Solution |CBSE-XII | Test No-PB_5 | Vidyarthi & Shiksha

Pre-Board Examination : 2025-26

Sub : Physics

(The figures in the margin indicate full marks for the questions)

Time – 3 hours **Full marks-70**

Section A(Each question carries 1 mark)

1 A point charge Q is placed at a point O as shown in the figure. Is the potential difference V_A-V_B positive, negative or zero if Q is (i) positive (ii) negative ?

(a) negative, negative (b) negative, positive
(c) positive, positive (d) Positive, negative

Ans (c) positive, positive

The electric potential V at a distance r from a point charge Q is given by the formula $V = \frac{kQ}{r}$

A is closer to Q origin **O** than **B** ($r_A < r_B$)

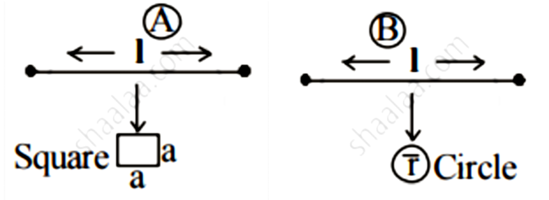
(i) If Q is positive: Since $r_A < r_B$, the potential V_A will be greater than V_B ($V_A > V_B$). Therefore, the potential difference $V_A - V_B$ is **positive**.

(ii) If Q is negative: The potentials V_A and V_B are both negative. Because r_A is smaller, V_A has a larger absolute magnitude but is more negative than V_B Thus, $V_A < V_B$, making $V_A - V_B$ **negative**.

2 A plane electromagnetic wave travels in free space

	along positive X axis. At a particular point in space, the electric field along Y axis is 9.3 V/m. The magnetic induction **B** along Z axis is (a) 3.1×10^{-7} T (b) 3.1×10^{-8} T (c) 3×10^{-5} T (d) 3×10^{-6} T
Ans	(b)3.1×10^{-8} T To find the magnetic induction B, $B = \frac{E}{c}$ Given $E = 9.3$ V/m and $c = 3 \times 10^{8}$ m/s $B = \frac{9.3}{3 \times 10^{8}} = 3.1 \times 10^{-8}$ T
3	Two wires of same length are shaped into a square and a circle respectively. If they carry same current, ratio of magnetic moment is: (a) 2 : π (b) π: 2 (c) π : 4 (d) 4 : π

l = length of wire



Area of a Square = a^2 Area of a Circle = πr^2

Also here $l = 4a$ $a = \frac{l}{4}$ Also here, $2\pi r = l$ $r = \frac{l}{2\pi}$

$\therefore$ Area $= \frac{l^2}{16}$ $A_1 = \frac{l^2}{16}$ Now Area $= \pi\left(\frac{l}{2\pi}\right)^2$ $A_2 = \frac{l^2}{4\pi}$

Now Magnetic moment = I A $\therefore M_1 = IA, \& M_2 = I A_2$

Since I (current) is same in both

$$\therefore \frac{M_1}{M_2} = \frac{A_1}{A_2} = \frac{l^2}{16} = \frac{4\pi}{l^2} = \frac{\pi}{4}$$

$M_1 M_2 = \pi : 4$

4 The current in ampere in an inductor is given by $I = 5 + 16t$, where t is in second. The self induced emf in it is 10 mV. The self inductance is

(a) 5.55×10^{-5} H (b) 6.25×10^{-4} H

(c) 5.26×10^{-6} H (d) 7.5×10^{-7} H

Ans

The expression of the current $I = 5 + 16t$

$$\frac{dI}{dt} = \frac{d}{dt}(5 + 16t) = 16 \text{ A/s}$$

The magnitude of the induced emf ε is

$$\varepsilon = L\frac{dI}{dt}$$

Given that $\varepsilon = 10$ mV $= 10 \times 10^{-3}$ V

$$\Longrightarrow 10 \times 10^{-3} = L \cdot 16$$

$$\Longrightarrow L = \frac{10 \times 10^{-3}}{16} = 0.625 \times 10^{-3} = 6.25 \times 10^{-4} \text{ H}$$

