MARKING SCHEME
SET 55/1/C

Q. No.	Expected Answer / Value Points	Marks	Total Marks
	Section - A		
Set-1, Q1 Set-2, Q5 Set-3, Q2	Power factor = 1	1	1
Set-1, Q2 Set-2, Q4 Set-3, Q5	i) Width of depletion layer will decrease ii) potential barrier will decrease iii) junction will conduct (Any one point)	1	1
Set-1, Q3 Set-2, Q2 Set-3, Q4	$\vec{P} = \epsilon_0 \ X_e \vec{E}$ (Also accept if the student writes $\vec{P} \propto \vec{E}$ or $\vec{P} = X_e \vec{E}$)	1	1
Set-1, Q4 Set-2, Q3 Set-3, Q1	Mobility is defined as drift velocity per unit electric field or $\mu = \frac{v_d}{E}$ S.I. Unit - m^2/Vs or Cm/Ns	½ ½	1
Set-1, Q5 Set-2, Q1 Set-3, Q3	$\frac{1}{f} = (\mu - 1)(\frac{1}{R_1} - \frac{1}{R_2})$ $\therefore \mu = 1.5$ (Award 1 mark even if direct answer is written)	½ ½	1
	Section - B		
Set-1, Q6 Set-2, Q7 Set-3, Q10	Two differences between Interference and Diffraction pattern 2 (table below) (Any two) [Award only 1 mark if student draws intensity distribution curves for both without writing points] **Or**	1×2	2

	Interference	Diffraction
1	All the bright bands are of same intensity.	Intensity of bright bands goes on decreasing with increasing order.
2	All the bright bands are of same width.	Not of same width.
3	Dark bands may be completely dark.	Not completely dark.
4	Number of fringes are more.	Less in number.

Difference in Construction - 1
Difference in Working – 1

	Microscope	Telescope	Marks	Total
Construction	Objective is of very short focal length and short aperture and eye piece of short focal length and large aperture. $[f_e > f_o]$	Objective is of large focal length and large aperture but eye piece of short focal length and short aperture.	½+ ½ ½+ ½	
Working	It will form magnified image of a small nearby object. (Object is placed close to focus of objective which forms real and magnified image.)	It will form magnified image of distant object. (Objective will form the image of distant object at its focus and image is diminished.)		2

Set-1, Q7
Set-2, Q10
Set-3, Q8

Postulate - 1
Formula for H'_α line – ½
Substitution and calculation- ½

Postulate- Energy is radiated when an electron jumps from a (permitted) higher to lower orbit and it equal to the difference in energy in the two orbits. 1

$$hv = E_i - E_f$$

$$\frac{1}{\lambda_\propto} = R_H[\frac{1}{2^2} - \frac{1}{3^2}]$$ ½

$= 1.03 \times 10^7 \times \frac{5}{36}$ $\because \lambda_\alpha = 6.99 \times 10^{-7}$ m = 699 nm ½ 2

[Award ½ mark if student only writes $\frac{1}{\lambda} = R_H[\frac{1}{{n_f}^2} - \frac{1}{n_i 2}]$

Set-1, Q8 Set-2, Q6 Set-3, Q9	Kirchhoff's laws ½+½ To justify them ½+½ Kirchhoff's I Law: (JUNCTION LAW) Sum of the incoming currents at a junction = Sum of outgoing currents [**Alternatively** Algebraic sum of all the currents meeting at a junction in the electrical circuit is zero] 2^{nd} Law : (LOOP LAW) The algebraic sum of the changes in potential around any closed loop involving resistors and cells in the loop is zero [**Alternatively** In any closed electrical part of circuit, sum of the e.m.f s is equal to sum of products of various currents and resistances through which currents pass.] To justify First law is based on the law of conservation of charge. Second Law is based on the law of conservation of energy.	½ ½ ½ ½	2
Set-1, Q9 Set-2, Q8 Set-3, Q7	Formula for de Broglie wavelength – 1 Calculation and result – 1 Formula used $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$ $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}}$ since $E_n \propto \frac{1}{n^2}$ For $n = 2$ $E_2 = \frac{E_1}{4}$ $\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}$ [Award ½ mark if the student only writes $\lambda = \frac{h}{mv}$] Also accept any other correct alternative answer.	1 ½ ½	2
Set-1, Q10 Set-2, Q9 Set-3, Q6	(a) Difference between Analog and Digital signal 1 (b) Any two uses of internet 1		

