ISC 2026 EXAMINATION
Sample Question Paper - 1
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. When cell of e.m.f. E is connected with an external resistance R, the p.d. across   **[1]**
       the cell becomes V. The expression for the internal resistance of the cell is

       a) $\frac{E-V}{V} R$ b) $\frac{V-E}{V} R$

       c) $\frac{(V-E)R}{E}$ d) $\frac{V-E}{E} R$

    ii. When two bar magnets are brought close to each other?   **[1]**

        a) None of these   b) Only attractive force exists

        c) Depends on the alignment of   d) Only repulsive forces exists
           the two magnets

    iii. In vacuum, the physical property which remains the same for microwave of   **[1]**
        wavelength 1 mm and UV radiation 1600 $\overset{o}{A}$ is

        a) Wavelength   b) Distance

        c) Frequency   d) Speed

    iv. The function of brush in a generator is   **[1]**

<table>
<tr><td>a) to connect load to generated a.c. constant</td><td>b) to keep the frequency of generated a.c. constant</td></tr>
<tr><td>c) to connect load to the field magnet</td><td>d) to transfer the current from armature to load</td></tr>
</table>

v. If a solid transmits the visible light and has a low melting point, it possesses **[1]**

    a) convalent bonding   b) van der Waals bonding

    c) ionic bonding   d) metallic bonding

vi. When a charged particle is projected perpendicular to a uniform magnetic field, it describes a circular path in which: **[1]**

    a) its kinetic energy increases   b) its momentum remains constant

    c) its speed remains constant   d) its velocity remains constant

vii. The equipotential surfaces of a uniform electric field E are planes parallel to the YZ plane. **[1]**

What is the direction of the electric field E?

    a) The electric field is along z-axis.   b) The electric field is along y-axis.

    c) The electric field is along negative y-axis.   d) The electric field is along x-axis.

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

  i. Give an example of coherent sources of light. **[1]**

  ii. An increase in the filament current in an X-ray tube increases the intensity of X-ray produced. Why? **[1]**

  iii. When current flowing through one coil changes from 0 Amp to 15 Amp in 0.2 s, emf of 750 V is induced in an adjacent coil. Calculate the coefficient of mutual inductance of the two coils. **[1]**

  iv. What is the relation between potential difference and capacitance? **[1]**

  v. According to Bohr, **Angular momentum of an orbiting electron is quantised**. What is meant by this statement ? **[1]**

  vi. State any one advantage of using a reflecting telescope in place of a refracting telescope. **[1]**

  vii. Consider the following nuclear reaction, **[1]**
$$_{1}^{2}\text{H} + _{1}^{2}\text{H} \longrightarrow _{2}^{3}\text{He} + _{0}^{1}n$$
What is the name of this reaction?

Section B

2. At a certain place, a compass points 13° W of geographic North. If the dip at that place is 60° and magnetic field is 0.16 gauss, then find the earth's magnetic field at that place. **[2]**

OR

A closely wound solenoid of 2000 turns and area of cross-section 1.6×10^{-4} m^2, carrying a current of 4 A, is suspended through its centre allowing it to turn in a horizontal plane. If the solenoid is treated

as a magnet, then

   i. What is the magnetic moment associated with the solenoid?

   ii. What are the force and torque on the solenoid, if a uniform horizontal magnetic field of 7.5×10^{-2} T is set up at an angle of 30° with the axis of the solenoid?

3. The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is B_0 = **[2]** 510 nT. What is the amplitude of the electric field part of the wave?

4. Obtain the resonant frequency (ω_r) of a series L-C-R circuit with L = 2.0 H , C = $32\mu F$ and R =10Ω. **[2]** What is the Q-value of this circuit?

<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. Zener diodes have higher dopant densities as compared to an ordinary p-n junction. How does it **[2]** affect the width of the depletion layer and the junction field?

6. The electron in a H-atom circles around the proton with a speed of 2.18×10^6 ms^{-1} in an orbit of **[2]** radius 5.3×10^{-11} m.

Calculate

   i. the equivalent current.

   ii. magnetic field produced at the proton. Given, charge on electron is 1.6×10^{-19} C and $\mu_0 = 4\pi \times 10^{-7}$ T mA^{-1}.

