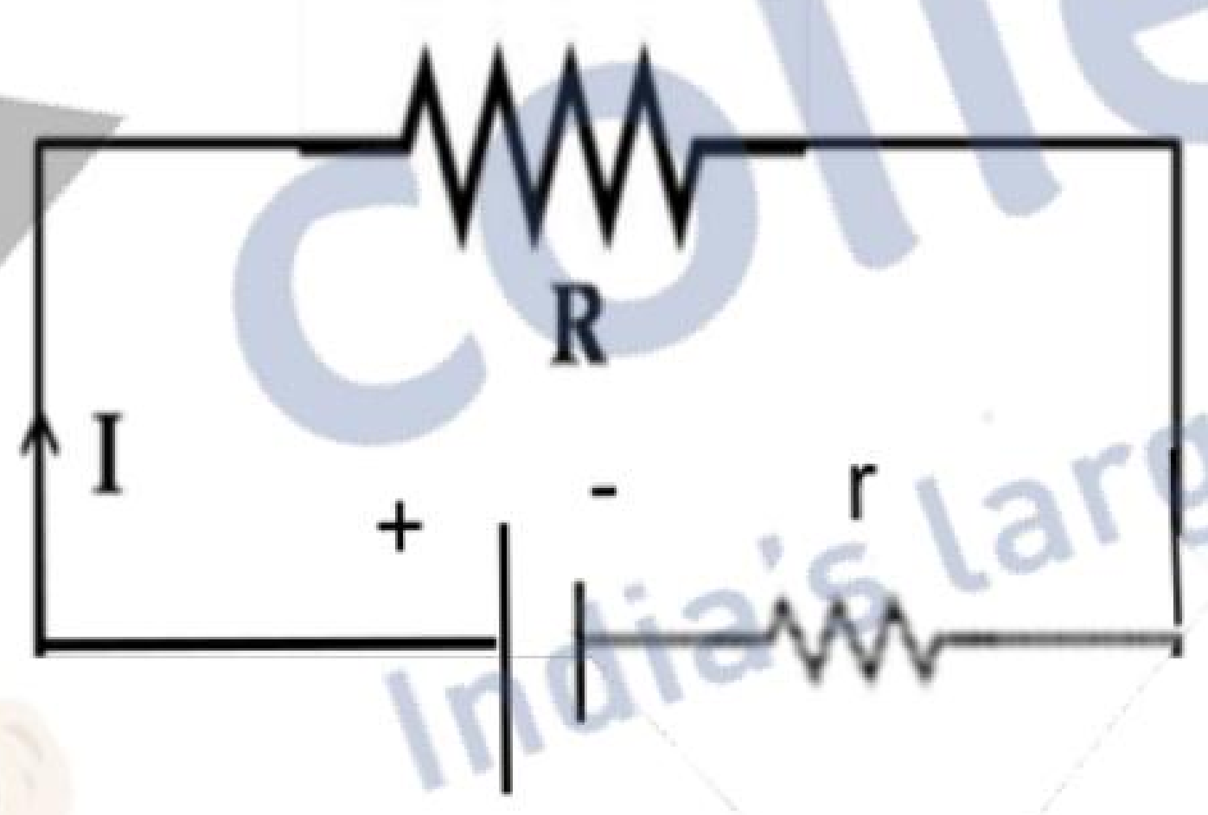
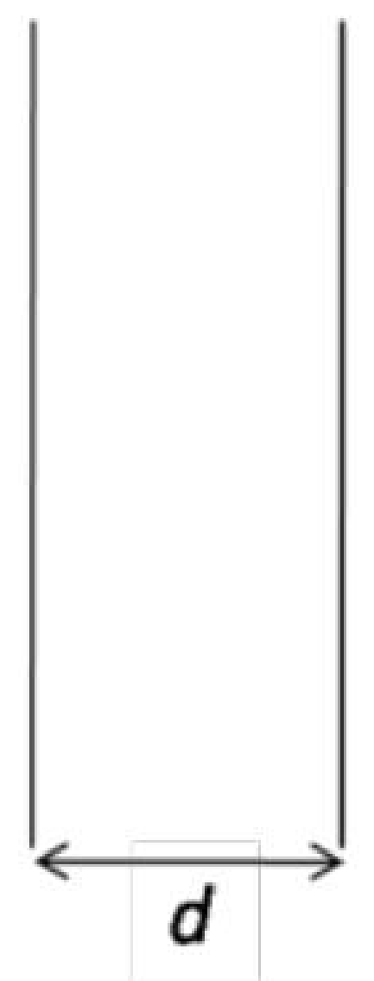
MARKING SCHEME

