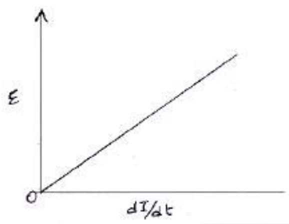
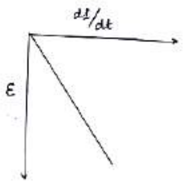
MARKING SCHEME: PHYSICS (042)

Code : 55/2/1

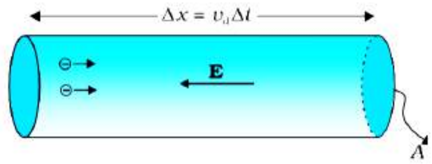
Q.No.	Value Points/Expected Answer	Marks	Total Marks
	SECTION A		
1	(D) R = 0	1	1
2	(A) Resistivity	1	1
3	(A) move in a straight line.	1	1
4	(B) ferromagnetic material becomes paramagnetic	1	1
5	(A) electric field is changing	1	1
6	(A) X – rays	1	1
7	(C) zero as diffusion and drift current are equal and opposite.	1	1
8	(B) just below the conduction band	1	1
9	(A) binding energy per nucleon increases	1	1
10	(A) neutron converts into a proton emitting antineutrino.	1	1
11	$(\emptyset_2 - \emptyset_1)\varepsilon_0 /\ (\emptyset_1 - \emptyset_2)\varepsilon_0$	1	1
12	Third OR $\frac{2\lambda}{a}$ [Alternatively, broader]	1	1
13	Small/ shorter	1	1
14	Perpendicular	1	1
15	Blue	1	1
16	$X_c = \frac{1}{2\pi\nu C}$ OR $Z = R$	1	1
17	Zero	1	1
18	 Alternatively 	1	1
19	6.03×10^{-7} m [Award full 1 mark even if a student writes 6×10^{-7} m]	1	1
20	For a given photosensitive material, there exists a certain minimum cut-off frequency of the incident radiation, called the **threshold frequency**, below which no emission of photo electrons takes place, no matter how intense the incident light is.	1	1
	SECTION B		
21	Definition of mobility or formula — 1 Derivation of relationship — 1 Mobility is defined as the magnitude of drift velocity per unit electric field. $\mu = \frac{\lvert \vec{V_d} \rvert}{E}$ [Even if a student writes only the mathematical relation award ½ mark] Given $V_d = \frac{e\tau E}{m}$ Hence, $\mu = \frac{V_d}{E} = \frac{e\tau}{m}$ OR	1 ½ ½	2

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>Definition of drift velocity
Relation between current density and drift velocity</td><td>1
1</td></tr>
</table>

The average speed with which electrons move when an electric field or potential difference is applied is called drift velocity.

$$\vec{V_d} = \frac{-e\vec{E}\tau}{m}$$

[Award 1/2mark if student writes the formulae]



The amount of charge crossing the area A in time Δt

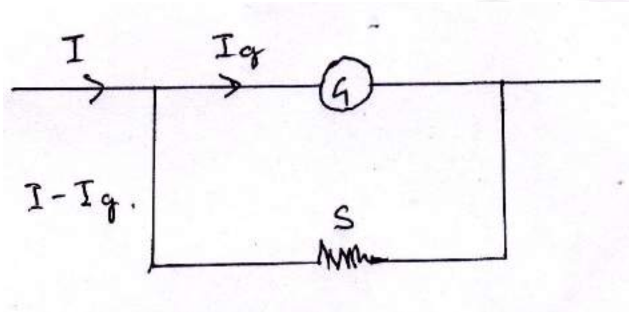
$$I\Delta t = ne\,A\left|\vec{V_d}\right|\Delta t$$

Hence current density

$$j = \frac{I}{A} = ne\,V_d$$
</td>
<td>1

½

½</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>
<table>
<tr><td>Diagram
Formula
Calculation of value of shunt</td><td>½
½
1</td></tr>
</table>



$$I_g = 1\ A$$

Resistance of ammeter, $R_A = 0.8\ \Omega$

$$I_g R_A = (I - I_g)\,S$$

$$\Rightarrow 1 \times 0.8 = (5-1)\,S$$

$$\Rightarrow S = 0.2\ \Omega$$
</td>
<td>½

1

½</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>
<table>
<tr><td>(a) Sharpness of resonance
(b) Value of power factor</td><td>1
1</td></tr>
</table>