7. Explain, why the following curves cannot possibly represent electrostatic field lines? **[2]**
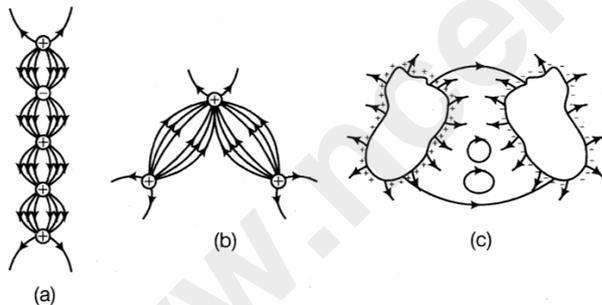
8. With reference to a semiconductor diode, explain the terms: **[2]**

   i. Depletion region

   ii. Potential barrier or barrier p.d.

<div align="center">**Section C**</div>

9. A proton and an electron have same de-Broglie wavelength. Which of them moves fast and which **[3]** possesses more kinetic energy? Justify your answer.

10. Figure below shows two thick metallic rails CD and GH kept parallel to each other 0.8 m apart. **[3]** They are joined to each other by a resistance wire R having a resistance of 5Ω. A thick metallic rod PQ rests on the rails. There is a uniform magnetic ield B = 0.2 T, which is perpendicular to the

plane of the rails, pointing into the paper.
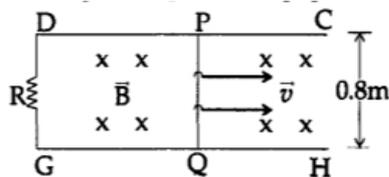
a. Calculate magnitude and direction of the current induced in the rod PQ if it is moved towards right with a constant velocity -36 km/hr.

b. The rod PQ is now made to perform simple harmonic motion with a frequency of 3Hz and an amplitude of 4 cm. Calculate the maximum value of the emf induced in the rod.

OR

i. Define the term **mutual-inductance** and write its SI unit.

ii. Obtain the expression for the mutual inductance of two long coaxial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2; and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.

11. In the circuit shown below, initially k_1 is closed and k_2 is opened, what are the charges on each of **[3]** the capacitors? Then k_1 was opened and k_2 was closed (order is important), what will be the charge on each capacitor now? [Given, $C = 1\mu\mathrm{F}$]
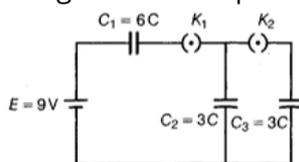

12. i. What is meant by the term activity of a radioactive substance? **[3]**

ii. A radioactive sample has a half-life of 1.4×10^{16} s and a mass number of 238. Calculate the number of disintegration of 1 g of this sample.

OR

A radioactive isotope has a half-life of T year. How long will it take the activity to reduce to

i. 3.125 % and

ii. 1 % of its original value?

13. With the help of a ray diagram obtain the expression for the magnifying power of a simple **[3]** microscope when the image is formed at least distance of distinct vision.

14. A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separate **[3]** all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of $^{63}_{29}\mathrm{Cu}$ atoms (of mass 62.92960 u).

15. i. What is meant by: **[3]**

a. Drift velocity and

b. Relaxation time

ii. A metallic plug AB is carrying a current I as shown in the figure below. State how the drift velocity of free electrons varies, if at all, from end A to end B
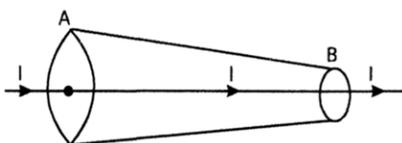
16. Derive an expression for the magnetic moment $(\vec{\mu})$ of an electron revolving around the nucleus **[3]** in terms of its angular momentum $(\vec{l})$. What is the direction of the magnetic moment of the electron with respect to its angular momentum?

17. The terminology of different parts of the electromagnetic spectrum is given in the text. Use the **[3]** formula E = hv (for energy of a quantum of radiation: photon) and obtain the photon energy in units of eV for different parts of the electromagnetic spectrum. In what way are the different scales of photon energies that you obtain related to the sources of electromagnetic radiation?

