CBSE Class 12 Physics Solution

QUESTION PAPER CODE 55/1/1/D

Q. No.	Expected Answer/value Points	Marks	Total Marks
1.	It is defined as the opposition to the flow of current in ac circuits offered by a capacitor.		
	Alternatively:		
	$X_c = \frac{1}{\omega C}$	½	
	S.I unit: ohm	½	1
2.	Zero	1	1
3.	Converging (convex lens),	1	1
4.	Side bands are produced due to the superposition of carrier waves of frequency ω_c over modulating / audio signal of frequency ω_m.	1	
	Alternatively:		
	(Credit may be given if a student mentions the side bands as $\omega_c \pm \omega_m$)		1
5.	DE : Negative resistance region	½	
	AB: Where Ohm's law is obeyed.(Also accept BC)	½	1
6.	Determination of ratio (i) accelerating potential — 1 (ii) speed — 1		
	(i) $\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow V = \frac{h^2}{2mq\lambda^2}$	½	

$m_\alpha = 4m_p, q_\alpha = 2q_p$

$\Rightarrow \frac{V_p}{V_\alpha} = \frac{m_\alpha q_\alpha}{m_p q_p}$

$= \frac{4m_p \times 2q_p}{m_p q_p}$

$= 8 : 1$ ½

(ii) $\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda}$ ½

$\Rightarrow \frac{V_p}{V_\alpha} = \frac{m_\alpha}{m_p} = 4$ ½ 2

7. | Showing that the radius of orbit varies as n^2 | 2 |
|---|---|

$\frac{mv^2}{r} = \frac{1}{4\pi \in_0} \frac{e^2}{r^2}$ ½

Or $mv^2 r = \frac{1}{4\pi \in_0} e^2$ .... (i)

$mvr = \frac{nh}{2\pi}$ ½

$m^2 v^2 r^2 = \frac{n^2 h^2}{4\pi^2}$ .... (ii)

Divide (ii) by (i) ½

$mr = \frac{n^2 h^2}{4\pi^2} \times \frac{4\pi \in_0}{e^2}$

$\therefore \; r = \frac{n^2 h^2}{4\pi^2 m e^2} \cdot 4\pi \in_0$ ½

$\therefore \quad r \propto n^2$

(Give full credit to any other correct alternative method) 2

8.	Distinction between intrinsic & extrinsic semiconductors	2

Intrinsic Semiconductor	Extrinsic Semiconductor	
(i) Without any impurity atoms.	(i) Doped with trivalent/ pentavalent impurity atoms.	1
(ii) $n_e = n_h$	(ii) $n_e \neq n_h$	1

(Any other correct distinguishing features.) 2

9.	Derivation of the required condition	2

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ ½

For concave mirror $f < 0$ and $u < 0$

As object lies between f and $2f$

(i) At $u = -f$

$$\frac{1}{v} = -\frac{1}{f} + \frac{1}{f}$$

$\Rightarrow \quad v = \propto$

At $u = -2f$

$\Rightarrow \frac{1}{v} = -\frac{1}{f} + \frac{1}{2f} = -\frac{1}{2f}$ ½

$\Rightarrow \quad v = -2f$ ½

$\Rightarrow$ Hence, image distance $v \geq -2f$ ½

Since v is negative, therefore, the image is real. 2

Alternative Method

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$ ½

For concave mirror ½

$f < 0, u < 0$

$\therefore \ 2f < u < f$

$$\Rightarrow \frac{1}{2f} > \frac{1}{u} > \frac{1}{f}$$

$$\frac{1}{2f} - \frac{1}{f} > \frac{1}{u} - \frac{1}{f} > \frac{1}{f} - \frac{1}{f}$$

$$\Rightarrow \frac{1}{2f} > \frac{1}{v} > 0 \qquad \because \frac{1}{u} > \frac{1}{f} > \frac{1}{-v}$$