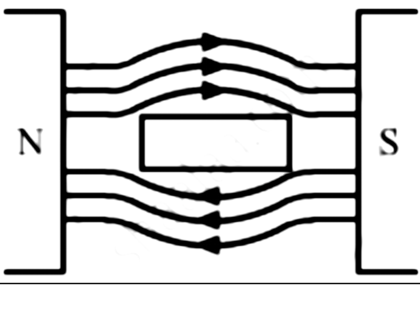
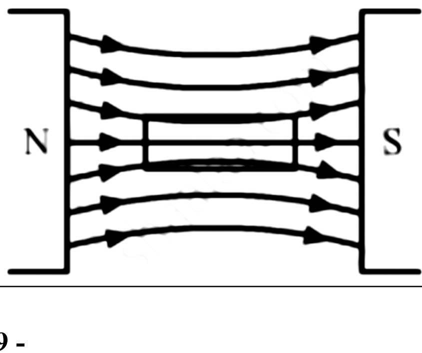
5	A 15 ohm resistor, an 80 mH inductor and a capacitor of capacitance C are connected in series with a 50 Hz ac source. If the source voltage and current in the circuit are in phase, the value of capacitance is (a) 100 μF (b) 127 μF (c) 142 μF (d) 160 μF
Ans	Voltage and current will be in phase when $X_C = X_L$ Or, $1/\omega C = \omega L$ Or, $1/2\pi fC = 2\pi fL$ Or, $C = 1/4\pi^2 f^2 L$ Or, $C = \dfrac{1}{4 \times (3.14)^2 \times (50)^2 \times 80 \times 10^{-3}}$ C = 127 μF
6	Two students A and B calculated the charge flowing through a circuit. A concludes that 300 C charge flows in one minute. B concludes that 3.125×10^9 electrons flow in one second. If the current measured in the circuit is 5 A, then the correct calculation is done by: (a) A (b) B (c) both A and B (d) neither A nor B

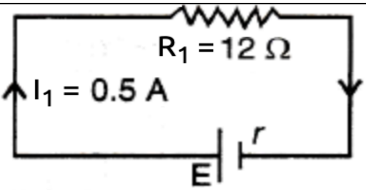
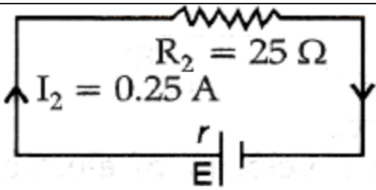
Ans	Current I is given by I = Q/t Student A: Q = 300C. t = 60s, so I = 300/60 = 5A(correct). Student B: Q = $(3.125 \times 10^{19}) \times (1.6 \times 10^{-19})$ = 5C, t = Is, so I = 5/1 = 5A (correct). thus, both A and B are correct. Answer: (c) Both A and B.
7	Beams of electrons and protons move parallel to each other in the same direction.They (a) Attract each other (c) neither attract nor repel (b) Repel each other (d) Attraction or repulsion depends upon Speed
Ans	(b) neither attract nor repel Beams of electrons and protons move parallel to each other in the same direction. They repel each other. **Explanation**: The direction of the current is determined by the flow of the positive charge. As a result of the opposing currents here, they will resist one other.
8	The momentum of a photon of wavelength **λ** is (a) h**λ** (b)h/**λ** (c) **λ**/h (d)h/c**λ**
Ans	(b) **Formula:** $p = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}$
9	If the kinetic energy of a particle is increased to 16 times its previous value, the percentage change in the

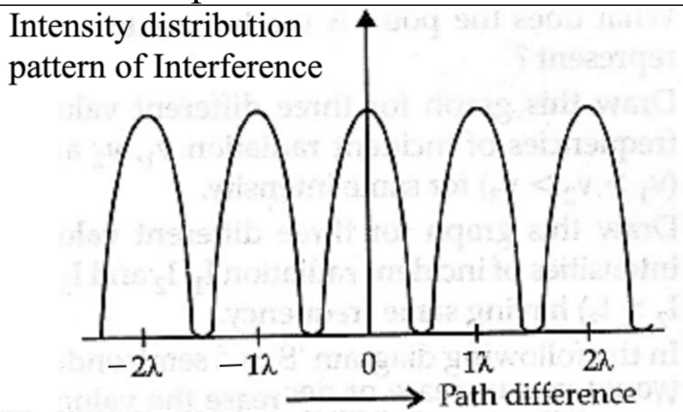
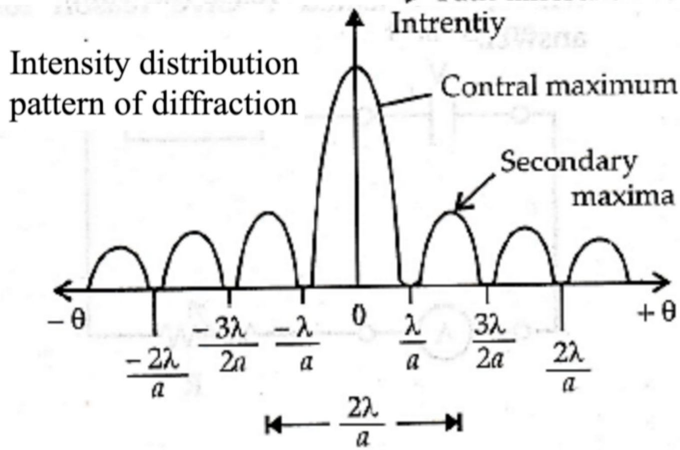
	de Broglie wavelength of the particle is (a) 60 (b) 50 (c) 25 (d) 75
<u>Ans</u>	(c) 75 Kinetic energy $k = \frac{p^2}{2m}$ where p is momentum $\therefore \frac{k_2}{k_1} = \frac{p_2^2}{p_1^2} \Rightarrow \frac{p_2}{p_1} = \sqrt{\frac{k^2}{k^1}} = \sqrt{16} = 4$ de Broglie wavelength $\lambda = \frac{h}{p}$ $\therefore \frac{\lambda_2}{\lambda_1} = \frac{p_1}{p_2} = \frac{1}{4}$ $\therefore \lambda_2 = \frac{\lambda_1}{4}$ $\therefore \lambda_1 - \lambda_2 = \frac{3}{4}\lambda_1$
10	A biconcave lens of power P vertically splits into two identical plano concave parts.The power of each part will be (a) 2P (b) P/2 (c) P (d) $P/\sqrt{2}$

