KCET PYQ 2022

PHYSICS

Q1 In a series *LCR* circuit, $R = 300\Omega, L = 0.9\text{H}, C = 2.0\mu\,\text{F}$ and $\omega = 1000\text{rad/s}$, then impedance of the circuit is

(A) 900Ω (B) 500Ω
(C) 400Ω (D) 1300Ω

Q2 Which of the following radiations of electromagnetic waves has the highest wavelength?

(A) UV-rays (B) IR-rays
(C) Microwaves (D) X-rays

Q3 The power of a equi-concave lens is -4.5 D and is made of a material of refractive index 1.6, the radii of curvature of the lens is

(A) 36.6 cm (B) -266 cm
(C) 115.44 cm (D) -26.6 cm

Q4 A ray of light passes through an equilateral glass prism in such a manner that the angle of incidence is equal to the angle of emergence and each of these angles is equal to $\frac{3}{4}$ of the angle of the prism. The angle of deviation is

(A) 39° (B) 20°
(C) 30° (D) 45°

Q5 A convex lens of focal length *f* is placed somewhere in between an object and a screen. The distance between the object and the screen is *x*. If the numerical value of the magnification produced by the lens is *m*, then the focal length of the lens is

(A) $\frac{mx}{(m-1)^2}$ (B) $\frac{(m+1)^2 x}{m}$
(C) $\frac{(m-1)^2 x}{m}$ (D) $\frac{mx}{(m+1)^2}$

Q6 A series resonant AC circuit contains a capacitance 10^{-6}F and an inductor of 10^{-4}H. The frequency of electrical oscillations will be

(A) 10 Hz (B) $\frac{10^5}{2\pi}$
(C) $\frac{10}{2\pi}Hz$ (D) 10^5 Hz

Q7 Focal length of a convex lens will be maximum for

(A) yellow light (B) green light
(C) red light (D) blue light

Q8 For light diverging from a finite point source,

(A) the intensity decreases in proportion to the distance squared
(B) the wavefront is parabolic
(C) the intensity at the wave front does not depend on the distance
(D) the wave front is cylindrical

Q9 The fringe width for red colour as compared to that for violet colour is approximately

(A) 2 times (B) 4 times
(C) 8 times (D) 3 times

Q10 In case of Fraunhoffer diffraction at a single slit, the diffraction pattern on the screen is correct for which of the following statements?

(A) Central bright band having alternate dark and bright bands of decreasing intensity on either side.
(B) Central dark band having uniform brightness on either side
(C) Central bright band having dark bands on either side.
(D) Central dark band having alternate dark and bright bands of decreasing intensity on either side.

Q11 When a compact disc (CD) is illuminated by small source of white light coloured bands are observed. This is due to

(A) diffraction (B) interference
(C) reflection (D) scattering

Q12 Consider a glass slab which is silvered at one side and the other side is transparent, Given the refractive index of the glass slab to be 1.5 if a ray of light is incident at an angle of 45" on the transparent side, then the deviation of the ray of light from its intial path, when it comes out of the slab is

(A) 180° (B) 120°
(C) 45° (D) 90°

Q13 The kinetic energy of the photoelectrons increases by 0.52 eV when the wavelength of incident light is changed from 500 nm to another wavelength which is approximately

(A) 400 nm (B) 1250 nm
(C) 1000 nm (D) 700 nm

Q14 The de-Broglie wavelength of a particle of kinetic energy K is λ, the wavelength of the particle, if its kinetic energy $\frac{K}{4}$ is

(A) 2λ (B) $\frac{\lambda}{2}$
(C) 4λ (D) λ

Q15 The radius of hydrogen atom in the ground state is 0.53 A. After collision with an electron, it is found to have a radius of 2.12 A, the principal quantum number n of the final state of the atom is

(A) n = 2 (B) n = 3
(C) n = 4 (D) n = 1

Q16 In accordance with the Bohr's model, the quantum number that characterises the Earth's revolution around the Sun in an orbit of radius 1.5×10^{11} m with orbital speed 3×10^4 ms^{-1} is [given, mass of Earth = 6×10^{24} kg]

(A) 2.57×10^{38}
(B) 8.57×10^{64}
(C) 2.57×10^{74}
(D) 5.98×10^{86}

Q17 If an electron is revolving in its Bohr orbit having Bohr radius of 0.529 $\overset{\circ}{A}$, then the radius of third orbit is

(A) 4496$\overset{\circ}{A}$ (B) 4.761$\overset{\circ}{A}$
(C) 5125 nm (D) 4234 nm

Q18 Binding energy of a nitrogen nucleus $\left[{}^{14}_{7}\mathrm{N}\right]$, given $m\left[{}^{14}_{7}\mathrm{N}\right] = 14.00307\mathrm{u}$

(A) 85 MeV (B) 206.5 MeV
(C) 78 MeV (D) 104.7 MeV

Q19 In a photo electric experiment, if both the intensity and frequency of the incident light are doubled, then the saturation photoelectric current

(A) is halved
(B) is doubled
(C) becomes four times
(D) remains constant

Q20 Which of the following radiations is deflected by electric field?

(A) Neutrons
(B) γ-rays
(C) α-particles
(D) X-rays

Q21 The resistivity of a semiconductor at room temperature is in between

(A) 10^{-3} to $10^{6} \Omega$ –cm

(B) 10^{6} to 10^{8} Ω–cm

(C) 10^{10} to 10^{12} Ω–cm

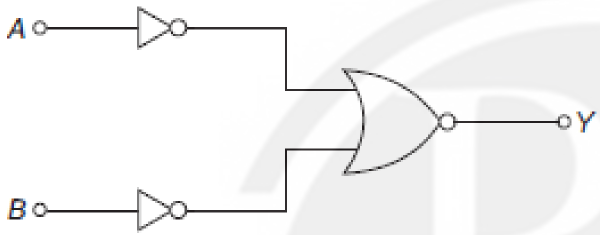
(D) 10^{-2} to 10^{-5} Ω–cm

Q22 The forbidden energy gap for Ge crystal at 0 K is

(A) 0.71 eV (B) 2.57 eV

(C) 6.57 eV (D) 0.071 eV

Q23 Which logic gate is represented by the following combination of logic gates?



(A) NAND (B) AND

(C) NOR (D) OR

Q24 A metallic rod of mass per unit length 0.5 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 30° with the horizontal. A magnetic field of strength 0.25 T is acting on it in the vertical direction. When a current *I* is flowing through it, the rod is not allowed to slide down. The quantity of current required to keep the rod stationary is

(A) 5.98 A (B) 14.76 A

(C) 11.32 A (D) 7.14 A

Q25 A nuclear reactor delivers a power of 10^9 W, the amount of fuel consumed by the reactor in one hour is

(A) 0.08 g (B) 0.72 g

(C) 0.96 g (D) 0.04 g

Q26 The displacement *x* (in m) of a particle of mass *m* (in kg) moving in one dimension under the action of a force, is related to time *t* (in sec) by $t = \sqrt{x} + 3$. The displacement of the particle when its velocity is zero, will be

(A) zero (B) 6 m

(C) 2 m (D) 4 m

Q27 Two objects are projected at an angle $\theta°$ and (90-$\theta°$), to the horizontal with the same speed. The ratio of their maximum vertical heights is

(A) tan θ $: 1$

(B) 1:tanθ

(C) $\tan^2\theta$ $: 1$

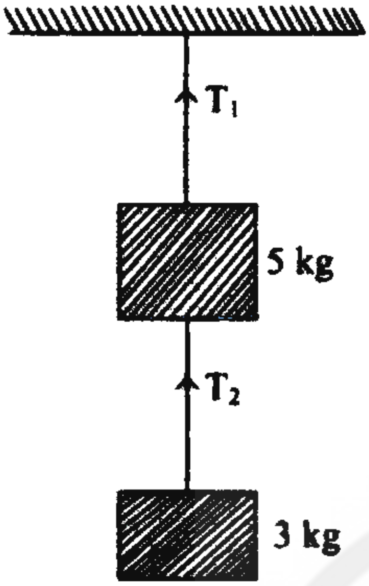
(D) 1:1

Q28 A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 ms^{-1}. A bob is suspended from the roof of the car by a light wire of length 1.0 m. The angle made by the wire with the vertical is (in rad)

(A) $\frac{\pi}{4}$ (B) zero

(C) $\frac{\pi}{3}$ (D) $\frac{\pi}{6}$

Q29 Two masses of 5 kg and 3 kg are suspended with the help of massless inextensible strings as shown in figure below.