<table>
<tr>
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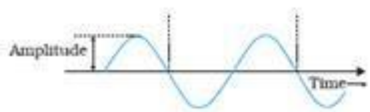
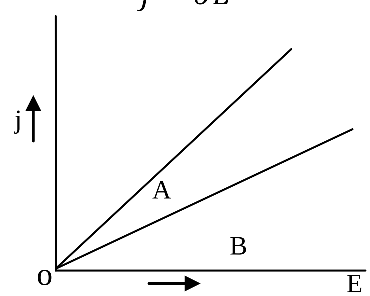
(a)
<table>
<tr><th>Analog signal
(Any one of the two)</th><th>Digital Signal
(Any one of the two)</th></tr>
<tr><td>It is single valued function of time or varies continuously with time</td><td>These signals take only discrete set of values i.e. 0 or 1</td></tr>
<tr><td>alternatively
</td><td>alternatively
</td></tr>
</table>
(b) Uses of Internet : Any two
(E mail, E- banking, chatting, file transfer, e-shopping, e-ticketing, surfing etc)
</td>
<td>1

½ + ½</td>
<td>2</td>
</tr>
<tr><td colspan="4">Section - C</td></tr>
<tr>
<td>Set-1, Q11
Set-2, Q20
Set-3, Q15</td>
<td>
<table>
<tr><td>Formula</td><td>½</td></tr>
<tr><td>Graph</td><td>1</td></tr>
<tr><td>Information from the graph</td><td></td></tr>
<tr><td>Selecting the materials</td><td>1</td></tr>
<tr><td>Explanation for large current</td><td>½</td></tr>
</table>
$j = \sigma E$

Slope of the graph= conductivity (σ)
Material with less slope (smaller conductivity) is used for making standard resistances and material with greater slope (higher conductivity) for making connecting wires

