ISC 2026 EXAMINATION
Sample Question Paper - 2
Physics

Time Allowed: 3 hours and 15 minutes   **Maximum Marks: 70**

General Instructions:

- You are allowed an additional 1 5 minutes for only reading the question paper.
- You must NOT start writing during reading time.
- This question paper has 20 questions.
- The paper has four sections: A, B, C and D. Internal choices have been provided in two questions each in Sections B, C and D.
- Section A consists of one question having fourteen sub-parts of one mark each.
- Section B consists of seven questions of two marks each.
- Section C consists of nine questions of three marks each.
- Section D consists of three questions of five marks each.
- Answer all questions.
- The intended marks for questions are given in brackets [].
- A list of useful constants and relations is given at the end of this paper.
- A simple scientific calculator without a programmable memory may be used for calculations.

Section A

1. **Answer the following questions:**   **[14]**

    (a) **In questions (i) to (vii) below, choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:**

    i. With reference to the free electron theory of conductors, Drift velocity is   **[1]**

        a) The velocity of free electrons with which they move towards the positive terminal.
        b) The speed of free electrons with which they move towards the negative terminal.

        c) The average velocity of free electrons with which they move towards the positive terminal.
        d) The average speed of free electrons with which they move towards the negative terminal.

    ii. A magnetic dipole moment is a vector quantity directed from   **[1]**

        a) East to West direction
        b) West to East direction

        c) South to North pole
        d) North to South pole

    iii. A plane electromagnetic wave of frequency 30 MHz travels in free space along x-direction. The electric field component of the wave at a particular point of space and time E = 6 Vm^{-1} along y-direction. Its magnetic field component B at this point would be **[1]**

a) 6×10^{-8} T along z-direction b) 2×10^{-8} T along y-direction

c) 6×10^{-8} T along x-direction d) 2×10^{-8} T along z-direction

iv. A generator produces a voltage given by V = 240 sin 120t, where t is in seconds. **[1]** The frequency and r.m.s. voltage are

   a) 60Hz, 120 V b) 120Hz, 60V

   c) 19Hz, $\frac{240}{\sqrt{2}}$ V d) 19Hz, $\frac{240}{\sqrt{3}}$ V

v. For the flow of electrons in a vacuum tube, vacuum is required, because **[1]**

   a) electrons may lose their energy on collision with air molecules in their path b) electrons are not ejected from cathode

   c) vacuum helps in extracting electrons from remaining gas molecules or atoms d) in vacuum work function of cathode is reduced

vi. The current flowing through a long solenoid is varied. Then, magnetic flux density **[1]** of the magnetic field inside it varies

   a) directly with I b) inversely with I^2

   c) directly with I^2 d) inversely with I

vii. The electric flux emanating from a sphere of radius 2 m is ϕ. If radius of the **[1]** sphere be made four times, without changing the charge enclosed, electric flux would

   a) Become $\left(\frac{2}{\phi}\right)$ b) Become $\left(\frac{\phi}{4}\right)$

   c) Become $\left(\frac{\phi}{2}\right)$ d) Become (ϕ)

(b) **Answer the following questions briefly:**

   i. State one condition for obtaining a sustained interference of light. **[1]**
   ii. Why atoms in a crystal are used as diffracting object for X-rays? **[1]**
   iii. A wire of length 0.3 m moves with a speed of 20 m/s perpendicular to the **[1]** magnetic field of induction 1 Wb/m^2. Calculate the induced emf.
   iv. Two point charges of 10 C each are kept at a distance of 3 m in a vacuum. **[1]** Calculate their electrostatic potential energy.
   v. Draw the graph between total number of α-particles scattered at different angles. **[1]**
   vi. Define the angular magnification of an optical instrument. **[1]**
   vii. Name a material which is used in making control rods in a nuclear reactor. **[1]**

Section B

2. If the solenoid is treated as a magnet of moment (= 0.6 J/T) is free to turn about the vertical **[2]** direction and a uniform horizontal magnetic field of 0.25 T is applied, what is the magnitude of torque on the solenoid when its axis makes an angle of 30^0 with the direction of applied field?

OR

A closely wound solenoid of 800 turns and area of cross-section 2.5×10^{-4} m^2 carries a current of 3.0

A. If it can be treated as a bar magnet, then find its magnetic moment.

3.   i. About 5% of the power of a 100 W light bulb is connected to visible radiation. What is the average intensity of visible radiation at **[2]**

   ii. distance of 1 m from the bulb

  iii. distance of 10 m? Assume that the radiation is emitted isotropically and neglect reflection.