When whole system is going upwards with acceleration 2m/s^2, the value of T_1 is (use, g = 9.8 m/s^2)

(A) 35.4 N (B) 23.6 N
(C) 59 N (D) 94.4 N

Q30 The Vernier scale of a travelling microscope has 50 divisions which coincides with 49 main scale divisions. If each main scale division is 0.5 mm , then the least count of the microscope is

(A) 0.5 mm (B) 0.01 mm
(C) 0.5 cm (D) 0.01 cm

Q31 The angular speed of a motor wheel is increased from 1200 rpm to 3120 rpm in 16 s. The angular acceleration of the motor wheel is

(A) $4\pi \text{rad/s}^2$ (B) $6\pi \text{rad/s}^2$
(C) $8\pi \text{rad/s}^2$ (D) $2\pi \text{rad/s}^2$

Q32 The centre of mass of an extended body on the surface of the earth and its centre of gravity

(A) are always at the same point only for spherical bodies
(B) can never be at the same point
(C) centre of mass coincides with the centre of gravity of a body if the size of the body is negligible as compared to the size (or radius) of the earth
(D) are always at the same point for any size of the body

Q33 A metallic rod breaks when strain produced is 0.2%. The Young's modulus of the material of the rod 7 × 10^9 N/m^2. The area of crosssection to support a load of 10^4 N is

(A) 7.1 × 10^{-5} m^2
(B) 7.1 × 10^{-4} m^2
(C) 7.1 × 10^{-2} m^2
(D) 7.1 × 10^{-8} m^2

Q34 A tiny spherical oil drop carrying a net charge is balanced in still air, with a vertical uniform electric field of strength $\frac{81}{7}\pi \times 10^5\ V/m$. When the field is switched OFF, the drop is observed to fall with terminal velocity 2×10^{-3}. Here g = 9.8 m/s^2, viscosity of air is 1.8×10^{-5} Ns/m^2 and density of oil is 900 kg m^{-3}. The magnitude of q is

(A) 8 × 10^{-19} C
(B) 1.6 × 10^{-19} C
(C) 3.2 × 10^{-19} C
(D) 0.8 × 10^{-19} C

Q35 "Heat cannot be flow itself from a body at lower temperature to a body at higher temperature". This statement corresponds to

(A) conservation of momentum

(B) conservation of mass

(C) first law of thermodynamics

(D) second law of thermodynamics

Q36 A smooth chain of length 2 m is kept on a table such that its length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg . The work done in pulling the entire chain on the table is (Take, $g = 10$ m/s^2)

(A) 6.3 J (B) 3.6 J

(C) 2.0 J (D) 12.9 J

Q37 Electrical as well as gravitational affects can be thought to be caused by fields. Which of the following is true for an electrical or gravitational field?

(A) Gravitational or electric field does not exist in the space around an object.

(B) Fields are useful for understanding forces actin through a distance.

(C) There is no way to verify the existence of a force field since it is just a concept.

(D) The field concept is often used to describe contact forces.

Q38 Four charges $+q_1 + 2q_1 + q$ and $-2q$ are placed at the corners of a square $ABCD$ respectively. The force on a unit positive charge kept at the centre O is

(A) along the diagonal BD

(B) along the diagonal AC

(C) perpendicular to AD

(D) zero

Q39 An electric dipole with dipole moment $4 \times 10^{-9}\mathrm{C-m}$ is aligned at 30° with the direction of a uniform electric field of magnitude $5 \times 10^{4}\mathrm{NC}^{-1}$, the magnitude of the torque acting on the dipole is

(A) $\sqrt{3} \times 10^{-4}\mathrm{N-m}$

(B) $10^{-5}\mathrm{N-m}$

(C) $10 \times 10^{-3}\mathrm{N-m}$

(D) $10^{-4}\mathrm{N-m}$

Q40 A charged particle of mass m and charge q is released from rest in an uniform electric field E . Neglecting the effect of gravity, the kinetic energy of the charged particle after t seconds is

(A) $\frac{Eq^2m}{2t^2}$ (B) $\frac{Eqm}{t}$

(C) $\frac{E^2q^2t^2}{2m}$ (D) $\frac{2E^2t^2}{mq}$

Q41 The electric field and the potential of an electric dipole vary with distance r as

(A) $\frac{1}{r^2} and \frac{1}{r}$ (B) $\frac{1}{r^2} and \frac{1}{r^3}$

(C) $\frac{1}{r^3} and \frac{1}{r^2}$ (D) $\frac{1}{r} and \frac{1}{r^2}$

Q42 The displacement of a particle executing SHM is given by $x = 3\sin\left[2\pi t + \frac{\pi}{4}\right]$, where is in metre and t is in seconds. The amplitude and maximum speed of the particles is

(A) $3m, 4\pi ms^{-1}$

(B) $3m, 6\pi ms^{-1}$

(C) $3m, 8\pi ms^{-1}$

(D) $3m, 2\pi ms^{-1}$

Q43 A parallel place capacitor is charged by connecting a 2 V battery across it. It is then disconnected from the battery and a glass slab is introduced between plates. Which of the following pairs of quantities decrease?

(A) Potential difference and energy stored

(B) Energy stored and capacitance

(C) Capacitance and charge

(D) Charge and potential difference

Q44 A charged particle is moving in an electric field of 3×10^{-10} Vm^{-1} with mobility 2.5×10^{6} m^2/V-s, its drift velocity is

(A) 8.33×10^{-4} m/s

(B) 1.2×10^{-4} m/s

(C) 25×10^{-4} m/s

(D) 7.5×10^{-4} m/s

Q45 Wire bound resistors are made by winding the wires of an alloy of

(A) Si, Tu, Fe

(B) Ge, Au, Ga

(C) Manganin, constantan, nichrome

(D) Cu, Al, Ag

Q46 10 identical cells each potential E and internal resistance are connected in series to form a closed circuit.

Determine the potential difference across three cells using an ideal voltmeter.

(A) 3E (B) 13 E

(C) 7 E (D) 10 E

Q47 In an atom electrons revolve around the nucleus along a path of radius $0.72\overset{o}{A}$ making 9.4×10^{18} revolutions per second. The equivalent currents is [given, $e = 1.6 \times 10^{-19}$C]

(A) 1.5 A (B) 1.4 A

(C) 1.8 A (D) 1.2 A

Q48 When a metal conductor connected to left gap of a meter bridge is heated, the balancing point

(A) shifts towards left

(B) remains unchanged

(C) shifts to the centre

(D) shifts towards right

Q49 Two tiny spheres carrying charges $1.8\mu C$ and 2.8 μC are located at 40 cm apart. The potential at the mid - point of the line joining the two charges is

(A) 2.1×10^{5} V

(B) 3.6×10^{5} V

(C) 1.3×10^{4} V

(D) 3.8×10^{4} V

Q50 A wire of a certain material is stretched slowly by 10%. Its new resistance and specific resistance becomes respectively