We have $I = nAev_d$

Although v_d is small but n (electron number density) is very large. Hence the current can be large.
</td>
<td>½
1
½
½
½</td>
<td>3</td>
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<tr>
<td>Set-1, Q12
Set-2, Q21
Set-3, Q16</td>
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<table>
<tr><td>Statement</td><td>½ mark</td></tr>
<tr><td>Derivation of magnetic field on axis</td><td>2 marks</td></tr>
<tr><td>Magnetic field at centre</td><td>½ mark</td></tr>
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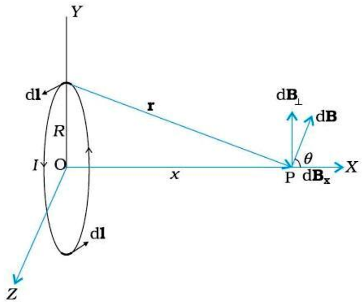
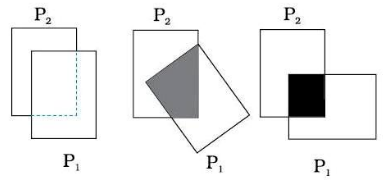
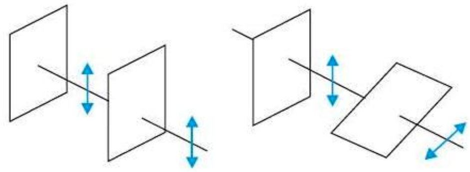
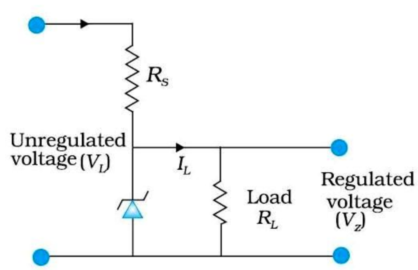
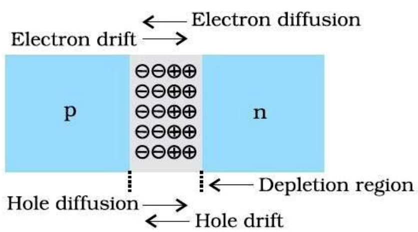
	Biot Savart's law $\overrightarrow{dB} \propto I \frac{\overrightarrow{dl} \times \vec{r}}{r^3}$ Or $\overrightarrow{dB} = \frac{\mu_o}{4\pi} I \frac{\overrightarrow{dl} \times \hat{r}}{r^2}$ [Also accept if the student writes $dB \propto I, dB \propto dl\ and\ dB \propto \frac{1}{r^2}$]  Derivation The resultant magnetic field will be along the axis as the perpendicular (to the axis) components cancel out in pairs. B = $\int_o^{e\pi R} dB\ \cos\theta$ $= \int_o^{2\pi R} \frac{\mu_0}{4\pi} \frac{Idl}{(R^2+x^2)} \frac{R}{(R^2+x^2)^{1/2}}$ $= \frac{\mu_0 I}{4\pi} \frac{2\pi R^2}{(R^2+x^2)^{3/2}} = \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$ At centre, x= 0 $\therefore B_0 = \frac{\mu_0 I}{2R}$	½ ½ ½ ½ ½ ½	3
Set-1, Q13 Set-2, Q22 Set-3, Q17	Polaroid 1 Transverse nature of light 1 Required Explanation 1 Polaroid consists of long chain molecules aligned in a particular direction Transverse nature of light.	1	

	 **Alternatively**  <u>Explanation:</u> Unpolarised light incident on a polaroid, gets linearly polarized with electric vector oscillating along the pass axis of Polaroid. It will pass out with same intensity from P_2, if pass axis of P_2 is parallel to that of P_1. On rotating P_2 intensity of light reduces to zero when their pass axes are perpendicular to each other showing transverse nature of light. <u>Explanation for intensity of light</u> Unpolarised light incident on a Polaroid, gets polarized and its intensity is reduced to half and it does not depend on the orientation of the Polaroid.	½ ½ ½ ½	3
Set-1, Q14 Set-2, Q16 Set-3, Q18	Fabrication of Zener Diode ½ Cause of high Electric field ½ Diagram for Zener Diode as Voltage Regulator 1 Working 1 Zener diode is fabricated by heavy doping of its p and n sections. Since doping is high, depletion layer becomes very thin. Hence, electric field $(=\frac{V}{d})$ becomes high even for a small reverse bias.  Working : If input voltage increases/ decreases, current through Zener diode will also increase/ decreases. It increases/ decreases voltage drop across R_s without any change in voltage across R_L as potential across Zener diode does not change in	½ ½ 1 1	3

	breakdown region giving the regulated output voltage. **OR** (a) Diagram ½ Formation of depletion region 1 Potential barrier ½ b) Effect on barrier potential 1 a)  Explanation Due to concentration gradient across p and n sides, holes from p diffuse into n section and leave behind ionized acceptor (negatively) ions which are immobile. As holes continue to diffuse from p to n, a layer of negative charge on p side of junction is formed. Similarly, the diffusion of electrons from n to p will form a positive charge space region on the n side. The space charge region on either side of the junction which gets devoid of mobile charge carrier is known as the **depletion layer**. The loss of electrons from n side and holes from p side cause a potential difference across the junction. This is known as the called barrier potential . b) Barrier potential decreases in forward bias . Barrier potential increases in reverse bias.	½ 1 ½ ½ ½	3
Set-1, Q15 Set-2, Q17 Set-3, Q11	Effect in each case 1½ Justification in each case 1½ i) Anode current will increase with increase of intensity More is intensity of light, more is the number of photons and hence more number of electrons are emitted ii) No effect	½ ½ ½	