4. When emf e = 300 sin $(100\pi t + \frac{\pi}{6})$V is applied to a circuit, the current I through it is I = 5.0 sin $(100\pi t - \frac{\pi}{6})$ A. Then, find the average power consumed by the circuit. **[2]**

<div align="center">OR</div>

A light bulb is rated 100 W for 220 V AC supply of 50 Hz. Calculate

  i. resistance of the bulb

  ii. the rms current through the bulb.

5. Draw a circuit diagram of n-p-n transistor amplifier in CE configuration. Under what conditions does the transistor act as an amplifier? **[2]**

6. A rectangular coil of area 2 × 10⁻⁴ m² and 40 turns is pivoted about one of its vertical sides. The coil is in a radial horizontal field of 60 G. What is the torsional constant of the hair springs connected to the coil, if a current of 4.0 mA produces an angular deflection of 16°? **[2]**

7. In the given statement, point out the correct or incorrect word or phrase with a proper explanation. The mutual forces between two charges do not get affected by the presence of other charges. **[2]**

8. Write the truth table for the circuit shown in the figure below. Name the gate that the circuit resembles. **[2]**

<div align="center">
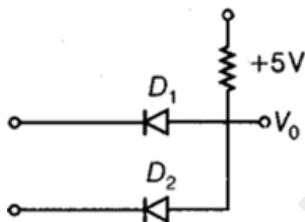
Section C

</div>

9. An X-ray tube is operated at a tube potential of 40,000 V. Calculate: **[3]**

  i. Kinetic energy of an electron emitted by the filament when it reaches the target/anode.

  ii. Wavelengths of all the X-rays emitted by the X-ray tube.

10. Figure shows a rectangular conducting loop PQRS in which arm RS of length l is movable. The loop is kept in a uniform magnetic field B directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed v. **[3]**
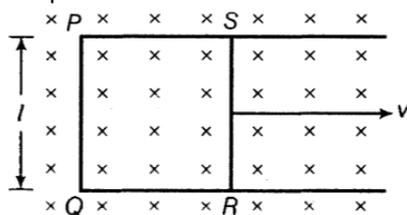
Deduce the expression for

  i. the emf induced across the arm RS

  ii. the external force required to move the arm and

  iii. the power dissipated as heat.

With the help of a neatly drawn labelled diagram, prove that the magnitude of motional emf **e** is given by e = Blv, where **l** is the length of a metallic rod and **v** is the velocity with which it is pulled in a transverse magnetic field **B**.

11. A parallel plate air capacitor has a capacitance of 5 μF. It becomes 50 μF when a dielectric medium occupies the entire space between its two plates. What is the dielectric constant of the medium? **[3]**

12. A 1000 MW fission reactor consumes half of its fuel in 5 yr. How much $^{235}_{92}\text{U}$ did it contain initially? Assume that the reactor operates 80% of the time that all the energy generated arises from the fission of $^{235}_{92}\text{U}$ and that this nuclide is consumed only by the fission process. **[3]**

OR

i. What is the nuclear density of $^{228}_{90}\text{Th}$?

ii. Is the nuclear density of an α-particle $\left(^{4}_{2}\text{He}\right)$ to be greater than, less than or equal to $^{228}_{90}$ Th? Explain.

iii. Determine the nuclear density of an α-particle.

13. Minimum deviation suffered by violet, yellow and red beams passing through an equilateral transparent prism are 39.2º, 38.7º and 38.4º, respectively. Calculate the dispersive power in the medium. **[3]**

14. Write one balanced equation each to show: **[3]**

i. Nuclear fission

ii. Nuclear fusion

iii. Emission of β- (i.e., a negative beta particle)

15. In a potentiometer arrangement, a cell of emf 2.25 V gives a balance point at 30 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 60 cm, what is the emf of the second cell? **[3]**

16. Three identical specimens of a magnetic material, nickel, antimony, aluminium are kept in a non-uniform magnetic field. Draw the modification in the field lines in each case. Justify your answer. **[3]**

17. Suppose that the electric field part of an electromagnetic wave in vacuum is E = [3.1 cos {1.8 y + (5.4 x 10^{6}t)}] $\hat{\mathbf{i}}$ **[3]**

i. What is the direction of propagation?

ii. What is the wavelength λ?

iii. What is the frequency v?

iv. What is the amplitude of the magnetic field part of the wave?

v. Write an expression for the magnetic field part of the wave.

Section D

18. i. Find the value of the phase difference between the current and the voltage in the series L-C-R circuit shown below. Which one leads in phase, current or voltage? **[5]**

L=100 mH C=2 μF R=400 Ω

V=V$_0$ sin (1000 t + φ)
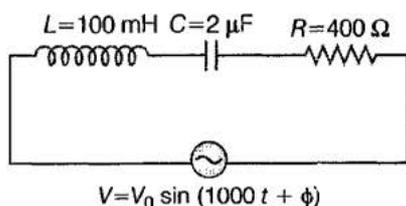
ii. Without making any other change, find the value of the additional capacitor C', to be connected in parallel with the capacitor C, in order to make the power factor of the circuit unity.