(A) 1.2 times, 1 times

(B) 1.21 times, 1.21 times

(C) both remains the same

(D) 1.1 times, 1.1 times

Q51 A proton moves with a velocity of $5 \times 10^{6}\hat{\mathbf{j}}\ \hat{m}^{-1}$ through the uniform electric field, $\vec{\mathbf{E}} = 4 \times 10^{6}\left[2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}}\right]\mathrm{Vm}^{-1}$ and the uniform magnetic field $\vec{\mathbf{B}} = 0.2\left[\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}}\right]\mathbf{T}$. The approximate net force acting on the proton is

(A) 25×10^{-13} N

(B) 2.2×10^{-13} N

(C) 14.4×10^{-13} N

(D) 5×10^{-13} N

Q52 A solenoid of length 50 cm having 100 turns carries a current of 2.5 A . The magnetic field at one end of the solenoid is

(A) $6.28 \times 10^{-4}\mathrm{T}$

(B) $1.57 \times 10^{-4}\mathrm{T}$

(C) $9.42 \times 10^{-4}\mathrm{T}$

(D) $3.14 \times 10^{-4}\mathrm{T}$

Q53 A galvanometer of resistance 50Ω is connected to a battery 3 V along with a resistance 2950Ω in series. A full scale deflection of 30 divisions is obtained in the galvanometer. In order to reduce this deflection to 20 divisions, the resistance in series should be

(A) 5550Ω (B) 5050Ω
(C) 4450Ω (D) 6050Ω

Q54 A circular coil of wire of radius r has n turns and carries a current I. The magnetic induction B at a point on the axis of the coil at a distance $\sqrt{3}r$ from its centre is

(A) $\frac{\mu_0 nI}{8r}$ (B) $\frac{\mu_0 nI}{16r}$
(C) $\frac{\mu_0 nI}{4r}$ (D) $\frac{\mu_0 nI}{32r}$

Q55 If voltage across a bulb rated 220V, 100W drops by 2.5% of its rated value, then the percentage of the rated value by which the power would decrease is

(A) 2.5% (B) 5%
(C) 10% (D) 20%

Q56 A long solenoid has 500 turns, when a current of 2 A is passed through it, the resulting magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb, then self induction of the solenoid is

(A) 2.5 H (B) 2.0 H
(C) 1.0 H (D) 4.0 H

Q57 A fully charged capacitor C with initial charge q_0 is connected to a coil of self inductance L at $t = 0$. The time at which the energy is stored equally between the electric and the magnetic field is

(A) $\sqrt{LC}$ (B) $\pi\sqrt{LC}$
(C) $\frac{\pi}{4}\sqrt{LC}$ (D) $2\pi\sqrt{LC}$

Q58 A magnetic field of flux densiity 1.0 Wb m^{-2} acts normal to a 80 turn coil of 0.01 m^2 area. If this coil is removed from the field in 0.2 s , then the emf induced in it is

(A) 8 V (B) 0.8 V
(C) 5 V (D) 4 V

Q59 An alternating current is given by $i = i_1 \sin\omega t + i_2 \cos\omega t$. The rms current is given by

(A) $\frac{i_1 - i_2}{\sqrt{2}}$ (B) $\sqrt{\frac{i_1^2 + i_2^2}{2}}$
(C) $\sqrt{\frac{i_1^2 + i_2^2}{\sqrt{2}}}$ (D) $\frac{i_1 + i_2}{\sqrt{2}}$

Q60 Which of the following statements proves that Earth has a magnetic field?

(A) Earth is a planet rotating about the NorthSouth axis
(B) Earth is surrounded by ionosphere
(C) A large quantity of iron-ore is found in the Earth
(D) The intensity of cosmic rays stream of charged particles is more at the poles than at the equator

Vernacular

Answer Key

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

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

Given,

$R = 300\Omega, L = 0.9\text{H}, \omega = 1000\text{rad/s}$

$C = 2.0\mu\text{ F} = 2 \times 10^{-6}\text{ F}$

Impedance of given $R - L - C$ circuit,

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

$= \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

$\left[\therefore X_L = \omega L \text{ and } X_C = \frac{1}{\omega C}\right]$

$= \sqrt{(300)^2 + \left(1000 \times 0.9 - \frac{1}{1000 \times 2 \times 10^{-6}}\right)^2}$

$= \sqrt{90000 + (900 - 500)^2}$

$= \sqrt{90000 + 160000} = \sqrt{250000} = 500\Omega$

Q2 Text Solution:

Increasing order of wavelength of given electromagnetic wave is given as

$\lambda_{\text{X-rays}} < \lambda_{\text{UV-rays}} < \lambda_{\text{IR-rays}} < \lambda_{\text{microwaves}}$

Hence, microwaves has highest wavelengths.

Q3 Text Solution:

The problem involves finding the radii of curvature of an equi-concave lens with a given power and refractive index.

Given:

Power of the lens, $P = -4.5\text{D}$

Refractive index, $\mu = 1.6$

Step-by-step Solution:

Calculate the focal length:

The power of a lens is related to its focal length by the equation:

$f = \frac{1}{P}$

Substituting the given power:

$f = \frac{1}{-4.5}\text{ m} = \frac{100}{-4.5}\text{ cm} = \frac{-200}{9}\text{ cm}$

Use the Lens Maker's Formula:

The lens maker's formula is:

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

Apply conditions for an equi-concave lens:

For an equi-concave lens, $R_1 = -R$ and $R_2 = -R$.

Substituting these into the formula:

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{-R} - \frac{1}{R}\right)$

Substitute and solve:

Let's substitute the given values into the equation:

$\frac{9}{200} = (1.6 - 1)\left(\frac{-2}{R}\right)$

Simplifying gives:

$\frac{9}{200} = 0.6\left(\frac{-2}{R}\right)$

Solving for :

$R = \frac{-0.6 \times 2 \times 200}{9} = -26.6\text{ cm}$

The radii of curvature for this equi-concave lens is -26.6 cm.

Q4 Text Solution:

In an equilateral glass prism, where the angle of the prism A is 60°, a ray of light passes through such that the angle of incidence (i) is equal to the angle of emergence (e), and both are $\frac{3}{4}$ of the angle of the prism.

This can be calculated as:

$i = \frac{3}{4}A = \frac{3}{4} \times 60^\circ = 45^\circ$

Thus, $e = i = 45^\circ$

For a prism, the relationship between the angle of the prism A, the angle of deviation δ, the angle of incidence i, and the angle of emergence e is given by:

$A + \delta = i + e$

Substituting the known values:

$\delta = i + e - A = 45^\circ + 45^\circ - 60^\circ = 90^\circ$

$- 60^\circ = 30^\circ$

Therefore, the angle of deviation is 30°.

Q5 Text Solution:

Given a convex lens with a focal length f positioned between an object and a screen, the total distance between the object and screen is x. The lens produces a magnification m.

To find the lens' focal length, consider:

Distance Relations:

The equation for distances is $u + v = x$, where u is the object distance and v is the image distance.

Magnification Equation:

Magnification $m = \frac{v}{u}$.

Expressing Distances Using Magnification:

Using the magnification equation, express the distances:

For object distance, we solve $u + mu = x$ giving $u(m + 1) = x$. Hence,

$$u = \frac{x}{m+1}$$

For image distance, we solve $\frac{v}{m} + v = x$, leading to

$$v = \frac{mx}{m+1}$$

Lens Formula Application:

The lens formula is given by

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

Substituting the values of and from above:

$$\frac{1}{f} = \frac{1}{\left(\frac{m\gamma}{m+1}\right)} - \frac{1}{\left(\frac{2}{m+1}\right)}$$

Simplify:

$$\frac{1}{f} = \frac{m+1}{mx} + \frac{m+1}{x}$$

$$= \frac{m+1}{x}\left[\frac{1}{m} + 1\right]$$

$$= \frac{m+1}{x} \cdot \frac{m+1}{m}$$

Resulting in:

$$= \frac{(m+1)^2}{mx}$$

Therefore, the focal length f is:

$$f = \frac{mx}{(m+1)^2}$$

This formula provides the focal length of the lens based on the given distances and magnification.