$$\Rightarrow \frac{1}{2f} < \frac{1}{v} < 0$$ ½

$\Rightarrow v < 0$ $\therefore$ Image is real

Also $v > 2f$ image is formed beyond $2f$. ½ 2

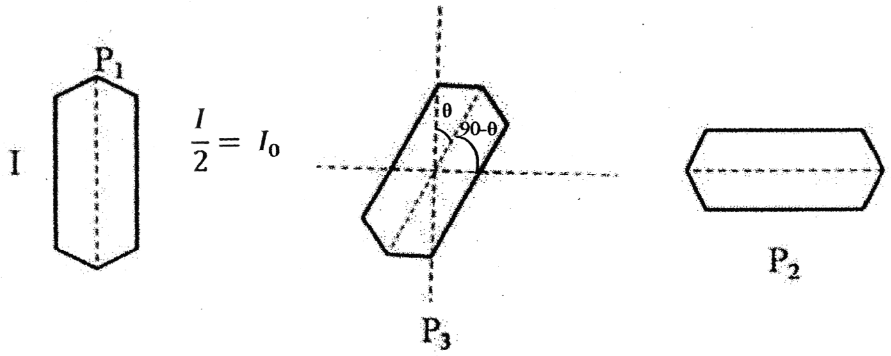
(Any alternative correct method should be given full credit.)

OR

Finding the expression for intensity	1½
Position of polaroid sheet for maximum intensity	½

Let the rotating polaroid sheet makes an angle θ with the first polaroid

∴ Angle with the other polaroid will be (90 - θ) ½



Applying Malus's law between P_1 and P_3

$I' = I_0 cos^2\theta$

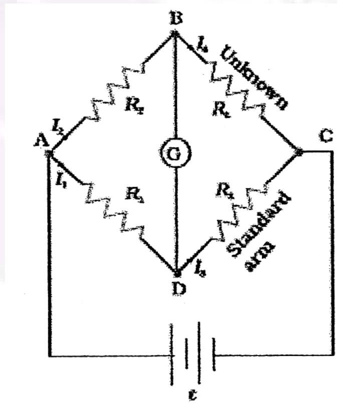
Between P_3 and P_2

$I'' = (I_0 cos^2\theta) cos^2(90 - \theta)$

$\Rightarrow \quad I'' = \frac{I_0}{4} \cdot \sin^2 2\theta$ ½

$\therefore$ Transmitted intensity will be maximum when $\theta = \frac{\pi}{4}$ ½ 2

10. | Obtaining condition for the balance Wheatstone bridge 2 |



½

Applying Kirchoff's loop rule to closed loop ADBA

$-I_1R_1 + 0 + I_2R_2 = 0 \quad (I_g = 0)$ ....(i) ½

For loop CBDC

$-I_2R_4 + 0 + I_1R_3 = 0$ ....(ii)

$\Rightarrow$ from equation (i) $\frac{I_1}{I_2} = \frac{R_1}{R_2}$

From equation (ii) $\frac{I_1}{I_2} = \frac{R_4}{R_3}$ ½

$\therefore \frac{R_1}{R_2} = \frac{R_4}{R_3}$ ½ 2

11.

Name of the parts of e.m. spectrum for a,b,c	½+½+½
Production	½+½+½

(a) Microwave ½

Production: Klystron/magnetron/Gunn diode (any one) ½

(b) Infrared Radiation ½

Production: Hot bodies / vibrations of atoms and molecules (any one) ½

(c) X-Rays ½

Production: Bombarding high energy electrons on metal target/ x-ray tube/inner shell electrons (any one). ½ 3

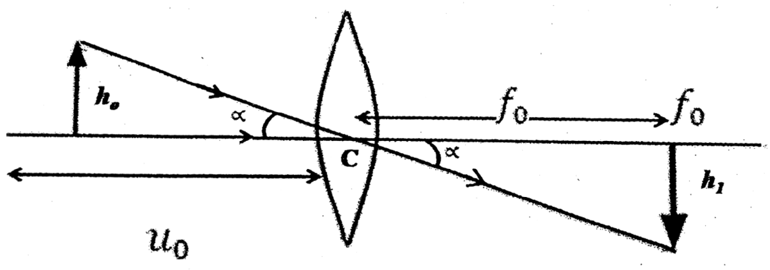
12.

