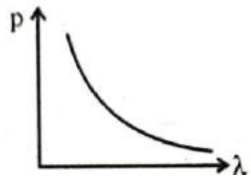
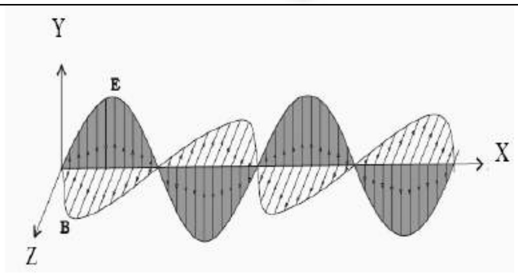
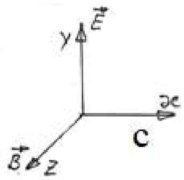
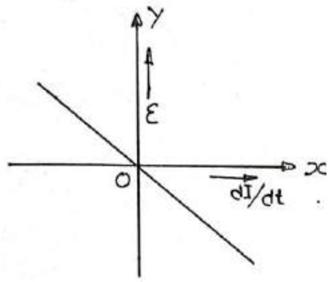
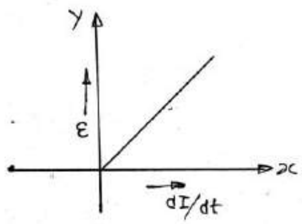
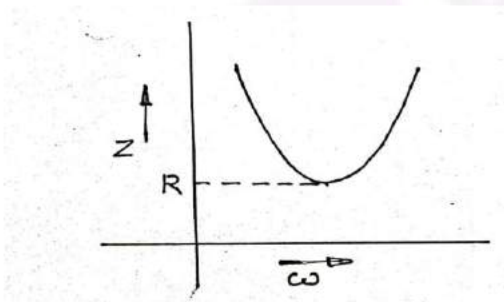
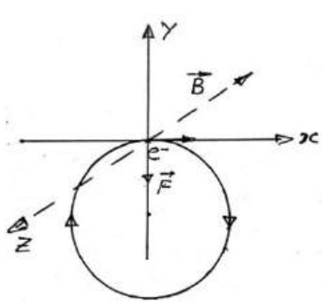
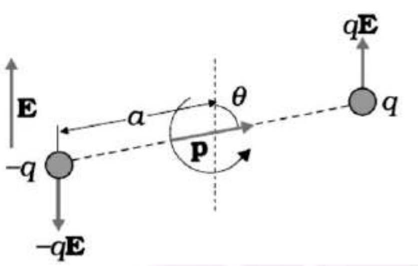
Marking Scheme: Physics (042)

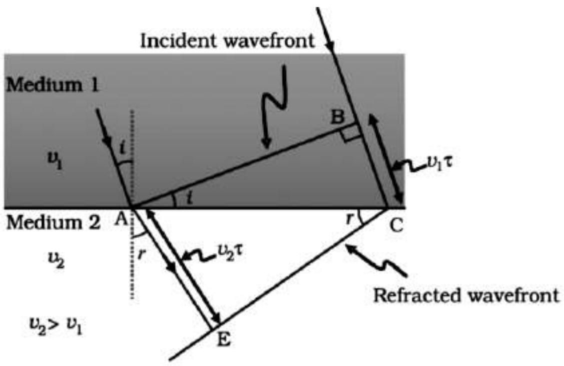
Code :55/5/1

Q.No.	VALUE POINTS/ EXPECTED ANSWERS	Marks	Total Marks
	SECTION A		
1.	(a) $v \tan\theta = c$	1	1
2.	(d) Optical Signals	1	1
3.	(c) L is large and R is small	1	1
4.	(b) 	1	1
5.	(a) Forward bias and energy gap of the semiconductor	1	1
6.	(b) $\sqrt{2}\,r$	1	1
7.	(a) Net Charge enclosed and permittivity of the medium	1	1
8.	(b) 3:4	1	1
9.	(a) 1	1	1
10.	(b) P/2	1	1
11.	Electrostatic potential difference/ Electric potential	1	1
12.	Electric current	1	1
13.	4:1	1	1
14.	Conductivity/ Resistivity (Also give full credit if a student writes semiconducting nature)	1	1
15.	Rectify	1	1
16.	Angular deflection of the galvanometer coil per unit current./deflection per unit current Alternatively $I_s = \frac{\phi}{I}$ alternatively $\frac{NAB}{K}$	1	1
17.	 Alternatively 	1	1