Q6 Text Solution:

Given, capacitancè, $C = 10^{-6}$ F

Inductance, $L = 10^{-4}$H

Frequency of oscillation of L-C series resonant circuit,

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10^{-4}\times10^{-6}}}$$

$$= \frac{1}{2\pi\times10^{-5}} = \frac{10^5}{2\pi} \text{ Hz}$$

Q7 Text Solution:

The focal length of a convex lens depends on the refractive index of the material from which the lens is made. The relationship given by the lens maker's formula is:

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

where f is the focal length, μ is the refractive index, and R_1 and R_2 are the radii of curvature of the lens surfaces.

The focal length f is inversely related to the factor $(\mu - 1)$:

$$\frac{1}{f} \propto (\mu - 1) \Rightarrow f \propto \frac{1}{(\mu-1)} \qquad (i)$$

The refractive index μ itself is inversely related to the wavelength λ of the light:

$$\mu \propto \frac{1}{\lambda} \qquad (ii)$$

Combining these relationships from equations (i) and (ii), we find:

$$f \propto \lambda$$

This tells us that the focal length is directly proportional to the wavelength of the light. Since red light has the longest wavelength among the visible spectrum components, the focal length of a convex lens will be maximum for red light.

Q8 Text Solution:

A light diverging from a finite point source produces spherical wavefront that moves in all directions from the point. The intensity of light dependent on the distance and it follows the inverse square law. Hence, the intensity decreases with an increase in the distance from the source.

Q9 Text Solution:

We know that, fringe width,

$\beta = \frac{D\lambda}{d}$

where, D = distance between the screen and source,

d = distance between the slits

and λ = wavelength of light used.

$\Rightarrow \ \beta \propto \lambda \ldots \ldots$ (i)

As we know that,

$\lambda_{\text{red}} \simeq 2\lambda_{\text{violet}}$

$\frac{\beta_{\text{red}}}{\beta_{\text{violet}}} = \frac{\lambda_{\text{red}}}{\lambda_{\text{violet}}} = \frac{2\lambda_{\text{violet}}}{\lambda_{\text{violet}}} = 2$

$\beta_{\text{red}} = 2\beta_{\text{violet}}$

Q10 Text Solution:

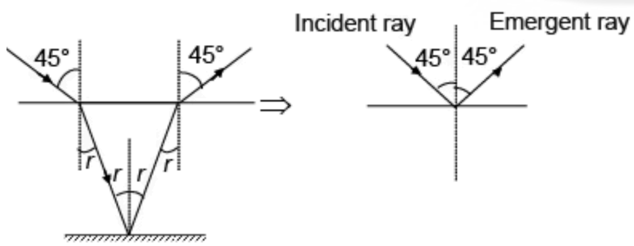
In case of Fraunhoffer diffraction at a single slit, the diffraction pattern on the screen, central bright band having alternate dark, and bright bands of decreasing intensity on either side.

Q11 Text Solution:

When a compact disc (CD) is illuminated by small source of white light, coloured bands are observed. This happens due to the phenomenon of diffraction, in which small ripples on the surface of it, break up white light into the colour of rainbow.

Q12 Text Solution:

The ray diagram for the given situation is shown below



Hence, emergent rays comes out at angle of 90° from inmcident ray.

Q13 Text Solution:

Given, change in kinetic energy of photoelectrons,

$\Delta K = 0.52\text{eV}$

$\lambda_1 = 500 \text{ nm}, \lambda_2 = ?$

We know that, kinetic energy of emitted photoelectron (using Einstein's equation)

$K = \frac{hc}{\lambda} - \phi$

At wavelength λ_1,

$K_1 = \frac{hc}{\lambda_1} - \phi \ldots (i)$

At wavelength λ_2,

$K_2 = \frac{hc}{\lambda_2} - \phi \ldots . (\text{ii})$

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

$\Rightarrow \ K_2 - K_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1}$

$\Rightarrow \ \Delta K = hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$

$\Rightarrow \ 0.52 = 1242\left(\frac{1}{\lambda_2} - \frac{1}{500}\right)$

$\Rightarrow \ \frac{0.52}{1242} = \frac{1}{\lambda_2} - \frac{1}{500}$

$\Rightarrow \ \frac{1}{\lambda_2} = \frac{0.52}{1242} + \frac{1}{500}$

$\Rightarrow \ \lambda_2 \approx 400 \text{ nm}$

Q14 Text Solution:

de-Broglie wavelength (λ) of the particle in terms of kinetic energy K is given as

$\lambda = \frac{h}{\sqrt{2mK}} \ldots$ (i)

where, m is the mass of the particle and h is Planck's constant.

Let at wavelength λ', kinetic energy of particle becomes $K' = \frac{K}{4}$

i.e. $\lambda' = \frac{h}{\sqrt{2mK'}} = \frac{h}{\sqrt{2m \cdot \frac{K}{4}}}$

$= \frac{h}{\frac{1}{2}\sqrt{2mK}} = 2\frac{h}{\sqrt{2mK}}$

$\Rightarrow \ \lambda' = 2\lambda$ [from Eq. (i)]

Q15 Text Solution:

Given, radius of H -atom in the ground state (n, = 1)

r_1 = 0.53 A

Radius of excited state (n_2)

r_1 = 2.12 A

We know that, $r \propto n^2$

$\Rightarrow \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2 \Rightarrow \frac{0.53}{212}$

$= \left(\frac{1}{n_2}\right)^2 \; [\because n_1 = 1]$

$\Rightarrow \frac{1}{4} = \frac{1}{n_2^2} \Rightarrow \left(\frac{1}{2}\right)^2 = \frac{1}{n_2^2} \Rightarrow n_2 = 2$

i.e., n = n = 2

Q16 Text Solution:

Given, $v = 3 \times 10^4$ m/s

$r = 1.5 \times 10^{11}$ m

$m_e = 6 \times 10^{24}$ kg

According Bohr's atomic model,

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

where, h = Planck's constant $= 6.62 \times 10^{-34}$ J – s

and. n = quantum number

$\therefore\; n \;=\; \frac{2\pi(m_e vr)}{h}$

$= \frac{2 \times 314 \times 6 \times 10^{24} \times 3 \times 10^4 \times 1.5 \times 10^{11}}{6.62 \times 10^{-34}}$

$= 2.57 \times 10^{74}$

Hence, the quantam number that characterises the Earth's revolution is 2.57 × 10^{74}.

Q17 Text Solution:

Given, Bohr radius, $r_1 = 0.529\ \mathring{A}$

We know that, radius of revolving electron in nth orbit is given as

$r \propto n^2$

$\Rightarrow \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2$

$\Rightarrow \frac{r_1}{r_2} = \left(\frac{1}{3}\right)^2 = \frac{1}{9} \; [\because n_1 = 1 \text{ and } n_2 = 3]$

$\Rightarrow r_2 = 9r_1 = 9 \times 0.529 = 4.761\mathring{A}$

Q18 Text Solution:

Given, mass of nucleus of nitrogen,

$m[{}_7\mathrm{N}^{14}] = 14.00307\mathrm{u}$

Mass of proton, m_p = 1.00783 amu

Mass of neutron, m_n = 1.0087 amu

Mass defect, $\Delta m = (7m_p + 7m_n) - m(7\,\mathrm{N}^{14})$

$= 7 \times 1.00783 + 7 \times 1.00807 - 14.00307$

= 0.11243 amu

- Binding energy of nitrogen nucleus

$= \Delta m \times 931 = 0.11243 \times 931$

$= 104.67 \simeq 104.7\mathrm{MeV}$

Q19 Text Solution:

In photoelectric effect, saturation photocurrent is directly proportional to the intensity of incident radiation but independent of frequency of incident radiation. Hence, saturation current in photoelectric effect becomes double when both intensity and frequency of the incident light are doubled.

