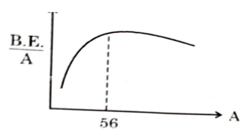
SOLUTIONS

: PHYSICS(042) Code: 55/1/2

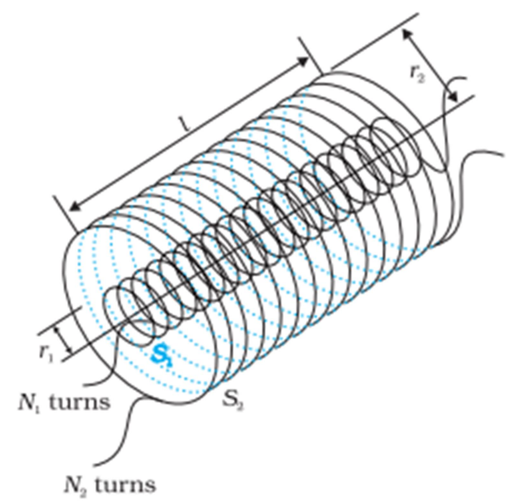
Q.No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks
	SECTION A		
1	(C) C	1	1
2	(B) Using a wire of same radius and half length.	1	1
3	(B) $\left(-3\hat{j}+2\hat{k}\right)\mu N$	1	1
4	(C) 2	1	1
5	(B) 2866	1	1
6	(D) $\frac{i_0 v_0}{2}\cos\phi$	1	1
7	(B) Speed / Wavelength / Frequency Remains same / Decreases / Increases	1	1
8	(A) medium '1' and at an angle greater that $\sin^{-1}\left(\frac{v_1}{v_2}\right)$	1	1
9	(A) 10^{16}	1	1
10	(A) 	1	1
11	(C) The barrier height and the depletion layer width both decrease.	1	1
12	(B) $\lambda_e > \lambda_p > \lambda_d$	1	1
13	(D) Assertion (A) is false and Reason (R) is also false.	1	1
14	(C) Assertion (A) is true but Reason (R) is false.	1	1
15	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
16	A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
	SECTION - B		
17	Obtaining Ohm's law from $\vec{E} = \rho\vec{j}$ — 1 ½ Writing the condition — ½ $\vec{E} = \rho\vec{j}$ $\frac{V}{l} = \rho\frac{I}{A}$	 ½ ½	

	$\frac{V}{I} = \rho \frac{l}{A}$ = constant (Ohm's Law) Condition for non- validity of Ohm's Law High temperature / in semiconductor	½ ½	 2
18	(a) **Calculating the width of the slit — 2** Condition for Minima a sinθ = nλ For First Minima n=1 $a \sin 30^\circ = 600 \times 10^{-9}$ m $a \times \frac{1}{2} = 600 \times 10^{-9}$ m $a = 1200 \times 10^{-9}$ m $= 1.2 \times 10^{-6}$ m OR (b) **Finding the Intensity — 2** Phase difference = $\frac{2\pi}{\lambda} \times$ path difference $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ $\because \Delta x = \frac{\lambda}{8}\ (given)$ $\Delta\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{8}$ $\Delta\phi = \frac{\pi}{4}$ $I = I_\circ + I_\circ + 2\sqrt{I_\circ I_\circ}\cos\frac{\pi}{4}$ $= 2I_\circ + 2I_\circ \times \frac{1}{\sqrt{2}}$ $I = 2I_\circ\left(1 + \frac{1}{\sqrt{2}}\right)$ $= I_\circ(2 + \sqrt{2})$ $I = 3.414\, I_\circ$ **Alternatively**	 1 ½ ½ ½ ½ ½ ½	