OR

i. A coil having self-inductance of 0.7 H and resistance of 165 Ω is connected to an a.c. source of 275 V, 50 Hz. if $\pi = \frac{22}{7}$. then Calculate:

a. Reactance of the coil

b. Impedance of the coil

c. Current flowing through the coil.

ii. Draw a labelled graph showing variation of impedance of a series L-C-R circuit with frequency of the AC supply.

19. In Young's double slit experiment, the two slits 0.15 mm apart are illuminated by monochromatic **[5]** light of wavelength 450 nm. The screen is 1 m away from the slits. Find the distance of the second

i. bright fringe.

ii. dark fringe from the central maxima

OR

In a double slit experiment using light of wavelength 600 nm, the angular width of the fringe formed on a distant screen is $0.1°$. Find the spacing between the two slits.

20.   i. Explain giving reasons, the basic difference in converting a galvanometer into **[5]**

a. a voltmeter.

b. an ammeter.

ii. Two long straight parallel conductors carrying steady currents I_1 and I_2 are separated by a distance d. Explain briefly, with the help of a suitable diagram, how the magnetic field due to one conductor acts on the other. Hence, deduce the expression for the force acting between the two conductors. Mention the nature of this force.

Solution

Section A

1. Answer the following questions:

    (a) In questions (i) to (vii) below, choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

        i.   **(c)** The average velocity of free electrons with which they move towards the positive terminal.

        Explanation:

        Drift velocity is defined as the average velocity with which free electrons in a conductor drifts in a direction opposite to the direction of the applied electric field i.e. towards the positive terminal.

        ii.   **(c)** South to North pole

        Explanation:

        Magnetic dipole moment vector is directed from the South pole to the North pole of a bar magnet.

        iii.   **(d)** 2×10^{-8} T along z-direction

        Explanation:

        The frequency of electromagnetic wave along x-direction, i.e. v = 30 MHz
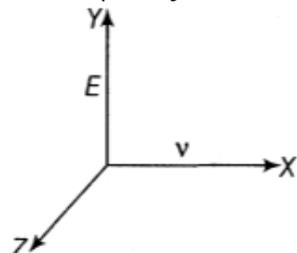
        The electric field component of the wave along y-direction. i.e $E = 6 \text{ Vm}^{-1}$

        In electromagnetic, the ratio of the amplitude of electric and magnetic field is always constant and it is equal to velocity of the electromagnetic waves.

        i.e. $\frac{E}{B} = c$

        $\Rightarrow B = \frac{E}{c} = \frac{6}{3 \times 10^8}$ = 2×10^{-8} T

        Magnetic field of component B is 2×10^{-8} T along z-direction.

        iv.   **(c)** 19Hz, $\frac{240}{\sqrt{2}}$ V

        Explanation:

        frequency = $\frac{\omega}{2\pi}$ = $\frac{120}{(2 \times 3.14)}$ = 19 Hz

        V_{rms} = $\frac{240}{\sqrt{2}}$ V

        v.   **(a)** electrons may lose their energy on collision with air molecules in their path

        Explanation:

        In a vacuum tube, the electrons are supplied by a heated cathode and the controlled flow of these electrons in vacuum is obtained by varying the voltage between its different electrodes.

        Vacuum is required in the inter-electrode space; otherwise the moving electrons may lose their energy on collision with the air molecules in their path.

        vi.   **(a)** directly with I

        Explanation:

        $B = \mu_0 n I$

        vii.   **(d)** Become (ϕ)

        Explanation:

From Gauss Theorem,

$$\phi = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

When radius becomes 4 times, the charge enclosed remains same. So,

$$\phi' = \phi$$

(b) Answer the following questions briefly:

    i. For sustained interference of light, the two interfering sources must be coherent.

    ii. The atomic separation in a crystal is of the order of wavelength of X-ray.
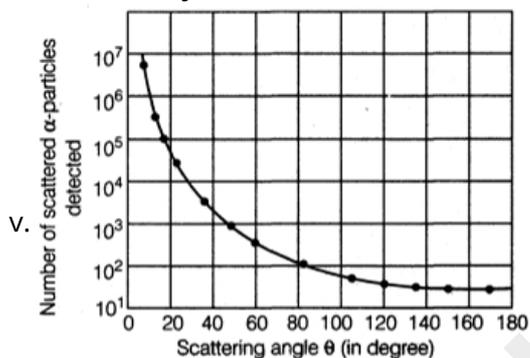
    iii. Given, velocity, v = 20 m/s

        Length, l = 0.3 m, Angle, θ = 90°

        Magnetic field, B = 1 Wb/m^2

        As, induced emf, e = Blv

        $\therefore$ e = 1 $\times$ 0.3 $\times$ 20 = 6V

    iv. $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r} = \frac{9 \times 10^9 \times 10 \times 10}{3}$ J

       = 3 $\times$ 10^{11} J

    v.