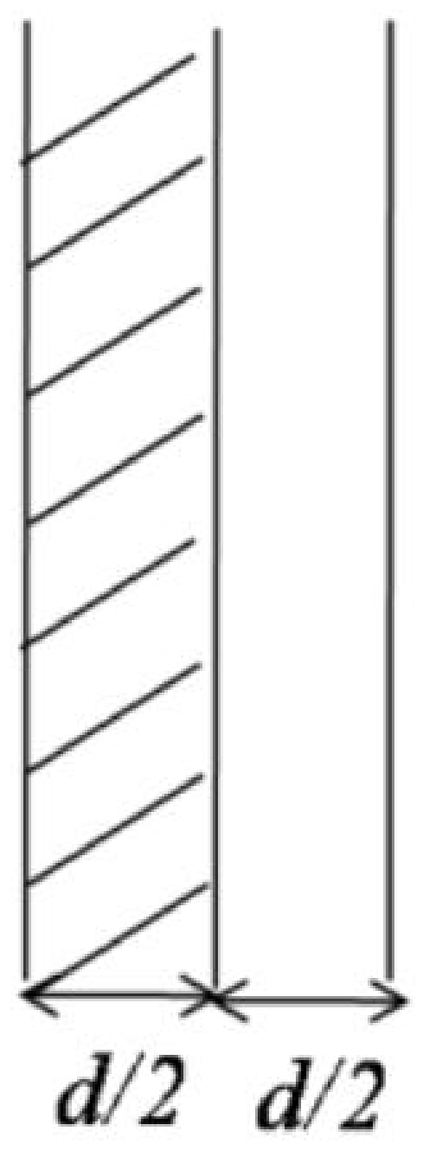
Q. No.	Expected Answer/ Value Points	Marks	Total Marks
	SECTION A		
Q1	Capacitive Reactance = $\frac{1}{\omega C}$ Alternatively : Impedance offered by a capacitor to the flow of current. SI Unit : ohm (Ω)	½ ½	1
Q2	Parallel / (along) to the direction of electron's velocity Alternatively: Anti parallel / opposite to the direction of electron's velocity	1	1
Q3	$\bar{T} = \frac{1}{\lambda}$ Alternatively: mean life = $\frac{1}{\text{decay constant}}$	1	1
Q4	Emf is greater than the terminal voltage when the cell is supplying a current. Alternatively: Emf equals terminal voltage only when the cell is on an open circuit (not supplying any current) Alternatively: Emf = $I(R + r)$  Terminal Voltage = IR Alternatively: $V = \varepsilon - Ir$	1	1
Q5	Photoelectric current increases with increase in intensity (Alternatively: It increases)	1	1
	SECTION B		
Q6	Expression for capacitance 2 We have, in the absence of dielectric, $C_o = {}^{Q}/_{V_o} = {}^{Q}/_{E_o d}$ In the dielectric, the field goes down by a factor *k* $E = \frac{E_o}{k}$ ∴ In the second case, $V = \frac{E_o}{k}\cdot\frac{d}{2} + E_o\frac{d}{2}$ 	½ ½ ½	

$$= \frac{E_o d}{2}\left(\frac{1+k}{k}\right) = \frac{E_o d}{2k}(1+k)$$

∴ Capacitance = C

$$C = \frac{Q}{V} = \frac{Q}{E_o d}\cdot\left(\frac{2k}{k+1}\right)$$

$$= C_o\left(\frac{2k}{k+1}\right)$$



½ 2

Q7

Function of
- i. Transmitter 1
- ii. Transducer 1

Transmitter : To process the incoming message signal and to transmit it. **1**

Transducer : To convert other forms of signals into an electrical signal. **1** **2**

Q8

Meaning of Universal Gates 1
Truth table for NAND Gate 1

Universal Gates : These are gates that can be suitably combined to realize any of the other basic logic gates.(i.e., the AND, OR, NOT Gates) **1**

Truth table for NAND Gate **1** **2**

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

OR

Intrinsic Semiconductor 1
Extrinsic Semiconductor 1

Intrinsic Semiconductor:
A pure semiconductor
Alternatively :
A semiconductor having equal number of electrons and holes as charge carriers. **1**

Extrinsic Semiconductor:
A pure semiconductor that has been suitably doped with a 3rd group or 5th group element.