(i)	Calculation of angular magnification	1½
(ii)	Calculation of image of diameter of Moon	1½

Angular Magnification

$$m = \frac{f_0}{f_e}$$ 1

$$= \frac{15}{10^{-2}} = 1500$$ ½



½

½

Angular size of the moon $= \left(\dfrac{3.48\times10^{6}}{3.8\times10^{8}}\right) = \dfrac{3.48}{3.8}\times10^{-2}$ radian

$\therefore$ Angular size of the image $= \left(\dfrac{3.48}{3.8}\times10^{-2}\times1500\right)$ radian ½ 3

Diameter of the image $= \dfrac{3.48}{3.8}\times 15 \times$ focal length of eye piece

$= \dfrac{3.48}{3.8}\times 15\times 1\text{cm}$

$= 13.7\text{cm}$

(Also accept alternative correct method.)

13.

(i)	Einstein's photoelectric equation	½
(ii)	Important features	½+½
(iii)	Derivation of expressions for λ_0 and work function	1½

$h\nu = \varphi_0 + k_{max}$ ½

or $h\nu = h\nu_0 + \dfrac{1}{2}\, mv^2_{max}$

Important features

(i) k_{max} depends linearly on frequency ν ½

(ii) Existence of threshold frequency for the metal surface. ½

(Any other two correct features.)

$h\nu = \varphi_0 + k_{max}$

$\frac{hc}{\lambda_1} = \frac{hc}{\lambda_0} + k_{max}$ ....(i)

$\frac{hc}{\lambda_2} = \frac{hc}{\lambda_0} + 2k_{max}$ ....(ii) ½

From (i) and (ii)

$\frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} = \frac{hc}{\lambda_0}$

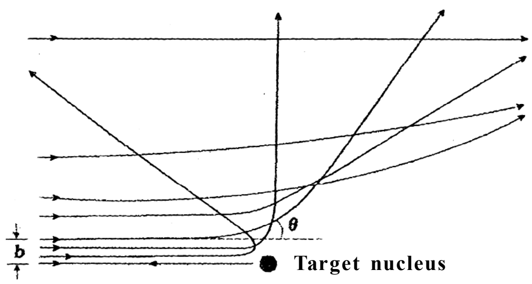
$\frac{1}{\lambda_0} = \left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$ ½

$\lambda_0 = \frac{\lambda_1\lambda_2}{2\lambda_2 - \lambda_1}$

Work function $\phi_0 = \frac{hc}{\lambda_0} = \frac{hc(2\lambda_2 - \lambda_1)}{\lambda_1\lambda_2}$ ½ 3

14.

(i)	Drawing of trajectory	1
(ii)	Explanation of information on the size of nucleus	½
(iii)	Proving that nuclear density is independent of A	1½



1

Only a small fraction of the incident α – particles rebound. This shows that the mass of the atom is concentrated in a small volume in the form of nucleus and gives an idea of the size of the nucleus. ½

Radius of the nucleus

$$R = R_0 A^{\frac{1}{3}}$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$ ½

$$= \frac{mA}{\frac{4}{3}\pi R^3}$$ where, m: mass of one nucleon

A: Mass number

$$= \frac{mA}{\frac{4}{3}\pi \left(R_0 A^{\frac{1}{3}}\right)^3}$$ ½

$$= \frac{3m}{4\pi R_0^3}$$

$\Rightarrow$ Nuclear matter density is independent of A ½ 3

OR

Distinction between nuclear fission and nuclear fusion	½+½
Showing release of energy in both processes	½
Calculation of release of energy	1½

The breaking of heavy nucleus into smaller fragments is called nuclear fission; the joining of lighter nuclei to form a heavy nucleus is called nuclear fusion. ½+½

Binding energy per nucleon, of the daughter nuclei, in both processes, is more than that of the parent nuclei. The difference in binding energy is released in the form of energy. In both processes some mass gets converted into energy. ½

Alternatively:

In both processes, some mass gets converted into energy.