Experimental data points (shown by dots) on
scattering of α-particles by a thin foil at
different angles

    vi. Angular magnification of an optical instrument is defined as the ratio of the visual angle subtended by the image formed by the instrument at the eye to the visual angle subtended by the object at an unaided eye, i.e., m = $\frac{\beta}{\alpha}$

    vii. Cadmium, Boron, Silver and Indium.

Section B

2. Given, magnetic field, B = 0.25 T

Angle between magnetic moment and the magnetic field, θ = 30°
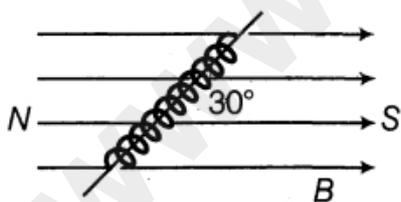
Magnetic moment, M = 0.6 J/T

Torque acting on the solenoid, when it is placed at an angle θ with the magnetic field.

τ = MB sin 0= 0.6 $\times$ 0.25 sin 30°

= 0.6 $\times$ 0.25 $\times$ $\frac{1}{2}$ = 0.075 N-m

Thus the magnitude of torque on the solenoid is 0.075 N-m.

<div align="center">OR</div>

Given, number of turns, n = 800

rea of cross-section of solenoid, A = 2.5 $\times$ 10^{-4} m^2

Current through solenoid, I =3 A

Magnetic moment of bar magnet,

M = nIA = 800 $\times$ 3 $\times$ 2.5 $\times$ 10^{-4} = 0.6 J/T along the axis of the solenoid.

3. i. $\therefore$ Intensity, I = = $\dfrac{\text{Power of visible light}}{\text{Area}}$

   == $\dfrac{100 \times \left(\frac{5}{100}\right)}{4\pi(1)^2} = 0.4\ \text{W/m}^2$

   ii. $I = \dfrac{100 \times \left(\frac{5}{100}\right)}{4\pi(10)^2}$ = 4 $\times$ 10^{-3} W/m^2

4. Given, I = $5\sin\left(100\pi t - \frac{\pi}{6}\right)$

   e = $300\sin\left(100\pi t - \frac{\pi}{6}\right)$

   We know that, average power consumed,

   P$_{av}$ = E$_{rms}$ I$_{rms}$ cos ϕ = $\dfrac{E_0}{\sqrt{2}} \times \dfrac{I_0}{\sqrt{2}}$ cos ϕ

   where, E$_0$ = peak emf = 300 V

   I$_0$ = peak current = 5 A

   cos ϕ = power factor = cos 60° = $\frac{1}{2}$ $\left[\because \phi = \phi_1 - \phi_2 = \frac{\pi}{6} + \frac{\pi}{6} = \frac{\pi}{3}\ \right]$

   $\therefore P_{\text{av}} = \dfrac{300}{\sqrt{2}} \times \dfrac{50}{\sqrt{2}} \times \dfrac{1}{2}$ = 3750 W

   OR

   i. Power, P = EI $\Rightarrow$ P = E $\times \dfrac{E}{R}$ $[\because$ I = $\frac{E}{R}]$

   $\Rightarrow$ R = $\dfrac{E^2}{P}$ = $\dfrac{(220)^2}{100}$ = $\dfrac{48400}{100}$ = 484 Ω

   ii. The peak voltage of the source is E$_{rms}$ = $\dfrac{E_0}{\sqrt{2}}$

   $\Rightarrow$ E$_0$ = E$_{rms}$ $\times \sqrt{2}$

   = $200\sqrt{2}$ = 311.13 V

   $\therefore$ Irms = $\dfrac{I_0}{\sqrt{2}} = \dfrac{E_0}{R\sqrt{2}}$

   = $\dfrac{311.13}{484\sqrt{2}}$ = 0.45A

5.
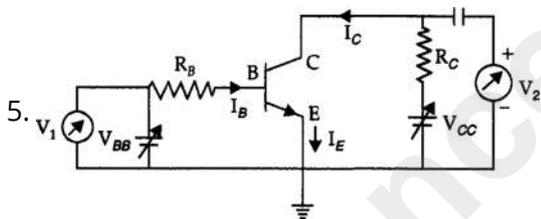
   Condition: The transistor must be operated dose to the centre of its active region.