<table>
<tr><td></td><td>Frequency of light affects the maximum K.E. of the emitted photoelectrons.

iii) Anode current will increase with anode potential
More anode potential will accelerate the electrons more till it attains a saturation value and get them collected at the anode at a faster rate.</td><td>½

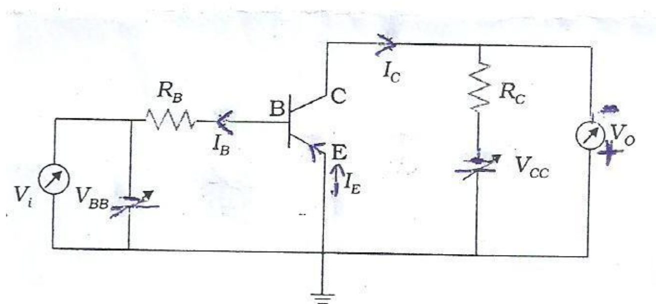
½
½</td><td>3</td></tr>
<tr><td>Set-1, Q16
Set-2, Q18
Set-3, Q12</td><td>

Active state	½
Circuit diagram	1
Working	½
Reasons in each case	1

<u>Active State :</u>

When the emitter base junction is forward biased and the base collector junction is reverse biased with $V_i > 0.6V \; or \; V_i > 0.3V$.
(Also accept any other correct answer)

<u>Diagram</u> :



$= V_{CE}$

<u>Explanation</u> :
If V_i is +ve or –ve , changes in V_{BE} will produce changes in I_c and hence changes in V_{CE} which will appear in amplified form

<u>Base</u> is thin so that there are few majority carriers in it.

<u>Emitter</u> is heavily doped so that it supplies more number of majority charge carriers.
(Note: Award 1 mark if the student writes the reason for any one case)
</td><td>½

1

½

½

½</td><td>3</td></tr>
<tr><td>Set-1, Q17
Set-2, Q19
Set-3, Q13</td><td>

Factors for need of modulation	1½
Sketch of carrier wave, modulating wave and AM wave	1½

<u>Need of Modulation:</u>

1. To have smaller height of antenna $[h \sim \frac{\lambda}{4}]$
</td><td>½</td><td></td></tr>
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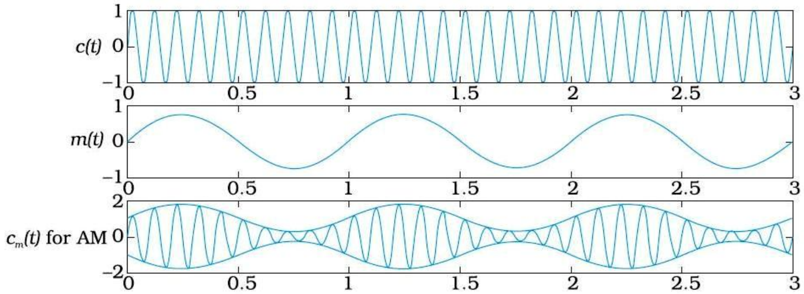
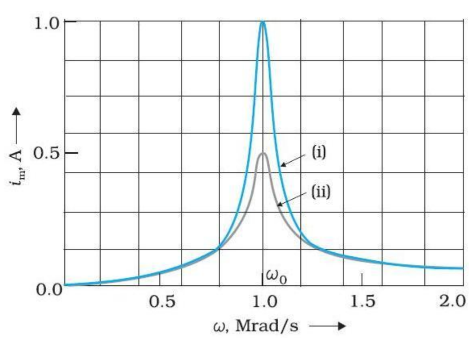
	2. So that more power is radiated by the antenna, $P \propto \frac{1}{\lambda^2}$ 3. To avoid mixing up of signals from different ransmissions. 	½ ½ ½ ½ ½	3
Set-1, Q18 Set-2, Q11 Set-3, Q14 .	Identification of circuit elements 1½ Impedance value ½ Plot of circuit vs frequency ½ Significance of plot ½ Identification of elements X- Resistor Y- Inductor Z- Capacitor Impedence Z=R Since $X_L = X_C$ (Also accept if the student writes $Z = \sqrt{R^2 + (X_L - X_C)^2}$ = R Plot of current vs frequency  (Only one curve is expected) Significance, at $w = \omega_o$ (resonance frequency) current is maximum (Alternatively: Gives information about sharpness of resonance or quality factor of the circuit)	 ½ ½ ½ ½ ½ ½	 3