	Alternatively : A semiconductor in which the either the electrons (or the holes) are the majority charge carriers; the holes (or the electrons) are the minority charge carriers. Alternatively : A semiconductor in which there is a large difference in the number of electrons and holes, as charge carriers.	**1**	**2**
Q9	Identification 1 Two Properties ½ + ½ The magnetic material is a diamagnetic material Two Properties i. Gets repelled by a magnet ii. Moves away from the region of stronger magnetic field. iii. Moves towards the region of weaker magnetic field. iv. Expels out the field lines of magnetic field. [Any Two]	**1** **½ + ½**	**2**
Q10	Derivation of the Expression for r_n 2 We have , for the hydrogen atom $m\, v_n r_n = n\, \frac{h}{2\pi}$ and $\frac{mv_n^2}{r_n} = \frac{1}{4\pi\epsilon_o} . \frac{e^2}{r_n^2}$ squaring the first equation, we get $m^2 v_n^2 r_n^2 = \frac{n^2 h^2}{4\pi^2}$ From the second equation, we get $m v_n^2 r_n = \frac{e^2}{4\pi\epsilon_o}$ Dividing, we get $m r_n = \frac{n^2 h^2}{4\pi^2} . \frac{4\pi\epsilon_o}{e^2}$ $\therefore r_n = \frac{\epsilon_o h^2}{m\pi e^2} . n^2$ $\therefore r_n \propto n^2$	½ ½ ½ ½	**2**
	SECTION C		
Q11	(a) Working Principle 1 (b) Answers to each part 1+1 (a) The Working Principle of a meter bridge is the same as that of a balanced Wheatstone Bridge. i.e. , At balance	**1**	

	$\frac{P}{Q} = \frac{R}{S}$ (b) (i) Thick Copper strips have (almost) zero resistance. Alternatively Thick Copper strips do not add additional resistance to the resistors being used. (ii) This results in a better accuracy in the measurements.	1 1	3
Q12	Formulae for energy stored in the two cases ½ +½ Calculation of C_1 and C_2 1+1 For the series combination $C_s = \frac{C_1 C_2}{C_1 + C_2}$ $\therefore$ Energy stored $= \frac{1}{2}\left(\frac{C_1 C_2}{C_1 + C_2}\right)(200)^2 = 0.04\text{J}$ For the parallel combination $C_p = C_1 + C_2$ $\therefore$ Energy stored $= \frac{1}{2}(C_1 + C_2)(200)^2 = 0.18\text{J}$ $\therefore C_1 + C_2 = 9 \times 10^{-6}\text{F}$ $\therefore \frac{1}{4} C_1 C_2 (200)^4 = 72 \times 10^{-4}$ $\therefore C_1 C_2 = \frac{288}{16} \times 10^{-12} = 18 \times 10^{-12}$ Now, $(C_1 - C_2)^2 = (C_1 + C_2)^2 - 4C_1C_2$ $= (81 - 72) \times 10^{-12} = 9 \times 10^{-12}$ $\therefore C_1 - C_2 = 3 \times 10^{-6}\text{F}$ $\therefore C_1 = 6\mu\text{F}$ and $C_2 = 3\mu\text{F}$	½ ½ ½ ½ ½ +½	3
Q13	Working of astronomical telescope 1 Writing the two formulae ½ +½ Calculating the two focal lengths ½ +½		