Energy Released

$$Q = \left[m\left({}^{2}_{1}\mathrm{H}\right) + m\left({}^{3}_{1}\mathrm{H}\right) - m\left({}^{4}_{2}\mathrm{He}\right) - m(\mathrm{n})\right] \times 931.5 \text{ MeV}$$ ½

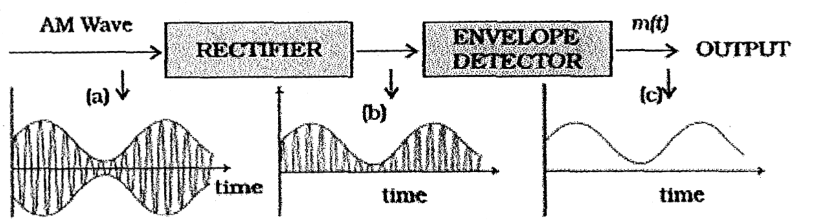
$= [2.014102 + 3.016049 – 4.002603 – 1.008665] \times 931.5$ MeV ½

$= 0.018883 \times 931.5$ MeV

$= 17.59$ MeV ½ 3

15.

Drawing block diagram of detector	1
Showing detection of message signal from input AM Wave	2



AM input wave   Rectified wave   Output (without RF component)

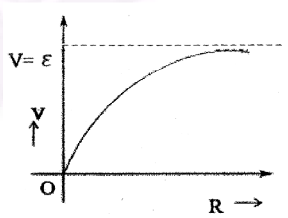
1

1+1 3

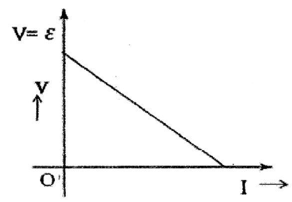
[**Note:** Award these 3 marks irrespective of the way the student attempts the question.]

16.

Drawing of Plots of Part (i) & (ii)	½+½
Finding the values of emf and internal resistance	1+1



½



½

(If the student just writes the relations $V = \varepsilon - IR$ and $V = \frac{\in R}{R+r}$ but does not draw the plots, award ½ mark)

$$I = \frac{E}{R+r}$$

$$I = \frac{E}{4+r}$$

$\Rightarrow \; E = 4 + r$ ....(i) ½

Also

$$0.5 = \frac{E}{9+r}$$

$E = 4.5 + 0.5\, r$ ....(i) ½

From equation (i) & (ii)

$4 + r = 4.5 + 0.5\, r$ ½

$\therefore \; r = 1\,\Omega$

Using this value of r, we get ½

$E = 5\text{V}$ 3

17.

Determination of C_1 and C_2	2
Determination of charge on each capacitor in parallel combination	½ + ½

Energy stored in a capacitor

$E = \frac{1}{2}\, CV^2$ ½

In series combination

$$0.045 = \frac{1}{2}\frac{c_1c_2}{c_1 + c_2}(100)^2$$

$$\Rightarrow \frac{c_1c_2}{c_1 + c_2} = 0.09 \times 10^{-4} \qquad \text{...... (i)}$$ ½

In parallel combination

$$0.25 = \frac{1}{2}(C_1 + C_2)(100)^2$$

$$\Rightarrow \quad C_1 + C_2 = 0.5 \times 10^{-4} \qquad \text{...... (ii)}$$ ½

On simplifying (i) & (ii)

$$C_1C_2 = 0.045 \times 10^{-8}$$

$$(C_1 - C_2)^2 = (C_1 + C_2)^2 - 4C_1C_2$$

$$= (0.5 \times 10^{-4})^2 - 4 \times 0.045 \times 10^{-8}$$

$$= 0.25 \times 10^{-8} - 0.180 \times 10^{-8}$$

$$(C_1 - C_2)^2 = 0.07 \times 10^{-8}$$

$$(C_1 - C_2)^2 = 2.6 \times 10^{-5} = 0.26 \times 10^{-4} \text{ ..... (iii)}$$

From (ii) and (iii) we have ½

$$\Rightarrow \quad C_1 = 0.38 \times 10^{-4}\text{ F and } C_2 = 0.12 \times 10^{-4}\text{ F}$$

Charges on capacitor C_1 and C_2 in parallel combination

$$Q_1 = C_1V = (0.38 \times 10^{-4} \times 100) = 0.38 \times 10^{-2}\text{ C}$$ ½

$$Q_2 = C_2V = (0.12 \times 10^{-4} \times 100) = 0.12 \times 10^{-2}\text{ C}$$ ½ 3

[Note: If the student writes the relations / equations

$$E = \frac{1}{2} CV^2$$

and $0.045 = \frac{1}{2}\left(\frac{c_1 c_2}{c_1 + c_2}\right)(100)^2$

$$0.25 = \frac{1}{2}(C_1 + C_2)(100)^2$$

but is unable to calculate C_1 and C_2, award him/her full 2 marks.