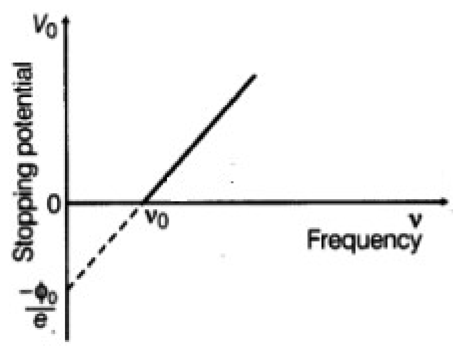
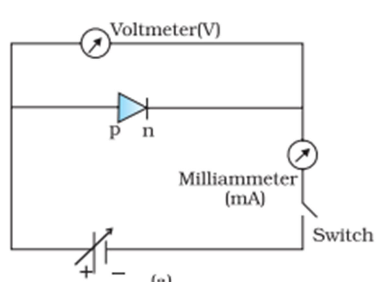
	Phase difference = $\frac{2\pi}{\lambda}\times$ path difference $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ $\because \Delta x = \frac{\lambda}{8}\ (given)$ $\Delta\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{8}$ $\Delta\phi = \frac{\pi}{4}$ $I = 4I_{\circ}\cos^2\left(\frac{\phi}{2}\right)$ $I = 4I_{\circ}\cos^2\left(\frac{\pi}{8}\right)$	½ ½ ½ ½	2
19	Finding the position 1½ Nature of the Image formed ½ Refraction from rarer to denser medium $\frac{n_1}{-u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$ $u=-\frac{R}{2}, n_1=1, n_2=1.5$ $\frac{2}{R}+\frac{1.5}{v}=\frac{1.5-1}{R}$ $\frac{1.5}{v}=\frac{0.5}{R}-\frac{2}{R}$ $\frac{1.5}{v}=-\frac{1.5}{R}$ v = - R The image is virtual in air at distance R.	½ ½ ½ ½	2
20	Finding the Angular momentum 2 $E_n = -\frac{13.6}{n^2}eV$ $n^2 = \frac{-13.6}{-3.4} = 4$ n=2 Angular momentum	½ ½	

	$L = \frac{nh}{2\pi}$ $L = \frac{h}{\pi} = \frac{6.63\times10^{-34}}{3.14} = 2.11 \times 10^{-34}$ Js	½ ½	2
21	Finding the number of holes 1 One example 1 1 dopant atom for 5×10^{7} Si atoms and number density of Si atoms = $5\times10^{28}\ \frac{\text{atoms}}{\text{m}^3}$ (*given*) No. of holes created per m^3 = $\frac{5\times10^{28}}{5\times10^{7}} = 10^{21}$ Number of holes created per cubic centimeter $= \frac{10^{21}}{10^{6}} = 10^{15}$ Any one example of dopant - Aluminium / Indium / Gallium	1 1	2
	SECTION - C		
22	(a) Finding (i) Equivalent emf of combination 1 (ii) Equivalent internal resistance of combination 1 (iii) Current drawn from combination 1 (i) Because $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$ $E_{eq} = \frac{3\times0.4 + 6\times0.2}{0.6} = 4$ V (ii) $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$ $r_{eq} = \frac{0.2\times0.4}{0.2+0.4} = 0.133\Omega$ (iii) $I = \frac{E}{R + r_{eq}}$ $I = \frac{4}{4+0.13} = \frac{4}{4.13} A$ $I = 0.9A$ OR	½ ½ ½ ½ ½ ½	

	(b) (i) Finding the relation (i) between R' and R 1 (ii) between v_d' and v_d 1 (ii) To identify whether all free electrons are moving in the same direction. 1		
	(i) $l' = 2l$ $Al = A'l'$ = volume of the wire $Al = A'(2l)$ $\frac{A}{2} = A'$	½	
	R = $\frac{\rho l}{A}$ $R' = \frac{\rho l'}{A'}$ $R' = \frac{\rho(2l)}{A/2}$	½	
	$\frac{R'}{R} = 4$		
	Alternatively	½	
	$R' = n^2 R$ n= 2	½	
	$R' = 4R$	½	
	(ii) $v_d = \frac{eE}{m}\tau$ $v_d = \frac{eV}{ml}\tau$ $v_d' = \frac{eV}{ml'}\tau$ $\frac{v_d'}{v_d} = \frac{l}{l'} = \frac{1}{2}$	½	
	(ii) No	1	3
23	a) Defining magnetic moment 1 SI unit of magnetic moment ½ b) Finding the magnitude of magnetic field 1½		
	a) Magnetic moment of a current carrying coil is defined as the product of	1	

	current flowing through the coil and Area of the coil. **Alternatively** $\vec{M} = I\vec{A}$ S.I. unit is Am^2 b) $\tau = NIABsin\theta$ $\tau_1 = 0.12 = 60 \times 2 \times 1.5 \times 10^{-3} \times Bsin\theta$ $Bsin\theta = \frac{2}{3}$ $\tau_2 = 0.05 = 60 \times 2 \times 1.5 \times 10^{-3} \times Bcos\theta$ $Bcos\theta = \frac{5}{18}$ $B = \sqrt{B^2sin^2\theta + B^2cos^2\theta}$ $= \sqrt{\left(\frac{2}{3}\right)^2 + \left(\frac{5}{18}\right)^2} = \frac{13}{18}T$	½ ½ ½ ½	3
24	Deriving the expression for mutual Inductance 2 Showing $M_{21} = M_{12}$ 1  Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively. When current I_2 is set up in S_2, flux linkage with solenoid S_1 is – $N_1\phi_1 = M_{12}I_2$ --(i) $N_1\phi_1 = (n_1 l)(\pi r_1^2)(\mu_0 n_2 I_2)$ $N_1\phi_1 = \mu_0 n_1 n_2 \pi r_1^2 l I_2$ --(ii) From (i) and (ii) $M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$	½ ½ ½ ½	