18.	(i) for constructive interference path difference, $\Delta p = n\lambda$ (ii) for destructive interference path difference, $\Delta p = (2n+1)\frac{\lambda}{2}, n = 0,1,2,3--$ Alternatively $\Delta p = (2n-1)\frac{\lambda}{2}, n = 1,2,3--$	½ ½	1
19.	 Induced e.m.f. in a coil, $\varepsilon = -L\frac{dI}{dt}$ [Award one full mark even if the student just draws the graph without writing the expression of induced emf] (Note: Award this one mark if a student draws the graph in first quadrant as shown below.)  **OR** $Z = \sqrt{R^2 + (X_L - X_C)^2}$  [Award one full mark even if the student just draws the graph without writing expression of impedance]	½ ½ ½ ½	**1** **1**
20	 **Alternatively:** Circular path in the X-Y plane in clockwise sense.	1 ½+½	

	[Note: If the student just writes, force on the electron will be along negative Y axis, i.e. $F = -e(v\,\hat{i}) \times (B(-\hat{k}) = evB(-\hat{j})$ *award* $1/2$ *mark only*) **OR** Magnitude of force on side NO is $= F$ **Alternatively** Let force on side MP be $= F_1$ Force on side $NO = \frac{F_1}{2}$ Magnitude of net force $= F_1 - \frac{F_1}{2} = \frac{F_1}{2} = F$ Therefore force on side NO $= \frac{F_1}{2} = F$ Give full credit if a student calculates the force as shown below. $F = \frac{\mu_0}{2\pi} I_1 I_2$	 ½ ½	 1
	SECTION B		
21.	Derivation of the expression for the torque 1½ Identification of the orientation of stable equilibrium ½  Force on q is q**E** and a force on –q is –q**E**. Hence torque $\tau = qE \times 2a \sin\theta$ $\tau = PE \sin\theta$ $\vec{\tau} = \vec{P} \times \vec{E}$ For stable equilibrium $\theta = 0^0$ **OR** Obtaining the expression for the energy stored 1½ Definition of energy density ½ Let the charge on the capacitor plates at any instant, during charging process be q, amount of work done to supply further charge dq to the capacitor	 ½ ½ ½ ½	

	$dW = Vdq$ $where\ V\ is\ the\ potential\ difference\ and\ equals\ to\ \frac{q}{C}$ $Total\ work\ done\ to$ charge $the\ capacitor\ upto$ charge Q $W = \int_0^Q Vdq$ $= \int_0^Q \frac{q}{C}dq = \frac{Q^2}{2C}\ \left(\frac{1}{2}CV^2 = \frac{1}{2}QV\right)$ Since $Energy\ stored = work\ done$ $\Rightarrow U = \frac{Q^2}{2C}\ \left(\frac{1}{2}CV^2 = \frac{1}{2}QV\right)$ Energy density: Electrical energy stored per unit volume is known as energy density. Alternatively: Energy density $= \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{\sigma^2}{\varepsilon_0}$	½ ½ ½ ½	 2
22.	Origin of gamma rays and radio waves ½+½ Main application of each ½+½ Gamma rays are emitted by radioactive nuclei/produced in nuclear reactions. Radio waves are produced by accelerated /oscillating charges/LC circuit. Gamma rays are used for the treatment of cancer/in nuclear reactions. Radio waves are used in communication systems/radio or television communication systems/cellular phones. (or any other correct applications)	 ½ ½ ½ ½	 **2**
23.	Effect and justification ½+½ Effect and justification ½+½ **(i)** Intensity of light transmitted by P_1 remains unaffected when P_1 is rotated about the direction of propagation of light. **Justification:** The intensity of unpolarized light transmitted by a Polaroid does not depend on the orientation of the Polaroid with respect to the direction of propagation of light. **(ii)** The intensity of light transmitted by P_2 will vary from I_1 to zero. **Justification:** As per Malus' Law $I = I_0 \cos^2\theta$ Where θ is the angle between the pass axis of the polaroid P_2 and the pass axis of polaroid P_1. As θ varies from 0^0 to $\pi/2$, I_2 will vary from I_1 to zero.	 ½ ½ ½ ½	 2