Also if the student just writes

$Q_1 = C_1V = C_1(100)$ and $Q_2 = C_2V = C_2(100)$

award him/her one mark for this part of the question.]

18.

Working principle	1
Finding the required resistance	1
Finding the resistance G of the galvanometer	1

Working principle: A current carrying coil experiences a torque when placed in a magnetic field which tends to rotate the coil and produces an angular deflection. 1

$$V = I(G + R_1)$$

$$\frac{V}{2} = I(G + R_2)$$ ½

$$\Rightarrow\ 2 = \frac{G + R_1}{G + R_2}$$

$$\Rightarrow\ G = R_1 - 2R_2$$ ½

Let R_3 be the resistance required for conversion into voltmeter of range 2V

$\therefore\ 2V = I_g (G + R_3)$

also $V = I_g (G + R_1)$

$\therefore\ 2 = \dfrac{G + R_3}{G + R_1}$ ½

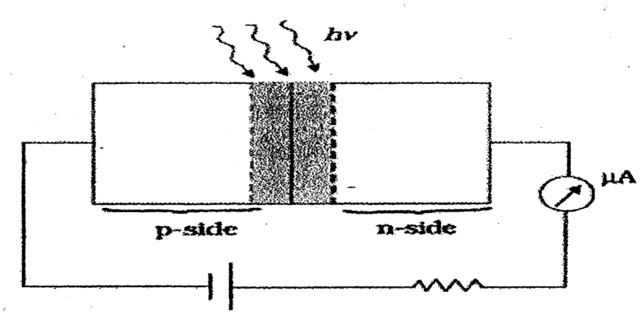
$\therefore\ R_3 = G + 2R_1 = R_1 - 2R_2 + 2R_1 = 3R_1 - 2R_2$ ½ 3

19.

Fabrication of photodiode	½
Working with suitable diagram	1½
Reason	1

It is fabricated with a transparent window to allow light to fall on diode. ½

When the photodiode is illuminated with photons of energy ($h\nu > E_g$) greater than the energy gap of the semiconductor, electron - holes pairs are generated. These gets separated due to the junction electric field (before they recombine) which produces an emf. 1



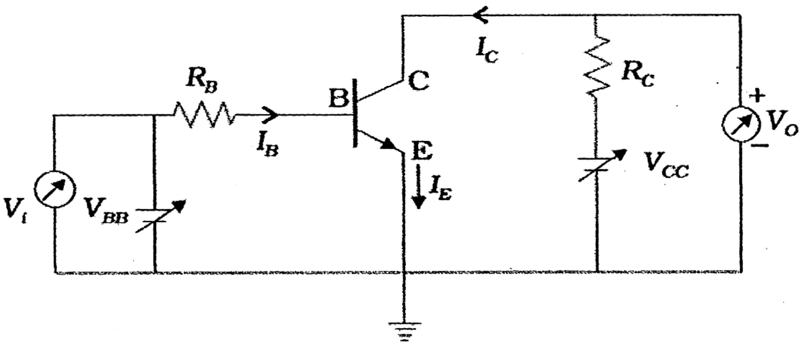
½

Reason: It is easier to observe the change in the current, with change in light intensity, if a reverse bias is applied. 1 3

Alternatively,

The fractional change in the minority carrier current, obtained under reverse bias, is much more than the corresponding fractional change in majority carrier current obtained under forward bias.

20. | Circuit diagram of transistor amplifier in CE-configuration 1½
Definition and determination of
(i) input resistance
(ii) current amplification factor 1½



1½

Input reisistance

$$R_{i_B} = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$ ½

Current amplification factor

$$\beta_{ac} = \left(\frac{\Delta V_c}{\Delta I_B}\right)_{V_{CE}}$$ ½

The value of input resistance is determined from the slope of I_B verses V_{BE} plot at constant V_{CE}.