Ans	The power P of a lens in air is given by the Lens Maker's Formula: $$P=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$ For a **biconcave lens**, the radii of curvature are $R_1=-R$ and $R_2=+R$ $$P=(n-1)\left(\frac{1}{-R}-\frac{1}{R}\right)=(n-1)\left(-\frac{2}{R}\right)=-\frac{2(n-1)}{R}$$ The first surface remains curved with $R_1=-R$. The second surface is now a plane surface, so $R_2=\infty$. The power P' of this plano-concave part is: $$P'=(n-1)\left(\frac{1}{-R}-\frac{1}{\infty}\right)=(n-1)\left(-\frac{1}{R}-0\right)=-\frac{(n-1)}{R}$$ $$P=-\frac{2(n-1)}{R} \qquad P'=-\frac{(n-1)}{R}$$ $$P'=\frac{P}{2}$$
11	In an N- type silicon, which of the following statements is true ? a) Electrons are majority carriers and trivalent atoms are dopants. b) Electrons are minority carriers and pentavalent atoms are dopants. c) Holes are minority carriers and pentavalent atoms are dopants. d) Holes are majority carriers and trivalent atoms are dopants.
Ans	c) Holes are minority carriers and pentavalent atoms are dopants.
12	The formation of depletion region in a P-N junction diode is due to

	a) Movement of dopant atoms b) Diffusion of electrons and holes c) Drift of electrons only d) Drift of holes only
Ans	b) Diffusion of electrons and holes.
13	Questions 13 to 16 consist of two statements, each labelled as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses. (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion. (b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion. (c) If the Assertion is correct but Reason is incorrect. (d) If both the Assertion and Reason are incorrect. Assertion: The poles of magnet can not be separated by breaking into two pieces. Reason: The magnetic moment will be reduced to half when a magnet is broken into two equal pieces.
Ans	(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion. **Explanation:** As we know every atom of a magnet acts as a dipole, so poles cannot be separated. When magnet is broken into two equal pieces, magnetic moment of each part will be half of the original magnet.
14	Assertion: Induced emf will always occur whenever there is change in magnetic flux.

	Reason : Current always induces whenever there is change in magnetic flux.
Ans	(c) If the Assertion is correct but Reason is incorrect.
15	Assertion : If the rays are diverging after emerging from a lens; the lens must be concave. Reason : The convex lens cannot give diverging rays.
Ans	(d) If both the Assertion and Reason are incorrect.
16	Assertion : Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Reason : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.
Ans	(c) If the Assertion is correct but Reason is incorrect. The binding energy per nucleon, B/A, starts at a small value, rises to a maximum at ^{62}Ni, then decreases to 7.5MeV for the heavy nuclei.
Section B(Each question carries 2 marks)	
17	Show diagrammatically the behavior of magnetic field lines in the presence of (i) paramagnetic and (ii) diamagnetic substances.
Ans	**The magnetic field lines in the presence of a diamagnetic substance**  **The magnetic field lines in the presence of a paramagnetic substance** 