Set-1, Q19 Set-2, Q12 Set-3, Q21	Equation of β^+ decay 1 Identification ½ Calculation of mass defect ½ Calculation of Q value 1 Equation $^{11}_{6}C \rightarrow \, ^{11}_{5}X + i^e + v + Q$ (Also accept if the student does not write v *or* Q on the R.H.S.) X is an isobar Mass defect (Δm) = $m(^{11}_{6}C) - m(^{11}_{5}X)$ = (11.011434 – 11.009305)u = 0.002129 u Q= Δm ×931.5 MeV = 0.002129 × 931.5 MeV = 1.98 MeV	1 ½ ½ ½ ½	3
Set-1, Q20 Set-2, Q13 Set-3, Q22	Calculation to find image formed by lens 1½ Nature of image ½ Distance of mirror from lens 1 For lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ $\frac{1}{v} - \frac{1}{-15} = \frac{1}{+10}$ $\frac{1}{v} + \frac{1}{15} = \frac{1}{10}$ $\therefore v = 30$ cm Nature of image- real, magnified Final image formed will be at the object itself only if image formed by lens is at the position of centre of curvature of mirror $\therefore D = (30 + R)cm = (30 + 20)cm = 50\ cm$ (Distance of mirror from lens)	½ ½ ½ ½ ½ ½	3

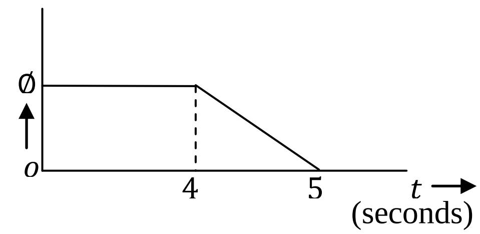
Set-1, Q21 Set-2, Q14 Set-3, Q19	Arranging in order 1½ Production of infrared waves ½ Role of infrared waves in Earth's warmth and physical therapy 1 Gamma(γ) rays, X-rays, Microwaves, Radiowaves Infrared rays are produced by hot bodies / vibration of atoms and molecules Infrared rays: (i) Maintain Earth's warmth through green house effect (ii) Produce heat	1½ ½ ½ ½	3
Set-1, Q22 Set-2, Q15 Set-3, Q20	Process of charging capacitor 1 Effect of dielectric on (i) Electric field and justification ½+½ (ii) Energy stored and justification ½+½ <u>Process of charging</u> The electrons, from the plate of the capacitor, which is connected to the positive terminal of the battery, move towards the battery. The reverse happens at the other plate. Hence, the plates get positively and negatively charged respectively. <u>Effect of dielectric</u> (a) Electric fields decreases Justification Because initially $E_1 = \frac{\sigma}{\varepsilon_0}$ and finally $E_2 = \frac{1}{K} \cdot \frac{\sigma}{\varepsilon_0}$, $E = \frac{E_1}{K}$ (b) Energy stored increases New capacitance $C = \left(\frac{\varepsilon_0 A}{2d}\right) k$ $= \frac{K}{2} C_o, \quad \therefore C < C_o$ Initially Energy $= \frac{Q^2}{2C}$ and Energy $= \frac{Q^2}{C} \cdot \frac{2}{K}$ as $1 < K < 2$	½ ½ ½ ½ ½ ½	3