	Working: The objective lens of the astronomical telescope forms an image of a distant object in its focal plane. This image lies at the focus of the eye piece (normal adjustment) or within the focus of the eye piece. It undergoes angular magnification through both the lenses. We have $m = \frac{f_0}{f_e}$ and $L = f_0 + f_e$ $\therefore \frac{f_0}{f_e} = 20$ and $f_0 + f_e = 105$ cm These give $f_e = 5$ cm and $f_0 = 100$ cm	½ ½ ½ +½ ½ +½	**3**
Q14	(a) Statement of the law of decay 1 (b) Formula ½ Calculation of time 1½ (a) $N = N_0e^{-\lambda t}$ [Alternatively, The number of radioactive atoms decay exponentially with time.] (b) $\lambda = \frac{1}{T_{1/2}}$ Let t be the required time. The number of atoms left over after a time $t = \left(1 - \frac{7}{8}\right)N_0 = \frac{1}{8}N_0$ $= \frac{1}{(2)^3}N_0$ $\therefore t = 3 \times \text{half life}$ $= 3 \times 50 \text{ days} = 150 \text{ days}$	1 ½ ½ ½ ½	3
Q15	Names of three modes ½ +½+½ Explanation of ionospheric reflection of radio waves 1½ Three modes of propagation: (i) Ground wave propagation (ii) Space wave propagation (iii) Sky wave propagation Ionospheric Reflection	½ ½ ½	

	The ionosphere contains a large number of ions or charged particles. The electric field of the incoming radio waves makes these charged particles oscillate at its own frequency. The oscillating charged particles then reradiate radio waves of the same frequencies back towards the earth. This phenomenon of bending of e.m. waves is similar to the phenomenon of total internal reflection in optics.	½ ½ ½	3
Q16	(i) Finding Power 1 (ii) Stating lensmaker's formula ½ Calculation of μ 1 ½ (i) $\text{Power} = \frac{1}{\text{Focal length(in metre)}}$ $= \frac{1}{0.25}\text{D} = 4\text{D}$ (i) We have $\frac{1}{f} = (\mu - 1)(\frac{1}{r_1} - \frac{1}{r_2})$ $\therefore \frac{1}{20} = (\mu - 1)\left(\frac{1}{20} - \frac{1}{(-25)}\right)$ $= \frac{(\mu - 1)}{100} \times 9$ $\therefore \mu - 1 = \frac{5}{9}$ $\therefore \mu = \left(1 + \frac{5}{9}\right) = \frac{14}{9} \simeq 1.55$	½ ½ ½ ½ ½ ½	3
Q17	Identification of each part ½ + ½+½ One use of each part ½ + ½+½ (i) Microwaves (any one use of microwaves) (ii) Infrared waves (any one use of infrared waves) (iii) Ultraviolet waves (any one use of ultraviolet waves)	½ ½ ½ ½ ½ ½	3

Q18	(a) Definition 1 Nature 1 (b) Statement of the required expression for electric field 1		
	(a) Electric dipole moment $\vec{p} = (2aq)\hat{a}$	**1**	
	It is vector quantity	**1**	
	(b) We have $$\vec{E} = \frac{-\vec{p}}{(4\pi\epsilon_0)(r^2 + a^2)^{3/2}}$$	**1**	**3**
	[Alternatively: $\vec{E} = \frac{-\vec{p}}{4\pi\epsilon_0 r^3}$ $(for\ r \gg a)$]		
Q19	Finding current drawn from the cell 2 Finding terminal p.d. of the cell 1		
	(i) Let *R* be the equivalent resistance of the parallel combination. We then have	½	
	$$\frac{1}{R} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10} = \frac{10+4+2}{20}$$ $$= \frac{16}{20} = \frac{4}{5}$$ $$\therefore R = \frac{5}{4}\Omega = 1.25\Omega$$	½	
	$$\therefore\ Total\ Resistance = (1.25 + 0.25)\Omega$$	½	
	$$= 1.5\Omega$$		
	$$\therefore\quad \text{Current drawn} = \frac{6\text{V}}{1.5\Omega} = 4\text{A}$$	½	
	(ii) $\text{Terminal p.d.} = \varepsilon - Ir$	½	
	$$= (6 - 4 \times 0.25)\text{V}$$ $$= 5\text{V}$$	½	**3**
Q20	Obtaining the expression for the current in the circuit 2 Inductive Reactance ½ Phase ½		
	When an AC voltage$(V = V_0\ \sin\omega t)$ is applied to an inductor (of self inductance *L*), we have $$V - L\frac{dI}{dt} = 0$$	½	
	Where *I* is the instantaneous current.	½	