(a)

Sharpness of resonance is the sharpness of the peak of the resonance curve / a graph between I_m and ω. The sharper or narrower the curve the narrower is the resonance or the resonance lasts over a very small range of frequencies /

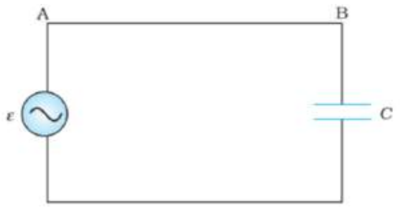
Q factor or quality factor is the measure of sharpness of curve.

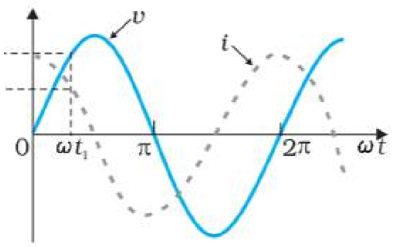
(b)

Z = R

Hence Power factor

$$\cos\emptyset = \frac{R}{Z}$$
</td>
<td>1</td>
<td></td>
</tr>
</table>

<table>
<tr><td></td><td>$\cos \emptyset = 1$
Even if a student just writes power factor is 1, award full 1 mark</td><td>1</td><td>2</td></tr>
<tr><td></td><td>OR
<table><tr><td>Deduction of expression for current
(i) Graph V vs ωt
(ii) Graph I vs ωt</td><td>1
½
½</td></tr></table>


$$I = \frac{dq}{dt} = \frac{d}{dt} C\, V_0 \ \sin \omega t = \ \omega C V_0 \cos \omega t$$
$$= \ I_0 \ \cos \omega t$$
$$= \ I_0 \ \sin\left(\omega t + \frac{\pi}{2}\right)$$
where $I_0 = \frac{V_0}{(^1/_{\omega C})}$
(i)


[Student can draw the two graphs separately also provided the graphs are co-related.]</td><td>½
½
1</td><td>2</td></tr>
<tr><td>24</td><td><table><tr><td>Identification of waves (a) & (b)
Uses</td><td>½ + ½
½ + ½</td></tr></table>
(a) minimum wavelength: γ rays
(b) minimum frequency: Microwaves
γ rays are used to treat cancer
Microwaves are used for communication
[or any other correct use]</td><td>½
½
½
½</td><td>2</td></tr>
<tr><td>25</td><td><table><tr><td>Values of f and u with sign conventions
Nature of image
Position of image</td><td>½
½
1</td></tr></table>
The focal length $f = \frac{-R}{2} = -30\ cm\ u = \ -20\ cm$
$$\frac{1}{V} + \frac{1}{u} = \frac{1}{f}$$
$$\therefore \frac{1}{V} - \frac{1}{20} = -\frac{1}{30} \quad \Rightarrow \frac{1}{V} = -\frac{1}{30} + \frac{1}{20}$$
$$\therefore \ V = +60\ cm$$
Nature of image: virtual, erect and magnified</td><td>½
½
½
½</td><td>2</td></tr>
</table>