	Considering Reverse case, when I_1 current is set up in S_1 , flux linkage with S_2 is – $N_2\phi_2 = M_{21}I_1$ --(iii) $N_2\phi_2 = (n_2 l)(\pi r_1^2)(\mu_0 n_1 I_1)$ --(iv) From (iii) and (iv) $M_{21} = n_1 n_2 \pi r_1^2 l$ $\therefore M_{12} = M_{21}$	½ ½	3
25	a) Showing that ($I_c + I_d$) has the same value. 2 b) Explanation of Kirchhoff's first rule at each plate of capacitor. 1 a) $\because$ Total current $I = I_c + I_d$ outside the capacitor $I_d = 0$ $\therefore I = I_c$ Inside the capacitor $I_c = 0$ $\therefore I = I_d = \varepsilon_0 \frac{d\phi_E}{dt}$ $= \varepsilon_0 \frac{d}{dt}[EA]$ $= \varepsilon_0 \frac{d}{dt}\left[\frac{\sigma}{\varepsilon_0} A\right]$ $= \frac{\varepsilon_0}{\varepsilon_0} A \frac{d}{dt}\left[\frac{Q}{A}\right]$ $I = \frac{dQ}{dt} = I_c$ **Alternatively** $\because$ Total current $I = I_c + I_d$ outside the capacitor $I_d = 0$ $\therefore I = I_c$ Inside the capacitor $I_c = 0$ $I = I_d = \varepsilon_0 \frac{d\phi_E}{dt}$ $= \varepsilon_0 \frac{d}{dt}\left[\frac{Q}{\varepsilon_0}\right]$ $I = \frac{dQ}{dt} = I_c$ hence $I_c + I_d$ has the same value at all points of the circuit.	½ (at $I_d = 0$) ½ (at $I_c = 0$) ½ (at $= \varepsilon_0 \frac{d}{dt}[EA]$) ½ (at $I = \frac{dQ}{dt} = I_c$) ½ (at $I_d = 0$) ½ (at $I_c = 0$) ½ (at $I = I_d = \varepsilon_0 \frac{d\phi_E}{dt}$) ½ (at $I = \frac{dQ}{dt} = I_c$)	

	b) Yes Current entering the capacitor is (I_c) and between the plates capacitor is (I_d) $I_c = I_d$ which validates Kirchhoff's junction rule.	1	3
26	a) Drawing a plot of frequency(ν) as a function of stopping potential (V_0) 1 Obtaining information from intercept ½ b) Calculating i) the momentum 1 ii) de Broglie wavelength ½ a)  Value of work function can be obtained from intercept. b) i) $p = \sqrt{2mK}$ $= \sqrt{2 \times 9.1 \times 10^{-31} \times 80 \times 1.6 \times 10^{-19}}$ $= 4.8 \times 10^{-24}$ kg m/s ii) $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{4.8 \times 10^{-25}} = 1.38 \times 10^{-9}$ m	1 ½ ½ ½ ½	3
27	a) Circuit Arrangement for studying V–I characteristics. 1 b) Showing the shape of characteristic curves. 1 c) Two informations from the characteristics ½ + ½ a)  Circuit diagram for forward characteristics	½	

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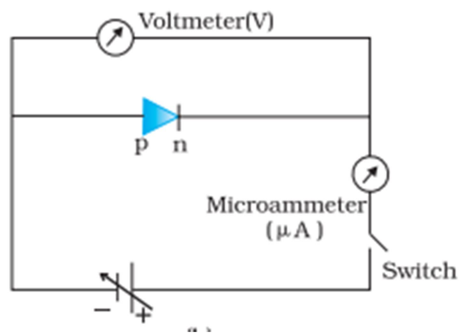
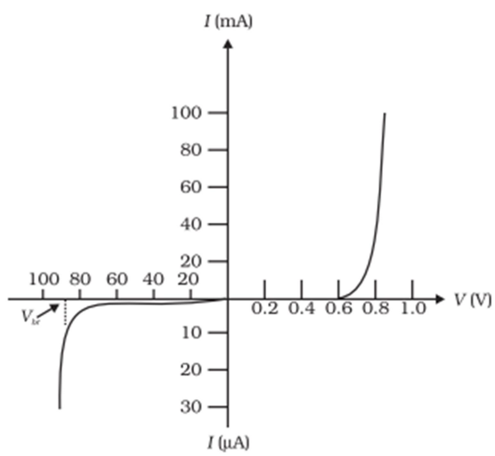