18	A battery that contains emf E and internal resistance r when connected across an external resistance of 12 ohm, produces a current of 0.5 A. When connected across a resistance of 25 ohm, it produces a current of 0.25 A. Find (i) internal resistance and (ii) emf of the cell.
Ans	  $E = I(R + r)$ $E = I(R + r)$ $E = I_1(R_1 + r)$ $E = I_2(R_2 + r)$ $E = 0.5(12 + r)$ $E = 0.25(25 + r)$ $E = 6 + 0.5\,r$ ...(i) $E = 6.25 + 0.25\,r$ ...(ii) From eqns. (i) and (ii) $6 + 0.5\,r = 6.25 + 0.25\,r$ $\Rightarrow 0.5r - 0.25\,r = 6.25 - 6.0$ $\Rightarrow 0.25\,r = 0.25$ $\Rightarrow r = 1\,\Omega$ Then $E = 6 + 0.5 \times 1 = 6.5\text{ V}$
19	A spherical rubber balloon carries a charge that is uniformly distributed over its surface. As the balloon is blown up, how does E vary for points (i) inside the balloon (ii) on the surface of the balloon.
Ans	As a uniformly charged spherical balloon is blown up, the total charge Q remains constant while the radius R increases. The electric field E varies as follows: **(i) Inside ($r < R$):** E remains zero, as no charge is enclosed.

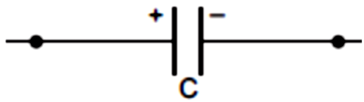
	(ii) On the surface ($r = R$): E decreases ($E = \frac{kQ}{R^2}$) because the radius increases. **(iii) Outside ($r > R$):** E decreases ($E = \frac{kQ}{r^2}$) at any fixed distance r from the center as the charge density drops.
20	Draw the intensity pattern for single slit diffraction and double slit interference. Hence state two differences between interference and diffraction patterns.
<u>Ans</u>	

	Difference : (i) Interference fringes are of same intensity whereas diffraction fringes are of different intensity. (ii) Fringe width is of the same size in interference whereas it is not so in diffraction.
	OR Two harmonic waves of monochromatic light $y_1 = a \cos \omega t$, $y_2 = a \cos (\omega t + \phi)$ are superimposed on each other. Show that maximum intensity in interference pattern is four times the intensity due to each slit.
Ans	$y_1 = a \cos \omega t$ ....(i) and $y_2 = a\cos(\omega t + \phi)$ ....(ii) According to the principle of superposition, $Y = y_1 + y_2$ $\Longrightarrow Y = a\cos\omega t + a\cos(\omega t + \phi)$ ....(iii) Using $\cos A + \cos B = 2\cos(\frac{A+B}{2})\cos(\frac{A-B}{2})$, we get: $\Longrightarrow Y = 2a\cos(\frac{\phi}{2})\cos(\omega t + \frac{\phi}{2})$ ....(iv) The resultant wave has the form $Y = A\cos(\omega t + \alpha)$, where the resultant amplitude A is: $A = 2a\cos(\frac{\phi}{2})$ ....(v) Intensity I is proportional to the square of the amplitude ($I = kA^2$) The intensity of each individual wave is: $I_0 = ka^2$ ....(vi) The resultant intensity I is: $I = k[2a\cos(\frac{\phi}{2})]^2 = 4ka^2\cos^2(\frac{\phi}{2})$ $\Longrightarrow I = 4I_0\cos^2(\frac{\phi}{2})$ ....(vii) Intensity is maximum when the term $\cos^2(\frac{\phi}{2})$ is maximum. The maximum value of $\cos^2(\frac{\phi}{2}) = 1$ (vii) $\Longrightarrow I_{max} = 4I_0(1) = 4I_0$ ....(viii)

21	Calculate the energy released in MeV in the following nuclear reaction : ${}_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4} + Q$ [Mass of ${}_{92}U^{238}$ = 238.05079 u Mass of ${}_{90}Th^{234}$ = 234.043630 u Mass of ${}_{2}He^{4}$ = 4.002600 u 1u = 931.5 MeV/c^2]
<u>Ans</u>	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + Q$ Mass of ${}^{238}_{92}U$: 238.05079 u Mass of ${}^{234}_{90}Th$: 234.04363 u Mass of ${}^{4}_{2}He$ (alpha particle): 4.00260 u The mass defect (Δm) is the difference between the mass of the parent nucleus and the sum of the masses of the products: $\Delta m = m({}^{238}_{92}U) - [m({}^{234}_{90}Th) + m({}^{4}_{2}He)]$ $\Delta m = 238.05079 - (234.04363 + 4.00260) = 0.00456$ u **Using the conversion factor 1 u = 931.5 MeV/c^2, the energy Q is:** $Q = \Delta m \times 931.5$ MeV/u $Q = 0.00456 \times 931.5 \approx 4.2476$ MeV