26

Identification of b and θ	½ + ½
Values of b	½ + ½

(a) b represents impact parameter ½

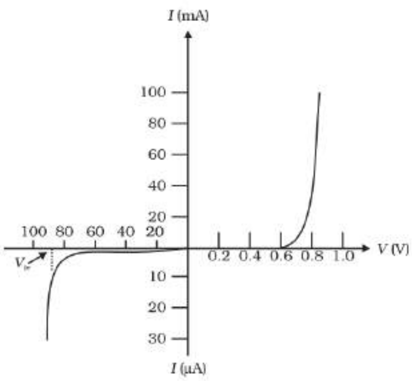
θ represents scattering angle ½

(b) (i) for $\theta = 0^0$ impact parameter is large or infinite ½

(ii) for $\theta = 180^0$ impact parameter is zero. ½ — 2

27

V-I characteristics	1
Explanation for voltage independence of reverse current	1



1

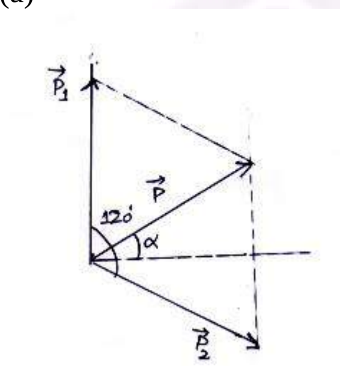
Since reverse current is due to flow of minority charge carriers across the junction, it is limited due to the concentration of minority carriers on either side of the junction. It is therefore independent of the voltage applied. 1 — 2

SECTION C

28

(a) Magnitude & direction of net dipole moment	1½
(b) Magnitude & direction of net torque	1½

(a)



½

$$P = (p_1{}^2 + p_2{}^2 + 2\, p_1\, p_2 \cos 120^0)^{1/2}$$
$$= (2p^2 - p^2)^{1/2}$$
$$= p$$ ½

Making 60^0 angle with $\vec{p_1}$ and α = 30^0 (angle with X axis) ½

[$p_1 = p_2 = p$]

[Do not deduct ½ mark if diagram is not drawn but dipole moment and its direction are correctly worked out.

If correct and complete vector diagram is drawn but dipole moment is not worked out then award 1 mark out of 1.5] ½

(b)

$$\vec{\tau} = \vec{P} \times \vec{E}$$ ½

$$\tau = PE \sin 30^0$$ ½

$$= \frac{1}{2} pE$$ 3

Direction of $\vec{\tau}$ is into the plane of the paper or along -z direction.

OR

(a) Equivalent capacitance	1
(b) Maximum charge supplied	1
(c) Total energy stored	1

1

½

(a) $C = C_4 = 4\mu F$ (as C_1, C_2, C_4, C_5 are short circuited) ½

(b) $Q = CV = 4 \times 7\ \mu C$ ½

$= 28\ \mu C$

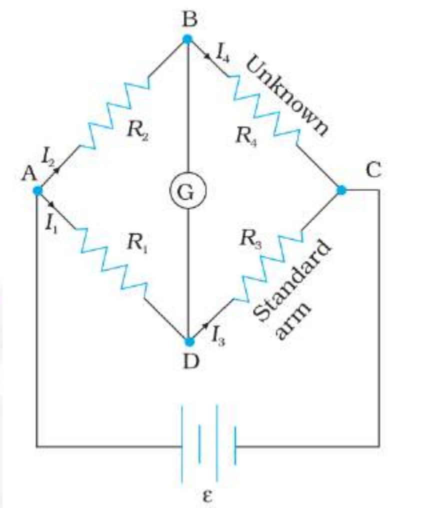
(c) $\mathcal{U} = \frac{1}{2} CV^2$ ½

$$= \frac{1}{2} \times 4 \times 10^{-6} \times 7 \times 7 = 98 \times 10^{-6} J$$ 3

29

(a) Derivation of balance condition	2
(b) Circuit diagram	1

(a)



½

In a balanced Wheatstone bridge $I_g = 0$

$$\therefore\ I_1 = I_3 \quad \text{and} \quad I_2 = I_4$$

Applying loop rule in ADBA

$$-I_1R_1 + 0 + I_2R_2 = 0$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1} \qquad \text{(i)}$$ ½

And in loop CBDC

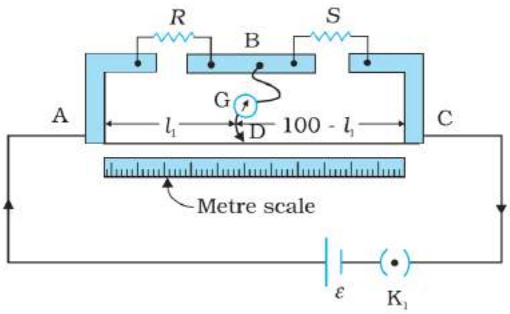
$$I_2R_4 + 0 - I_1R_3 = 0$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{R_4}{R_3} \qquad \text{(ii)}$$ ½