	OR Definition of wave front 1 Obtaining refracted wave front 1 The wave front is a surface of constant phase. **Alternatively** The wave front is the locus of all points that are oscillating in phase. 	1 1	2
24.	Finding Binding Energy of P, Q and R ½+½+½ Finding energy released ½ B.E. of heavy nucleus P $= 240 \times 7.6$ MeV=1824 MeV B.E. of nucleus Q $= 110 \times 8.5$ MeV=935 MeV B.E. of nucleus R $= 130 \times 8.4$ MeV=1092 MeV Energy released $= [(935 + 1092) - 1824]$ MeV $= [2027 - 1824]$ MeV $= 203$ MeV	½ ½ ½ ½	2
25.	Finding Planck's constant from the graph 1 Effect on stopping potential ½ Justification ½ According to Einstein's Photo electric equation $h\nu = \phi_0 + eV_s$ $eV_s = h\nu - \phi_0$ $V_s = \frac{h\nu}{e} - \frac{\phi_0}{e}$ since $\nu = c/\lambda$	½	

	$\therefore V_s = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$ $= \left(\frac{hc}{e}\right)\frac{1}{\lambda} + \left[\frac{-\phi_0}{e}\right]$ Comparing with the equation of straight line y=mx +c (a) The slope of the line $m = \frac{hc}{e}$. Hence, Planck's constant $h = \frac{me}{c}$ (b) Stopping potential will remain same **Justification** Variation of distance of light source from the metal surface will alter the intensity while the stopping potential however depends only on the frequency and not on the intensity of the incident light.	½ ½ ½	2
26.	Expression for angular momentum ½ Expression for magnetic moment 1 Relation between the two ½ According to Bohr's model $L = Angular\ momentum = mvr = \frac{nh}{2\pi}$ $\mu =$ M$agnetic\ moment = current \times area\ of\ the\ orbit$ $\mu = \|e\| \times \nu \times \pi r^2 = \frac{\|e\| vr}{2}$ $\therefore \frac{L}{\mu} = \frac{mvr \times 2}{\|e\| vr} = \frac{2m}{\|e\|}$ $\mu = \frac{\|e\|}{2m} L$	½ ½ ½ ½	2
27.	Effect and justification ½+½ Effect and justification ½+½ (i) On increasing the width of the slit, the size of the central bright band will decrease (ii) **Justification:** Angular width $= \frac{2\lambda}{a}$, i.e. angular width is inversely proportional to the width of the slit (iii)The intensity of central bright band will increase **Justification:** The amplitude/intensity of light passing through slit has increased.	½ ½ ½ ½	2
	SECTION C		
28.	(a) Difference between electrical resistance and resistivity 2 (b) Obtaining the expression for effective resistivity 1		

	(a) Electrical resistance (R) of a conductor equals the ratio of the potential difference (V) applied across it, to the resulting current (I) flowing through it. (Alternatively: $R = \frac{V}{I}$) The resistivity of a conductor equals the resistance of a wire of unit length and unit area of cross section, drawn from the material of that conductor. (Alternatively: $R = \rho \frac{l}{A}$ or $\rho = \frac{RA}{l}$) (or any other one relevant difference) (b) For the parallel combination equivalent resistance is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{A_1 + A_2}{\rho_{eq} L} = \frac{A_1}{\rho_1 L} + \frac{A_2}{\rho_2 L}$ Where $(A_1 + A_2)$ is the effective area of cross section of combined rod in parallel combination of the rods. $\frac{\rho_1 \rho_2}{(\rho_2 A_1 + \rho_1 A_2)} = \frac{\rho_{eq}}{(A_1 + A_2)}$ $\Rightarrow \rho_{eq} = \frac{\rho_1 \rho_2 (A_1 + A_2)}{(\rho_2 A_1 + \rho_1 A_2)}$ **(Note :**If a student just writes the expression of equivalent resistance, award half mark of this part)	1 1 ½ ½	3
29.	Finding the energy in the first excited state — 1 Finding the associated kinetic energy — 1 Finding the associated de-Broglie wavelength — 1 Energy of the electron in the first excited state $E_1 = -\frac{13.6}{2^2} eV = -3.4 eV$ $= -3.4 \times 1.6 \times 10^{-19} J$ $= -5.44 \times 10^{-19} J$ Associated kinetic energy =Negative of total energy $K = 5.44 \times 10^{-19} J$ de-Broglie wavelength, $\lambda = h/p$ $\lambda = \frac{h}{\sqrt{2mK}}$	½ ½ ½ ½ ½	