Section D

18. A resistor of 400 Q, an inductor of $\frac{5}{\pi}$ H and a capacitor of $\frac{50}{\pi} \mu F$ are connected m series across n a **[5]** source of alternating voltage of 140 sin$100\pi t$ V. Find the voltage (rms) across the resistor, the inductor and the capacitor. Is the algebraic sum of these voltage more than the source voltage? If yes, resolve the paradox.

OR

An AC generator generating an emf of ε = 300 sin($100\pi t$)V is connected to a series combination of 16 μF capacitor, 1H inductor and 100Ω resistor. Calculate

   i. impedance of the circuit at the given frequency.

   ii. resonant frequency f_0.

   iii. power factor at resonant frequency f_0.

19. In Young's double slit experiment using monochromatic light L_1 of wavelength 700 nm, 10th **[5]** bright fringe was obtained at a certain point P on a screen.
   Which bright fringe will be obtained at the same point P, if monochromatic light of wavelength 500 nm is used in place of L_1. (No other alterations were made in the experimental set up.)

OR

A beam of light, consisting of two wavelengths 560 nm and 420 nm, is used to obtain interference fringes in a Young's double slit experiment. Find the least distance from the central maxima, where the bright fringes due to both the wavelengths coincide. The distance between the two slits is 4 mm and the screen is at a distance of 1m from the slits.

20. Explain using a labelled diagram, the principle and working of a moving coil galvanometer. What **[5]** is the function of

   i. uniform radial magnetic field?

   ii. soft iron core? Also, define the terms.

   iii. current sensitivity?

   iv. voltage sensitivity of a galvanometer? Why does increasing the current sensitivity not necessarily increase voltage sensitivity?

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.   **(a)** $\frac{E-V}{V}R$

      Explanation:

      : Current in the circuit = I = V/R

      If r = internal resistance of the cell, then

      V = E - Ir

      $\therefore r = \frac{E-V}{I} = \frac{E-V}{\frac{V}{R}} = \frac{E-V}{V}R$

   ii.   **(a)** None of these

      Explanation:

      Attraction or repulsion of a bar magnet depends upon the alignment of the bar magnet when similar poles are aligned together, repulsion occurs when dissimilar poles are aligned together, attraction occurs.

   iii.   **(d)** Speed

      Explanation:

      All types of electromagnetic waves travel with the speed of light in vacuum.

   iv.   **(d)** to transfer the current from armature to load

      Explanation:

      A brush is an electrical contact which conducts current from the rotating armature to static load.

   v.   **(b)** van der Waals bonding

      Explanation:

      A van der Waals solid transmits light and has a low melting point.

   vi.   **(c)** its speed remains constant

      Explanation:

      Particle in circular motion maintains constant speed.

   vii.   **(d)** The electric field is along x-axis.

      Explanation:

      Equipotential surface is always perpendicular to the electric field.

(b) Answer the following questions briefly:

   i. The two illuminated slits in a Young's Double slit experiment is an example of coherent sources of light.

   ii. When we increase the intensity of filament current, the number of electrons striking the target increases therefore intensity of X-ray increases.

   iii. Change in current = 15 A

     Time = 0.2 s

     Induced emf = e = 750 V

     $e = M\frac{dI}{dt}$

     $750 = M \times \frac{15}{0.2}$

     $M = 750 \times \frac{0.2}{15}$ = 10 H

   iv. $V = \frac{Q}{C}$.

   v. Electron can revolve only in those orbits in which their angular momentum is an integral multiple of $\frac{h}{2\pi}$, where h is planck's constant. According to this postulate,

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

Where, n is the principal quantum number.

vi. Image is free from spherical aberration. or

Image is free from chromatic aberration. or

Image is brighter/sharper/easier to install/less distorted/better quality.

vii. The given reaction shows that two atoms are combining to form third atom and a neutron released from it. Thus, it is a nuclear fusion reaction.

Section B

2. The angle of declination is 13°. It specifies the vertical plane containing the magnetic field direction. If B_E be the earth's magnetic field and θ is the angle of dip, then the horizontal component of the earth's field is

$$B_H = B_E \cos\theta$$
$$\dot{B}_E = \frac{B_H}{\cos\theta}$$
$$= = \frac{0.16}{0.5} = 0.32 \text{ Gauss}$$

Thus, the earth's magnetic field B_E has a magnitude of 0.32 G and lies in a vertical plane 13° West of the geographic meridian, making an angle of 60° (upwards) with the horizontal (magnetic South to magnetic North direction).