Section – D

Set-1, Q23 Set-2, Q23 Set-3, Q23	Necessity 1 Explanation; low power factor implies large power loss? 1 Two values each displayed by Ajit and his uncle 1+1		

	a) For the same power at high voltage, current in the transmission wires becomes smaller. ∴ power loss is less [Award ½ mark if the student just writes $P = I^2 R$] b) If power factor is less, current in the cables is more so power loss is more [Alternately $P_{av} = E_v I_v \cos\theta$ If $\cos\theta$ is less, I_v is more so power loss is more] (Award ½ mark if the student just writes $P = E_E I_v \cos\theta$ c) Values displayed By Ajit (Any two) – Social Awareness, understanding nature, concern for society By Uncle- Knowledgeable, professional honesty, concern for society. (Also accept other suitable values)	½ ½ 1 ½ +½ ½ +½	 4
Section - E			
Set-1, Q24 Set-2, Q26 Set-3, Q25	Definition of self-inductance — 1 Expression for energy stored — 2 Direction of induced current — ½ Duration of induced current — ½ Graphs of magnetic flux and induced e.m.f — 1 a) Self inductance of a coil is numerically equal to magnetic flux linked with the coil when unit current passes through it. $L = \frac{\varphi}{I}$ Alternately Self inductance of a coil is numerically equal to induced e.m.f. produced in it when rate of change of current is unity in it. Expression for energy Induced e.m.f. produced in coil, $\varepsilon = -L\frac{dI}{dt}$ ∴ work done by the source, dw= $+\varepsilon I dt = LIdI$ $W = \int_0^I LIdI = \frac{1}{2}LI^2$ b) Direction of induced current – clockwise (MNOP) [A student can also show the direction in the diagram itself] Duration of induced current - 1s	 1 ½ ½ ½+½ ½ ½	

Plot of graph



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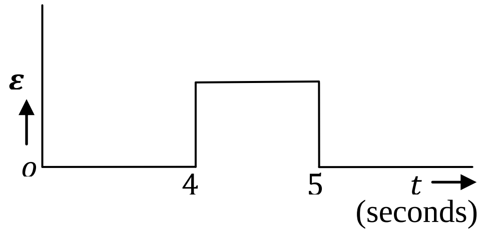


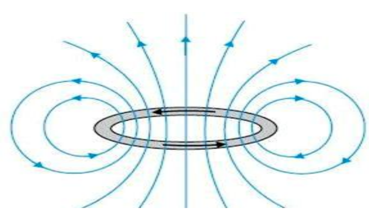
½ 5

(Award this 1 mark even if the student draw the two graphs correctly without mentioning the values on the time axis)

OR

Plot of magnetic field lines	1
To show, $\vec{m} = I\vec{A}$	1
Expression for magnetic field due to finite solenoid and comparison with bar magnet	3

(a)



1

Magnetic field due to circular loop on its axis for far off points

$$B = \frac{\mu_0}{4\pi}\ \frac{2IA}{x^3}$$ ½

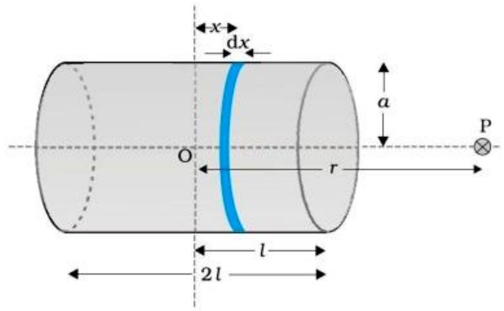
Magnetic field due to bar magnet at an axial point

$$B = \frac{\mu_0}{4\pi}\ \frac{2m}{x^3}$$ ½

By comparison m = IA

[**Alternatively:** Students can also get this equality by comparing the torque values in the two cases]

a) Magnetic field on the axis of a finite solenoid



1

Magnetic field due to element dx at point P

$$dB = \frac{\mu_0 n dx I\, a^2}{2[(r-x)^2 + a^2]^{3/2}}$$ ½

½

$$\therefore B = \int dB = \frac{\mu_0 I a^2 \times n}{2}\int_{-l}^{+l} \frac{dx}{[(r-x)^2 + a^2]^{3/2}}$$