Circuit diagram for Reverse characteristics
b)



Note : Please do not deduct marks for not writing values.

c) Any two informations
Knee voltage / reverse saturation current / Breakdown voltage / very low resistance in forward biasing / very high resistance in Reverse biasing.
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½ + ½</td>
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<tr><td>a)</td><td>Defining Mass Defect</td><td>½</td></tr>
<tr><td></td><td>Defining Binding Energy</td><td>½</td></tr>
<tr><td></td><td>Describing Fission Process</td><td>½</td></tr>
<tr><td>b)</td><td>Calculation of Mass Defect</td><td>1</td></tr>
<tr><td></td><td>Calculation of Energy</td><td>½</td></tr>
</table>
a) Difference in the mass of the nucleus and its constituents is defined as mass defect.
Binding Energy is the energy required to separate the nucleons from the nucleus.
In Fission process a heavy nucleus splits into lighter nuclei and energy is released. As a result the Binding Energy per nucleon increases.
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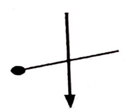
	b) $\Delta m = (m_p + m_n) - m_d$ $\Delta m = (1.007277 + 1.008665) - 2.013553$ $\Delta m = 0.002389$ u Energy released = $\Delta m \times c^2$ Energy released = 0.002389×931.5 = 2.2253 MeV ≈2.22 MeV	½ ½ ½	 3
	SECTION - D		
29	i) (C)  ii) (A) For a convex mirror magnification is always negative iii) (B) 2f OR (B) 12 cm iv) (C) $\sqrt{X_1X_2}$	1 1 1 1	 4
30	i) (B) 5mC ii) (A) zero iii) (D) [$M^0L^0TA^0$] iv) (A) $\frac{1}{2\sqrt{e}} mA$ **Note: 1 mark for this part may be given to all the students who have attempted other parts of the question.** OR (B) 0.5 mA	1 1 1 1	 4
	SECTION - E		
31	a) i) 1) Definition of coherent sources. 1 Necessity of coherent sources for sustained interference pattern 1 2) Explanation 1 ii) 1) Finding distance between adjacent bright fringes. 1 2) Finding angular width 1 i) 1) If the phase difference between the displacement produced by each of the wave from two sources does not change with time then two sources are said to be coherent. **Alternatively** Two sources are said to be coherent if they emit light continuously of same frequency / wavelength and having zero or constant phase difference. Coherent sources are required to get constant phase difference. 2) Two independent sources will never be coherent because phase difference between them will not be constant. ii) 1) Distance between adjacent bright fringe = fringe width	 1 1 1	

$$\beta = \frac{\lambda D}{d}$$ ½

$$= \frac{600\times10^{-9}\times1.2}{0.1\times10^{-3}} = 7.2\,\text{mm}$$ ½

2) $$\theta = \frac{\lambda}{d}$$ ½

$$= \frac{600\times10^{-9}}{0.1\times10^{-3}} = 6\times10^{-3}\ \text{rad} = 0.34°$$ ½

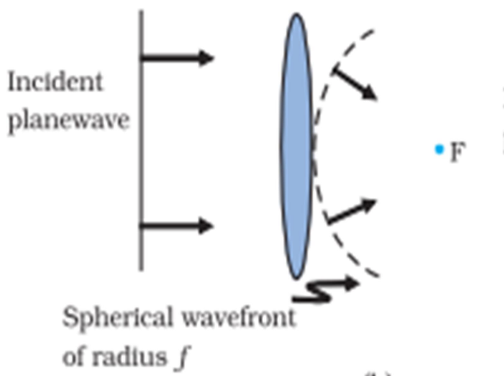
Give full marks if the student writes the answer in radians only.