	$\therefore L\frac{dI}{dt} = V = V_0\ \sin \omega t$ $\therefore \frac{dI}{dt} = \frac{V_0}{L} \sin \omega t$ Integrating, we get	½	
	$I = \frac{-V_0}{\omega L} \cos \omega t$ $= \frac{V_0}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right)$	½	
	$= I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ where $I_0 = \frac{V_0}{\omega L}$ This expression shows that (i) Inductive reactance = ωL	½	
	(ii) The current lags the applied voltage, in phase, by $\frac{\pi}{2}$	½	3
	OR (a) Definition of mutual inductance 1 Its SI unit ½ (b) Derivation of the expression for *M* 1 ½		
	(a) Mutual Inductance, of a pair of coils, equals the magnetic flux linked with one due to a unit current in the other. <u>Alternatively,</u> Mutual inductance of a pair of coils, equals the magnitude of the emf induced in one when the current in the other is changing at a unit rate.	1	
	The SI unit of mutual inductance is henry (H) (b) Let n_1 and n_2 be the number of turns, per unit length, of the primary and secondary coils respectively.	½	
	Let a current *I* flow through the primary. Then magnetic field, $B = \mu_0 n_1 I$ The magnetic flux linked with each turn of the secondary = $(\pi r^2)B$	½	
	$(r = \text{(nearly)equal to the radius of each coil})$ $\therefore$ Total magnetic flux linked with its secondary coil $\varphi = (n_2 l)(\pi r^2)B = MI$ $(l = length\ of\ each\ coil)$	½	
	$\therefore M = (\mu_0 n_1 n_2 . \pi r^2 l)$	½	3

Q21	Naming the three important features ½ +½ +½ Finding the expression for work function 1 ½		
	Three features are (i) Independence of maximum kinetic energy from the intensity of incident radiation (ii) Existence of a threshold frequency (iii) Proportionality of maximum kinetic energy and frequency of incident light. (iv) Instantaneous nature of photoelectrons (any three)	½ +½+½	
	We have $K_{max} = \frac{hc}{\lambda} - \phi_0$	½	
	$\therefore K = \frac{hc}{\lambda_1} - \phi_0$ And $2K = \frac{hc}{\lambda_2} - \phi_0$	½	
	$\therefore \frac{hc}{\lambda_2} - \phi_0 = 2\left(\frac{hc}{\lambda_1} - \phi_0\right)$ $\therefore \phi_0 = hc(\frac{2}{\lambda_1} - \frac{1}{\lambda_2})$ $= \frac{hc}{\lambda_1\lambda_2}(2\lambda_2 - \lambda_1)$	½	**3**
Q22	Polarization by a polaroid 1 Explanation of 2 maxima and 2 minima in one complete rotation 2		
	The electric field vector of the unpolarized light can vibrate along either of the two directions perpendicular to its direction of propagation.	½	
	The Polaroid allows only one of these(perpendicular) vibrations to pass through it. Hence umpolarized light gets linearly polarized when passed through a Polaroid.	½	
	Let the pass axis of the second Polaroid be inclined at an angle θ to pass axis of the first Polaroid. The intensity of light coming out of the second Polaroid $= I_0 \cos^2 \theta$ (Malus' law)	½	
	Where I_0 is the intensity of light incident on the second polaroid.		

	∴ When $\theta = 0^\circ$, $I = I_0$(maxima) and when $\theta = \pi$, $I = I_0$(maxima) Also when $\theta = \frac{\pi}{2}$, $I = 0$(minima) and when $\theta = \frac{3\pi}{2}$, $I = 0$ (minima) Hence, one would see two maxima and two minima when the second Polaroid is rotated through 2π	½ ½ ½ ½ ½	3
	SECTION D		
Q23	i. Names of the device ½ Principle of its working ½ ii. Possibility or not ½ Explanation ½ iii. Values displayed by the students and the teacher 1 + 1 i. The transformer is used to bring high voltage ac down to low values. It works on the basis of the phenomenon of electromagnetic induction. ii. No, not possible in case of dc. There would be no induced emf in the secondary coil as the magnetic flux, linked with it, would not be changing with time. iii. Students : Inquisitive, eager to learn (any one) Teacher: Helpful; knowledgeable, ready to share knowledge (any one)	½ ½ ½ ½ 1 1	4
	SECTION E		
Q24	a) Fabrication of npn transistors. 1 b) Working principle of any two devices 2+2 a) A npn transistor is fabricated by having a (thin) segment of a p-type semiconductor between two segment of n type semiconductors. [The student has to write the answer for any two devices.] b) i. Full Wave Rectifier: A full wave rectifier uses two p-n junction diodes and a transformer having a centre tapping in its secondary coil. The circuit is set up in such a way that each diode sends the current through the load in the same direction for both directions of the input current in the primary coil. ii. Transistor Amplifier: The amplifier uses the active region of	1 1 1	

