)$

$= 1.51\ \text{eV}$

Q47 Text Solution:

According to Rutherford's a-particles scattering experiment, following observations are made

(i) Most of the a-particles passed through the gold foil undeflected.

(ii) Only about 0.14% of the incident a-particles scattered by an angle greater than 1°.

(iii) About one a-particle in every 8000a-particles deflects by angle more than 90°.

So, from above observation, we can conclude about the number of a-particle in given figure as,

$n_A > n_C > n_B$

i.e., number of a-particle will be maximum in A' and minimum in B'.

Q48 Text Solution:

The nuclear forces are short range forces in range of few fm (ferrometre).

whereas, electromagnetic force are long range forces.

So, at a separation of 10 nm, the electromagnetic force is greater than the nuclear force between two protons, i.e.

$F_e >> F_n$

Q49 Text Solution:

The process of β^- decay is shown below

${}_Z^A X \xrightarrow{\beta^-} {}_{Z+z}^{A} Y + e^- + \overline{v} + energy$

Thus, in this decay a neutron inside the nucleus decays into a proton with the emission of an electron e^- and a particle called anti-neutrino $(\overline{v})$.

Q50 Text Solution:

Given, half-life, $T_{1/2} = 15$ years

Time, t = 30 years

$\therefore$ Number of half-life, $n = \frac{t}{T} = \frac{30}{15} = 2$

The number of nuclei left undecayed in 30 years or 2 half-lives is

$N = N_0\left(\frac{1}{2}\right)^n \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

$\therefore$ Fraction of decayed element $= \left(1 - \frac{N}{N_0}\right) = 1 - \frac{1}{4}$

$= \frac{3}{4} or 0.75$

Q51 Text Solution:

As *p-n* junction diode conducts electricity during only positive half-cycle (forward biased condition). So, the potential difference across the capacitor is

V = Peak value of input AC voltage

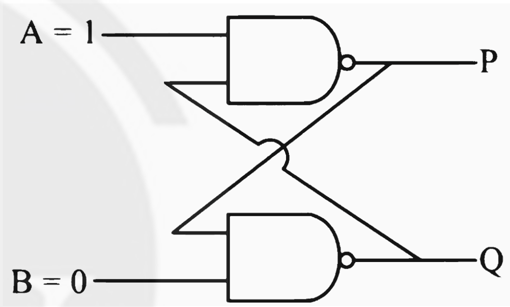
$= V_0 = V_{\text{rms}} \times \sqrt{2}$

$\text{Given}, V_{\text{rms}} = 220\text{V}$

$\therefore \quad V = 220\sqrt{2}\text{V}$

Q52 Text Solution:

The given circuit is as shown



The truth table for P can be shown as

A	Q	$P = \overline{A \cdot Q}$
1	0	1
1	1	0

The truth table for Q can be shown as

B	P	$Q = \overline{B \cdot P}$
0	0	1
0	1	1

Thus, Q is 1 for any value of P. So, the values satisfying given condition are,

$P = 0, Q = 1$

Q53 Text Solution:

At room temperature, some of the valence electrons acquire thermal energy greater than E_g (energy gap between conduction and valence band) and some of the valence electrons becomes free. Thus, we can say that a valence electron is shifted to conduction band leaving a vacancy of electron in valence. This vacancy is known as hole and carries a positive charge.

Q54 Text Solution:

The magnetic field in between because of each will be in opposite direction.

$$B_{\text{in between}}=\frac{\mu_0 i}{2\pi x}\hat{\mathbf{j}}-\frac{\mu_0 i}{2\pi(2d-x)}-\hat{\mathbf{j}}$$

$$=\frac{\mu_0 i}{2\pi}\left[\frac{1}{x}-\frac{1}{2d-x}\right]\hat{\mathbf{j}}$$

At $x=d, B_{\text{in between}}=0$

For $x<d, B_{\text{in between}}=\hat{\mathbf{j}}$

For $x>d, B_{\text{in between}}=-\hat{\mathbf{j}}$

Towards x, net magnetic field will add up and direction will be $(-j)$.

Towards x, net magnetic field will add up and direction will be $(\hat{j})$.

Q55 Text Solution:

Gives, mass $m=(0.3\pm 0.003)\text{g}$

Radius $r=(0.5\pm 0.005)\text{ mm}$

Lenght $l=(6\pm 0.06)\text{ cm}$

Density of cylinder $\rho=\frac{\text{Mass}}{\text{Volume}}=\frac{m}{\pi r^2 l}$

Fraction error in ρ

$$\frac{\Delta\rho}{\rho}=\frac{\Delta m}{m}+\frac{2\Delta r}{r}+\frac{\Delta l}{l}$$

Percentage error in ρ

$$\frac{\Delta\rho}{\rho}\times 100=\frac{\Delta m}{m}\times 100+\frac{2\Delta r}{r}\times 100+\frac{\Delta l}{l}\times 100$$

$$=\frac{0.003}{0.3}\times 100+2\times\frac{0.005}{0.5}\times 100+\frac{0.06}{6}\times 100$$

$$=1+2(1)+1=4\%$$

Q56 Text Solution:

To find the time taken by the girl to walk up on the moving escalator, we can use the concept of relative speeds.