	$\lambda = \frac{6.63\times10^{-34}}{(2\times9.1\times10^{-31}\times5.44\times10^{-19})^{1/2}}$ m $\lambda = \frac{6.63\times10^{-34}}{(99.008)^{1/2}\times10^{-25}}$ m $\approx 0.663\times10^{-9}$ m $= 0.663$nm $= 6.63A^{\circ}$	½	3
30.	(a) Definition of decay constant — 1 (b) Calculation of the activity — 2 (a) The decay constant (λ) of a given radioactive sample is the constant of proportionality between its instantaneous decay rate $\left(-\frac{dN}{dt}\right)$ and the total number of its decaying nuclei (N) at that instant. **Alternatively** decay constant, $\lambda = \frac{\lvert dN/dt \rvert}{N}$ **Alternatively** decay constant, $\lambda = \ln 2 / T_{1/2}$ where $T_{1/2}$ is the half life of the radioactive substance **Alternatively** decay constant, $\lambda = 1/T_m$ where T_m is the mean life of the radioactive substance (b) Activity, $R = \lambda N$ Here $\lambda = \frac{0.6931}{4.5\times10^{9}}$ years^{-1} also N = number of atoms in the 10g sample of ${}^{238}_{92}U$ $N = \frac{10}{238}\times6.023\times10^{23}$ *atoms* $\therefore R = \frac{0.6931}{4.5\times10^{9}}\times\frac{10}{238}\times6.023\times10^{23}$ *atoms / year* $R = 0.039\times10^{16}$ *atoms / year* $= 3.9\times10^{14}$ *atoms / year* $= 1.24\times10^{7}$ atoms/second (Note: Do not deduct any mark if a student does not write answer in atoms per second.)	1 ½ ½ ½ ½	3
31.	Solar cell — 1 V-I characteristics — ½ Three processes involved — ½+½+½		

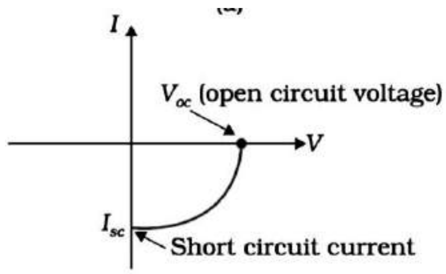
A solar cell is basically a p-n junction which generates emf when solar radiation falls on the p-n junction.

1

Alternatively:

A solar cell works on the same principle as the photodiode, however, no external bias applied to it and its junction area is much larger than that of a photodiode.

V-I Characteristics



½

Three processes involved in the working of the solar cell are

Generation: Light $(h\nu > E_g)$ generates electron-hole pairs.

½

Separation: Electric field, of the depletion region, separates the electron and the holes.

½

Collection: The front contact collects the electrons reaching the n-side and back contact collects holes reaching the p-side.

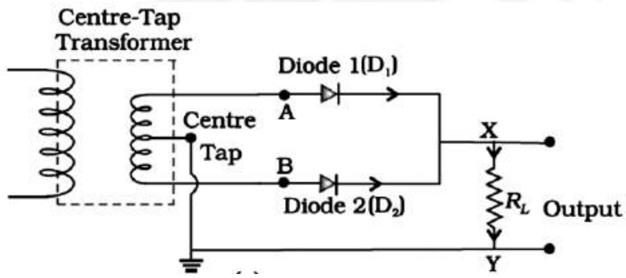
½

[**Note:** For the last part, award one mark if the student just writes the three names of three processes without giving any explanation.]