From (i) and (ii)

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$ ½

Condition for balanced Wheatstone bridge

<table>
<tr><td></td><td>(b)

</td><td>1</td><td>3</td></tr>
<tr><td>30</td><td>

(a) Capacitance of the capacitor	1
(b) Value of inductance	1
(c) Graph	1

(a) From graph $X_c = 6\ \Omega$ at $\upsilon = 100$ Hz

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi\upsilon C}$$

$$C = \frac{1}{2\pi\upsilon X_c} = \frac{1}{2\pi \times 600}$$

$$C = \frac{1}{1200\ \pi} = 0.265\text{mF} = 0.265 \times 10^{-3} f$$

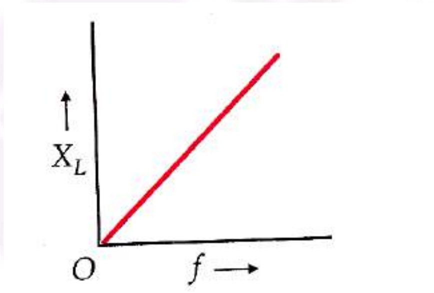
[Even if a student evaluates part(a)correctly using any other point on the graph, award full 1 mark.]

(b)

$$X_C = X_L = \omega L = 6 \quad \text{at } 100 \text{ Hz}$$

$$L = \frac{6}{2\pi\upsilon}$$

$$= \frac{6}{2\pi \times 100} = 0.955 \times 10^{-2}\text{H}$$

(c)


</td><td>½
½
½
½
1</td><td>3</td></tr>
<tr><td>31</td><td>

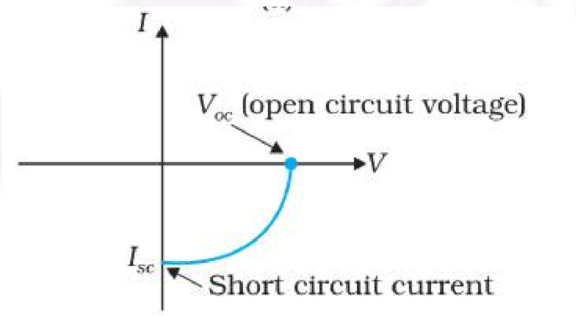
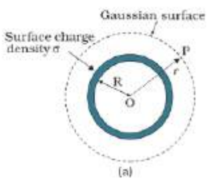
Differences in construction	1 mark
Determination of position of object	2 marks

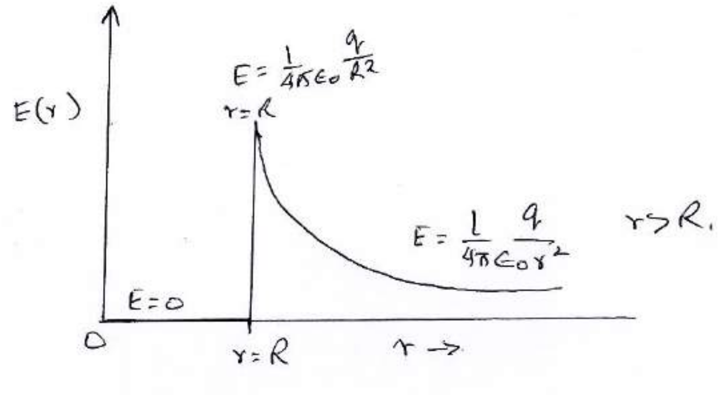
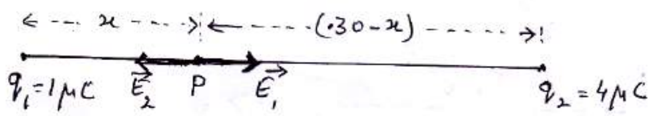
Aperture of telescope objective lens is large whereas aperture of microscope objective is small