OR

i. M = niA = 2000 × 4 × 1.6 × 10⁻⁴

M = 1.28 J/T

ii. torque = μ_m B sin θ

= 1.28 × 7.5 × 10⁻² × sin 30°

= 0.048 Nm²

3. Given, amplitude of the magnetic field part of harmonic electromagnetic wave,

B_0 = 510 nT = 510 × 10⁻⁹ T

Speed of light in vacuum, c = $\frac{E_0}{B_0}$

where, E_0 is the amplitude of electric field part of the wave.

$$\Rightarrow 3 \times 10^8 = \frac{E_0}{510 \times 10^{-9}}$$
$$\Rightarrow E_0 = 153 \text{ N/C}$$

Thus, the amplitude of the electric field part of wave is 153 N/C.

4. Given, L = 2.0 H, C = 32 × 10⁻⁶ F and R = 10Ω

$$\therefore \omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2.0 \times 32 \times 10^{-6}}} = \frac{10^3}{8} = 125 \text{rad/s}$$

and $Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{2}{32 \times 10^{-6}}}$

$= \frac{1}{10 \times 4 \times 10^{-3}}$ = 25

OR

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

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

ii. The peak voltage of the source is E_{rms} = $\frac{E_0}{\sqrt{2}}$

$\Rightarrow E_0 = E_{rms} \times \sqrt{2}$

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

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

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

5. The width of depletion region depends on the dopant density, i.e. higher the dopant density of charge carrier the lower the width of depletion region. So, in Zener diode due to the high concentration of

dopant charges, the depletion region decreases, therefore the junction field increases.

6. Here, $v = 2.18 \times 10^6$ m/s, $r = 5.3 \times 10^{-11}$ m

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

   i. Time period of revolution of electron is given by

   $T = \frac{2\pi r}{v}$

   $= \frac{2\pi \times 5.3 \times 10^{-11}}{2.18 \times 10^6}$

   $= 1.528 \times 10^{-16}$ s

   Equivalent current, $I = \frac{\text{Charge}}{\text{Time}} = \frac{e}{T}$

   $I = \frac{1.6 \times 10^{-19}}{1.528 \times 10^{-16}}$

   $\Rightarrow I = 1.05 \times 10^{-3}$ A

   ii. Field at proton due to orbiting electron is

   $B = \frac{\mu_0 I}{2r}$ or $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I}{r}$

   $B = \frac{10^{-7} \times 2\pi \times 1.05 \times 10^{-3}}{5.3 \times 10^{-11}}$

   $= 12.4$ T

7. a. Electrostatic field lines cannot start from a negative charge.

   b. Electrostatic field lines cannot end at positive charge.

   c. Electrostatic field lines cannot form closed loops.

8. i. **Depletion region:** In a p-n junction, this region is depleted from any free charge carriers. The only elements left in this region are immobile ions.

   ii. **Potential barrier:** The electric field formed in the depletion region acts as a barrier. Normally charge carriers cannot cross the barrier. External energy is to be applied to charge carriers to across the barrier. The potential difference required to cross the depletion region is known as barrier potential.

Section C

9. Kinetic energy of particle of mass m having momentum p is given by

   $K = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mK}$

   The de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$

   $\therefore p = \frac{h}{\lambda}$ ...(i)

   and $K = \frac{h^2}{2m\lambda^2}$ ...(ii)

   IF λ is constant, then from Eq. (i), we get

   p = constant, i.e. $m_p v_p = m_e v_e$

   or $\frac{v_p}{v_e} = \frac{m_e}{m_p} < 1$ or $v_p < v_e$

   $K \propto \frac{1}{m}$

   $\therefore \frac{K_p}{K_e} = \frac{m_e}{m_p} < 1$ or $K_p < K_e$.

   It means that the velocity of electron is greater than that of proton. Kinetic energy of electron is greater than that of proton.