Let's define:

v_{girl} as the speed of the girl walking.

$v_{escalator}$ as the speed of the escalator.

When the girl walks up on the stationary escalator, she takes 20 seconds. This gives us:

$d=v_{\text{girl}}\times 20\text{ s}$

When the escalator alone moves and the girl does not walk, the time taken is 30 seconds. Thus:

$d=v_{\text{escalator}}\times 30\text{ s}$

When the girl walks up on the moving escalator, both her speed and the escalator's speed contribute to her total speed:

$d=(v_{\text{girl}}+v_{\text{escalator}})\times t$

Setting the distances equal since they all cover distance d:

From v_{girl}

$v_{\text{girl}}=\frac{d}{20}$

From $v_{escalator}$

$v_{\text{escalator}}=\frac{d}{30}$

Combining both in the case of the moving escalator:

$d=\left(\frac{d}{20}+\frac{d}{30}\right)\times t$

Simplifying the combination:

$1=\left(\frac{1}{20}+\frac{1}{30}\right)\times t$

Finding a common denominator and solving:

$\frac{1}{20}+\frac{1}{30}=\frac{3}{60}+\frac{2}{60}=\frac{5}{60}=\frac{1}{12}$

Now, solve for t:

$1=\frac{1}{12}\times t$

So:

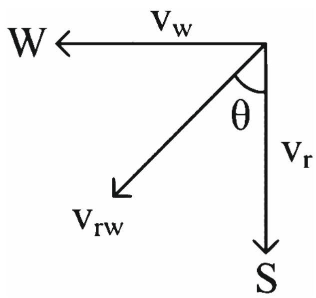
$t=12\text{ s}$

Hence, the time taken by her to walk up on the moving escalator is 12 seconds.

Option C: 12 s is the correct answer.

Q57 Text Solution:

The given situation is shown below



Here, velocity of rain, $v_r = 12ms^{-1}$

and velocity of woman, $v_w = 12ms^{-1}$

The relative velocity of rain w.r.t. woman is

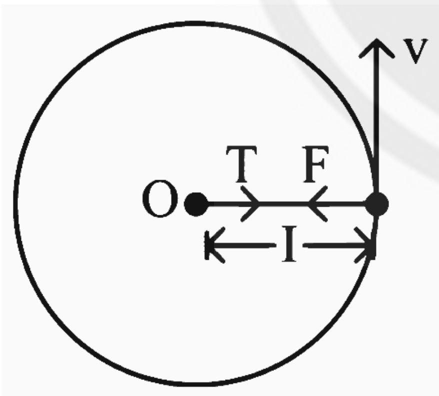
$$v_{nw} = \sqrt{v_w^2 + v_r^2}$$
$$= \sqrt{(12)^2 + (12)^2} = 12\sqrt{2}\,\mathrm{ms}^{-1}$$

The direction in which the woman should hold her umbrella is

$$\sin\theta = \frac{v_w}{v_{rw}} = \frac{12}{12\sqrt{2}}$$
$$\Rightarrow \quad \theta = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ, \text{ towards east}$$

Q58 Text Solution:

Consider a string of length *l* connected to a particle as shown in figure



As the particle is moving with velocity *v* in uniform circular motion, so the net force must be equal to the centripetal force, which is provided by the tension in the string.

$$\therefore \text{Net force} = \text{Centripetal force}\,(F_C)$$
$$= \text{Tension in string}(T)$$
$$\Rightarrow \quad \frac{mv^2}{l} = T$$

Q59 Text Solution:

Let in time *t*, the body will acquire a velocity of *v* from rest. $P \propto t$

As, power (*P*) = rate of doing work = $\frac{dW}{dt}$

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

For motion in one dimension

$$P = Fv\cos 0^\circ = Fv.......(i)$$

From first equation of motion,

$$v = u + at$$
$$v = at......(ii)(\because u = 0)$$

From Eqs. (i) and (ii), we get

$$P = F \times at = ma \times at(F = ma)$$
$$= ma^2 t$$

As ma^2 is constant

So,

Q60 Text Solution:

Given, mass, $M = 2kg$

$$I_x = 0.2\mathrm{kg} - \mathrm{m}^2$$
$$I_y = 0.3\mathrm{kg} - \mathrm{m}^2$$
$$\text{and} I_y = 0.3\mathrm{kg} - \mathrm{m}^2$$

According to the perpendicular axis theorem, the moment of inertia of the rectangular plate about an axis passing through *O* and perpendicular to the plane of plate is

$$I = I_x + I_y = 0.2 + 0.3$$
$$= 0.5\ kg\ m^2$$

Also, $I = Mk^2$

where, k = radius of gyration.

$$\Rightarrow \quad k = \sqrt{\frac{I}{M}} = \sqrt{\frac{0.5}{2}} = \sqrt{0.25}$$
$$= 0.5\mathrm{m or} 50\,\mathrm{cm}$$