OR

b)

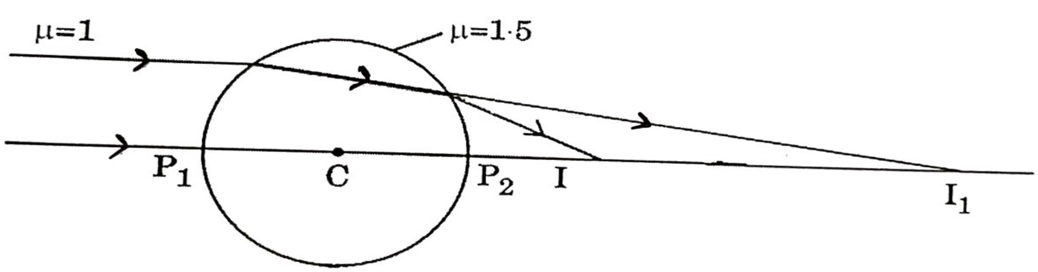
i) Definition of wave front.	1
Drawing the incident and refracted wave front	½ + ½
ii) Drawing the ray diagram	1
Obtaining the position of final image	2

i) A wavefront is a locus of all the points which oscillate in phase. 1



½ + ½

ii)



1

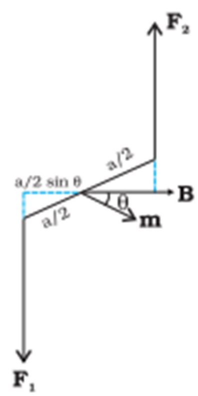
From I[st] surface , Refraction is from rarer to denser medium and object is at ∞

$n_1 = 1$, $n_2 = 1.5$, R = 15 cm , u= ∞

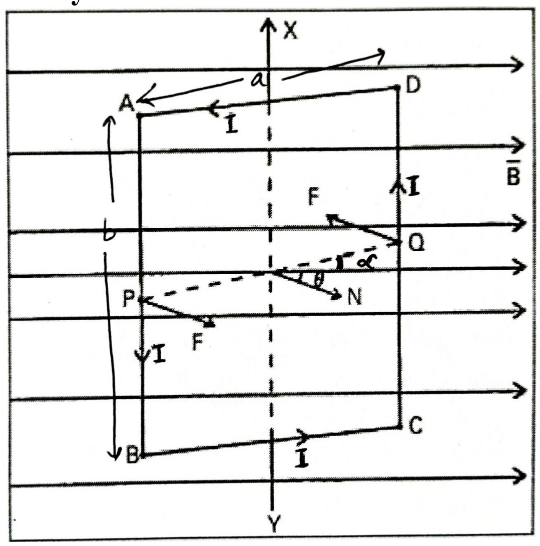
$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$ ½

	$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5-1}{15}$ v= 45 cm From 2nd surface , Refraction is from denser to rarer medium and object is at 15 cm $n_1 = 1$, $n_2 = 1.5$, R = -15 cm , u= 15cm $\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$ $\frac{1}{v} - \frac{1.5}{15} = \frac{1-1.5}{-15}$ v= 7.5 cm	½ ½ ½	5
32	a) i) Calculating the change in electrostatic energy of the system — 2 ii) (1) Finding the capacitance. — 1 (2) Finding the potential difference. — 1 (3) Answering and Reason — ½ + ½ (i) $\vec{E} = \frac{3\times10^5}{r^2}\hat{r}$ (Given) $dV = -\vec{E}.d\vec{r}$ $V = 3 \times 10^5 / r$ Electrostatic energy of the system in the absence of the field $U_i = \frac{Kq_1q_2}{r_{12}}$ Electrostatic energy in the presence of the field $U_f = \frac{Kq_1q_2}{r_{12}} + q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$ $\Delta U = U_f - U_i = q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$ $\Delta U = \frac{5\times10^{-6}\times3\times10^5}{3\times10^{-2}} - \frac{1\times10^{-6}\times3\times10^5}{3\times10^{-2}}$ = 40 J ii) 1) $C = \frac{Q}{V} = \frac{80}{16} = 5\mu F$ 2) $C' = KC$ $= 3\times5\mu F = 15\ \mu F$ $V' = \frac{Q}{C'} = \frac{80\mu C}{15\mu F} = 5.33V$ 3) No, The capacitance of the system depends on its geometry. OR	½ ½ ½ ½ 1 ½ ½ ½ ½	