   Alternatively: The base-emitter junction of the transistor must be (suitably) forward biased and the collector emitter junction must be (suitably) reverse biased.

6. Here, B = 60 G, A = 2 $\times$ 10^{-4} m^2, N = 40

   I = 4 mA = 4 $\times$ 10^{-3} A, θ = 16°

   $\because$ I = $\dfrac{k}{NBA} \theta$

   $\Rightarrow$ k = $\dfrac{NBAI}{\theta}$

   = $\dfrac{40 \times 60 \times 2 \times 10^{-4} \times 4 \times 10^{-3}}{16}$

   = 1.2 $\times$ 10^{-4} N-m per degree

7. Correct, because mutual force acting between two point charges is proportional to the product of magnitude of charges and inversely proportional to the square of the distance between them, i.e. independent of the other charges.

8. The circuit resembles AND gate. The Boolean expression of this circuit is V0 = A $\cdot$ B, i.e. V_0 equals A AND B. The truth table of this gate is as given below

A	B	$V_0 = A \cdot B$
0	0	0
0	1	0

1	0	0
1	1	1

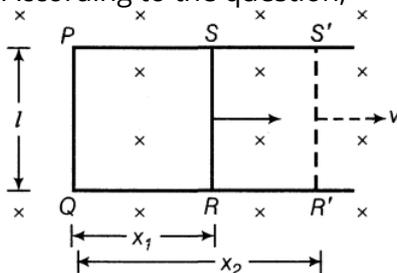**Section C**

9. i. Given, V = 40,000 V

    We know, KE = eV

    = $1.6 \times 10^{-19} \times 40,000$

    = 6.4×10^{-15} J.

    ii. We know $\lambda_{\min} = \frac{hc}{eV}$

    = $\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 40000}$

    = $\frac{1.98 \times 10^{-25}}{1.6 \times 10^{-19} \times 40000}$

    = 309×10^{-11}

    = $0.0309 \overset{o}{A}$

    Range $\rightarrow 0.0309 \overset{o}{A}$ to ∞.

10. According to the question,

    i. Let RS moves with speed v rightward and also RS is at distances x_1 and x_2 from PQ at instants t_1 at t_2, respectively.

    $\therefore$ At t_1, flux linked with loop 1, i.e. PQRS, ϕ_1 = B(lx_1)

    Similarly, at instant t_2, flux linked with loop 2, i.e. PQR'S',

    ϕ_2 = B(lx_2)

    $\therefore$ Change in flux, $\Delta\phi = \phi_2 - \phi_1$ = Bl(x_2 - x_1) = $Bl\Delta x$

    $\Rightarrow \frac{\Delta\phi}{\Delta t} = Bl\frac{\Delta x}{\Delta t} = Blv$ [$\because v = \frac{\Delta x}{\Delta t}$]

    By Faraday's law, magnitude of induced emf, e = vBl.

    ii. If resistance of loop is R, then $I = \frac{vBl}{R}$

    $\therefore$ Magnetic force = IBl sin 90° = $\left(\frac{vBl}{R}\right) Bl = \frac{vB^2l^2}{R}$ [$\because$ sin90° = 1]

    $\therefore$ External force must be equal to magnetic force and in opposite directions.
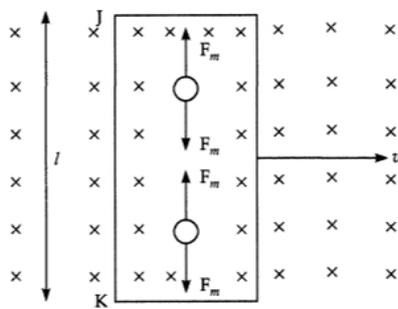
    $\therefore$ External force = $\frac{vB^2l^2}{R}$

    iii. As, P = I²R $\left(\frac{vBl}{R}\right)^2 \times R = \frac{v^2B^2l^2}{R^2} \times R$

    $\therefore P = \frac{v^2B^2l^2}{R}$

    OR

    Let a conducting rod of length l is taken in the magnetic field $\perp$ to the plane of the paper directed downward. As the rod is moving, so, charge contained inside is also moving. So, force acting on the electrons inside the rod is given by F_m = qvB Due to the magnetic force electrons move towards the end K.

Due to the drift of electrons to the end K, the end J becomes positively charged and K becomes negatively charged.

Therefore, an electric field, the value of $\vec{E}$ is set up $E = \frac{e}{l}$ where e is the induced potential difference.

