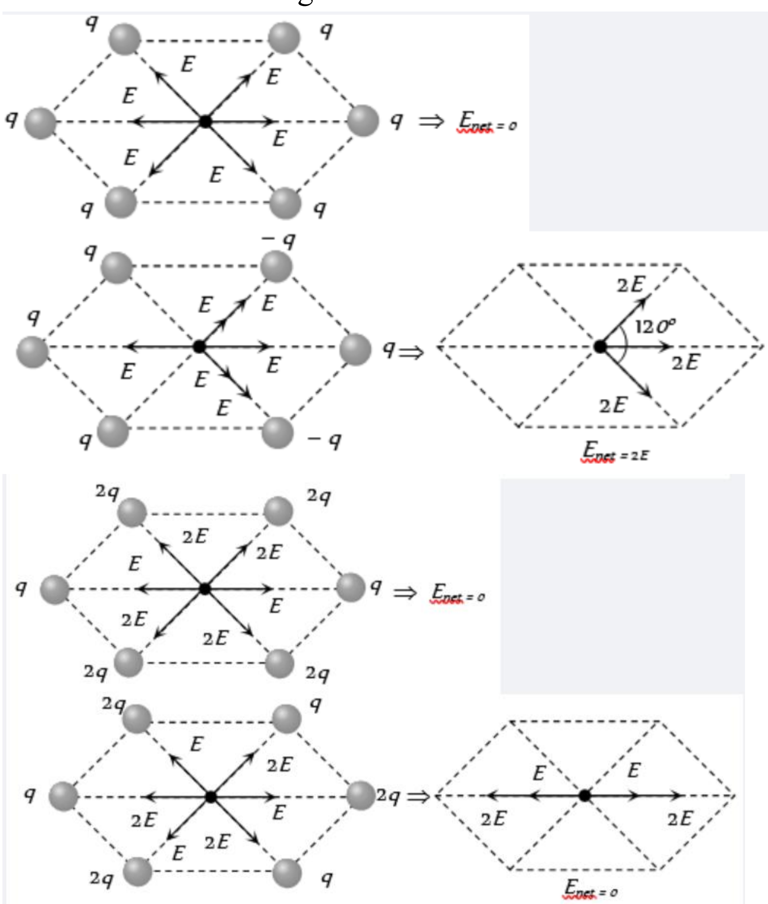
COMMON PRE-BOARD EXAMINATION

PHYSICS-Code No. 042

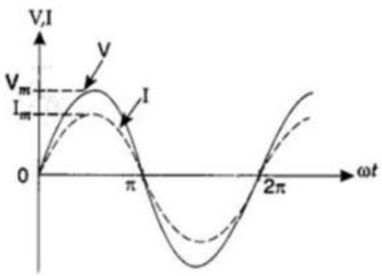
Class-XII-(2025-26)

SET: 1 MARKING SCHEME

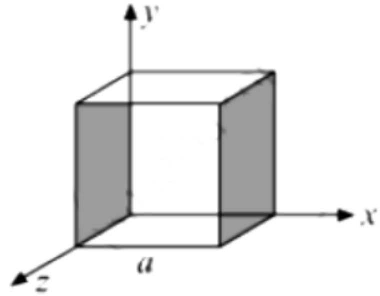
Time allowed: 3 Hrs. **Maximum Marks: 70**

	SECTION A	
1.	(B) 2 Electric field at a point due to positive charge acts away from the charge and due to negative charge, it acts towards the charge. 	1
2.	(B) v/2	1

	Given initial drift velocity $(v_{d_1}) = v$; initial current $(I_1) = I$, initial radius $(r_1) = r$, final radius $(r_2) = 2r$ and final current $(I_2) = 2I$. The drift velocity is given by $v_d = \frac{I}{neA} = \frac{I}{ne\times\pi r^2}$ i.e., $v_d \propto \frac{I}{r^2}$ Therefore, $\frac{v_{d_1}}{v_{d_2}} = \frac{I_1}{I_2} \times \frac{r_2^2}{r_1^2} = \frac{I}{2I} \times \frac{(2r)^2}{r^2} = 2$ $\therefore v_{d_2} = \frac{v_{d_1}}{2} = \frac{v}{2}$	
3.	(C) Move towards the wire or towards Left. The long straight wire and side AB carry current in the same direction, hence will attract each other. The long straight wire and side CD carry current in the opposite direction, hence will repel each other. Force on side BC will be equal and opposite to force on side DA. Since CD is farther from the wire than AB, the force of attraction on AB will exceed the force of repulsion on CD. Hence, there will be a net force of attraction on the loop ABCD and it will move towards the wire.	1
4.	(A) $ef\pi r^2$ Magnetic moment of the electron revolving round the nucleus, $m = I.A$ Here, I = current produced due to moving electron and A = area of the orbit Now, m = I . A $m = (e/t)\ \pi r^2 = ef\pi r^2$	1
5.	(D) 5 V Here , area A $= 500(10/100)^2 = 5m^2$ $\frac{dB}{dt} = 1Ts^{-1}$ Induced emf $\lvert\varepsilon\rvert = \frac{d\phi}{dt} = A\frac{dB}{dt} = 5 \times 1 = 5$volt	1
6.	(D) an iron rod is inserted in the coil.	1

	Explanation: Impedance is given as, $Z = \frac{\sqrt{R^2 + X_L^2}}{R^2 + (L \times 2\pi f)^2}$ ∴ Impedance lowers as frequency falls. Self inductance and consequently impedance decrease as the number of turns decreases. $X_C = X_L$ at resonance, and impedance falls. Impedance rises when an iron rod is introduced. As a result, the current diminishes. As a result, option (D) is correct.	
7.	(B)  Voltage and current are in phase with each other in purely resistive circuit.	1
8.	(B) $\frac{1}{\sqrt{\mu\varepsilon}}$	1
9.	(A) yellow, orange, red We know that; $\sin c = \frac{1}{\mu}$ or $c = \sin^{-1}\left(\frac{1}{\mu}\right)$ ∴ as μ decreases with increase in λ. Yellow, orange and red have higher wavelength's than green, thus μ is less for these rays. If μ is less, then critical angle for these rays will be high. Thus if green is totally internally reflected just, then yellow, orange and red emerge out.	1
10.	(B) 25:1 The amplitudes of interfering beams are in the ratio 2:3. ∴ The ratio of I_{max} to I_{min} i.e., $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{5^2}{1} = 25.$	1