The value of current amplification factor is obtained from the slope of collector I_C verses V_{CE} plot using different values of I_B. ½ 3

(If a student uses typical charateristics to determine these values, full credit of one mark should be given)

21. | Finding the spacing between two slits 1
Effect on wavelength and frequency of reflected and refracted light 2

(a)	Angular width of fringes		
	$\theta = \lambda/d$,	½	
	where d = separation between two slits		
	Here $\theta = 0.1^{\circ} = 0.1 \times \dfrac{\pi}{180}$ radian		
	$\therefore \quad d = \dfrac{600 \times 10^{-9} \times 180}{0.1 \times \pi}$ m		
	$= 3.43 \times 10^{-4}$ m		
	$= 0.34$ cm	½	
(b)	**For Reflected light:**		
	Wavelength remains same	½	
	Frequency remains same	½	
	For Refracted light:		
	Wavelength decreases	½	
	Frequency remains same	½	3

22.

Change in the Brightness of the bulb in cases (i), (ii) & (iii)	½+½+½
Justification	½+½+½

(i)	**Increases**		
	$X_L = \omega L$	½	
	As number of turns decreases, L decreases, hence current through	½	
	bulb increases. / voltage across bulb increases.	½	
(ii)	**Decreases**		
	Iron rod increases the inductance, which increases X_L, hence	½	
	current through the bulb decreases / voltage across bulb decreases.	½	

(iii)	**Increases**		
	Under this condition ($X_C = X_L$) the current through the bulb will become maximum / increase.	½	3

23.

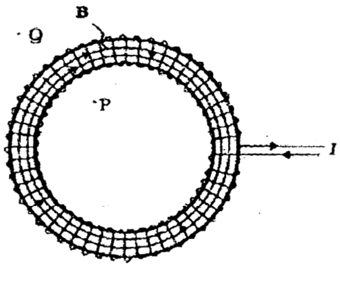
(i)	Name of device and principle of working	½+1
(ii)	Possibility and explanation	½
(iii)	Values displayed by students and teachers	1+1

(i)	Transformer	½	
	Working principle: Mutual induction		
	Whenever an alternative voltage is applied in the primary windings, an emf is induced in the secondary windings.	1	
(ii)	No, There is no induced emf for a dc voltage in the primary	½	1
(iii)	Inquisitive nature / Scientific temperament (any one)		
	Conceren for students / Helpfulness / Professional honesty(any one)		
	(Any other relevant values)	1	4

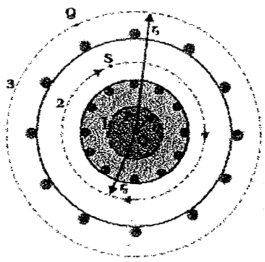
24.

(a)	Statement of Ampere's circuital law	1
	Expression for the magnetic field	1½
(b)	Depiction of magnetic field lines and specifying polarity	½+½
	Showing the solenoid as bar magnet	1½

(a)	Line integral of magnetic field over a closed loop is equal to the μ_0 times the total current passing through the surface enlosed by the loop .	
	Alternatively	
	$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$	1



(a)



(b) ½

Let the current flowing through each turn of the toroid be I. The total number of turns equals $n.(2\pi r)$ where n is the number of turns per unit length.

Applying Ampere's circuital law, for the Amperian loop, for interior points.

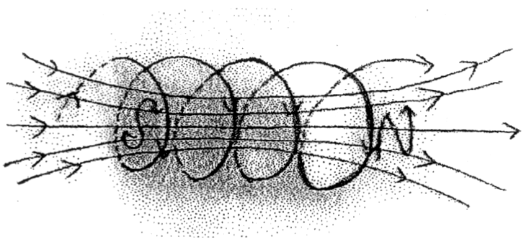
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (n2\pi rI)$$

$$\oint Bdl\cos\theta = \mu_0 n2\pi rI$$ ½

$$\Rightarrow B \times 2\pi r = \mu_0 n\, 2\pi rI$$

$\therefore$ $$B = \mu_0 nI$$ ½

(b)



½+½

The solenoid contains N loops, each carrying a current I. Therefore, each loop acts as a magnetic dipole. The magnetic moment for a current I, flowing in loop of area (vector) **A** is given by $\mathbf{m} = I\mathbf{A}$	½ ½	
The magnetic moments of all loops are aligned along the same direction. Hence, net magnetic moment equals NIA.	½	5