10. a. emf induced, e = Blv

    $= 0.2 \times 0.8 \times \frac{36 \times 1000}{60 \times 60}$

    = 1.6 V

    Induced current, $i = \frac{1.6}{5}$ = 0.32 A in the direction QPDG.

    b. When PQ performs simple harmonic motion with a frequency of 3 Hz and an amplitude of 4 cm, then its linear speed is 24 cm/s = 0.24 m/s

    $\therefore$ Maximum value of induced emf, e = Blv

    $= 0.2 \times 0.8 \times 0.24$

    = 0.0384 V

    OR

i. Mutual inductance of two coils is equal to the emf induced in one coil when the rate of change of the current through the other coil is unity or it is equal to the amount of magnetic flux linked with one coil when unit current flow through the other coil.

If I is the current flowing through one coil and ϕ is the flux linked with other coil,

then $\phi \propto I$ or $\phi = MI$, where M is mutual inductance.

For unity current, that is, I = L, we get M = ϕ

The SI unit of mutual inductance is henry (H)

ii.
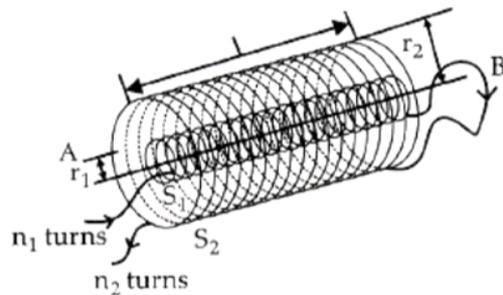
Let a current I_2 flow through the outer coil

The magnetic field due to this current = $\mu_0 \frac{N_2}{l} \times I_2$

The resulting magnetic flux linked with the inner coil

$= \phi_{12} = N_1 \left(\mu_0 \frac{N_2}{l} \times I_2 \right) \times \pi r_1^2$

$= \left(\mu_0 \frac{N_1 N_2}{l} \pi r_1^2 \right) I_2$

$= M_{12} I_2$

$M_{12} = \mu_0 \frac{N_1 N_2}{l} \cdot \pi r_1^2$

11. In the circuit, when initially K_1 is closed and K_1 is opened, the capacitor C_1 and C_2 acquire potential difference V_1 and V_2, respectively. So, we have

$V_1 + V_2 = E$

and $V_1 + V_2 = 9$ V

Also, in series combination, $V \propto \frac{1}{C}$

$V_1 : V_2 = \frac{1}{6} : \frac{1}{3}$

On solving,

$\Rightarrow V_1 = 3V$ and $V_2 = 6$ V

$\therefore Q1 = C_1 V_1 = 6 \ \mu C \times 3V$

$= 18 \ \mu C \ [\because c = 1 \ \mu F]$

$\Rightarrow Q_2 = C_2 V_2 = 3 \ \mu C \times 6 \ V = 18 \ \mu C$

and $Q_3 = 0$

When K_1 was opened and K_2 was closed, the parallel combination of C_2 and C_3 in series with C_1.

[Charge on C_1 remains unchanged]

i.e. $Q_1' = Q_2 = 18 \ \mu C$

Charge on C_2 is shared between C_2 and C_3 in parallel.

As, $C_2 = C_3$

$\therefore Q_2' = Q_2 = \frac{Q_2}{2} = \frac{18}{2} = 9 \mu C \ [\because Q_2 = 18 \ \mu C]$

12. i. The decay rate of a sample, rather than number of radioactive nuclei is more direct experimentally measurable quantity and is called activity. The rate of decay of a radioactive substance, R is given by

$R = -\frac{dN}{dt}$

ii. Given, $T_{\frac{1}{2}} = 1.4 \times 10^{16}$ s

Mass number, A = 238

Total number of atoms decaying in 1g of the sample,

$N = \frac{6.023 \times 10^{23}}{238}$

We know that,

$R \propto N \Rightarrow R = -\lambda N$

[where, λ = radioactive constant = $\frac{0.693}{T_{\frac{1}{2}}}$]