11.	(D) reduce to $(1/4)^{th}$ of the original value When v is doubled, kinetic energy increases to 4 times the values. Since $r_0 = \frac{2Ze^2}{4\pi\varepsilon_0 E_k}$ r_0 reduces to $\left(\frac{1}{4}\right)$ times the initial value.	1
12.	(B) 16 : 9 Radius of a nucleus, $R = R_0 A^{\frac{1}{3}}$ $A_1(Zn) = 64,\ A_2(Al) = 27$ $\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}} = \left(\frac{64}{27}\right)^{\frac{1}{3}} = \frac{4}{3}$ Surface area of a sphere $\propto$ (radius)^2 $\therefore \frac{(\text{Surface area})_1}{(\text{Surface area})_2} = \left(\frac{4}{3}\right)^2 = \frac{16}{9}$	1
13.	(C) Assertion is true but Reason is false.	1
14.	(B) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion. $\mu = \frac{\mu_g}{\mu_c} = \frac{1.5}{1.65} < 1$ As $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\therefore f$ becomes negative. Therefore, the lens behaves as a diverging lens.	1
15.	(A) Both Assertion and Reason are true and Reason is the correct explanation of Assertion. Reason: For diffraction to occur, the size of an obstacle/ aperture is comparable to the wavelength of light wave. The order of wavelength of light wave is 10^{-7} m. so diffraction occurs.	1
16.	(A) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.	1
	SECTION B	

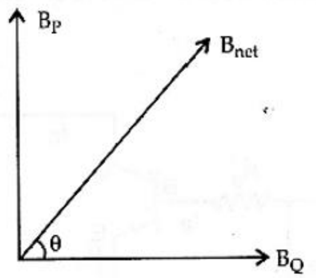
17.	Since the electric field has only x component, for faces normal to x direction, the angle between E and ΔS is $\pm \pi/2$. Therefore, the flux is separately zero for each face of the cube except the two shaded ones.	
		
	The magnitude of the electric field at the left face is $E_L = 0$ (As $x = 0$ at the left face)	
	The magnitude of the electric field at the right face is $E_R = 2a$	½
	(As $x = a$ at the right face)	
	The corresponding fluxes are	
	$\phi_L = \vec{E}.\Delta\vec{S} = 0$	
	$\phi_R = \vec{E}_R.\Delta\vec{S}$	
	$= E_R \Delta S \cos\theta$	
	$= E_R \Delta S \quad (\because \theta = 0^\circ)$	½
	$\Rightarrow \phi_R = E_R a^2$ Net flux (ϕ) through the cube $= \phi_L + \phi_R = 0 + E_R a^2 = E_R a^2$	
	$\phi = 2a(a)^2 = 2a^3$	½
	We can use Gauss's law to find the total charge q inside the cube.	
	$\phi = \frac{q}{\varepsilon_0}$	
	$q = \phi\varepsilon_0 = 2a^3\varepsilon_0$	½
18.	We know that, $R(t) = R_0[(1 + \alpha(T - T_0)]$	½
	$R(T) = 1.2\ \Omega$, $R_0 = 1.0\ \Omega$; $\alpha = 3.8 \times 10^{-3}/°C$, $T = 20\ °C$	½
	$\therefore\ 1.2 = 1.0\ [1 + 3.8 \times 10^{-3}\ (T - 20)]$	
	Solving this we get, $T = 72.6\ °C$	1
19.	**(I)**	

Magnetic field at center of loop P having radius = 5 cm and current 3A

$$B_P = \frac{\mu_0 I}{2r} = \frac{\mu_0 \times 3}{2(5\times10^{-2})}\text{ Tesla}$$ ½

Similarly, ½

$$B_Q = \frac{\mu_0 \times 4}{2(5\times10^{-2})}\text{ Tesla}$$



Both the fields are perpendicular to each other

$$\therefore \quad B_{net} = \sqrt{B_P^2 + B_Q^2}$$

$$= \sqrt{\left(\frac{\mu_0 \times 3}{2(5\times10^{-2})}\right)^2 + \left(\frac{\mu_0 \times 4}{2(5\times10^{-2})}\right)^2}$$

$$= \frac{\mu_0}{2\times5\times10^{-2}}\sqrt{3^2+4^2}$$

$$= \frac{4\pi\times10^{-7}}{2\times5\times10^{-2}}\times5$$

$$= 2\pi \times 10^{-5}\text{ Tesla}$$ ½

Also, $\tan\theta = \frac{B_P}{B_Q} = \frac{3}{4}$ ½

$\Rightarrow \quad \theta = \tan^{-1}\frac{3}{4}$

OR

(II)