<u>Section C(Each question carries 3 marks)</u>

22	A capacitor of unknown capacitance is connected across a battery of V volt. The charge stored is 360μC. When potential across the capacitor is reduced

	by 120 V, the charge stored becomes 120μC. Calculate the potential V and the unknown capacitance C.
Ans	(i) If unknown capacitor of capacitance 'C' is connected to a battery of 'V' volts,  $Q = CV \Rightarrow CV = 360\,\mu C$ (1) On reducing the potential/voltage by 120V So, $Q' = C\,(V - 120)$ $\Rightarrow C\,(V - 120) = 120\,\mu C$ (2) On solving equation (1) and (2) $\frac{360\mu C}{V} = \frac{120\mu C}{V - 120} \Rightarrow V = 180V$ Unknown capacitance from equation (1) $Q = CV$ $\Rightarrow 360\,\mu C = C \times 180V$ $\Rightarrow C = \frac{360\,\mu C}{180V} = 2 \Rightarrow C = 2\,\mu F$
23	What is a wave front? What is the geometrical shape of a wave front of light emerging out of a convex lens, when point source is placed at the focus ? Using Huygen's principle show that, for a parallel beam incident on a reflecting surface, the angle of reflection is equal to the angle of incidence.
24	a) Name the em wave produced during radioactive decay of nucleus. Mention one use of it.

	b) Why do welders wear special type of goggles while working? c) Which part of electromagnetic spectrum has a wavelength range of 390 to 770 nm?
Ans	a) Gamma rays are produced during the radioactive decay of a nucleus. Frequency range is 3×10^{19} to 5×10^{24}Hz. b) Welders wear special goggles or helmets with tinted lenses to protect their eyes from intense electromagnetic radiation, specifically harmful ultraviolet (UV) and infrared (IR) light produced by the welding arc. c) The part of the electromagnetic spectrum with a wavelength range of approximately 390 to 770 nm is **visible light** (or the visible spectrum).
25	(a) Monochromatic light of wavelength 589 nm is incident from air on a water surface. If refractive index for water is 1.33, find the wavelength, frequency and speed of refracted light. (b) A compound lens is made of two lenses in contact having powers +11.5 D and -1.5 D. An object is placed at 15cm from this compound lens. Find the position of the image formed
Ans	(a) The frequency of light (f) is calculated using the speed of light in vacuum ($c \approx 3\times10^{8}$m/s) and the

wavelength in air (λ_{air} =589×10^{-9}m):

$$f = \frac{c}{\lambda_{air}} = \frac{3\times10^8}{589\times10^{-9}} \approx 5.09\times10^{14}\ \text{Hz}$$

The speed of light in a medium (v) depends on the refractive index (n). For water (n=1.33):

$$v = \frac{c}{n} = \frac{3\times10^8}{1.33} \approx 2.26\times10^8\ \text{m/s}$$

The wavelength in a medium (λ_{water}) decreases relative to the wavelength in air:

$$\lambda_{water} = \frac{\lambda_{air}}{n} = \frac{589\ \text{nm}}{1.33} \approx 444\ \text{nm}$$

(b) Given P_1=11.5D and P_2= 1.5 D

$$P = P_1 + P_2 = 11.5 + 1.5 = 13.0\ \text{D}$$

The focal length f in meters is

$$f = \frac{1}{P} = \frac{1}{13}\ \text{m}$$

$$f = \frac{100}{13}\ \text{cm} \approx 7.69\ \text{cm}$$

We use the thin lens formula to find the image

	position v. According to the sign convention, the object distance u is negative (u= -15cm): $$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$ $$\Rightarrow \frac{1}{v}-\frac{1}{-15}=\frac{13}{100}$$ $$\Rightarrow \frac{1}{v}+\frac{1}{15}=0.13$$ $$\Rightarrow \frac{1}{v}=0.13-\frac{1}{15}$$ $$\Rightarrow \frac{1}{v}=\frac{13}{100}-\frac{1}{15}=\frac{39-20}{300}=\frac{19}{300}$$ $$\Rightarrow v=\frac{300}{19}\approx 15.79\text{ cm}$$
26	A potential difference of V volt is applied to a conductor of length 1 and diameter D. How will the drift velocity of electrons and the resistance of the conductor change when (i) V is doubled (i) L is halved where the other two factors remain the same. Give reason.
Ans	We know, Electric field, $E=\frac{V}{L}$

	Drift velocity, $v_d = \frac{eE}{m}\tau = \frac{eV}{mL}\tau$ Resistance, $R = \rho\frac{L}{A} = \frac{4\rho L}{\pi D^2}$ (i) When V is doubled, E becomes double, v_d becomes double R remains unchanged. (ii) When L is doubled, E becomes half v_d becomes half and R becomes double. (iii) When D is doubled, E remains unchanged, v_d is also unchanged and R becomes one-fourth.
27	Draw a plot showing the variation of photoelectric current with collector plate potential for two different frequencies, $\nu_1 > \nu_2$, of incident radiation having the same intensity. In which case will the stopping potential be higher ? Justify your answer.
28	a) A student wants to use two p-n junction diodes to convert alternating current into direct current. Draw the labeled circuit diagram she would use and explain how it works. b) Show graphically the input and output voltages. OR (a) Draw the circuit arrangement for studying the V - I characteristics of a p-n junction diode in forward bias.