OR

(a)	Definition of mutual inductance and S.I. unit	1½
(b)	Derivation of expression for the mutual inductance of two long coaxial solenoids	2½
(c)	Finding out the expression for the induced emf	1

(a) $\phi = MI$

Mutual inductance of two coils is equal to the magnetic flux linked with one coil when a unit current is passed in the other coil. 1

Alternatively,

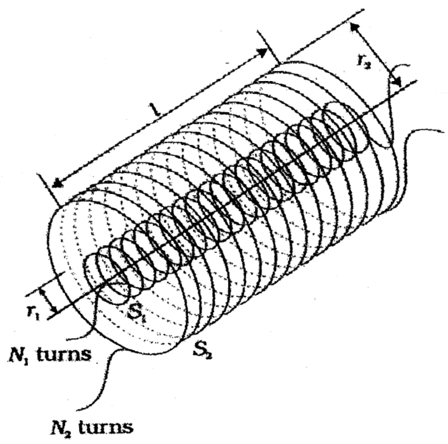
$$e = -M\frac{dI}{dt}$$

Mutual inductance is equal to the induced emf set up in one coil when the rate of change of current flowing through the other coil is unity.

SI unit: henry / (weber ampere^{-1}) / (volt second ampere^{-1})

(Any one) ½

(b)



½

Let a current I_2 flow through S_2.This sets up a magnetic flux ϕ_1 through each turn of the coil S_1.

Total flux linked with S_1

$N_1\ \phi_1 = M_{12} I_2$ ....(i) ½

where M_{12} is the mutual inductance between the two solenoids

Magnetic field due to the current I_2 in S_2 is $\mu_0 n_2 I_2$. ½

Therefore, resulting flux linked with S_1.

$N_1\ \phi_1 = [(n_1 l)\ \pi r_1^2]\ (\mu_0 n_2 I_2)$ ....(i) ½

Comparing (i) & (ii),we get

$M_{12} I_2 = (n_1 l)\ \pi r_1^2\ (\mu_0 n_2 I_2)$

$\therefore \quad M_{12} = \mu_0 n_1 n_2\ \pi r_1^2 l$ ½

(c) Let a magnetic flux be (ϕ_1) linked with coil C_1 due to current (I_2) in coil C_2

We have:

$\phi_1 \propto I_2$

$\Rightarrow \quad \phi_1 = M I_2$

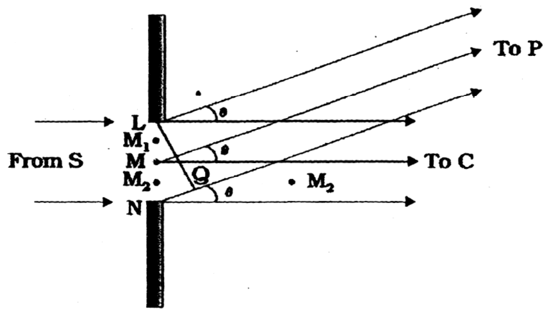
$\therefore \dfrac{d\phi_1}{dt} = M \dfrac{dI_2}{dt}$ ½

$\Rightarrow\ e = -M \dfrac{dI_2}{dt}$ ½ 5

25.

(a)	Explanation of diffraction pattern using Huygen's construction	2
(b)	Showing the angular width of first diffraction fringe as half of the central fringe	2
(c)	Explanation of decrease in intensity with increasing n	1

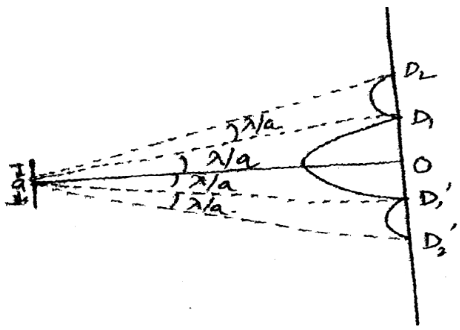
(a)



1

We can regard the total contribution of the wavefront LN at some point P on the screen, as the resultant effect of the superposition of its wavelets like LM, MM_2, M_2N. These have to be superposed taking into account their proper phase differences .We, therefore, get maxima and minima, i.e. a diffraction pattern, on the screen. 1

(b)