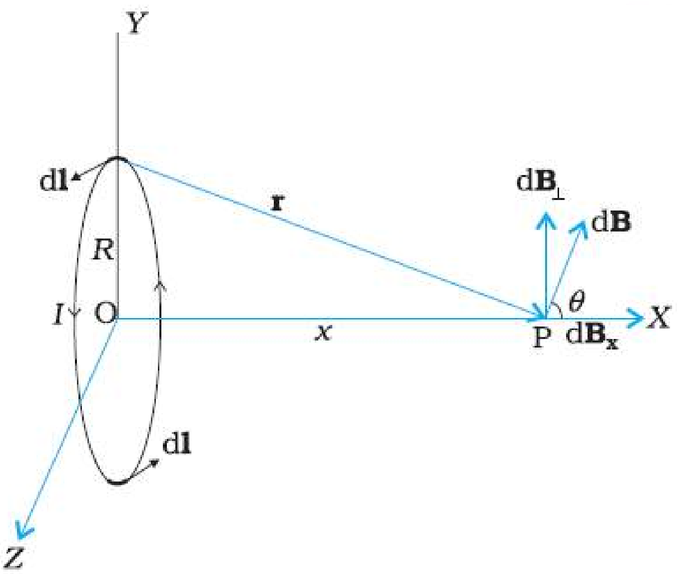
$f_o > f_e$ in telescope
$f_o < f_e$ in microscope

[Alternatively, focal length of telescope objective is large whereas focal length of microscope objective is very small]
[Award full 1 mark even if a student writes only one difference]
</td><td>½
½</td><td></td></tr>
</table>

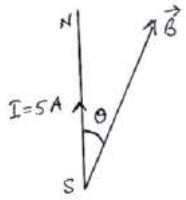
	$m = m_o \times m_e$ $m_e = 1 + \frac{D}{f_e} = 1 + \frac{25}{5} = 6$ $\therefore m_o = \frac{30}{6} = -5$ $m_o = \frac{v}{u} = -5$ $v = -5u$ $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ $\frac{1}{1.25} = \frac{1}{5u_o} + \frac{1}{u_0}$; $u = -u_0$ $u_0 = \frac{6}{5} \times 1.25 = 1.5cm$ [Alternatively, $m_o = \frac{v}{u} = \frac{f_o}{f_o + u_o}$ $-5 = \frac{1.25}{1.25 + u_o}$ $-7.5 = 5u_o$ $u_o = -1.5cm$ (for last ½ mark)]	½ ½ ½ ½	3
32	Deduction of expression for threshold wavelength — 2 marks Deduction of expression for work function — 1 mark $K_{max} = \frac{hc}{\lambda_1} - \phi_o = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_o}\right)$ when $\lambda = \lambda_2$ $2K_{max} = hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_o}\right)$ $\frac{K_{max}}{2K_{max}} = \frac{1}{2} = \frac{\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_o}\right)}{\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_o}\right)}$ $\lambda_o = \frac{\lambda_1 \lambda_2}{2\lambda_2 - \lambda_1}$ = Threshold wavelength $\phi_o = \frac{hc}{\lambda_o} = \frac{hc(2\lambda_2 - \lambda_1)}{(\lambda_1 \lambda_2)}$	½ ½ ½ ½ 1	3
33	a) Differentiation between Half life and Average life — ½ + ½ b) Deduction of fraction of amount of the substance — 2 Half life is the time it takes for a radioactive sample, that has initially N_o radio nuclei, to reduce to $\frac{N_o}{2}$ $T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$ Mean life is obtained by adding the lives of all the nuclei over time 0 to infinity and dividing it by total number N_o of nuclei at t=0 $\tau = 1/\lambda$	½ ½	