For r >> a, (r >> l) ½

$$\therefore B = \frac{\mu_0 I a^2 n}{2 \times r^3}\int_{-l}^{+l} dx = \frac{\mu_0 n I}{2}\frac{2la^2}{r^3}$$ ½ 5

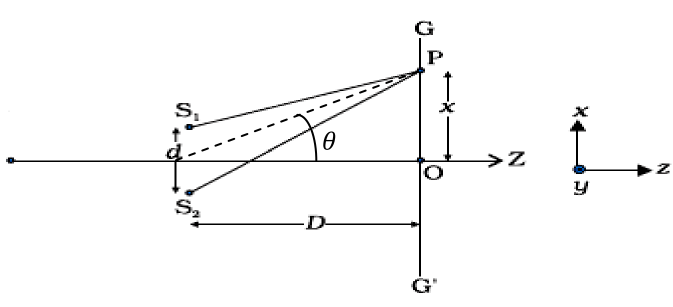
Magnetic moment of solenoid, $m = (n \times 2l)I(\pi a^2)$

$\therefore B = \frac{\mu_o}{4\pi}\frac{2m}{r^3}$ same as that of a bar magnet

Set-1, Q25
Set-2, Q24
Set-3, Q26

Conditions for constructive and destructive interference	1½
Expression for fringe width	2
Fringe pattern in double slit related to diffraction pattern	½
Numerical	1

Diagram



½

(a) Path difference $(\Delta) = S_2P - S_1P = d\ \sin\theta = \frac{dx}{D}$ ½

For constructive interference, $\Delta = n\lambda\ [n = 0,1,2..]$ ½

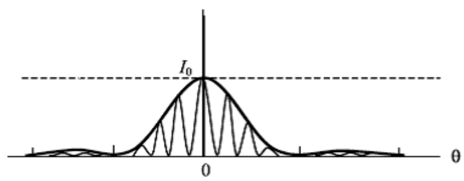
Destructive interference, $\Delta = (2n-1)\frac{\lambda}{2}\ [n = 1,2..]$ ½

For bright bands, $\Delta = n\lambda = \frac{x_n d}{D}\ or\ x_n = \frac{n\lambda D}{d}$ ½

For dark bands, $\Delta = (2n-1)\frac{\lambda}{2} = \frac{x_n d}{D}\ or\ x_n = (2n-1)\frac{\lambda D}{2d}$ ½

Fringe width $\beta = X_n - X_{n-1} = \frac{\lambda D}{d}$ ½

b)



½

[Alternately
It is a broader diffraction peak in which there appears several fringes of smaller width due to double slit interference pattern]

(c) $10\ \beta$= width of central maxima

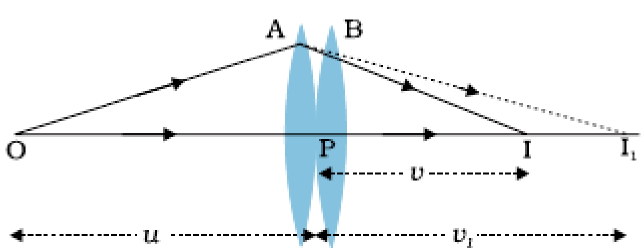
$$10\frac{D\lambda}{d} = 2\frac{D\lambda}{a}$$ ½

$$a = \frac{d}{5} = \frac{1}{5}mm = 0.2\ mm$$ ½

5

OR

Diagram for image formation	½
Derivation for combines focal length	1½
Ray diagram through prism	1
Calculation of angle of incidence and angle of deviation	2