	Draw the typical V- I characteristics of a silicon diode. (b) Describe briefly the following terms (I) Minority carrier injection' in forward bias (ii) 'Breakdown voltage' in reverse bias
Section D(Each question carries 4 marks)	
29	A prism is a portion of a transparent medium bounded by two plane faces inclined to each other at a suitable angle. A ray of light suffers two refraction on passing through a prism and hence deviates through a certain angle from its original path. The angle of deviation of a prism is d = (μ -1) A, through which a ray deviates on passing through a thin prism of small refracting angle A. If μ is the refractive index of the material of the prism then the prism formula is $\mu = \sin(A + d_m)/2)/\sin(A/2)$. (i) For which colour, angle of deviation is minimum ? (a) Voilet (b) Yellow (c) Red (d) Blue. (ii) When white light moves through vacuum a) all colours have same speed b) different colours have different speed c) violet has more speed then red d) red has more speed then violet. (iii) The deviation through a prism is maximum when angle of incidence is (a) 45^0

	(b) 70^0 (c) 90^0 (d) 60^0 . OR What is the deviation produced by a prism of angle 60^0 ? (μ =1.644) (a) 3.840 (b) 4.595 (c) 7.259 (d) 1.252. (iv) A ray of light falling at an angle of 50^0 is refracted through a prism and suffers minimum deviation. If the angle of prism is 60^0, then the angle of minimum deviation is (a) 45^0 (b) 75^0 (c) 50^0 (d) 40^0
Ans	(i) (c) Red (ii)(a) all colours have same speed. (iii) (c) 90^0 Or For a thin prism , the angle of deviation (δ) is independent of the angle of incidence and is calculated using: $\delta=(\mu-1)A$ Substitute the given values into the formula:

$\delta=(1.644-1)\times6^0 = 0.644\times6^0 = 3.864$

(iv) Given the angle of incidence $i=50^0$

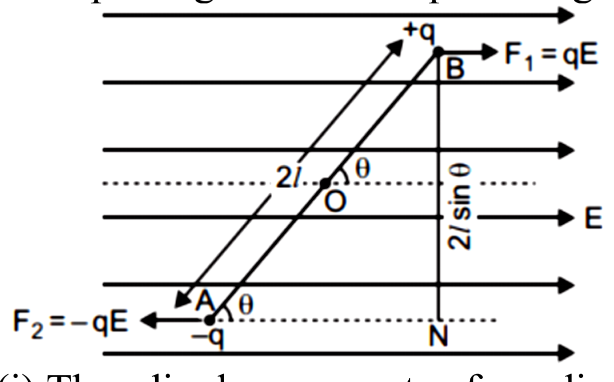
and the angle of the prism $A=60^0$

we rearrange the formula to solve for $2i=A+\delta_m$

$\Rightarrow \delta_m=2i-A$

Substituting the values: $\delta_m=2(50^0)-60^0=100^0-60^0=40^0$

30 When electric dipole is placed in uniform electric field, its two charges experience equal and opposite forces, which cancel each other and hence net force on electric dipole in uniform electric field is zero. However these forces are not collinear, so they give rise to some torque on the dipole. Since net force on electric dipole in uniform electric field is zero, so no work is done in moving the electric dipole in uniform electric field. However some work is done in rotating the dipole against the torque acting on it.



(i) The dipole moment of a dipole in a uniform

	external field E is p. Then the torque τ acting on the dipole is (a) τ = p x E (b) τ = p. E (c) τ = 2(p+E) (d) τ = (p+E) (ii)An electric dipole consists of two opposite charges, each of magnitude 1.0 μC separated by a distance of 2.0 cm. The dipole is placed in an external field of 10^5 NC^{-1}. The maximum torque on the dipole is a) 0.2 x 10^{-3} Nm b) 1x 10^{-3} Nm c) 2 x 10^{-3} Nm d) 4x 10^{-3} Nm (iii) Torque on a dipole in uniform electric field is minimum when O is equal to (a) 0° (b) 90° (c) 180° (d) Both (a) and (c) OR When an electric dipole is held at an angle in a uniform electric field, the net force F and torque τ on the dipole are (a) F = 0 , τ = 0 (b) F ≠ 0 , τ ≠ 0 (c) F = 0 , τ ≠ 0 (d) F ≠ 0 , τ = 0