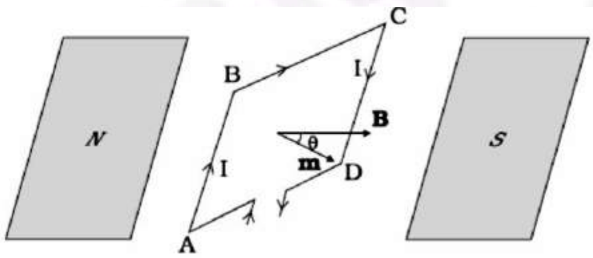
	[Even if a student writes only the relations for $T_{1/2}$ and τ award full marks for the definitions] $$N = N_o e^{-\lambda t}$$ At $t = \tau = 1/\lambda$ $$N = N_o e^{-\lambda \times \frac{1}{\lambda}}$$ $$\frac{N}{N_o} = \frac{1}{e}$$	½ ½ 1	3
34	Function of solar cell — 1 mark Working of solar cell — 1 ½ mark IV characteristics — ½ mark Solar cell is a device which converts solar energy into electrical energy. [Alternatively, when solar radiation falls on a solar cell, it generates emf.] Working When solar radiation falls on a solar cell three important phenomena occur 1) Generation: e-h pair generation near the depletion region 2) Separation: e-h will separate due to the electric field in depletion region 3) Collection- electrons are collected by front contact on n side and holes are collected by back contact on p side. Thus, a potential difference will be created. 	1 ½ ½ ½ ½	3
	SECTION D		
35	(a) Expression for electric field outside a charged shell — 2 Graph of E vs r — 1 b) Location of point where field is zero — 2 (a) 	½	

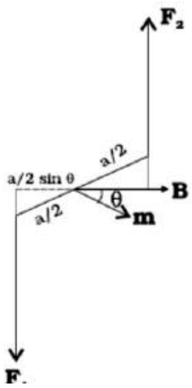
	$$\phi = \frac{q}{\epsilon_0}$$	½	
	$$E \times 4\pi r^2 = \frac{\sigma(4\pi R^2)}{\epsilon_0}$$	½	
	$$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r^2}$$ $$[\therefore q = \sigma(4\pi R^2)]$$ which is electric field due to a point charge q at a distance r from it	½	
	 For r<R, E=0 because q=0 inside the shell	1	
	(b) 	½	
	E_1=E_2		
	$$\frac{1}{4\pi\epsilon_o}\frac{1\times10^{-6}}{x^2} = \frac{1}{4\pi\epsilon_o}\frac{4\times10^{-6}}{(0.3-x)^2}$$	½	
	$$(0.3-x)^2 = 4x^2$$	½	
	$$0.3-x = 2x$$		5
	$$x = 0.1m = 10\ cm\ (to\ the\ right\ of\ q_1)$$	½	
	OR		
	a) Work done in assembling the system — 2 b) (i) Evaluation of electric field — 1 ½ (ii) Electric flux through the cube — 1 ½		
	(a) The work done in bringing charge q_1 from infinity to r_1 is $$W_1 = q_1V_1$$	½	
	The work done in bringing charge q_2 from infinity to r_2 is $$W_2 = q_2V_2$$	½	
	Work done in moving q_2 against the field due to q_1 $$W_3 = \frac{1}{4\pi\epsilon_o}\frac{q_1q_2}{r}$$	½	
	Hence total work done is $W = W_1 + W_2 + W_3$		