(A) (i) X is diamagnetic and Y is ferromagnetic. ½ + ½

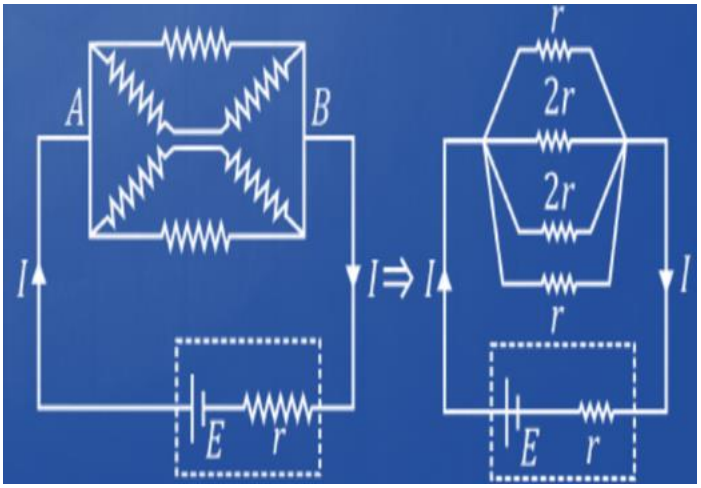
(B) Diamagnetic materials have permeabilities less than 1 (one) and have negative susceptibility. Their atoms and molecules do not have permanent dipole moment. The field lines get expelled in them. ½

Ferromagnetic materials have permeability more than one and susceptibility positive. Their atoms and molecules have permanent dipole moment. So, the field lines get concentrated in them. ½

20. (I) 1

	$\omega = 2\pi f \Rightarrow f = \frac{\omega}{2\pi} = \frac{2\times 10^{11}\pi}{2\pi} = 10^{11}\,\text{Hz}$ (II) $\frac{E_0}{B_0} = c \Rightarrow E_0 = c\cdot B_0$ $E_0 = 3\times 10^8 \times 60 = 1.8\times 10^{10}\,\text{V/m}$	 1
21.	(I) According to Einstein's Photoelectric equation $\frac{hc}{\lambda} - \phi_0 = K_{\max}$ So, $V_0 = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$ Graph of V_0 vs $\frac{1}{\lambda}$ is a straight line having slope $\frac{hc}{e}$, which is independent of material. So, $\tan\theta = \frac{hc}{e}$ $\Rightarrow h = \frac{e\tan\theta}{c}$ can be determined from the graph. **OR** (II) Change in energy $= -1.51 + 3.4$ $= 1.89\text{ eV}$ $\therefore \quad \Delta E = \frac{hc}{\lambda}$ $\lambda = \frac{hc}{\Delta E} = \frac{12400}{1.89}\,\text{Å} = 6560\,\text{Å}$ for $n = 2$, $\quad E_2 = \frac{-13.6}{(2)^2} = -3.4\text{ eV}$ for $n = 3$, $\quad E_3 = \frac{-13.6}{(3)^2} = -1.51\text{ eV}$ for transition from 3^{rd} orbit to 2^{rd} orbit, the series is Balmer.	 1 ½ ½ 1 1

22. (I) Circuit can be redrawn as



½

For net resistance between point A and B.

Here, $r, 2r, 2r$ and r are in parallel.

So, $\frac{1}{R_{AB}} = \frac{1}{r} + \frac{1}{r} + \frac{1}{2r} + \frac{1}{2r}$; $\frac{1}{R_{AB}} = \frac{3}{r}$ or, $R_{AB} = \frac{r}{3}$ ½

Net resistance of the circuit, $R = r + R_{AB} = r + \frac{r}{3} = \frac{4r}{3}$ ½

Current drawn from the cell $I = \frac{E}{R} = \frac{E}{(4r/3)} = \frac{3E}{4r}$ ½

(II)

Power consumed in network, $P = I^2 R_{AB}$ ½

$\therefore P = \left(\frac{3E}{4r}\right)^2 \frac{r}{3} = \frac{3E^2}{16r}$ ½

23. (I) (A) The kinetic energy (K) a particle gains when accelerated through a potential difference (V) is equal to the work done on it by the electric field, which is the product of its charge (q) and the potential difference. ⟹ K=qV ½

The charges of the particles are:

- Proton: $q_p = +e$
- Deuteron: $q_d = +e$
- Alpha particle: $q_\alpha = +2e$

Since they are all accelerated through the same potential difference V, their kinetic energies will be:

- Proton: $K_p = eV$
- Deuteron: $K_d = eV$
- Alpha particle: $K_\alpha = 2eV$

Therefore, the kinetic energies of the proton and deuteron are equal, and the kinetic energy of the alpha particle is twice that of the proton or deuteron.

$$K_p = K_d$$

$$K_\alpha = 2K_p = 2K_d$$ 1

(B)

The radius r of the circular path in a magnetic field is given by:

$$r = \frac{mv}{qB}$$

where v is the velocity of the particle.

From the kinetic energy formula:

$$KE = \frac{1}{2}mv^2 \implies v = \sqrt{\frac{2KE}{m}} \implies r = \frac{m\sqrt{\frac{2KE}{m}}}{qB} = \frac{\sqrt{2mKE}}{qB}$$ ½

Using the kinetic energy ratios:

- For the proton:

$$r_p = \frac{\sqrt{2m \cdot eV}}{eB}$$

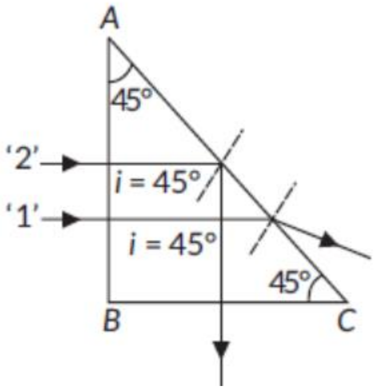
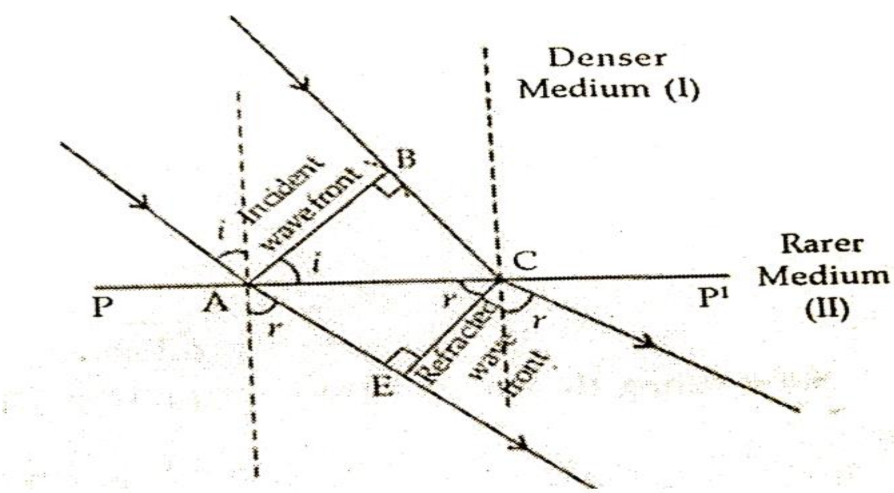
- For the deuteron:

$$r_d = \frac{\sqrt{2(2m) \cdot eV}}{eB} = \frac{\sqrt{4m \cdot eV}}{eB} = 2r_p$$ ½

- For the alpha particle: ½

$$r_\alpha = \frac{\sqrt{2(4m) \cdot 2eV}}{2eB} = 2\sqrt{2}r_p$$

	Given that the radius of the proton's path $r_p = 5$ cm, we can find the radii of the deuteron and alpha particle: 1. For the deuteron: $r_d = 2r_p = 2 \times 5 \text{ cm} = 10 \text{ cm}$ 2. For the alpha particle: $r_\alpha = 2\sqrt{2}r_p = 2\sqrt{2} \times 5 \text{ cm} \approx 14.14 \text{ cm}$ **OR** **(II) (A)** (i) For θ = 0° between $\vec{M}$ and $\vec{B}$, dipole is in stable equilibrium. (ii) For θ = 180° between $\vec{M}$ and $\vec{B}$, dipole is in unstable equilibrium. **(B)** Potential energy, $U = -\vec{M}\cdot\vec{B}$ At θ = 0°, $U_i = -MB\cos 0° = -MB$ $= -0.30 \times 0.50 = -0.15$ J At θ = 180°, $U_f = -MB\cos 180° = MB = +0.15$ J **(C)** Torque on magnet is $\tau = MB\sin\theta$ At θ = 0°, $\tau = MB\sin 0° = 0$ At θ = 180°, $\tau = MB\sin 180° = 0$	½ + ½ ½ + ½ ½ + ½
24.	(I) The two necessary conditions for total internal reflection are: i. The light must travel from a denser medium to a rarer medium. ii. The angle of incidence must be greater than the critical angle for the pair of media. (II) Critical angle for ray '1' : $\mu_1 = \frac{1}{\sin C_1}$	1 ½

	$\sin C_1 = \frac{1}{\mu_1} = \frac{1}{1.33} = 0.75 \Rightarrow C_1 \approx 48^\circ$ Critical angle for ray '2': $\mu_2 = \frac{1}{\sin C_2}$ $\sin C_2 = \frac{1}{\mu_2} = \frac{1}{1.45} = 0.69 \Rightarrow C_2 \approx 43^\circ$  Both the rays will fall on the side *AC* with angle of incidence, *i* equal to 45°. Critical angle of ray '1' is greater than *i*. Hence, it will emerge from the prism as shown in the figure. Critical angle of ray '2' is less than *i*. Hence, it will be internally reflected as shown in the figure.	½ ½ ½
25.	AB: Incident Plane Wave Front and CE is Refracted Wave Front. $\sin i = \frac{BC}{AC}$ and $\sin r = \frac{AE}{AC}$ $\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v_1}{v_2}$ = constant $\frac{v_1}{v_2} = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r}$ $\mu_2 \sin r = \mu_1 \sin i$. This proves the Snell's law of refraction.  	1 1 1
26.	(I) Any 2	1

NUCLEAR FISSION	NUCLEAR FUSION
A heavy nucleus breaks up to form two lighter nuclei.	Two light nuclei combine to form a heavy nucleus.
It involves a chain reaction.	Chain reaction is not involved.
The heavy nucleus is bombarded with neutrons.	Light nuclei are heated to an extremely high temperature.
We have proper mechanisms to control fission reaction for generating electricity.	Proper mechanisms to control fusion reaction are yet to be developed.
Disposal of nuclear waste is a great environmental problem.	Disposal of nuclear waste is not involved.
Raw material is not easily available and is costly.	Raw material is comparatively cheap and easily available.

(II)

Given : $m = 100$ g, $P = 500$ W

Here two deuterium nuclei produce 3.27 MeV energy

$= 5.232 \times 10^{-13}$ J

$\therefore$ Energy per nuclei $= \dfrac{5.232 \times 10^{-13}}{2}$ 1

$= 2.616 \times 10^{-13}$ J

No. of deuterium atoms in 100 g

$= \dfrac{6.023 \times 10^{23} \times 100}{2} = 3.011 \times 10^{25}$ atoms

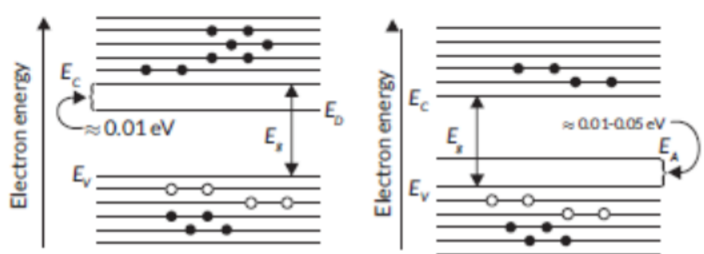
$\therefore$ Total energy $= 3.011 \times 10^{25} \times 2.616 \times 10^{-13}$

$= 7.88 \times 10^{12}$ J

Power $= \dfrac{\text{Energy}}{\text{Time}} \Rightarrow t = \dfrac{7.88 \times 10^{12}}{500} = 1.58 \times 10^{10}$ s 1