	(iv) An electric dipole of moment p is placed in an electric field of intensity E. The dipole acquires a position such that the axis of the dipole makes an angle with the direction of the field. Assuming that potential energy of the dipole to be zero when θ = 90°, the torque and the potential energy of the dipole will respectively be (a) pEsinθ , -pEcosθ (c) pEsinθ, 2pEcosθ (b) pEsinθ, - 2pEcosθ (d) pEcosθ, - pEsinθ
Ans	(i)The torque τ acting on a dipole in a uniform external field $\vec{E}$ is given by $\tau = \vec{p} \times \vec{E}$. Hence, the correct option is (a). **(ii)** The maximum torque on an electric dipole is given by $\tau_{max} = pE,$ where $p = qd.$ Here, $q = 1.0\mu C = 1.0 \times 10^{-6} C$ and $d = 2.0cm = 2.0 \times 10^{-2} m.$ Therefore, $p = 1.0 \times 10^{-6} C \times 2.0 \times 10^{-2} m = 2.0 \times 10^{-8} Cm.$ The external field $E = 10^5 NC^{-1}$ Thus, $\tau_{max} = 2.0 \times 10^{-8} Cm \times 10^5 NC^{-1} = 2.0 \times 10^{-3} Nm.$ Hence, the correct option is (c). (iii) The torque on a dipole in a uniform electric field is given by $\tau = pE\sin\theta$. The torque is minimum when $\theta = 0^0$ or 180^0 because $\sin 0^0 = \sin 180^0 = 0$. Hence, the

	correct option is (d). Or (iii) When an electric dipole is held at an angle in a uniform electric field, the net force *F* on the dipole is zero because the forces on the positive and negative charges cancel each other out. However, the torque τ is non-zero because the forces are not collinear. Hence, the correct option is (c). (iv) The torque on the electric dipole is $\tau = pE\sin\theta$ and the potential energy of the electric dipole is $U = - pE\cos\theta$. So the correct option is (a)
Section E(Each question carries 5 marks)	
31	a) State Biot - Savart law. Using this law, find expression for the magnetic field at apoint on the axis of a circular current carrying coil. b) From the above result obtain an equation for magnetic field at the centre of the coil. c) Schematically represent the direction of the magnetic field lines through a circular coil carrying current. Also mention the law used to find the direction. OR a) With the help of a diagram, explain the principle and working of a moving coil galvanometer.

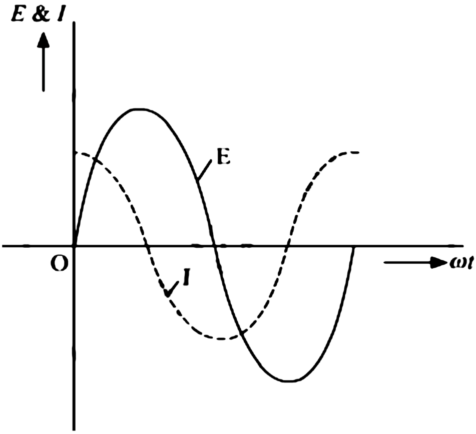
	b) What is the importance of radial magnetic field and how is it produced? c) Why is it that while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used.
Ans	b)The uniform radial magnetic field keeps the plane of the coil always parallel to the direction of the magnetic field. That is, the angle between the plane of the coil and the magnetic field is zero in all the orientation of the coil. c) A moving coil galvanometer needs a **high series resistance** to become a voltmeter to minimize current draw and prevent changing the circuit's voltage.
32	A device X is connected across an ac source of voltage $v = V_o \sin \omega t$ the current through X is given as $i = I_o \sin(\omega t + \pi/2)$. a) Identify the device X and write the expression for its reactance. b) Draw graphs showing the variation of voltage and current with time over one cycle of ac, for x. c) How does the reactance of the device X vary with frequency of ac? Show this variation graphically. d) Draw the phasor diagram for this device X.

Ans

a) Since the current is leading the voltage by 90 degrees, the device X is a capacitor.

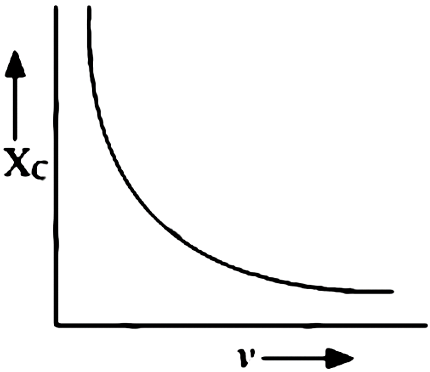
The expression for reactance is $X_c = \dfrac{1}{\omega c} = \dfrac{1}{2\pi \upsilon c}$

b)Variation of voltage and current with time over one cycle of ac, for X , i.e. capacitor