$R = -\frac{0.693}{1.4 \times 10^{16}} \times \frac{6.023 \times 10^{23}}{238}$

$= 1.25 \times 10^{54}$ per second

OR

i. Given, half-life, $T_{\frac{1}{2}}$ = T yr

Since, activity $\propto$ N

So, N = 3125 % of N_0

$\therefore \frac{N}{N_0} = \frac{3125}{100} = \frac{1}{32}$

We know that, $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\therefore \frac{1}{32} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^n$

or n = 5

So, time, $t = n \times T_{\frac{1}{2}} = 5T$

After 5 half-time period activity reduces to 3.125 % of initial activity.

ii. Given,

N = 1 % of N_0

$\therefore \frac{N}{N_0} = \frac{1}{100}$

According to law of radioactive decay,

$\therefore \frac{N}{N_0} = e^{-\lambda t}$

$\therefore \frac{1}{100} = e^{-\lambda t}$

Taking log on both sides, we get

$\log_e 1 - \log_e 100 = -\lambda t \log_e e$
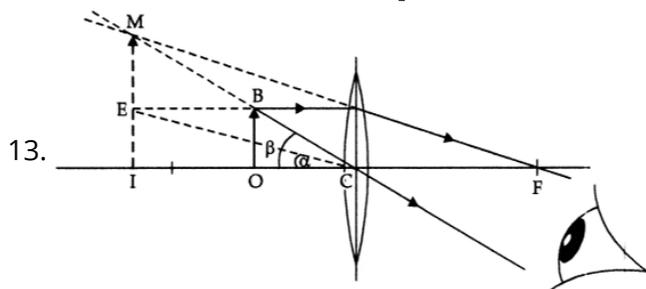
$\Rightarrow 0 - 2 \log_e 10 = -\lambda t$

$\Rightarrow -2 \times 2.303 \log_{10} 10 = -\lambda t$

$\Rightarrow -2.303 \times 2 = -\lambda t$

or t = $\frac{4.606}{\lambda}$

Also, we know that, $\lambda = \frac{0.693}{T_{\frac{1}{2}}}$

$\therefore t = \frac{4.606 T_{\frac{1}{2}}}{0693} = 665 T_{\frac{1}{2}}$

13.

β = angle subtended by the image (when it is at near point)

α = angle subtended by the object (when it is at near point)

Angular magnification = $\frac{\beta}{\alpha}$

In $\triangle$IMC, $\tan\beta = \frac{IM}{IC}$

In $\triangle$IEC, $\tan\alpha = \frac{IE}{IC}$

α and β being small,

$\beta = \frac{IM}{IC}$

$\alpha = \frac{IE}{IC}$

$\therefore$ Angular magnification $= \frac{IM}{IE} = \frac{IM}{OB}$

= Linear magnification

Applying lens formula,

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

Or, $1 - m = \frac{v}{f} = \frac{-d}{f}$

(m is magnification and v = -D)

$\therefore$ m = $1 + \frac{D}{f}$

14. Given, mass of coin = 3g

Atomic mass of Cu = 63

Mass of $^{63}_{29}\text{Cu}$, m = 62.92960 u

Avogadro's number = 6.023×10^{23}

Mass of proton, m_p = 1.007825 u

Mass of neutron, m_n = 1.008665 u

Nuclear energy required to separate neutrons and protons, E_b = ?

Since, each atom of copper contains 29 protons and 34 neutrons. Therefore, mass defect of each atom using the relation,

Δm = [Z m_p + (A - Z) m_n] - M

Δm = [29 $\times$ 1.007825 + 34 $\times$ 1.008665] - 6292960 = 0.591935 u

Number of atoms in 3 g coin $= \frac{6.023 \times 10^{23} \times 3}{63}$ = 2.868 $\times 10^{22}$

Total mass defect of all atoms,

$(\Delta$m$)_{total}$ = 0.591935 $\times$ 2.868 $\times 10^{22}$ = 1.6977 $\times 10^{22}$

The nuclear energy required (E_b) to separate all the neutrons and protons from each other and can be calculated by using the relation,

$E_b = (\Delta$m$) \times c^2 = (\Delta$m$) c^2 \times 931$MeV/c^2 [$\because$ 1 u = 931MeV]

= 1.6977 $\times 10^{22} \times$ 931 MeV

= 1.58 $\times 10^{25}$ MeV

15. i. a. The small average velocity of free electrons along the direction of positive potential is called the drift velocity.