$= \dfrac{1.58 \times 10^{10}}{365 \times 24 \times 60 \times 60} = 500$ years

27. (I) 1+1



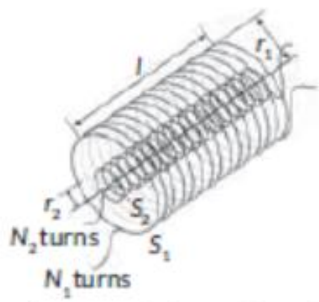
(a) Energy band diagram of *n*-tpe semiconductor at $T > 0$ K

(b) Energy band diagram of *p*-type semiconductor at $T > 0$ K

(II)

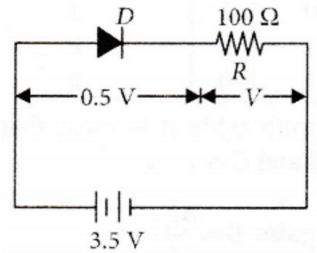
In *n*-type extrinsic semiconductors, the number of free electrons in conduction band is much more than the number of holes in valence band. The donor energy level lies just below the conduction band. In 1

<table>
<tr><td></td><td>p-type extrinsic semiconductor, the number of holes in valence band is much more than the number of free electrons in conduction band. The acceptor energy level lies just above the valence band.</td><td></td></tr>
<tr><td>28.</td><td>(I) Mutual Inductance : The phenomenon according to which an opposing emf is produced as a result of change in current or magnetic flux linked with another coil.
(II)
Consider two long coaxial solenoids each of length l. Let n_1 be the number of turns per unit length of inner solenoid X of radius r_1, n_2 be the number of turns per unit length of outer solenoid Y of radius r_2. Let N_1 and N_2 be the total number of turns of solenoids X and Y respectively.



When a current I is passed through X, the magnetic flux linked with solenoid Y is
$N_2\phi_2 = M_{21}I$ ...(i)
where, M_{21} is called the mutual inductance of solenoid Y with respect to solenoid X. It is also referred as the coefficient of mutual induction.
The magnetic field due to current I in Y is
$B_2 = \mu_0 n_2 I$ ...(ii)
∴ The magnetic flux linked with Y is
$N_1\phi_1 = B_2(\pi r_1^2)n_1 l = \mu_0 n_1 n_2 \pi r_1^2 L I$ ...(iii)
where, $n_1 l$ is the total number of turns in solenoid X.
From (i) and (iii), we get
$M_{21} = \mu_0 n_1 n_2 \pi r_1^2 l$ ...(iv)
which is required expression.
Similarly, $M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$ ...(v)
From (iv) and (v), we get
$M_{12} = M_{21} = M$
Hence, coefficient of mutual induction between two coaxial solenoids is
$M = \mu_0 n_1 n_2 \pi r_1^2 l$ or, $M = \dfrac{\mu_0 N_1 N_2 \pi r_1^2}{l}$</td><td>1

2</td></tr>
<tr><td></td><td>SECTION D</td><td></td></tr>
<tr><td>29.</td><td>(I) (C) 30 mA</td><td>1</td></tr>
</table>

	 The potential difference across the resistance R is $V = 3.5\text{ V} - 0.5\text{ V} = 3\text{ V}$ By Ohm's law, The current in the circuit is $I = \frac{V}{R} = \frac{3\text{ V}}{100\ \Omega} = 3 \times 10^{-2}\text{ A}$ $= 30 \times 10^{-3}\text{ A} = 30\text{ mA}$	
	(II) (D) 10^{-6}	1
	(a) From the curve, at $I = 20$ mA, $V = 0.8$ V; $I = 10$ mA, $V = 0.7$ V $r_{fb} = \Delta V/\Delta I = 0.1\text{V}/10\text{ mA} = 10\ \Omega$ (b) From the curve at V = –10 V, $I = -1\ \mu$A, Therefore, $r_{rb} = 10\text{ V}/1\mu\text{A} = 1.0 \times 10^{7}\ \Omega$	
	(III) (B) 2.3 V	1
	Let V be the potential difference between A and B, then $V - 0.3 = (5 + 5) \times 10^3 \times (0.2 \times 10^{-3}) = 2$ $\Rightarrow V = 2.3\ V$	
	(IV) (A) (i) & (iv)	1
	(i) $V_A - V_B = 7 - 5 = +2$ V Forward Biased (ii) $V_A - V_B = 0 - 2 = -2$ V Reverse Biased (iii) $V_A - V_B = -10 - 0 = -10$ V Reverse Biased (iv) $V_A - V_B = -5 + 12 = +7$ V Forward Biased.	
30.	(I) **(a)** Maximum frequency produced by the X-rays = v The energy of the electrons is given by the relation. E = hv Where, h = Planck's constant = 6.626×10^{-34} Js $\therefore v = \frac{E}{h}$	1+1

$$= \frac{1.6 \times 10^{-19} \times 3 \times 10^4}{6.626 \times 10^{-34}}$$

$$= 7.24 \times 10^{18} \text{ Hz}$$

Hence, the maximum frequency of X-rays produced is 7.24×10^{18} Hz.

(b) The minimum wavelength produced by the X-rays is given as:

$$\lambda = \frac{c}{v}$$

$$= \frac{3 \times 10^8}{7.24 \times 10^{18}}$$

$$= 4.14 \times 10^{-11} \text{ m}$$

$$= 0.0414 \text{ nm}$$

(II)

No. of photons emitted per sec,

$$n = \frac{\text{Power}}{\text{Energy of photon}}$$ 1

$$= \frac{P}{h\upsilon} = \frac{10000}{6.6 \times 10^{-34} \times 880 \times 10^3}$$

$$= 1.72 \times 10^{31}$$

(III)

From Einstein's relation

$$eV_s = h\upsilon - W$$

As work function is a constant for a surface. 1

$$e(V_{s_2} - V_{s_1}) = h(\upsilon_2 - \upsilon_1)$$

$$V_{s_2} = V_{s_1} + \frac{h}{e}(\upsilon_2 - \upsilon_1)$$

$$= 0.19 + 1240\left(\frac{1}{190} - \frac{1}{550}\right) = 4.47 \text{ V}$$

SECTION E

31. (I) (A) 1

(i) The electric field between the plates is

$$E = \frac{V}{d}$$

The distance between plates is doubled, $d = 2d$

$$\therefore\ E' = \frac{V'}{d'} = \left(\frac{V}{K}\right) \times \frac{1}{2d} = \frac{1}{2}\left(\frac{E}{K}\right)$$

Therefore, if the distance between the plates is double, the electric field will reduce to one half.