½

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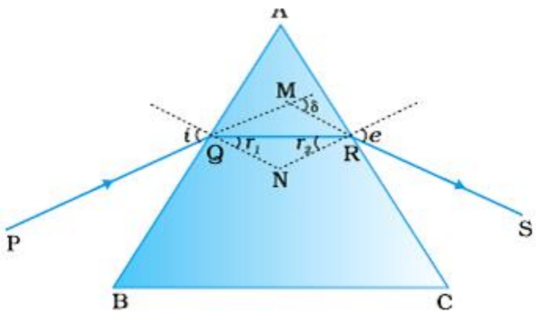
For First lens $\frac{1}{v_1}-\frac{1}{u}=\frac{1}{f_1}\qquad (i)$
For Second lens $\frac{1}{v}-\frac{1}{v_1}=\frac{1}{f_2}\qquad (ii)$
By adding i) and ii) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f_1}+\frac{1}{f_2}$
Or $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$
b) Ray Diagram


Given A=60°, $\mu=\sqrt{3}$
It is minimum deviation position of prism,
$\therefore r=\frac{A}{2}=30°$
$\mu=\frac{\sin i}{\sin r}$
$\therefore \sqrt{3}\times\sin 30=\sin i$
$\Rightarrow i=60°$
$\therefore e=60°$
$i+e=A+D$
$60+60=60+D \therefore D=60°$
Alternately
$[i=\frac{A+D_m}{2}\quad \therefore D_m=60°]$
</td>
<td>½
½
½
1
½
½
½
½</td>
<td>5</td>
</tr>
<tr>
<td>Set-1, Q26
Set-2, Q25
Set-3, Q24</td>
<td>
<table>
<tr><td>Expression for potential energy</td><td>2</td></tr>
<tr><td>Numerical</td><td>3</td></tr>
</table>
a) Expression for potential energy
i) To bring charge q_1 from ∞ to point$(\vec{r_1})$
Work done = $W_1 = q_1 V(r_1)$
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	ii) To bring charge q_2 from ∞ to point$(\overrightarrow{r_2})$ Work done = $W_2 = q_2V(r_2) + \frac{1}{4\pi\varepsilon_o} \cdot \frac{q_1q_2}{r_{12}}$	½	
	$\therefore$ Potential energy $U = W_1 + W_2 = q_1V(r_1) + q_2V(r_2) + \frac{Kq_1q_2}{r_{12}}$	1	
	b) $U_i = \frac{1}{4\pi\varepsilon_o}\left[\frac{Q\times 2Q}{l} + \frac{Q(-3)Q}{l} + \frac{2Q\times(-3)Q}{l}\right]$ $= -\frac{1}{4\pi\varepsilon_o}\frac{7Q^2}{l}$ $U_f = \frac{1}{4\pi\varepsilon_o}\left[\frac{Q\times 2Q}{\frac{l}{2}} + \frac{Q(-3)Q}{\frac{l}{2}} + \frac{2Q\times(-3)Q}{\frac{l}{2}}\right]$	1	
	$= -\frac{1}{4\pi\varepsilon_o}\frac{14Q^2}{l}$	1	
	$W = U_f - U_i = -\frac{1}{4\pi\varepsilon_o}\frac{7Q^2}{l}$	1	5
	(If a student writes $U_i = \frac{1}{4\pi\varepsilon_o}\left[\sum\sum\frac{q_iq_j}{r_{ij}}\right]$, award ½ mark) **Or** Definition of electric flux — 1 S.I. unit — ½ State and explain Gauss's law — 1½ Outward flux — 1 Flux is independent of shape and size — 1		
	Electric flux through a given area is defined as the number of electric field lines crossing normally through that area [Alternately, Electric flux is the surface integral of electric field over the surface $\Phi = \oint \vec{E}.\overrightarrow{ds}$]	1	
	S.I. unit - Nm^2C^{-1} *or* Vm	½	
	Gauss Law: Electric flux through a given closed surface is $\frac{1}{\varepsilon_o}$ times the charge enclosed by the closed surface [*Alternatively*: $\phi = \frac{q}{\varepsilon_o}$]	1½	
	Flux of a point charge placed at the centre of cube = $\frac{q}{\varepsilon_o}$	1	

	As the Electric field is radial and inversely proportional to the square of distnce. Therefore, it is independent of shape and size. The number of electric field lines, crossing normally through a closed surface depends only on the charge enclosed by it.	1	5