   b. Relaxation Time: The time of free travel of a free electron between two successive collisions of electron with lattice ions/atoms is called the relaxation time.

   ii. In moving from A to B, the area of cross-section is decreasing. So, drift velocity increases as
   $v_d = \frac{I}{neA}$ or $v_d \propto \frac{1}{A}$

16. We have $\mu = lA$

$= \frac{e.v}{2\pi r} \cdot \pi r^2 = \frac{evr}{2}$

l = mvr

$vr = \frac{l}{m}$

$\vec{\mu} = \frac{-e\vec{l}}{2m}$

The direction of $\vec{\mu}$ is opposite to that of $\vec{l}$ because of the negative charge of the electron.

17. Given, energy of photon, E = hv

For γ-rays

Frequency of γ-rays, v = 3 $\times 10^{20}$ Hz

Energy of γ-rays, $E = h\nu = 6.6 \times 10^{-34} \times 3 \times 10^{20}$

$= 19.8 \times 10^{-14}$ J

$\Rightarrow E = \frac{19.8 \times 10^{-14}}{1.6 \times 10^{-19}}$ = 1.24×10^6 eV

The source of γ-rays is nuclear origin.

For X-rays

Frequency of X-rays, $\nu = 3 \times 10^{18}$ Hz

Energy of X-rays, $E = h\nu = 6.6 \times 10^{-34} \times 3 \times 10^{18}$

$= 19.8 \times 10^{-16}$ J

$\Rightarrow E = \frac{19.8 \times 10^{-16}}{1.6 \times 10^{-19}}$ = 1.24×10^4 eV

The retardation of high energy electron produces X-rays. Similarly, we can find for ultraviolet rays, visible rays, infrared rays, microwaves and radio waves.

They originate by oscillating current.

Types of radiation	Photon Energy
γ-rays	1.24×10^6 eV
X-rays	1.24×10^4 eV
Ultraviolet rays	4.12 eV
visible rays	2.475 eV
Infrared waves	4.125×10^{-2} eV
Microwaves	4.125×10^{-5} eV
Radio waves	1.24×10^{-6} eV

Section D

18. Given, applied voltage, $V = 140\sin100\pi t$ V

$C = \frac{50}{\pi}\mu F = \frac{50}{\pi} \times 10^{-6} F$,

$L = \frac{5}{\pi} H, R = 400\Omega$

Comparing with $V = V_0 \sin \omega t$, we get

$V_0 = 140$ V and $\omega = 100\pi$

Inductive reactance, $X_L = \omega L$

$= 100\pi \times \frac{5}{\pi} \times 500\Omega$

Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{100\pi \times \frac{50}{\pi} \times 10^{-6}}$ = 200Ω

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

$= \sqrt{(400)^2 + (500 - 200)^2}$

$= \sqrt{1600 + 900}$ = 500Ω

Maximum current in the circuit, $I_0 = \frac{V_0}{Z} = \frac{140}{500}$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{140}{500 \times \sqrt{2}}$ = 0.2A

V_{rms} across resistor, $V_R = I_{rms}R$

$= 0.2 \times 400 = 80$ V

V_{rms} across inductor, $V_L = I_{rms}X_L$

$= 0.2 \times 500 = 100$ V

V_{rms} across capacitor, $V_C = I_{rms}X_C$

$= 0.2 \times 500 = 40$ V

Now, $V \neq V_R + V_L + V_C$

Because V_C, V_L and V_R are not in same phase, instead

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

= $\sqrt{80^2 + (100 - 40)^2}$ = 100 V

Which is same as that of applied rms voltage.

OR

The equation of emf is given by

ε = 300sin(100πt)V

The standard equation of emf,

ε = ε_0 sinωt

$\therefore \omega$ = 100ωt

$2\pi f$ =100ωt [$\because \omega = 2\pi f$]

f = 50 Hz

  i. Impedance of the circuit (L-C-R),

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

$$= \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$$

$$= \sqrt{100^2 + \left(100\pi \times 1 - \frac{1}{100\pi \times 16 \times 10^{-6}}\right)^2}$$