(ii) As the capacitance of the capacitor

$$C' = \frac{\varepsilon_0 KA}{d'} = \frac{\varepsilon_0 KA}{2d} = \frac{1}{2}C$$

Energy stored in the capacitor is $U = \frac{Q^2}{2C}$ 2

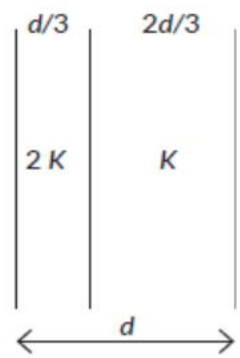
New energy, $U' = \frac{Q^2}{2C'} = \frac{Q^2}{2(1/2)C} = 2\left(\frac{Q^2}{2C}\right) = 2U$

Therefore, when the distance between the plates is doubled, the capacitance reduces to half and the energy stored in the capacitor becomes double.

(B)

$$C_1 = \frac{2K\varepsilon_0 A \times 3}{d}$$

$$C_2 = \frac{K\varepsilon_0 A \times 3}{2d}$$



Now both are in series 2

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d}{6K\varepsilon_0 A} + \frac{2d}{3K\varepsilon_0 A}$$

$$\frac{1}{C_S} = \frac{d + 4d}{6K\varepsilon_0 A}$$

$$C_S = \frac{6K\varepsilon_0 A}{5d}$$

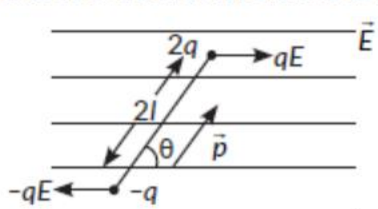
OR

(I) (A)

Consider a dipole with charge $-q$ and $+q$ seperated by a finite distance $2l$, placed in a uniform electric field $\vec{E}$. 3

It experiences a torque $\vec{\tau}$ which tends to rotate it as shown in figure below,

$\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\theta$



To neutralize this torque, let us assume an external torque $\vec{\tau}_{ext}$ be applied, which rotates it in the plane of the paper from angle q_0 to angle θ, without angular acceleration and at an infinitesimal angular speed.

Work done by the external torque.

$$W=\int_{\theta_0}^{\theta}\tau_{ext}(\theta)d\theta=\int_{\theta_0}^{\theta}pE\sin\theta d\theta$$

$$=pE\left[-\cos\theta\right]_{\theta_0}^{\theta}$$

$= pE[-\cos\theta - (-\cos\theta_0)]$

$= pE[-\cos\theta + \cos\theta_0]$

$= pE[\cos\theta_0 - \cos\theta]$

This work done is stored as the potential energy of the system in the position when the dipole makes an angle θ with the electric field.

Assuming potential energy to be zero when $\theta = 90°$

Putting $\theta_1 = 90°$, $U_1 = 0$

and $\theta_2 = \theta$, $U_2 = U$

$U - 0 = pE(\cos 90° - \cos\theta) \Rightarrow U = -pE\cos\theta$

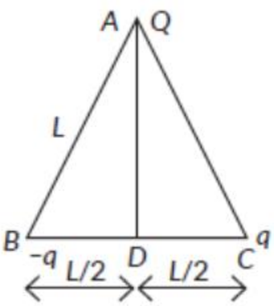
In vector form, $U=-\vec{p}\cdot\vec{E}$

(B)

(i) $\text{PE}=\sum\frac{kq_iq_j}{r_{ij}}$

Potential energy of the arrangement is given by

$$U=\frac{kQ(-q)}{L}+\frac{kQq}{L}+\frac{k(-q)q}{L}$$ 1



$$\therefore\ U=-\frac{kq^2}{L}$$

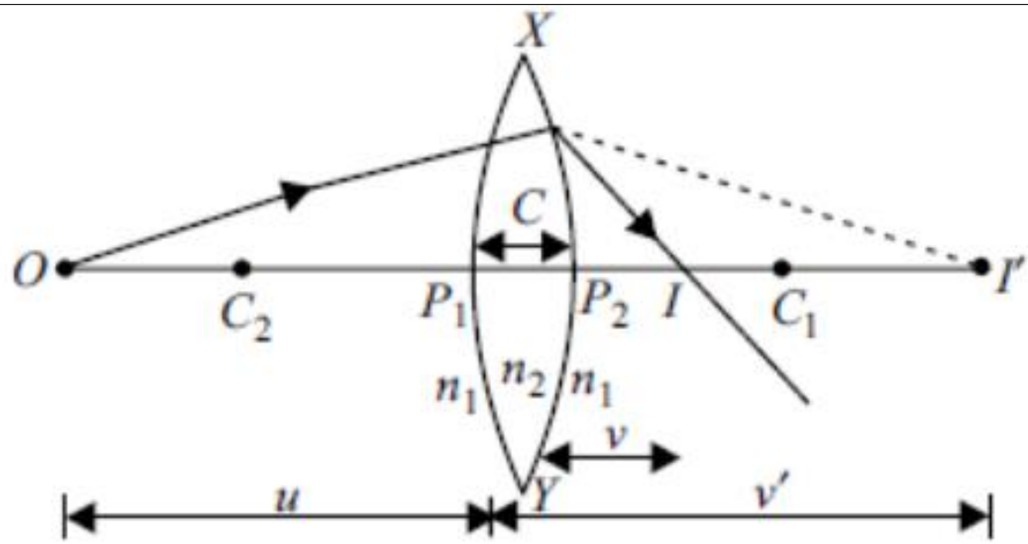
(ii) $AD=\sqrt{L^2-\frac{L^2}{4}}=\frac{\sqrt{3}}{2}L$

Potential at D

$$V=\frac{k(-q)\times 2}{L}+\frac{kq\times 2}{L}+\frac{kQ\times 2}{\sqrt{3}L}$$ 1

$$\therefore\ V=\frac{2kQ}{\sqrt{3}L}$$

32. (I) (A) 3+2



For refraction at spherical surface XP_1Y, object is at O and image is at I'.