OR

Circuit diagram	1
Working	1
Input and output waveform	1

3



1

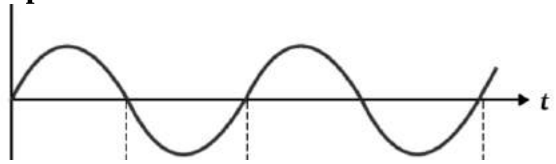
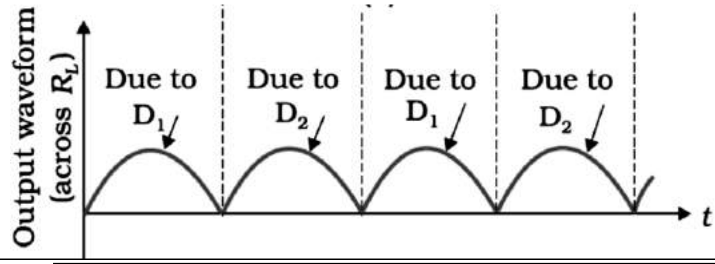
During one half cycle of the input a.c. signal, only diode 1 is forward biased and conducts.

During the next half cycle of the input ac signal only diode 2 is forward biased and conducts.

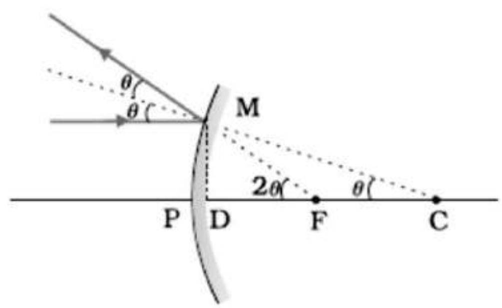
½

However, due to the use of the centre tapped transformer, the current in the load flows in the same direction during both these half cycles. The current through the load is therefore unidirectional.

½

	Input waveform  **Output waveform**  	½ ½	3
32.	Identification 1 Calculation of magnifying power 2 Objective lens with a power of 100 D, has a focal length of 1cm (very short focal length) Eye piece, with a power of 50 D, has a focal length of 2cm (short focal length) The optical instrument is therefore a compound microscope. (**Note:** Award this one mark if a student writes directly compound microscope without justifying.) When the final image is formed at infinity, the magnification of a compound microscope equals $m = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$ $L = 25\ cm,\ D = 25\ cm$ $f_0 = 1\ cm,\ f_e = 2\ cm$ $m = \left(\frac{25}{1} \times \frac{25}{2}\right)$ $= 312.5$	½ ½ 1 ½ ½	3
33.	(a) Deducing the expression for potential energy 1½ (b) Expression for energy in the presence of an external electric field 1½ (a) Work done in bringing the charge q_2, from infinity, to a point $= q_2 \times$ potential at the point due to charge q_1 $= q_2 \times \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_{12}}$	½	

	$\therefore$ potential energy of the system $= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_{12}}$ (b)Let the potentials, at two points, due to an external electric field (E) be V_1 and V_2 respectively. Now the total energy of the system is: $\left[q_1V_1 + q_2V_2 + \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_{12}}\right]$	1 1½	 3
34.	Finding (i) The charge passed through the loop 1 (ii) Change in magnetic flux through the loop 1 (iii) Magnitude of the magnetic field applied 1 (i) Total charge passed through the loop (Q) $Q =$ area under the I-t graph $= \frac{1}{2}\times 0.4\times 1$ coulomb $= 0.2C$ (ii) Change in magnetic flux Total charge passing $= \left(\frac{\text{change in magnetic flux}}{R}\right)$ Change in magnetic flux $= [R\times 0.2C]$ $= [10\times 0.2]$ Wb $= 2$Wb (iii) Magnitude of magnetic field applied Let B be the magnitude of the magnetic field applied Initial magnetic flux $= \text{B}\times(10\times 10^{-4})\,Wb$ Final magnetic flux $= zero$ Change in magnetic flux $= (\text{B}\times 10^{-3} - 0) = 2$ $\Rightarrow B = 2\times 10^3\,Wb/m^2$ (**Note:** Award two marks to a student who only calculates charge and not able to calculate correctly the remaining two parts of this question)	 ½ ½ ½ ½ ½ ½	 3
	SECTION D		
35.	(a)Definition of focal length 1 Obtaining the relation between focal length and radius of curvature 1½ (b)Calculation of angle of emergence 2 Qualitative change in the angle of emergence ½		