$$= \sqrt{100^2 + (314 - 199)^2}$$

$$= \sqrt{100^2 + 115^2}$$

= 152.39 Ω

  ii. Resonant frequency,

$f_0 = \frac{1}{2\pi\sqrt{LC}}$

= $2\pi\sqrt{1 \times 16 \times 10^{-6}}$

$= \frac{1}{2\pi \times 4 \times 10^{-3}}$

= 39.8 Hz

 iii. Power factor, cos θ = $\frac{R}{Z}$

At resonant frequency, = R =Z

$\therefore$ cos θ = 1

19. According to the question, for the same arrangement of YDSE, the ratio of d/D remains constant.

$y_n = n\frac{D}{d}\lambda$

Given, $\lambda_1 = 700$ nm, $n_1 = 10th$ bright fringe,

$\lambda_2 = 500$ nm, $n_2 = ?$

We know that, $y = n\frac{D\lambda}{d}$

For the same point, x is constant and for same arrangement, then $\frac{d}{D}$ is constant.

$\Rightarrow n_1\lambda_1 = n_2\lambda_2$

$\Rightarrow 10 \times 700 = n_2 \times 500$

or $n_2 = \frac{10 \times 700}{500}$ = 14

OR

Given, distance between the screen and slit, D = 1 m

Slit width,

$d = 4 \times 10^{-3}$ m

$\lambda_1 = 560$ nm, $\lambda_2 = 420$ nm

Let nth order bright fringe of λ_1 coincides with (n + 1)th order bright fringe of λ_2.

$\therefore \frac{Dn\lambda_1}{d} = \frac{D(n+1)\lambda_2}{d} (\lambda_1 > \lambda_2)$

$\Rightarrow n\lambda_1 = (n+1)\lambda_2$

$\Rightarrow \frac{n+1}{n} = \frac{\lambda_1}{\lambda_2}$

$\therefore 1 + \frac{1}{n} = \frac{560 \times 10^{-9}}{420 \times 10^{-9}}$

$\Rightarrow 1 + \frac{1}{n} = \frac{4}{3}$

$\therefore n = 3$

$\therefore$ Least distance from the central fringe where bright fringe of two wavelengths coincides = distance of 3rd order bright fringe of λ_1

$\therefore y_n = \frac{3D\lambda_1}{d}$

$= \frac{3 \times 1 \times 560 \times 10^{-9}}{4 \times 10^{-3}}$

$= 0.42 \times 10^{-3}$m

$\therefore y_n = 0.42$ mm

3rd bright fringe of λ_1 and 4th bright fringe of λ_2 coincide at 0.42 mm from central fringe.

20. Principle and working of galvanometer

When current (I) is passed in the coil, torque τ acts on the coil,

given by τ = NIABsinθ

here θ is the angle between the normal to plane of coil and the magnetic field of strength B, N is the number of turns in a coil.

When the magnetic field is radial, as in the case of cylindrical pole pieces and soft iron core, then in every position of coil the plane of the coil, is parallel to the magnetic field lines, so that θ = 90° and sin 90° =1 Deflecting torque, τ = NIAB

If C is the torsional rigidity of the wire and θ is the twist of suspension strip, then restoring torque =Cθ

For equilibrium, deflecting torque = restoring torque

i.e. NIAB = Cθ

$\therefore \theta = \frac{NAB}{C}$ I ...(i)

i.e. $\theta \propto$ I

deflection of coil is directly proportional to current flowing in the coil and hence we can construct a linear scale.

i. **Cylindrical soft iron:** core which not only makes the field radial but also increases the strength of the magnet.

ii. **Radial magnetic field:** is a field in which coil of the galvanometer always remains parallel to the field even on large deflection.

iii. **Current sensitivity:** It can detect very small currents, down to a few microamperes. Current sensitivity: The deflection induced in the coil of a galvanometer per unit passage of electric current through it is known as current sensitivity.

iv. **Voltage sensitivity:** determines how much the galvanometer will undergo deflection when some potential difference is applied across its ends.

Current sensitivity does not depend upon resistance (R), whereas voltage sensitivity does, as evident from their expression. Current sensitivity can be increased by increasing the number of turns of the coil. However, this increases the resistance of the coil, since voltage sensitivity decreases with increase in the resistance of the coil the effect of increase in number of turns is nullified in the case of voltage sensitivity.