	b) i) Comparing the magnitude of the Electric fields 2 ii) Calculating the work done on the charge 3 Total charge for A = Total charge for B = Total charge for C = +4q As , $E = \frac{kQ}{r^2}$ Since Q = 4q and r = 3R $E = \frac{k(4q)}{9R^2} = \frac{4kq}{9R^2}$ $\therefore E_A = E_B = E_c$ ii) $V_c = \left[\frac{k\times 6\times 10^{-6}}{5\times 10^{-2}} - \frac{k\times 6\times 10^{-6}}{5\times 10^{-2}}\right]$ $= 0$ $V_A = \left[\frac{k\times 6\times 10^{-6}}{15\times 10^{-2}} - \frac{k\times 6\times 10^{-6}}{5\times 10^{-2}}\right]$ $= \frac{k\times 6\times 10^{-6}}{10^{-2}}\left[\frac{1-3}{15}\right]$ $= -\frac{9\times 10^{9}\times 6\times 10^{-6}\times 2}{15\times 10^{-2}}$ $= -7.2\times 10^{5}$ V $W = q\left[V_A - V_c\right]$ $= 5\times 10^{-6}\left[-7.2\times 10^{5} - 0\right]$ W = - 3.6 J	 1 ½ ½ 1 ½ ½ ½ ½	 5
33	a) i) Finding the direction of magnetic field near points P,Q and R ½ + ½ + ½ Conclusion about the relative magnitude of magnetic field. ½ + ½ + ½ ii) Showing the given expression of magnetic moment. 2 i) <u>Near point P</u> Magnetic field is acting into the plane of the paper as Force is acting upwards. <u>Near point Q</u> Magnetic field is into the plane of paper as force is acting upwards. <u>Near point R</u> Magnetic field is acting out of the plane of the paper as $\vec{F}$ is acting downwards. <u>Relative Magnitude of the Magnetic field.</u> As $B \; \alpha \frac{1}{r}$ Therefore, Near point P, magnitude of B is small. Near point Q, B is relatively smaller than point P.	 ½ ½ ½ ½ ½	

	Near point R, B is relatively larger than point P. ($B_Q < B_P < B_R$)	½	
	ii) Let r be the radius of the circular coil and I is the current in the coil then $B = \frac{\mu_0 I}{2r}$ or $I = \frac{2Br}{\mu_0}$	½	
	A = πr^2 r = $\sqrt{\frac{A}{\pi}}$	½	
	M = IA	½	
	$= \frac{2Br}{\mu_0} A$ $= \frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$	½	
	OR		
	b) i) Deriving the expression for the torque. — 3 ii) 1) Finding the change in radius. — 1 2) Finding the change in time period of Revolution. — 1		
	i) 	½	
	$\vec{F_1}$ *and* $\vec{F_2}$ are the forces acting on two arms of the rectangular coil having sides a and b. $\lvert\vec{F_1}\rvert = \lvert\vec{F_2}\rvert = I\,b\,B$ (b = length of the arm)	1	
	Forces constitute a couple. The magnitude of Torque on the loop is – $\tau = F_1 \frac{a}{2}\sin\theta + F_2 \frac{a}{2}\sin\theta$	½	
	$= I\,a\;b\,B\sin\theta$		
	$= IA\,B\sin\theta$	½	
	$\vec{\tau} = I\vec{A} \times \vec{B}$	½	

Alternatively



½

If the plane of the current carrying coil marks an angle ∝ with the magnetic field

$\vec{F}_{DA} = -\vec{F}_{Bc}$ (cancel each other) . ½

Force on the arm DC is into the plane of the paper

$|F_{DC}| = IbB$. ½

Force on the arm AB is out of the plane of the paper. ½

$|F_{AB}| = IbB$

Both of them form a couple and Torque acting on the coil is

τ=either force ×perpendicular distance between the two forces.

$\tau = IbB \times a\cos\alpha$

$= IabB\cos\alpha$

$\tau = IAB\cos\alpha$ ½

Let $\hat{n}$ =outward drawn normal to the plane of the coil.

$\theta + \alpha = 90^0$

$\alpha = 90^0 - \theta$

$\tau = IAB\cos(90-\theta)$

$= IAB\sin\theta$ ½

$\vec{\tau} = I\vec{A} \times \vec{B}$

ii) 1) $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$ ½

$r \;\alpha\; \sqrt{K}$

$\frac{r'}{r} = \frac{\sqrt{K/2}}{\sqrt{K}} = \frac{1}{\sqrt{2}}$

$r' = \frac{r}{\sqrt{2}}$ ½

	2) $T=\frac{2\pi m}{qB}$ Time period does not depend on Kinetic Energy ∴ Time period will not change.	½ ½	5