Q20 Text Solution:

α-particles are deflected in electric and magnetic field both because it has a charge of +2e. γ-rays and X-rays are electromagnetic waves which do not deflected in electric and magnetic field. Neutrons are neutral (chargeless) particles, hence it cannot deflect in electric and magnetic field.

Q21 Text Solution:

The resistivity of a material is a measure of how strongly the material resists the flow of electric current. Semiconductors have resistivity values that are between those of good conductors (like metals) and good insulators (like ceramics).

Option A states that the resistivity range is from to 10^{-3} to 10^{6} Ω-cm.

Option B suggests a range from 10^{6} to 10^{8} Ω-cm.

Option C offers a range from 10^{10} to 10^{12} Ω-cm.

Option D proposes a range from 10^{-2} to 10^{-5} Ω-cm.

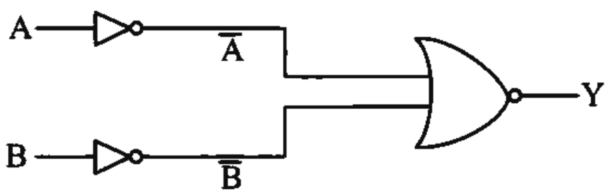
The correct resistivity range for semiconductors at room temperature is typically closer to Option A: 10^{-3} to $10^{6}\Omega$-cm. This range is wide because it can be affected by several factors, including the type of semiconductor material, the presence of impurities (doping), and the temperature of the material.

Q22 Text Solution:

Ge is a semiconductor material which behaves as an insulator at 0 K. We know that, forbidden energy gap of an insulator is arond 0.78 ev Hence, among the given options, option (A) is correct.

Q23 Text Solution:

The given logic gate is represented as



Output of logic gate is written as

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

$[According\ to\ Demorgan's\ law\ \overline{x+y} = \overline{x} \cdot \overline{y}[]$

= $A.B$ = Output of AND gate

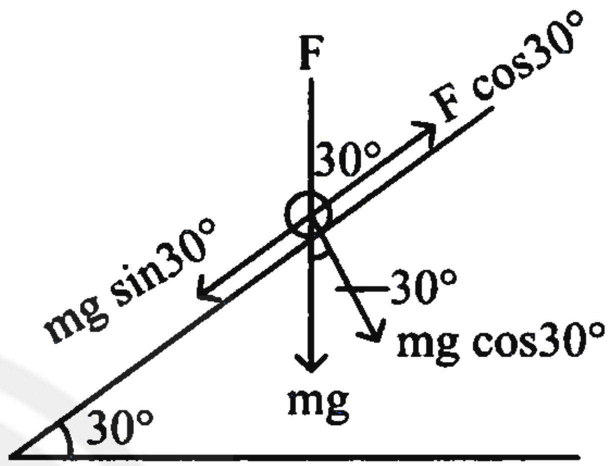
Q24 Text Solution:

Given, magnetic field, B=0.25T

Mass per unit length, $\frac{m}{l} = 0.5\ kg\ m^{-1}$

$\theta = 30°$

The given situation is shown alongside.



At balance condition,

$F\cos 30^{\circ} = mg\sin 30^{\circ}$

$\Rightarrow\ BIl\cos 30^{\circ} = mg\sin 30^{\circ}$

$\Rightarrow\ BIl \times \frac{\sqrt{3}}{2} = mg\frac{1}{2} \Rightarrow \sqrt{3}BI = \left(\frac{m}{l}\right)g$

$I = \left(\frac{m}{l}\right)g \cdot \frac{1}{\sqrt{3}B} = 0.5 \times 10 \times \frac{1}{\sqrt{3} \times 0.25}$

$= 11.32\text{ A}$

Q25 Text Solution:

Given, power delivered by nuclear reactor,

$P = 10^{9}$ W

c = 3×10^{8} m/s

t = 1 h = 60 × 60 s

Since, $P = \frac{E}{t} = \frac{mc^2}{t}\left[\because\ E = mc^2\right]$

$\Rightarrow\ m = \frac{Pt}{c^2} = \frac{10^{9} \times 60 \times 60}{(3 \times 10^{8})^{2}}$

$= \frac{10^{9} \times 3600}{9 \times 10^{16}} = 4 \times 10^{-5} kg$

$= 0.04 \times 10^{-3} kg = 0.04g$

Q26 Text Solution:

Displacement of the particle related with time is given as

$t = \sqrt{x} + 3 \Rightarrow \sqrt{x} = t - 3$

Squaring on both sides, we get

$\Rightarrow \; x = (t-3)^2$

$\Rightarrow x = t^2 - 6t + 9 \; (i)$

Velocity of the particle,

$v = \frac{dx}{dt} = \frac{d}{dt}\left(t^2 - 6t + 9\right) = 2t - 6$

when $v = 0$

i.e. $2t - 6 = 0 \Rightarrow t = 36$

i.e velocity of particle is zero at $t = 36$.

Displacement of particle at $t = 3$ s,

$x = 3^2 - 6 \times 3 + 9$ [from Eq. (i)]

$= 0$

Q27 Text Solution:

We know that, maximum vertical height in projectile motion,

$H = \frac{u^2 \sin^2\phi}{2g}$ [where, ϕ is angle of projection.]

$\Rightarrow \; H \propto \sin^2\phi$

$\Rightarrow \; \frac{H_1}{H_2} = \frac{\sin^2\phi}{\sin^2\phi_2} = \frac{\sin^2\theta}{\sin^2(90-\theta)}$

[Given, $\phi_1 = \theta$ and $\phi_2 = 90^\circ - \theta$]

$= \frac{\sin^2\theta}{\cos^2\theta} = \tan^2\theta$

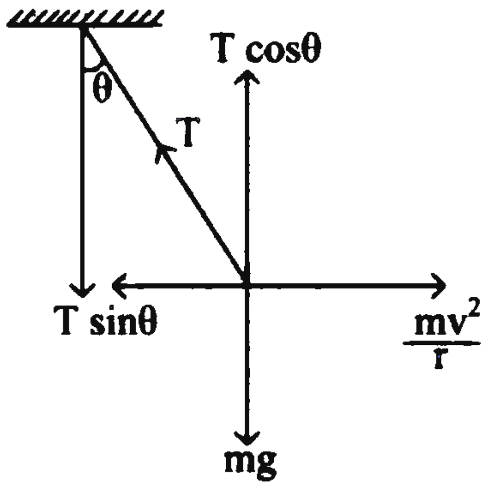
$\therefore \; H_1 : H_2 = \tan^2\theta : 1$

Q28 Text Solution:

Radius of circular track, $r = 10$m

speed of car, $v = 10$m/s

The given situation is shown below



$T\sin\theta = \frac{mv^2}{r} \qquad (i)$

$T\cos\theta = mg \qquad (ii)$

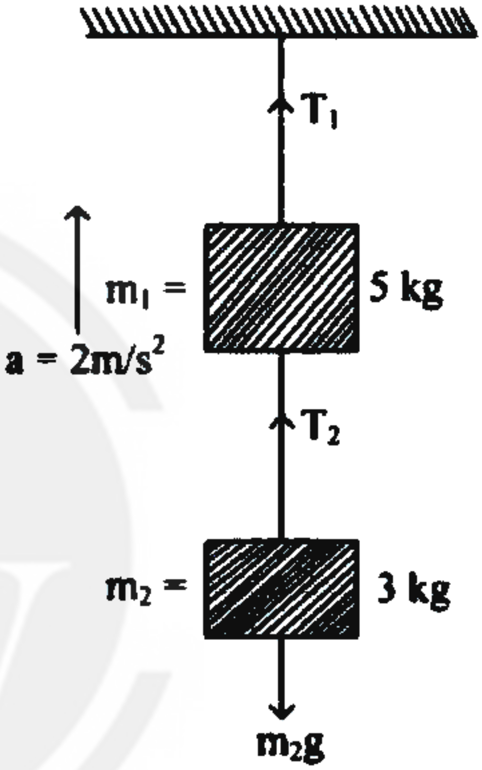
Dividing Eq. (i) by Eq. (ii), we get

$\frac{T\sin\theta}{T\cos\theta} = \frac{mv^2/r}{mg} \Rightarrow \tan\theta = \frac{v^2}{rg} = \frac{10^2}{10\times10} = 1$