	(a) **Focal length of mirror**: It is the distance of the point from the pole of mirror through which ray of light moving parallel to its principle axis passes (or appear to come from).	1	
	Alternatively: It is half of the distance of its centre of curvature from the pole of a mirror.		
		½	
	Let C be the centre of curvature of mirror, MD be the perpendicular from M to the principal axis.		
	$\angle MCP = \theta$ *and* $\angle MFP = 2\theta$		
	$\tan\theta = \frac{MD}{CD}$, $\tan 2\theta = \frac{MD}{FD}$ (1)	½	
	For small angles, $\tan\theta \approx \theta$ and $\tan 2\theta \approx 2\theta$		
	From equation 1, $\frac{MD}{FD} = 2\frac{MD}{CD}$		
	$FD = \frac{CD}{2}$ $----equation\ (2)$		
	For small θ, the point D is very close to the point P		
	$\therefore$ $\mathrm{FD} \simeq \mathrm{FP} = f$ and $\mathrm{CD} \simeq \mathrm{CP} = R$		
	$\therefore$ from equation 2, we get $\mathrm{f} = \frac{R}{2}$	½	
	(b) Applying Snell's law at face AB, we get		
	$\sqrt{3}\sin 30 = 1 \cdot \sin \mathrm{e}$	½	
	$\sqrt{3} \times \frac{1}{2} = \sin e$	½	
	$\frac{\sqrt{3}}{2} = \sin e$		
	$\sin 60 = \sin e$	½	
	$e = 60^0$	½	
	When the medium (the air) in which the prism is kept is replaced with a liquid of refractive index 1.3 the angle of emergence would decrease. It is because bending in the ray of light will be lesser.	½	

OR

(a) Definition of resolving power	1
(i) Effect and justification	½+½
(ii) Effect and justification	½+½
(b) Calculation of focal length	2

Resolving power of a telescope is defined as the reciprocal of the smallest angular separation between two distinct objects whose image can be just resolved by it. **1**

Alternatively: Resolving power $= \frac{1}{d\theta} = \frac{D}{1.22\lambda}$

Alternatively

It is the reciprocal of the limit of resolution.

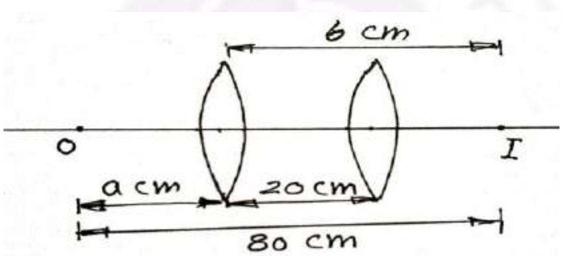
(i) As λ increases, R.P. decreases ½

Reason R.P.$= \frac{D}{1.22\lambda}$ i.e. $R.P.\alpha \frac{1}{\lambda}$ ½

(*ii*) As D increases, R.P. increases ½

Reason R.P.$= \frac{D}{1.22\lambda}$ i.e. $R.P.\alpha D$ ½

The two positions of the lens are as shown



$for\ position\ 1$

$u = -a\ cm$

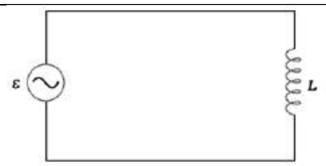
$v = b = +(80 - a)\ cm$ ½

for position 2

$u = -(a + 20)\ cm$

$v = +(b - 20) = +(60 - a)\ cm$ ½

	By lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ $\therefore \frac{1}{(80-a)}+\frac{1}{a}=\frac{1}{(60-a)}+\frac{1}{(20+a)}$ This gives a(80-a)=(a+20)(60-a) or $80a-a^2=40a+1200-a^2$ *or* $a=30cm$ $\therefore \frac{1}{f}=\frac{1}{50}+\frac{1}{30}=\frac{3+5}{150}=\frac{8}{150}$ $\therefore f=\frac{150}{8}cm=18.75cm$ **Alternatively** $F=\left(\frac{D^2-x^2}{4D}\right)=\frac{80^2-20^2}{4\times 80}=18.75cm$ **Alternatively** The values of $a=\lvert u\rvert$ *and* $b=\lvert v\rvert$ simply get interchanged in the two positions. b+a $=80cm$ b-a $=20cm$ *This gives* $b=50cm$ *and* $a=30cm$ $\therefore \frac{1}{f}=\frac{1}{50}-\left(\frac{1}{-30}\right)=\frac{8}{150}$ $f=18.75\ cm$	½ ½ 1+1 ½ ½ ½ ½	 5
36.	(a) Showing No dissipation of power — 2 (b) (i) Calculation of self inductance — 1 (ii) Calculation of capacitance — 2 (a)		