Electric force F_e = qE = $q\frac{e}{l}$

As more and more electrons drift $\vec{E}$ increases

$\therefore$ The force acting on the electron i.e.,

F_e increase, when $F_e = F_m$ further drifting of electron stops.

$\therefore F_e = F_m$

$q\frac{e}{l} = qvB$

e = Blv

11. Given, capacitance in air, C_0 = 5 μF

Capacitance with dielectric, C = 50 μF

$\therefore$ Dielectric constant, $K = \frac{C}{C_0} = \frac{50\mu\text{F}}{5\mu\text{F}} = 10$

12. Given, power of reactor, P = 1000 MW

We will use concept that the energy generated in one fission of $^{235}_{92}\text{U}$ is 200 MeV.

Number of $^{235}_{92}\text{U}$ atoms in $1\text{ g} = \frac{1}{235} \times 6.023 \times 10^{23}$

$\therefore$ Energy generated per gram of $^{235}_{92}\text{U}$

= ($\frac{1}{235} \times 6.023 \times 10^{23} \times 200 \times 1.6 \times 10^{-13}$)

Total energy generated in 5 yr with 80% of the time

= $1000 \times 10^6 \times 5 \times 365 \times 24 \times 60 \times 60 \times \frac{80}{100}$ [as E = Pt]

$\therefore$ Mass of $^{235}_{92}\text{U}$ consumed in 5 yr,

$m = \dfrac{\text{Total energy}}{\text{Energy consumed per gram}}$

$= \dfrac{1000 \times 10^6 \times 5 \times 365 \times 24 \times 60 \times 60 \times 0.8}{\left(\frac{1}{235}\right) \times 6.023 \times 10^{23} \times 200 \times 1.6 \times 10^{-13}}$

= 1.538 x 10^6 g

= 1538 kg

$\therefore$ Initial amount of $^{235}_{92}\text{U}$ = (1544 $\times$ 2) kg = 3088 kg

OR

i. We know that,

$\rho = \frac{3m}{4\pi R_0^3}$

$\therefore \rho = \dfrac{3 \times 1.6 \times 10^{-17}\text{ kg}}{4 \times 3.14 \times \left(1.2 \times 10^{-15}\right)^3}$
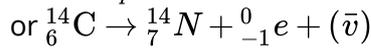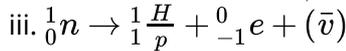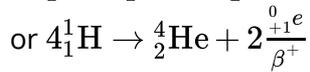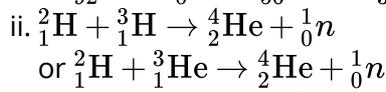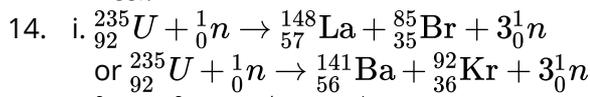
= 2.3 $\times$ 10^{17} kg/m^3

ii. Nuclear density (ρ) is independent of mass number, hence nuclear density of α-particle $\left(^4_2\text{He}\right)$ and thorium $\left(^{228}_{90}\text{Th}\right)$ is equal to each other.

iii. For α-particle, also nuclear density is equal to = 2.3 $\times$ 10^{17} kg/m^3, as nuclear density is independent of mass number.

13. ∴ Dispersive power $= \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{\left(\frac{\delta_v}{A}\right) - \left(\frac{\delta_r}{A}\right)}{\left(\frac{\delta_y}{A}\right)}$

$[\because \delta = (\mu - 1)A]$

$= \frac{39.2 - 38.4}{38.7} = 0.0204$

14. i. $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{148}_{57}\text{La} + ^{85}_{35}\text{Br} + 3^{1}_{0}n$

   or $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}\text{Ba} + ^{92}_{36}\text{Kr} + 3^{1}_{0}n$

   ii. $^{2}_{1}\text{H} + ^{3}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + ^{1}_{0}n$

   or $^{2}_{1}\text{H} + ^{3}_{1}\text{He} \rightarrow ^{4}_{2}\text{He} + ^{1}_{0}n$

   or $4^{1}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + 2\underset{\beta^+}{\overset{0}{{}_{+1}}e}$

   iii. $^{1}_{0}n \rightarrow ^{1}_{1}\frac{H}{p} + ^{0}_{-1}e + (\bar{v})$

   or $^{14}_{6}\text{C} \rightarrow ^{14}_{7}N + ^{0}_{-1}e + (\bar{v})$

15. Given, E_1 = 2.25 V , l_1 = 30 cm,

   l_2 = 60 cm, E_2 = ?

   As, we know that in case of potentiometer, the potential gradient remains constant.