	the V_o versus V_i curve of the transistor.	½	
	A small change in the input signal(in the forward biased BE junction.) appears as a large change in the output signal (in the reverse biased CE junction) .		
	The energy, for amplification, is derived from the biasing batteries.	½	
	iii. Zener diode:		
	The Zener diode has a heavy doping in both its p and n region.	½	
	The depletion layer is very thin. Hence even a small reverse voltage can cause a very strong electric field across the junction. This can cause a breakdown, resulting in a large reverse current.	1	
	This feature helps the Zener down to work as a voltage regulator.	½	5
	OR		
	a) Reason for diffusion of holes. 1 b) Effect of forward biasing on i. Barrier potential ½ ii. Depletion region ½ with explanation ½ + ½ c) Photodiode operation 2		
	a) The holes diffuse from the p-side to n-side due to the presence of a concentration gradient (of the holes) on the two sides.	1	
	b)		
	i. Barrier Potential decreases	½	
	The applied potential, during forward biasing, opposes the barrier potential.	½	
	ii. The width of the depletion layer decreases.	½	
	The applied voltage mostly drops across the depletion region. The width of the depletion layer, therefore, decreases.	½	
	c) When light is made to fall on a photodiode, electron hole pairs get generated due to the absorption of photons.	1	
	The photodiode is generally operated under reverse bias as that makes it easier to observe changes in current due to changes in light intensity.	1	5
Q25	Underlying principle 1 Working and explanation 1 Cyclotron frequency expression 2 Two uses ½ + ½		
	The cyclotron uses crossed electric and magnetic fields to accelerate charged particles, or ions, to high energies.	½	
	The fields are so arranged, and adjusted, as to make the charged particles get continuously and repeatedly accelerated by the 'correct	½	

	half cycle' of the applied alternating electric field.		
	Working: The particles are made to move inside two semicircular discs – called "dees" by a 'normal' magnetic field. The alternating electric field, applied between the "dees", accelerates them (in correct phase) when they cross the gap between the "dees". Many such repeated accelerations make the charged particles acquire high energies.	½ ½	
	Cyclotron Frequency: For a charged particle of mass *m*, charge *q*, moving with a velocity *v*, in a 'normal' magnetic field(*B*) we have $\frac{mv^2}{r} = qvB$ $\therefore v = \frac{rqB}{m}$	½	
	The time period, *T*, is given by $T = \frac{2\pi r}{v}$ $\therefore T = \frac{2\pi rm}{rqB} = \frac{2\pi m}{qB}$	½	
	∴The frequency v_c is given by $v_c = \frac{1}{T} = \frac{qB}{2\pi m}$	½	
	We call this frequency as the cyclotron frequency. It is seen to be independent of the velocity and hence the energy of the charged particle.	½	
	The frequency of the applied alternating electric field is kept equal to v_c. This makes the charged particle get accelerated every time it crosses the "dees"		
	Two uses: i. To accelerate charged particles for nuclear reactions. ii. To implant ions into solids to modify their properties. iii. To synthesise new materials. iv. To produce appropriate radioactive substances [Any two]	½ + ½	5
	OR		
	a) Working the expression for force 1 Defining the unit of magnetic field. 1 b) Action of 'magnetic field' on one – another 1 Expression for the force 2		
	a) The required expression is $\vec{F} = q\vec{v} \times \vec{B}$ (Also, accept $F = qvBSin\theta$) Now, $\lvert\vec{F}\rvert = qvBSin\theta$ $\therefore \lvert\vec{F}\rvert = B$ if $q = 1, v = 1$ and $\theta = \frac{\pi}{2}$ We may, therefore, define the unit of magnetic field (the tesla) as	**1**	