So, object distance is u and image distance is v'. Also, ray of light is travelling from rarer medium (n_1) to denser medium (n_2).

So, $\frac{n_2 - n_1}{R_1} = \frac{n_2}{v'} - \frac{n_1}{u}$ ...(i)

For refraction at spherical surface XP_2Y, point I' behaves as virtual object and image is formed at I. Also, ray of light is travelling from denser medium (n_2) to rarer medium (n_1)

$\frac{n_2 - n_1}{R_2} = \frac{n_2}{v'} - \frac{n_1}{v}$ ...(ii)

Subtracting equation (ii) from (i), we get

$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ...(iii)

When the object is at infinity, light rays incident on lens are parallel and are converged at common point on principal axis known as principal focus F of lens.

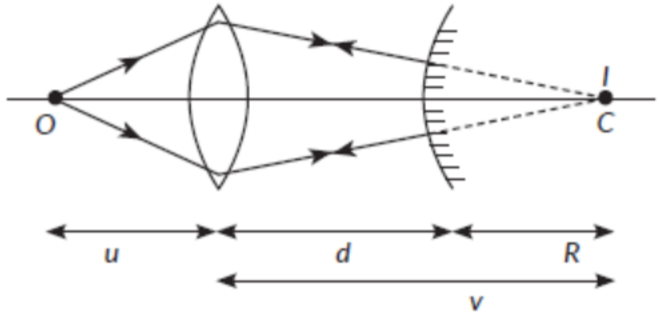
So, when $u = -\infty$ then $v = +f$ (focal length)

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

This is the lens maker formula when the lens of glass of refractive index n_2 is placed in any medium of refractive index n_1.

(B) The final image formed by the combination is coinciding with the object itself. Therefore rays from the object are retracing their path after refraction from the lens and reflection from the mirror.

The refracted rays are therefore, falling normally on the mirror. Thus, the image of the convex lens should form at the centre of curvature of the convex mirror.



Using lens formula,

$$\frac{1}{v} - \frac{1}{(-12)} = \frac{1}{10} \Rightarrow \frac{1}{v} = \frac{1}{10} - \frac{1}{12} = \frac{1}{60} \Rightarrow v = 60\,\text{cm}$$

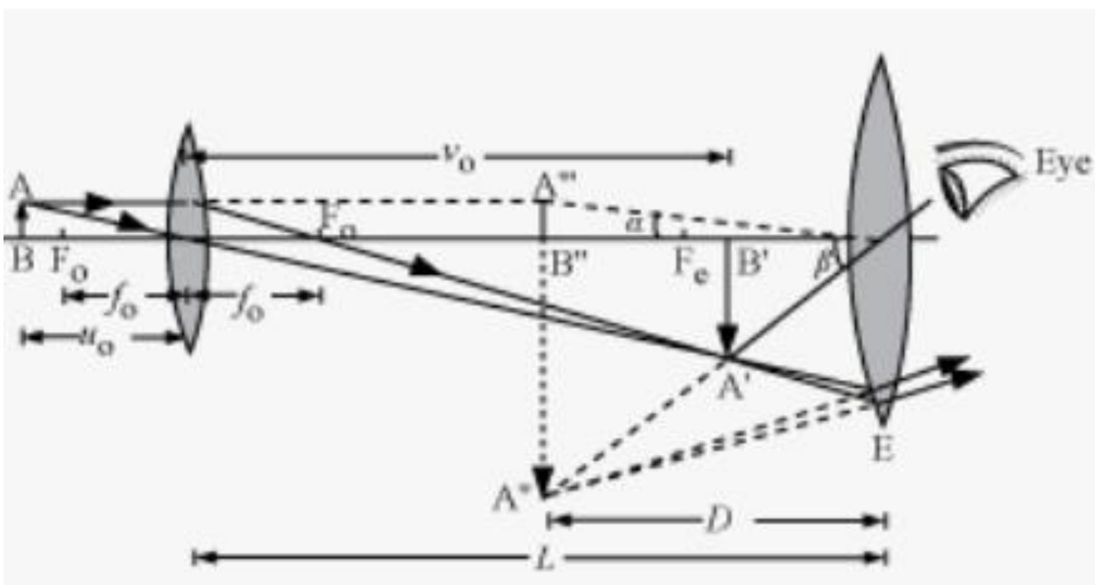
Radius of curvature, $R = v - d$

$\therefore \quad R = 60 - 10 = 50$ cm

$\therefore \quad$ Focal length, $f = \frac{R}{2} = 25\,\text{cm}$

OR

(II) (A)



1

(B) Compound microscope : It consists of two convergent lenses of short focal lengths and apertures arranged co-axially. Lens (of focal length *fo*) facing the object is known as objective or field lens while the lens (of focal length *fe*) facing the eye, is known as eye-piece or ocular. The objective has a smaller aperture and smaller focal length than eye-piece. Magnifying power of a compound microscope