$V = V_0 \sin \omega t$

$I = I_0 \sin(\omega t - \pi / 2)$

The instantaneous power supplied to the inductor ½

$P_L = IV$ ½

$= I_0 \sin(\omega t - \pi / 2)(V_0 \sin \omega t)$

$= -I_0 V_0 \cos \omega t \sin \omega t$

$= -\frac{I_0 V_0}{2} \sin 2\omega t$ ½

Now average power over a completer cycle,

$\langle P_L \rangle = \left\langle -\frac{I_0 V_0}{2} \sin 2\omega t \right\rangle$

$= -\frac{I_0 V_0}{2} \langle \sin 2\omega t \rangle = 0$ ½

$\therefore$ Average value of $\sin 2\omega t$ over a complete cycle is zero.

Thus average power dissipated over a complete cycle is zero.

(b) $(i) X_L = 2\pi f L$ ½

$L = \frac{X_L}{2\pi f} = \frac{40}{2\pi \times 200} = 0.1 / \pi \; henry = 0.032H$ ½

Maximum power dissipation takes place at resonance ½

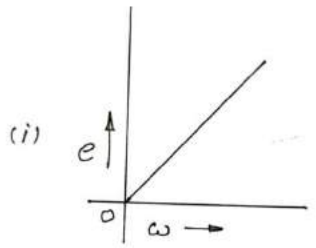
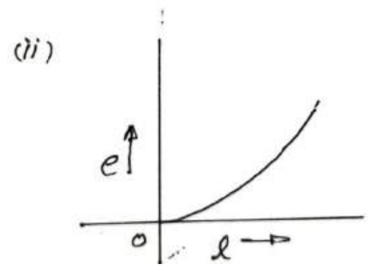
$\nu = \frac{1}{2\pi\sqrt{LC}}$ ½

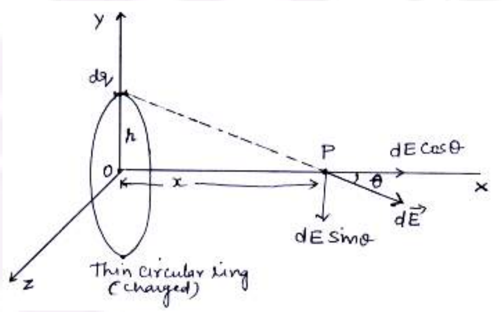
$\therefore C = \frac{1}{L \times 300^2 \times 4\pi^2} F$ ½

$C = \frac{\pi}{0.1 \times 9 \times 10^4 \times 4\pi^2} F = 8.8 \mu F$ ½ 5

OR

(a) Formula	1
Plot of two graphs	½+½
(b) (i) Finding the coefficient of mutual induction	1½
(ii)Finding the induced emf	1½

	e.m.f. induced in the rod $= \left\| -\frac{d\phi}{dt} \right\|$	½	
	$\therefore e = \frac{1}{2} B l^2 \omega$	½	
	 	½+½	
	(i) Imagine a current I to flow through the larger coil.		
	Magnetic flux linked with linked with the smaller coil $= MI$		
	$= B_{centre} \times \pi \times 10^{-4}$ Wb	½	
	$= \frac{\mu_0 I}{2 \times 20 \times 10^{-2}} \times \pi \times 10^{-4}$ Wb		
	$\Rightarrow M = \frac{\mu_0 \pi}{4} \times 10^{-3}$ H	½	
	$= \frac{4\pi \times 10^{-7} \pi \times 10^{-3}}{4} H$		
	$= 9.9 \times 10^{-10} H$		
	$= 10^{-9} H$	½	
	(ii)		
	$e.m.f.\ induced = -M \frac{dI}{dt}$	½	
	$= -10^{-9} \times \frac{5}{10^{-3}} V$	½	
	$= -5 \times 10^{-6} V$	½	
	Alternatively		
	$e.m.f.\ induced = -\frac{d\phi}{dt}$		
	$= -\frac{d}{dt}(B_c A_i) = -A_i \frac{dB_c}{dt}$	½	