	follows. The magnetic field, at a point, equals one tesla, if a charge of one coulomb, moving with a speed of 1 m/s, along a direction normal to the direction of the magnetic field, experiences a force of one newton. [Also accept if the student says that B= 1 tesla if for $q = 1\text{C}$, $v = 1\text{m/s}$, $\theta = {}^{\pi}/_{2}$, the force F = 1N $\vec{F} = q\vec{v} \times \vec{B}$	1	
	b) For two long straight parallel conductors, carrying currents, i. The current, in one of the wires produces a ('normal to the current') magnetic field at all points on the second wire.	½	
	ii. The second current carrying wire then experiences a force due to this (normal) field.	½	
	Expression : The current I_1, in the first wire, produces a (normal) magnetic field, B_1, at any point on the second wire. We have $B_1 = \frac{\mu_0 I_1}{2\pi d}$	½	
	The force, F_{12}, on a length ℓ of the second wire, carrying a current I_2, is given by $F_{12} = \mu_0 I_2 \ell B_1$ $= = \frac{\mu_0 I_1 I_2}{2\pi d}\ell$	½	
	Hence the force per unit length, of either wire, is given by $F \quad = \frac{\mu_0 I_1 I_2}{2\pi d}$	½	
	This is the required expression	½	5
Q26	a) Secondary wavelets 1 Formation of diffraction pattern 2 b) Relation between angular widths 1 ½ c) Explanation of maxima becoming weaker and weaker 1		
	a) Huygen's theory of secondary wavelets tells us that each point, on a wavefront, can be regarded as a 'power of secondary wavelets'.	½	
	Let a beam of monochromatic light be incident normally on a narrow slit of width a. We can imagine the incident plane wavefront, on the slit, to be subdivided into an appropriate number of equal parts.	½	
	We get maxima at these points on the slit where there is some 'in-phase' contribution of the secondary wavelets from the whole slit or a odd numbered fractional part of the slit.	½	
	We get minima at those points on the slit where the overall contributions of the secondary wavelets (from different even numbered parts of the slit) are in opposite phase.	½	
	The combination, of the points of maxima and minima, appears as a diffraction pattern on the screen.	½	

	b) The angular width of the central maxima is $\theta_0 \simeq \frac{2\lambda}{a}$ The first minima occurs at $\theta_1 = \frac{\lambda}{a}$	½	
	The first secondary maxima occurs at $\theta_2 = \frac{1}{2}\frac{\lambda}{a}$ Hence the angular width of the first diffraction fringe is	½	
	$$2\left[\frac{\lambda}{a} - \frac{1}{2}\frac{\lambda}{a}\right] = \frac{\lambda}{a}$$ ∴ The angular width of the first diffraction fringe is half that of the central fringe.	½	
	c) The maxima are given by $$\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$$ With increasing n, the (odd fractional) part of the slit, contributing to the maxima, keeps on decreasing. (Alternatively: The parts of the slit, contributing to the maxima, are the fractions $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \ldots \ldots$ of the whole width of the slit)	½	
	Hence, the maxima became weaker and weaker with increasing n.	½	5
	OR		
	a) The required writing relation 2 b) Writing the similar relation 1 Obtaining the lens maker's formula 2		
	a) Let u and v denote the 'positions' of the object and the image. The relation between the different quantities is $$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$	**2**	
	b) A similar relation for the second concave spherical surface, having a radius of curvature R' is $$\left(\frac{n_1}{v'} - \frac{n_2}{v}\right) = \left(\frac{n_1 - n_2}{(R')}\right)$$	**1**	
	Adding the two expressions, we get $$\frac{n_1}{v'} - \frac{n_1}{u} = (n_2 - n_1)\left(\frac{1}{R} - \frac{1}{R'}\right)$$	½	
	When $u \rightarrow \propto$, we have $v' = f$.	½	
	Hence, for this case, we have $$\frac{n_1}{f} - 0 = (n_2 - n_1)\left(\frac{1}{R} - \frac{1}{R'}\right)$$ $$or\ \frac{1}{f} - 0 = \frac{(n_2 - n_1)}{(n_1)}\left(\frac{1}{R} - \frac{1}{R'}\right)$$ $$\therefore \frac{1}{f} = (n - 1)\left(\frac{1}{R} - \frac{1}{R'}\right)$$	½	
	This is the lens maker's formula	½	5