$M = mo \times me$

Total angular magnification, $m = \dfrac{\beta}{\alpha}$

β → Angle subtended by the image

α → Angle subtended by the object

Since α and β are small,

$\tan\alpha \approx \alpha$ and $\tan\beta \approx \beta$

$m = \dfrac{\tan\beta}{\tan\alpha}$

$\tan\alpha = \dfrac{AB}{D}$ 2

And

$\tan\beta = \dfrac{A''B''}{D}$

$m = \dfrac{\tan\beta}{\tan\alpha} = \dfrac{A''B''}{D} \times \dfrac{D}{AB} = \dfrac{A''B''}{AB}$

On multiplying the numerator and the denominator with A′B′, we obtai

$m = \dfrac{A''B'' \times A'B'}{A'B' \times AB}$

Now, magnification produced by objective, $m_0 = \dfrac{A'B'}{AB}$

Magnification produced by eyepiece, $m_e = \dfrac{A''B''}{AB}$

Therefore,

Total magnification, $(m) = m_0\, m_e$

$m_0 = \dfrac{V_0}{u_0} = \dfrac{\text{Image distance for image produced by objective lens}}{\text{Object distance for the objective lens}}$

$m_e = \left(1 + \dfrac{D}{f_e}\right)$

f_e → Focal length of eyepiece

$m = m_0 m_e$

$= \dfrac{V_0}{u_0}\left(1 + \dfrac{D}{f_e}\right)$

(C)

<table>
<tr><td></td><td>

Given: μ_0 = -1.5 cm, f_0 = 1.25 cm

We have,

$$\frac{1}{f_0}=\frac{1}{v_0}-\frac{1}{u_0}$$

$$\frac{1}{1.25}=\frac{1}{v_0}-\frac{1}{-1.5}$$

$$\Rightarrow v_0 = 7.5 \text{ cm}$$

$$m=\frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)$$

$$=\frac{7.5}{-1.5}\left(1+\frac{25}{5}\right)$$

⇒ m = -30

</td><td>2</td></tr>
<tr><td>33.</td><td>

(I) (A), (B)

$$B_A=\frac{\mu_0 I}{2\times\pi x} \quad \text{(upwards)}$$

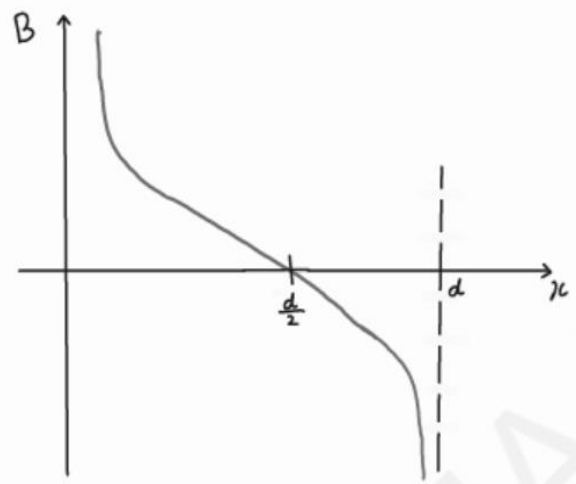
$$B_B=\frac{\mu_0 I}{2\times\pi\times(d-x)} \quad \text{(downwards)}$$

$$B=B_A-B_B$$

$$=\frac{\mu_0 I}{2\times\pi}\times\left(\frac{1}{x}-\frac{1}{d-x}\right)$$

$$=\frac{\mu_0 I}{2\times\pi}\times\frac{d-x-x}{x(d-x)}$$

$$=\frac{\mu_0 I}{2\times\pi}\cdot\frac{d-2x}{x(d-x)} \quad \text{(upwards)}$$



(C)

Thus we define ampere as the current flowing in each conductor separated by a unit distance so that one conductor applies a force of 2×10^{-7} N on a unit length of another parallel conductor.

OR

(II)

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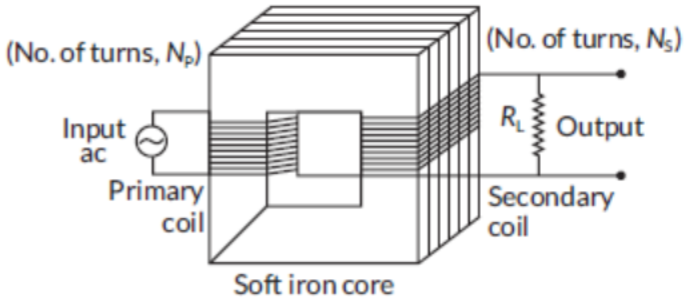
(a) Step-up transformer (or transformer) is based on the principle of mutual induction. 2



An alternating potential (V_p) when applied to the primary coil induced an emf in it.

$$\varepsilon_p = -N_p \frac{d\phi}{dt}$$

If resistance of primary coil is low $V_p = \varepsilon_p$.

i.e., $V_p = -N_p \frac{d\phi}{dt}$

As same flux is linked with the secondary coil with the help of soft iron core due to mutual induction, emf is induced in it.

$$\varepsilon_s = -N_s \frac{d\phi}{dt}$$

If output circuit is open $V_s = \varepsilon_s$

$$V_s = -N_s \frac{d\phi}{dt}$$

Thus, $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

For an ideal transformer, $P_{out} = P_{in}$

$\Rightarrow \quad I_s V_s = I_p V_p$

$$\therefore \quad \frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{N_s}{N_p}$$

For step-up transformer, $\frac{N_s}{N_p} > 1$

In case of dc voltage, flux does not change. Thus no emf is induced in the circuit. 1

(i) The core of the transformer is laminated to reduce eddy current losses.

(ii) Thick copper wire is used in winding of transformers because of its low resistivity *i.e.*, low resistance.

	(b) $N_p = 3000, V_p = 2200$ V, $V_s = 220$ V, $N_s = ?$ As, $\frac{V_s}{V_p} = \frac{N_s}{n_p}$ or, $N_s = \frac{N_p V_s}{V_p}$ $\therefore \quad N_s = \frac{3000 \times 220}{2200} = 300$	2