$\Rightarrow \tan\theta = \tan45^\circ \Rightarrow \theta = 45^\circ = \frac{\pi}{4}\text{rad}$

Q29 Text Solution:

The given situation is shown below



Equation of motion for body m_2,

$T_2 - m_2 g = m_2 a$

$T_2 - 3g = 3 \times 2$

$T_2 = 3g + 6 = 3 \times 9.8 + 6 = 35.4$ N

Equation of motion of mass of 5 kg,

$T_1 - T_2 - m_1 g = m_1 a$

$\Rightarrow \; T_1 - 35.4 - 5 \times 9.8 = 5 \times 2$

$\Rightarrow \; T_1 - 84.4 = 10$

$\Rightarrow \; T_1 = 10 + 84.4 = 94.4 \; N$

Q30 Text Solution:

The least count of a measuring instrument is the smallest value that can be measured with the instrument and is calculated by the formula:

Least Count
$= \frac{\text{Value of one main scale division}}{\text{Number of divisions on the Vernier scale}}$
In the given travelling microscope, there are 50 divisions on the Vernier scale which coincides with 49 main scale divisions. Each main scale division is of 0.5 mm.
First, we need to find out the value of one main scale division:
Given that one main scale division is 0.5 mm , we keep this value for the calculation.
Next, to calculate the least count, we divide this value by the number of divisions on the Vernier scale.
Least Count $= \frac{0.5 \text{ mm}}{50}$
To calculate the value that the Vernier scale can measure beyond the main scale, we consider the discrepancy between the 49 main scale divisions and the 50 Vernier divisions. Since 49 main scale divisions coincide with 50 Vernier divisions, the length covered by 50 Vernier divisions is equal to the length covered by 49 main scale divisions.
Therefore, one Vernier division is equivalent to $\frac{49}{50}$ of a main scale division. The difference between the value of one main scale division and one Vernier division gives us the least count:
Main scale division value - Vernier scale division value = Least Count
Least Count $= \frac{0.5 \text{ mm}}{50} \times 49$
Since there is a difference of 1 Vernier division in 50 divisions, the Vernier scale is more precise by:
Least Count $= \frac{0.5 \text{ mm}}{50}$
Simplifying the fraction:
Least Count $= \frac{0.5}{50}$ mm
Least Count = 0.01 mm
So the correct answer is:
Option B
0.01 mm

Q31 Text Solution:

Given, initial angular frequency of wheel,
$f_0 = 1200\text{rpm} = \frac{1200}{60}\text{rps} = 20\text{rps}$
Initial angular velocity,
$\omega_0 = 2\pi f_0 = 2\pi \times 20 = 40\pi\text{rad/s}$
Similarly, final angular speed,
$\omega = 2\pi \times \left(\frac{3120}{60}\right)\text{rad/s} = 104\pi\text{rad/s}$
Time, t = 16s
If α be the angular acceleration of the wheel, then
$\omega = \omega_0 + \alpha t$
$\Rightarrow \alpha = \frac{\omega - \omega_0}{t} = \frac{104\pi - 40\pi}{16}$
$= \frac{64\pi}{16} = 4\pi\text{rad/s}^2$

Q32 Text Solution:

The correct option is C : Centre of mass coincides with the centre of gravity of a body if the size of the body is negligible as compared to the size (or radius) of the earth.
The center of mass of an object is the point where the distribution of mass is balanced in all directions, and it is calculated using the positions and masses of the object's components. The center of mass is purely a function of the distribution of mass within the object and does not depend on external gravitational fields.
The center of gravity, on the other hand, is the point within an object from which the force of gravity appears to act. When the gravitational field is uniform, as it is often approximated to be close to the Earth's surface, the center of gravity falls directly on the center of mass.
For very large bodies or for those where the gravitational field is not uniform across the object, such as a large mountain near the Earth's pole, the center of gravity and center of mass may not coincide. This is because the center of gravity is influenced by the distribution of mass and the gradient of the gravitational field it is in.
Options A and D are incorrect because they make general assertions that do not take into

account the uniformity of the gravitational field or the relative size of the body to the Earth.

Option B is also incorrect because the center of mass and center of gravity do coincide in common situations where bodies are small compared to the size of the Earth or when the gravitational field can be considered uniform. Although there may be specific cases where they do not coincide, this option states they "can never be at the same point" which is false as in many practical situations they are at the same point.

In summary, if the body is small relative to the Earth and the gravitational field can be approximated as uniform, the center of mass and center of gravity are effectively in the same location, which is the essence of option C.

Q33 Text Solution:

Given, Youngs' modulus, $Y=7\times10^9\ \mathrm{N/m^2}$

Load, $F=10^4$N

We know that,

$Y=\frac{Fl}{A\Delta l}$

$\Rightarrow A=\frac{Fl}{Y\Delta l}=\frac{F}{Y}\times\frac{1}{\left(\frac{\Delta l}{l}\right)}$

$=\frac{10^4}{7\times10^9}\times\frac{1}{0.2}=7.1\times10^{-4}\ \mathrm{m^2}$

Q34 Text Solution:

Given, $E=\frac{81\pi}{7}\times10^5\ \mathrm{V/m}$

Terminal velocity, $v=2\times10^{-3}\ \mathrm{m/s}$

$g=9.8\ \mathrm{m/s^2}$

Viscosity, $\eta=1.8\times10^{-5}\ \mathrm{N-s/m^2}$

Density, $\rho=900\ \mathrm{kg/m^3}$

Since, *qE = mg .....(i)*

In the absence of electric field,

$mg=6\pi\eta rv$

$\Rightarrow qE=6\pi\eta rv$ *[from Eq. (i)]*

$\Rightarrow r=\frac{qE}{6\pi\eta v}\#(ii)$

From Eq. (i), we get

$m=\frac{qE}{g}$

$\Rightarrow \frac{4}{3}\pi r^3 d=\frac{qE}{g}\Rightarrow\frac{4}{3}\pi\left(\frac{qE}{6\pi\eta v}\right)^3 d=\frac{qE}{g}$

$\Rightarrow q=\sqrt{\frac{3\times6^3\pi^2\eta^3v^3}{4E^2g}}$

$=\sqrt{\frac{3\times6^3\times(314)^2\times\left(1.8\times10^{-5}\right)^3\times\left(2\times10^{-3}\right)^3}{4\times\left(\frac{81\pi}{7}\times10^5\right)^2\times9.8}}$

$=8\times10^{-19}C$

Q35 Text Solution:

According to second law of thermodynamics, heat cannot be itself flow from a body at lower temperature to a body at higher temperature without doing external work.

Q36 Text Solution:

Mass per unit length of chain,

$\frac{M}{L}=\frac{4}{2}=2\ \mathrm{kg/m}$

Work done in pulling the chain of small length *dx*,

dW = mass of length *dx* × *g* × *x*

$=\frac{M}{L}\times dx\times g\times x$

$=2\times dx\times10\times x=20xdx$

Work done, $W=\int_0^{0.6}dW\,dx=\int_0^{0.6}20x\,dx$

$=\left[20\frac{x^2}{2}\right]_0^{0.6}=\left[10x^2\right]_0^{0.6}=10\times(0.6)^2$

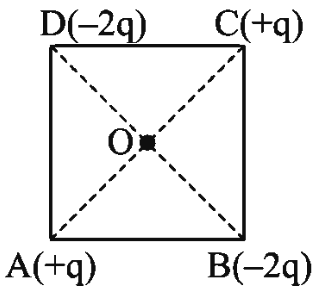
$=3.6\ \mathrm{J}$

Q37 Text Solution:

Concept of field is a model used to explain the influence that a massive body or charged particle extends into the space around itself, producing a force on another massive body or charged body placed in space. Therefore, force concept of field is used to explain gravitational and electrostatic phenomena.