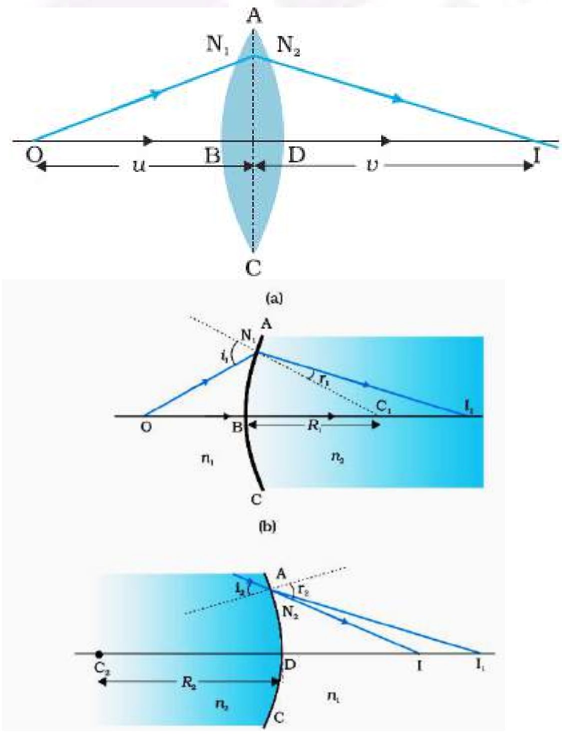
	$W = q_1V_1 + q_2V_2 + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r}$ [V_1 and V_2 are potentials at the two points in the electric field] (b) (i) $E = \frac{-dV}{dx} = -\frac{d}{dx}(10x+5)$ $\therefore \vec{E} = -10\hat{i}$ N/C (ii) Electric flux through the cube, ϕ =sum of electric flux through 6 faces Electric flux through faces perpendicular Y and Z axis = 0 $\because$ E is along x axis Electric flux through faces perpendicular to x axis $= \phi_1 + \phi_2$ $= 10 \times (0.2)^2 - 10 \times (0.2)^2$ =0	½ 1 ½ ½ ½ ½	5
36	(a) Magnetic field at a point on the axis of the current loop 3 (b)Magnitude and direction of the magnetic force 2 (a)  $dB = \frac{\mu_0 Idl}{4\pi(x^2+R^2)}$ dB has two components dB_x and $dB_\perp$, perpendicular components from diametrically opposite elements dl cancel out, thus only dB_x components remain effective $dB_x = dB\cos\theta$ and $\cos\theta = \frac{R}{(x^2+R^2)^{\frac{1}{2}}}$ $\therefore B = \int dB_x$ $= \int_0^{2\pi R} \frac{\mu_0 IdlR}{4\pi(x^2+R^2)^{\frac{3}{2}}}$	½ ½ ½ ½	

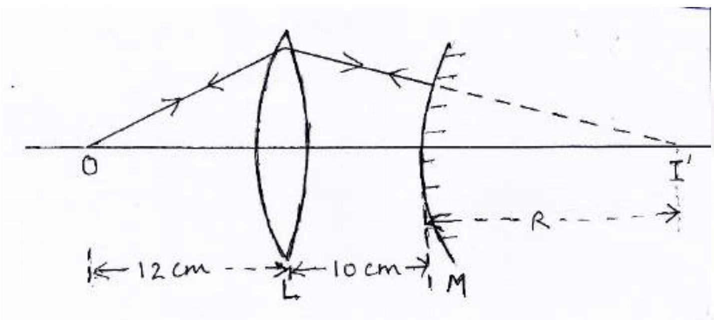
<table>
<tr><td></td><td>$$= \frac{\mu_0 I R^2}{2(x^2 + R^2)^{\frac{3}{2}}}$$ along the axis of the loop</td><td>1</td><td></td></tr>
<tr><td></td><td>(b)

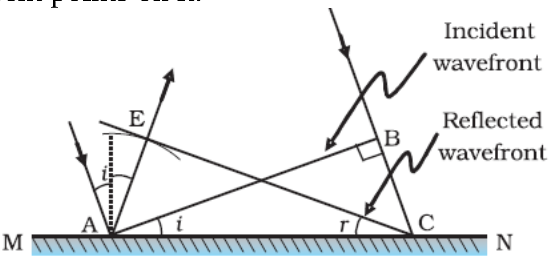
(i)

</td><td>½</td><td></td></tr>
<tr><td></td><td>$\vec{F} = I[\vec{l} \times \vec{B}]$</td><td>½</td><td></td></tr>
<tr><td></td><td>$F = IlB \sin\theta$
$= 5 \times 2 \times 0.6 \times 10^{-4} \times 0.5 = 3 \times 10^{-4} N$</td><td>½</td><td></td></tr>
<tr><td></td><td>(ii) Towards east</td><td>½</td><td>5</td></tr>
<tr><td></td><td>OR

(a) Derivation of torque — 2
Reason of radial magnetic field — 1
(b) Kinetic Energy of the particle — 2</td><td></td><td></td></tr>
<tr><td></td><td>(a)