	$= -A_i \frac{d}{dt}\left(\frac{\mu_0 I}{2R}\right)$ $= -\frac{A_i \mu_0}{2R}\frac{dI}{dt}$ $= \frac{-\pi \times 10^{-4} \times 4\pi \times 10^{-7} \times 5}{2 \times (20 \times 10^{-2}) \times 10^{-3}} V$ $= -\frac{20\pi^2 \times 10^{-6}}{2 \times 20} V$ $= -5 \times 10^{-6} V$	½ ½	5
37.	(a) Two important characteristics 1+1 (b) Derivation of the expression of the electric field 2½ Showing the behaviour as point charge ½ (a) For equipotential surfaces (i) Potential has the same value at all points on the surface. (ii) Electric field is normal to the equipotential surface at all points (iii) Work done in moving any charge between any two points on the equipotential surface is zero (any two) (b)  Electric field due to any elemental (point) charge dq, at point P. $= dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{(x^2+r^2)}$ This is directed along AP Its component along the axis OP of the ring is $= dE\cos\theta = dE\frac{x}{\sqrt{x^2+r^2}}$	1+1 ½ ½	

The component, perpendicular to the axis gets cancelled by the elemental electric field due to another elemental charge symmetrically located on the other side of the axis.

Hence total electric field

$$E = \int dE \cos\theta$$ ½

$$= \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{\left(x^2+r^2\right)} \frac{x}{\sqrt{x^2+r^2}}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{x}{(x^2+r^2)^{3/2}}\int \lambda dl$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{x\lambda}{(x^2+r^2)^{3/2}}\times 2\pi r$$ ½

$$= \frac{Q}{4\pi\varepsilon_0}\frac{x}{(x^2+r^2)^{3/2}}$$ ½

Where $Q = \lambda \times 2\pi r$ = total charge on the ring

This field is directed along the axis.

When x much larger than r, we have

$$E = \frac{Q}{4\pi\varepsilon_0}\frac{x}{(x^2)^{3/2}} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}$$ ½

5

This corresponds to the expression for the electric field due to a point charge. Thus at large distances the ring behaves like a point charge.

(**Note:** Award these three marks even if a student tries to attempt this part)

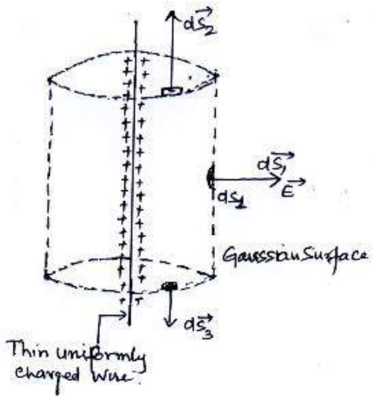
OR

(a)	Statement of Gauss's law	1
	Derivation of the expression of the electric field	2½
(b)	Finding the increase in potential	1½

(a) Gauss law: Electric flux through of a closed surface is $\frac{1}{\varepsilon_0}$ times the charge enclosed by the surface.

Alternatively

$$\phi_E = \frac{q}{\varepsilon_0}$$ 1

		½	
	Let the charge be uniformly distributed on a wire $\phi = \oint d\phi = \int_{s_1} \vec{E} \cdot d\vec{s}_1 + \int_{s_2} \vec{E} \cdot d\vec{s}_2 + \int_{s_3} \vec{E} \cdot d\vec{s}_3$	½	
	$= \int_{s_1} Eds_1 \cos 0^0 + \int_{s_2} Eds_2 \cos 90^0 + \int_{s_3} Eds_3 \cos 90^0$	½	
	$= E \int_{s_1} ds_1 = E.2\pi rl$ *byGauss'slaw*	½	
	$\frac{q}{\varepsilon_0} = E \cdot 2\pi rl$ $E = \frac{q}{2\pi\varepsilon_0 rl} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$	½	
	(b) $E = 10r+5$ $dV = -E \cdot dr$ $\int dV = -\int_1^{10} \vec{E}\, d\vec{r}$	½	
	$= -\int_1^{10} (10r+5)dr$ $V = -\left[\int_1^{10} 10r\, dr + \int_1^{10} 5dr\right]$	½	
	$V = 10\left[\frac{r^2}{2}\right]_1^{10} + 5(r)_1^{10}$ $V = -5[100-1] + 5[10-1]$ $V = -5 \times 99 + 5 \times 9 = -540V$	½	5