Q38 Text Solution:

The given situation is shown below



Since, charges kept at point *A* and *C* are in same magnitude and same nature (i.e. both positive), hence net force due these two charges on unit charge at centre *O* will be zero.

Force due to charge (+2*q*) at unit positive charge at centre will be towards *BO* and also force due to charge at unit positive charge (–2*q*) at centre will be towards *OD*.

Therefore, net force on the unit positive charge kept at centre *O* will be towards *BD*.

Q39 Text Solution:

Given, for an electric dipole, dipole moment,

$p = 4 \times 10^{-9} \mathrm{C}$

$\theta = 30^{\circ}$

Magnitude of electric field, $E = 5 \times 10^{4}$ N/C

Torque, $\tau = pE\sin\theta$

$= 4 \times 10^{-9} \times 5 \times 10^{4} \sin 30^{\circ} = 10^{-4}$ N – m

Q40 Text Solution:

According to given situation, force on charge particle in uniform electric field, *F* = *qE*

Acceleration of charge particle,

$a = \frac{F}{m} = \frac{qE}{m}$

Velocity of charge particle after time *t* is given as

$v = u + at = 0 + \frac{qE}{m}t \Rightarrow v = \frac{qEt}{m}$

Kinetic energy of the charged particle

$K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{qEt}{m}\right)^2 = \frac{E^2q^2t^2}{2m}$

Q41 Text Solution:

We know electric field and potential due to electric dipole on axial position is given as

$E = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ *and* $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

i.e., $E \propto \frac{1}{r^3}$ *and* $E \propto \frac{1}{r^2}$

Q42 Text Solution:

Given, displacement equation of particle executing SHM,

$X = 3\sin\left[2\pi t + \frac{\pi}{4}\right]$

Comparing with displacement equation of SHM as $y = A\sin(\omega t + \phi)$, we get

Amplitude, *A* = 3 m

Angular velocity, ω = 2πrad/s

Maximum speed,

$v_{\max} = \omega A = 2\pi \times 3 = 6\pi$ m/s

Q43 Text Solution:

When a charged capacitor is disconnected from the battery and a glass slab (dielectric material) is introduced between the plates, then charge (*Q*), capacitance (*C*), electric potential (*V*) and stored energy (*U*) is given as

$Q = Q_0, C = KC_0, V = \frac{V_0}{K}$ *and* $U = \frac{U_0}{K}$

where, *K* = dielectric constant

V = electric potential

U = potential energy

V_0 = initial potential of charged capacitor

U_0 = Initial energy of charged capacitor

From above, we see that *V* and *U* decreases after introducing glass plate of dielectric constant *k* whereas capacitance increases and charge remains same because battery is disconnected after introducing dielectric material.

Q44 Text Solution:

The drift velocity (v_d) of a charged particle moving in an electric field can be calculated using the relation between drift velocity, electric field (*E*), and mobility (μ) of the charged particle, which is given by:

$v_d = \mu E$

Where:

μ is the mobility of the charged particle, which is the velocity per unit electric field strength.

is the electric field strength.

Given:

The mobility of the charged particle is $\mu = 2.5 \times 10^6\ \mathrm{m^2/V-s}$.

The electric field strength is $E = 3 \times 10^{-10}\mathrm{Vm^{-1}}$.

Now let's calculate the drift velocity:

$v_d = (\mu)(E)$

$v_d = (2.5 \times 10^6\ \mathrm{m^2/V-s})(3 \times 10^{-10}\mathrm{Vm^{-1}})$

$v_d = 7.5 \times 10^{-4}\ \mathrm{m/s}$

Therefore, the drift velocity of the charged particle is $7.5 \times 10^{-4}\ \mathrm{m/s}$, which corresponds to Option D.

Q45 Text Solution:

Wire bound resistors are made by winding the wires of an alloy of manganin, constantan and nichrome. The choice of these materials is directed mostly by the fact that their resistivities are relatively intensive to temperature. These resistances are typically in range of a fraction of an ohm to a few hundred ohms.

Q46 Text Solution:

According to given situation, total voltage of 10 cells = 10*E*

Total resistance of 10 cells = 10*r*

Current in the circuit, $I = \frac{10E}{10r} = \frac{E}{r}$

Potential difference across 3 cells,

$V = I \times (3r) = \frac{E}{r} \times 3r = 3E$

Hence, ideal voltmeter will read 3E.

Q47 Text Solution:

Given, radius of circular path,

$r = 0.72\overset{o}{A} = 0.72 \times 10^{-10}\ \mathrm{m} = 7.2 \times 10^{-11}\ \mathrm{m}$

$\left(\frac{n}{t}\right) = 9.4 \times 10^{18}\mathrm{rev/s}$

$e = 1.6 \times 10^{-19}\mathrm{C}$

Equivalent current,

$I = \frac{ne}{t} = \left(\frac{n}{t}\right)e$

$= 9.4 \times 10^{18} \times 1.6 \times 10^{-19} = 1.504 \simeq 1.5\ \mathrm{A}$

Q48 Text Solution:

We know that, resistance of unknown wire can be determined by using meter bridge as

$\frac{R}{S} = \frac{l}{100-l} \Rightarrow S = \frac{R(100-l)}{l}\ (i)$

where *R* = known resistance, *l* = balancing length and *S* = unknown resistance.

When a metal conductor of resistance *R* connected to left gap is heated, then its resistance increases i.e. *R* increases. Hence, from Eq. (i), we see that when *R* will increase, then (100-*l*) will decrease also, i.e will increase. Therefore, balancing point will shift towards right.

Q49 Text Solution:

Charge on first sphere, $q_1 = 1.8\mu\mathrm{C} = 1.8 \times 10^{-6}\mathrm{C}$

Charge on second sphere, $q_2 = 2.8\mu\mathrm{C} = 2.8 \times 10^{-6}\mathrm{C}$

Distance between the two spheres, $r = 40\ \mathrm{cm}$

Distance between mid-point and each sphere

$r_1 = r_2 = 20\ \mathrm{cm} = 0.2\ \mathrm{m}$

Electric potential at mid-point due to both charged sphere

$V = V_1 + V_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r_1} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{r_2}$

$= 9 \times 10^9 \times \frac{1.8\times10^{-6}}{0.2} + 9 \times 10^9 \times \frac{2.8\times10^{-6}}{0.2}$

$= 9 \times 10^3(9 + 14) = 2.07 \times 10^5\ \mathrm{V} \simeq 2.1 \times 10^5\ \mathrm{V}$

Q50 Text Solution:

Let initial length of the wire be . After stretching new length of the wire r' is given as

$l' = l + 10\%$ of $l = l + \frac{10}{100}l = \frac{11l}{10} = 1.1l$

i.e. length is increased by 1.1 times

$\therefore\ n = 1.1$

We know that, when length of a wire is increased by n times, then its new resistance is increased by n^2times i.e.

$R' = n^2 R = (1.1)^2 R$ $[\because$ Here, n=1.1]

= 1.21R

Specific resistance (resistivity) of a wire does not depends on its dimensions (length, width etc.) because it is a characteristic property of a material and depends only nature of material of wire. Hence, specific resistance remains same.