   So, $E \propto l$

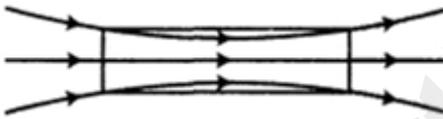 $\therefore \frac{E_1}{E_2} = \frac{l}{l_2}$ ...(i)
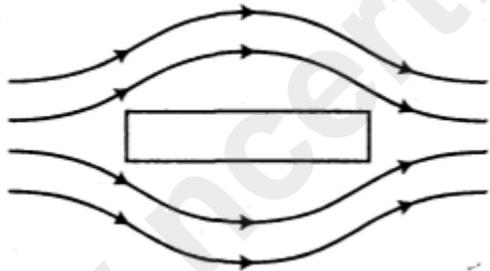
   Substituting the given values in Eq.(i), we get

   $\frac{2.25}{E_2} = \frac{30}{60}$
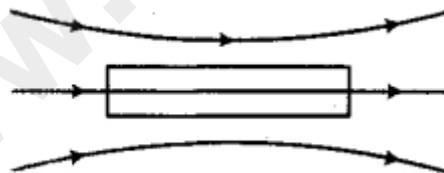
   $\therefore E_2 = \frac{2.25 \times 60}{30} = 4.5V$

16.

   The modification in the field lines shown in the figure are as such because

   i. nickel is a ferromagnetic substance.

   ii. antimony is a diamagnetic substance.

   iii. aluminium is a paramagnetic substance.

17. i. The given equation signifies that the electromagnetic wave is moving along Y-axis and also in negative direction, so it moves in - $\hat{\mathbf{j}}$ - direction.

   ii. The electric part of electromagnetic wave in vacuum,

   E = [3.1 cos {1.8 y + (5.4 × 10^{6}t)}] $\hat{\mathbf{i}}$

   Comparing with standard equation,

   E = E$_0$ cos (ky + ωt), we get

   Angular frequency, ω = 5.4 × 10^6 rad/s

   Wave number, k = 1.8 rad/m

   The amplitude of the electric field part of the wave,

E_0 = 3.1 N/C

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{1.8}$ = 3.491 m

$\Rightarrow \lambda$ = 3.5 m

iii. Angular frequency, $\omega = 2\pi v$

$v = \frac{\omega}{2\pi} = = \frac{5.4 \times 10^6 \times 7}{2 \times 22}$ = 0.86 × 10^6 Hz

iv. As, c = $\frac{E_0}{B_0}$

Amplitude of magnetic field,

$B_0 = \frac{E_0}{c} = \frac{3.1}{3 \times 10^8}$

= 1.03 × 10^{-8} T

v. Expression for the magnetic field part of wave,
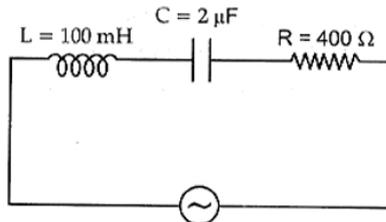
B = B_0 cos (ky + ωt)$\hat{\mathbf{k}}$

B = 1.03 × 10^{-8} cos (1.8 y + 5.4 × 10^6 t) $\hat{\mathbf{k}}$

Section D

18. i. $\omega = 1000$

$X_L = \omega L = 1000 \times 100 \times 10^{-3} \Omega$

$= 100\Omega$

C = 2 μF

L = 100 mH   R = 400 Ω

V = V$_0$ sin(1000 t + φ)

$X_C = \frac{1}{wc} = \frac{1}{2 \times 10^{-6} \times 1000}$

$= \frac{1000}{2} = 500\Omega$

$\cos\phi = \frac{R}{Z} = \frac{400}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{400}{400\sqrt{2}} = \frac{1}{\sqrt{2}}$

ϕ = 45°

ii. For unit power factor, cos ϕ) = 1

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

where, C' is the total capacitance.

$\Rightarrow R^2 + \left(\omega L - \frac{1}{\omega C''}\right)^2 = R^2 \Rightarrow \omega L = \frac{1}{\omega C''}$
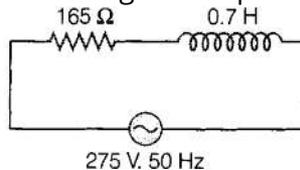
$\Rightarrow \omega L = 100 = \frac{1}{\omega C''}$

$\Rightarrow$ C" = $\frac{1}{10^5}$ = 10^{-5} = $10\mu F$

Additional capacitance C' required in parallel

C' = C" - C = 10μF - 2μF = 8μF

OR

i. According to the question,

165 Ω   0.7 H

275 V, 50 Hz

a. Reactance of the coil is ωL = X$_L$ = (2πfL)