</td><td>½</td><td></td></tr>
<tr><td></td><td>Arms AD and BC experience no net force whereas arm AB and CD experience forces which constitute torque
$F_1 = F_2 = IbB$
Therefore magnitude of torque</td><td>½</td><td></td></tr>
</table>

	$\tau = \left(F_1 \frac{a}{2} + F_2 \frac{a}{2} \right) \sin\theta$ $\tau = I(ab)\sin\theta$ *where* $ab = A$(*area of the loop*) $\Rightarrow \tau = IAB\sin\theta$ *for N number of turns* $\tau = NIAB\sin\theta$ $\tau = \vec{M} \times \vec{B}$ Where magnetic moment M=NIA Galvanometer has Radial magnetic field to increase the field strength and to make torque independent of orientation θ/ it maximise the torque (b) The kinetic energy $KE = \frac{1}{2} \frac{q^2B^2R^2}{m}$ $= \frac{1}{2} \times \frac{(1.6 \times 10^{-19})^2 \times (0.4)^2 \times (0.4)^2}{1.6 \times 10^{-27}} J$ $= \frac{(1.6 \times 10^{-19})^2 \times (0.4)^2 \times (0.4)^2}{2 \times 1.6 \times 10^{-27} \times 1.6 \times 10^{-19}} eV$ $= 1.28\ MeV$	½ ½ 1 ½ ½ ½ ½	5
37	(a) Derivation of the lens maker's formula 2½ (b) Ray diagram 1 (c) Focal length of the mirror 1½ (a) 	½ ½	

(b)	For first refracting surface $\frac{\mu_2}{v_1} - \frac{\mu_1}{u} = \frac{\mu_2-\mu_1}{R_1}$ ----------------------------1 For second refracting surface ADC $\frac{\mu_1}{v} - \frac{\mu_2}{v_1} = \frac{\mu_1-\mu_2}{R_2}$ ------------------------------2 Adding equations 1 and 2, we get $\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $\Rightarrow \frac{1}{v} - \frac{1}{u} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $\because \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ $\therefore \frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ also $\frac{\mu_2}{\mu_1} = \mu$ $\therefore \frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$	½ ½ ½	
	 	1	
	$f_1 = 10\,cm$ $u = -12\,cm$ *Aplying lens formula* $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ $\frac{1}{10} = \frac{1}{v} - \frac{1}{-12}$ $\Rightarrow v = 60\,cm$ $\therefore$ *radius of curvature of the mirror* $R = 60\,cm - 10\,cm = 50\,cm$ *hence focal length of the morror* $f_m = \frac{R}{2} = 25\,cm$	½ ½ ½	5
	OR (a) Definition of wavefront ½ Propagation of wavefront ½ Verification of law of refraction 2 (b) (i) Determination of width of the slit 1 (ii) Calculation of distance of secondary maxima 1		

	(a) Wavefront is a surface of constant phase. Alternatively, It is the locus of all those points which are in the same phase of disturbance. The wave propagates in a direction perpendicular to the wavefront through secondary wavelets originating from different points on it.  Consider a plane wave AB incident at an angle I with speed v on the surface MN in time τ Therefore BC=v τ Using Huygen's principle, a sphere of radius v τ which has tangent plane CE is reflected at an angle r $\therefore AE = BC = v\tau$ $\because \Delta EAC$ and ΔBAC are congruent $\because \angle i = \angle r$ (b) (i) $x = \frac{\lambda D}{d}$ $\Rightarrow d = \frac{\lambda D}{x} = \frac{500 \times 10^{-9} \times 1}{2.5 \times 10^{-3}} = 2 \times 10^{-4}$m (ii) For the first Secondary maxima $x = \frac{3\lambda D}{2d}$ $= \frac{3\times500\times10^{-9}\times1}{2\times2\times10^{-4}}$ =3.75mm [Even if a student finds location of first secondary maxima by (2.5)+ ($\frac{1}{2} \times 2.5$) =3.75mm, award full 1 mark for b(ii)]	½ ½ ½ ½ ½ ½ ½ ½ ½ ½	5