Q51 Text Solution:

Given, speed of proton, $v = 5 \times 10^6 \hat{\mathbf{j}}$ m/s

Electric field,

$\mathbf{E} = 4 \times 10^6 \left[2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.\mathbf{k}\hat{\mathbf{k}}\right] \mathrm{V/m}$

Magnetic field, $\mathbf{B} = 0.2\left[\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}}\right]\mathrm{T}$

Charge on proton, $q = 1.6 \times 10^{-19}\mathrm{C}$

Net force acting on the proton is calculated according to Lorentz's force as

$\mathbf{F} = q[\mathbf{E} + \mathbf{v} \times \mathbf{B}]$

$= 1.6 \times 10^{-19}\left[4 \times 10^6\left(2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}}\right)\right.$

$\left.+5 \times 10^6 \hat{\mathbf{j}} \times 0.2\left(\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}}\right)\right]$

$= 1.6 \times 10^{-19} \times 10^6\left[4\left(2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}}\right)\right.$

$\left.+\left(-\hat{\mathbf{k}} + 0 + \hat{\mathbf{i}}\right)\right]$

$\Rightarrow \mathbf{F} = 1.6 \times 10^{-13}\left[9\hat{\mathbf{i}} + 0.8\hat{\mathbf{j}} - 0.6\hat{\mathbf{k}}\right]$

$\therefore \mathbf{F} = |\mathrm{F}| = 1.6$

$\times 10^{-13}\sqrt{(9)^2 + (0.8)^2 + (0.6)^2}$

$= 1.6 \times 10^{-13}\sqrt{82} = 14.4 \times 10^{-13}\ \mathrm{N}$

$= 14.4 \times 10^{-13}\ \mathrm{N}$

Q52 Text Solution:

Given, length of solenoid, $l = 50\ \mathrm{cm} = 0.5\ \mathrm{m}$

Number of turns, N = 100

Current, I = 2.5A

Number of turns per unit length in the solenoid

$n = \frac{N}{l} = \frac{100}{0.5} = 200$ turns/m

Magnetic field at the one end of solenoid,

$B = \frac{\mu_0 nI}{2} = \frac{4\pi \times 10^{-7} \times 200 \times 2.5}{2}$

$= 10\pi \times 10^{-5} = \pi \times 10^{-4} = 3.14 \times 10^{-4}\ \mathrm{T}$

Q53 Text Solution:

Resistance of galvanometer, $R_g = 50\Omega$

Emf of battery, $V = 3\ \mathrm{V}$

Resistance connected in series, $R_s = 2950\Omega$

Total resistance,

$R' = R_g + R_s = 50 + 2950 = 3000\Omega$

Current, $I = \frac{V}{R'} = \frac{3}{3000} = 10^{-3}\ \mathrm{A}$

If the deflection has to be reduced to 20 divisions, then current,

$I' = \frac{I}{30} \times 20 = \frac{2}{3} \times 10^{-3}\ \mathrm{A}$

Let R_E be the effective resistance of the circuit, hence

3 = $R_E I'$

$\Rightarrow R_E = \frac{3}{I'} = \frac{3}{\frac{2}{3} \times 10^{-3}} = 4.5 \times 10^3$

$= 4500\Omega$

Resistance to be added = R_E - R_g

$= 4500 - 50 = 4450\Omega$

Q54 Text Solution:

Magnetic field on the axis current carrying circular coil,

$B = \frac{\mu_0 I r^2 n}{2\left(x^2 + r^2\right)^{3/2}}$

where, I = current in the coil,

n = number of turns,

r = radius of coil.

and x = distance of the point of observation from centre of coil.

Here, x = $\sqrt{3}r$

$\therefore\ B = \frac{\mu_0 I r^2 n}{2\left[\left(\sqrt{3}r\right)^2 + r^2\right]^{3/2}} = \frac{\mu_0 I r^2 n}{2\left[3r^2 + r^2\right]^{3/2}}$

$= \frac{\mu_0 I r^2 n}{2(4r^2)^{3/2}} = \frac{\mu_0 I r^2 n}{2[(2r)^2]^{3/2}} = \frac{\mu_0 I r^2 n}{2 \times 8r^3} = \frac{\mu_0 n I}{16r}$

Q55 Text Solution:

Given,

P = 100 W

V = 220 V

We know that, $P = \frac{V^2}{R}$

where, R is resistance of bulb.

$\Rightarrow R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\Omega$

Now, according to question, voltage drops by 2.5% of its rated value.

New voltage, V' = 220 - 2.5% of 220

$= 220 - \frac{2.5}{100} \times 220 = 214.5 \text{ V}$

New power,

$P' = \frac{(V')^2}{R} = \frac{214.5 \times 214.5}{484} = 95.06 \text{ W}$

% decrease in power $= \frac{P-P'}{P} \times 100$

$= \frac{100-95.06}{100} \times 100 \simeq 5\%$

Q56 Text Solution:

Given, number of turns in the solenoid,

N = 500

Current, I = 2A

Magnetic flux, $\phi = 4 \times 10^{-3}$ Wb

Self-inductance of coil,

$L = \frac{N\phi}{I} = \frac{500 \times 4 \times 10^{-3}}{2} = 1\text{H}$

Q57 Text Solution:

In LC-oscillation, maximum stored energy in inductor coil L is $\frac{1}{2} L I_0^2$ and maximum stored energy in capacitor (C) is $\frac{q_0^2}{2C}$.

Since, energy is equally divided in L and C. Hence, total stored energy $E = \frac{1}{2} \times$ maximum stored energy in either L or C

$\Rightarrow \frac{1}{2} L I^2 = \frac{1}{2} \times \frac{1}{2} L I_0^2 \Rightarrow I^2 = \left(\frac{I_0}{\sqrt{2}}\right)^2$

$\Rightarrow I = \frac{I_0}{\sqrt{2}}$

We know that, $I = I_0 \sin \omega t$

$\Rightarrow \frac{I_0}{\sqrt{2}} = I_0 \sin\omega t \Rightarrow \sin\frac{\pi}{4} = \sin\frac{2\pi}{T} \cdot t$

$\Rightarrow \frac{\pi}{4} = \frac{2\pi}{T} \cdot t \Rightarrow t = \frac{T}{8} = \frac{2\pi\sqrt{LC}}{8} = \frac{\pi\sqrt{LC}}{4}$

Q58 Text Solution:

Given, magnetic flux density,

$B = 1 \text{ Wb/m}^2$

Number of turns, N = 80

Area of coil, A=0.01m^2

$\Delta t = 0.2$ s

According to Faraday's law of electromagnetic induction, induced emf

$|e| = \frac{N\Delta\phi}{\Delta t} = N \cdot \frac{BA}{\Delta t} \; [\because \Delta\phi = BA]$

$= \frac{80 \times 1 \times 0.01}{0.2} = 4 \text{ V}$

Q59 Text Solution:

Equation of alternating current,

$i = i_1 \sin\omega t + i_2 \cos\omega t$

Let $i_1 = I\cos\phi$

and $i = I\sin\phi$

$i = I cos\phi sin\omega t + I sin\phi cos\omega t \#(ii)$

$\Rightarrow \; i = I\sin(\omega t + \phi)$

rms value of i_1,

$i_{\text{rms}} = \frac{I}{\sqrt{2}} \quad (iii)$

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

$i_1^2 + i_2^2 = I^2\cos^2\phi + I^2\sin^2\phi$

$= I^2(\cos^2\phi + \sin^2\phi) = I^2$

$\Rightarrow \sqrt{i_1^2 + i_2^2} = I \qquad (iv)$

From Eqs. (iii) and (iv), we get

$i_{\text{rms}} = \sqrt{\frac{i_1^2+i_2^2}{2}}$

Q60 Text Solution:

The intensity of cosmic rays stream of charged particles is move at the poles than at the equator because the Earth's magnetism is strongest at poles. Therefore, cosmic rays are deflected away from the equator. In order to reach at equator, they need to pass greater kinetic energy which shows that the Earth has a magnetic field.