$= 2 \times \frac{22}{7} \times 50 \times 0.7$

= 220 Ω

b. Impedance of the coil = $\sqrt{X_L^2 + R^2}$

$$= \sqrt{(\omega L)^2 + R^2}$$
$$= \sqrt{(2\pi \times 50 \times 0.7)^2 + (165)^2}$$
$$= \sqrt{(48400 + 27225)}$$
$$= \sqrt{(75625)} = 275$$

c. Current flowing through the coil, V = IR

$\Rightarrow I = \frac{V}{R}$ (where, R = resistance of circuit and V = voltage applied)

$\Rightarrow I = \frac{275}{275} \Rightarrow$ I = 1A
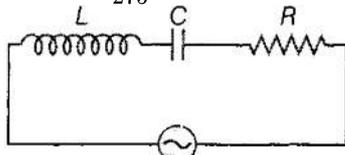
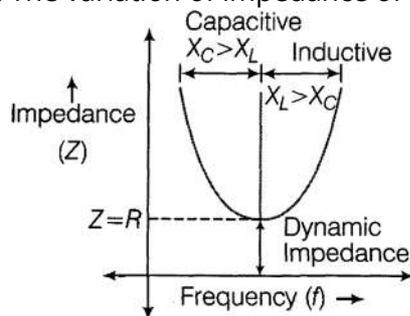
$$E = E_0 \sin \omega t$$

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

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

ii. The variation of impedance of a series L-C-R circuit with frequency of AC supply is given below.

19. i. The distance of nth order bright fringe from central fringe is given by

$y_n = \frac{nD\lambda}{d}$

For second bright fringe,

$y_2 = \frac{2D\lambda}{d}$

$= \frac{2 \times 1 \times 4.5 \times 10^{-7}}{1.5 \times 10^{-4}}$,

$y_2 = 6 \times 10^{-3}$ m

The distance of the second bright fringe

y_2 = 6 mm

ii. The distance of nth order dark fringe from central fringe is given by.

$y_n' = (2n - 1)\frac{D\lambda}{2d}$

For second dark fringe, $n = 2$

$y_n' = (2 \times 2 - 1)\frac{D\lambda}{2d} = \frac{3D\lambda}{2d}$

$\Rightarrow y_n' = \frac{3}{2} \times \frac{1 \times 4.5 \times 10^{-7}}{1.5 \times 10^{-4}}$

$= 4.5 \times 10^{-3}$ m

$\therefore$ The distance of the second dark fringe

$y_n' = 4.5$ mm

OR

Here, $\lambda = 600$ nm $= 600 \times 10^{-9}$ m $= 6 \times 10^{-7}$ m

$\Rightarrow 0.1^\circ = \frac{0.1\pi}{180}$ rad

From angular width, $\theta = \frac{\lambda}{d}$

$$\Rightarrow d = \frac{\lambda}{\theta}$$

$$= \frac{6 \times 10^{-7}}{\frac{\pi}{180} \times 0.1} = 3.44 \times 10^{-4} m$$

20. i. A galvanometer of range I_g and resistance G can be converted into

   a. a voltmeter of range V, by connecting a high resistance R in series with galvanometer whose value is given by

   $R = \frac{V}{I_g} - G$

   b. an ammeter of range I, by connecting a very low resistance (shunt) in parallel with galvanometer whose value is given by $S = \frac{I_g G}{I - I_g}$

   ii. The magnetic field, due to wire 1, at any point on the wire 2, is directed normal to the direction of current flow in wire 2.
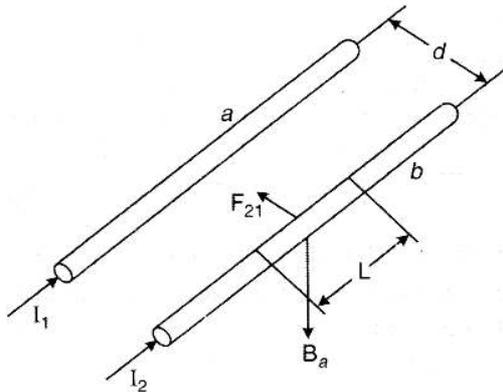
   Magnetic field around wire 2 due to a current I_1 in wire

   $B_a = \frac{\mu_0 I_1}{2\pi r}$

   Force upon conductor carrying current due to magnetic field

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

   $\therefore$ Force, F_{21} on a length l of wire 2 = $I_2 l \frac{\mu_0 I_1}{2\pi r}$

   $= \frac{\mu_0 I_1 I_2}{2\pi r} \cdot l$ Similarly,

   $F_{12} = \frac{\mu_0 I_1 I_2}{2\pi r} \cdot l$

   The nature of the force is repulsive for currents in opposite direction and attractive when currents flow in the same direction.