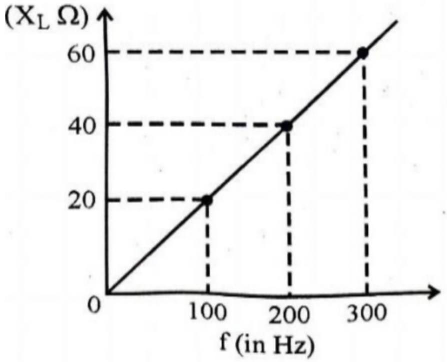
c) $X_c = \dfrac{1}{\omega c} = \dfrac{1}{2\pi \upsilon c}$ where υ = frequency of the signal

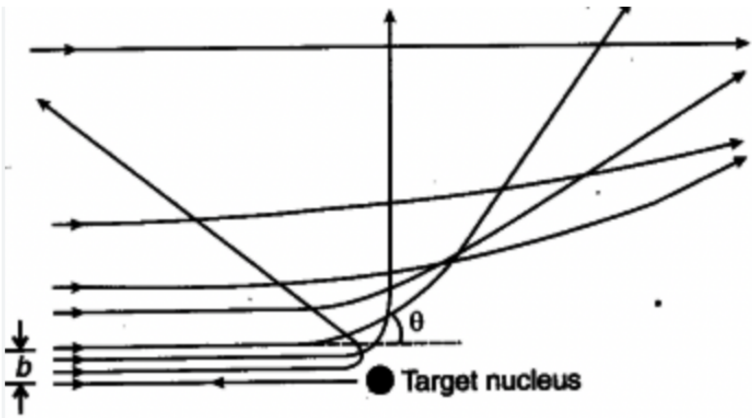
The reactance varies inversely with frequency.



OR

a) Show that an ideal inductor does not dissipate power in an ac circuit.

	b) The variation of inductive reactance (X_L) of an inductor with the frequency (f) of the ac source of 100 V and variable frequency is shown in the figure.  (i) Calculate the self inductance of the inductor. (i) When this inductor is used in series with a capacitor of unknown value and a resistor of 10 ohm at 300 s^{-1} , maximum power dissipation occurs in the circuit. Calculate the capacitance of the capacitor.
Ans	(i) We know that $X_L = \omega L = 2\pi f$ where f is frequency in Hz. $$\text{So, } L = \frac{X_L}{2\pi f} = \frac{20}{2\pi(100)} = \frac{40}{2\pi(200)} = \frac{60}{2\pi(300)}$$ $$\text{So, } L = 31.84 \times 10^{-3} \approx 32 \text{ mH}$$ (ii) we know that power dissipation is maximum when $X_L = X_C$ $$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega^2 L} \Rightarrow C = \frac{1}{4\pi^2 f^2 L}$$ $$\Rightarrow C = \frac{1}{4 \times 3.14 \times 3.14 \times 300 \times 300 \times 32 \times 10^{-3}} = 8.8\mu F$$
33	a) Draw a schematic arrangement of Geiger-Marsden experiment showing the scattering of a-particles by

	a thin foil of gold. b) Why is it that most of the α-particles go right through the foil and only a small fraction gets scattered at large angles ? c) Draw the trajectory of the α-particle in the coulomb field of a nucleus. d) What is the significance of impact parameter and what information can be obtained regarding the size of the nucleus ? (e)Estimate the distance of closest approach to the nucleus (Z = 79) if a 7.7 MeV α-particle before it comes momentarily to rest and reverses its direction
Ans	**(b)** When alpha particles are sent through a thin gold foil, most of them go straight through the foil, because most of the part of an atom is empty space. **(c)** <u>Trajectory of α-particle in the coulomb field of a nucleus</u>. 

(d) Significance of Impact Parameter (b):

1.Trajectory- It determines the scattering angle (θ) and trajectory of alpha particles.

2-Small b(Head-on Collision): If b is small, the alpha particle comes close to the nucleus, resulting in a large scattering angle (θ $\approx 180^0$).

3-**Large b(Grazing Collision):** If b is large, the particle barely deflects (θ $\approx 0^0$).

(e) Here Z=79 , K= 7.7MeV=$7.7\times10^6\times1.6\times10^{-19}$J

The distance of closest approach is given as

$$d = \frac{1}{4\pi\epsilon_0}\frac{2Ze^2}{K} = \frac{(9\times10^9)\times2\times79\times(1.6\times10^{-19})^2}{1.232\times10^{-12}}$$

=> d $\approx 2.95\times10^{-14}$m $\approx$ 29.5fm

OR

a) Depict the variation of potential energy of a pair of nucleons with the separation between them.

b) Plot a graph showing the variation of binding energy nucleon as a function of mass number. Which property of nuclear force explains the approximate constancy of binding energy in the

	range 30<A<170 ? How does one explain the release of energy in both the processes of nuclear fission and fusion from the graph?