½

Condition for first minimum on the screen

$$a \, Sin\theta = \lambda$$

$\Rightarrow \theta = \lambda/a$ ½

$\therefore$ Angular width of the central fringe on the screen (from figure)

$= 2\theta = 2\lambda/a$ ½

Angular width of first diffraction fringe (From fig) = λ/a ½

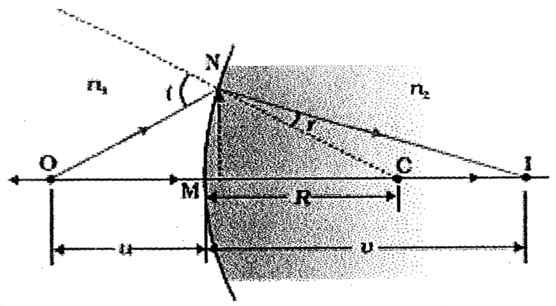
Hence angular width of central fringe is twice the angular width of first fringe.

Maxima become weaker and weaker with increasing n. This is because the effective part of the wavefront, contributing to the maxima. becomes smaller and smaller, with increasing n. 1 5

OR

a)	Drawing the ray diagram showing the image formation	1
	Derivation of relationship	2
b)	Ray diagram	½
	Similar relation	½
	Derivation of lens maker's formula	1

(a)



1

(Deduct ½ mark for not showing direction of propagation of rays)

For small angles

$$\angle NOM \simeq \tan \angle NOM = \frac{MN}{OM}$$

$$\angle NCM \simeq \tan \angle NCM = \frac{MN}{MC}$$ ½

$$\angle NIM \simeq \tan \angle NIM = \frac{MN}{MI}$$

In ΔNOC, $\angle i = \angle NOM + \angle NCM$

$$\therefore \ \angle i = \frac{MN}{OM} + \frac{MN}{MC} \qquad ....(i)$$ ½

Similarly

$\angle r = \angle NCM - \angle NIM$

$$= \frac{MN}{MC} - \frac{MN}{MI} \qquad \text{........(ii)}$$

Using Snell's Law

$n_1 \sin i. = n_2 \sin r$

For small angles

$n_1\, i = n_2\, r$

Substituting for i and r, we get

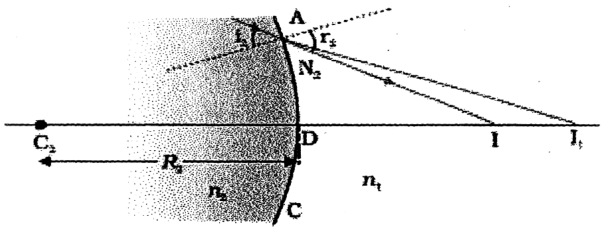
$$\frac{n_1}{OM} + \frac{n_2}{MI} = \frac{n_2 - n_1}{MC}$$ ½

Here, OM = – u, MI = + v, MC = + R

Substituting these, we get

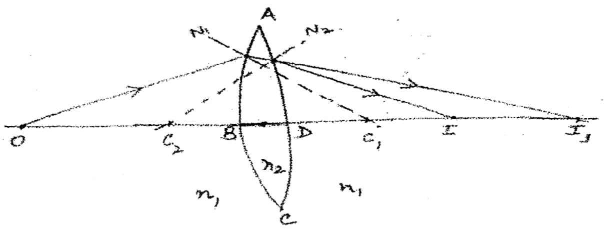
$$\Rightarrow \quad \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$ ½

b)



½

(Alternatively accept this Ray diagram)



Similarly relation for the surface ADC.

$$\frac{-n_2}{DI_1}+\frac{n_1}{DI}=\frac{n_2-n_1}{DC_2} \quad ....(i)$$ ½

Refraction at the first surface ABC of the lens.

$$\frac{n_1}{IB}+\frac{n_2}{BI_1}=\frac{n_2-n_1}{BC_1} \quad ....(i)$$

Adding (i)and (ii), and taking $BI_1 \cong DI_1$, we get

$$\frac{n_1}{OB}+\frac{n_1}{DI}=(n_1-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right)$$ ½

Here, $OB = -u$

$DI = +v$

$BC_1 = +R_1$

$DC_2 = -R_2$

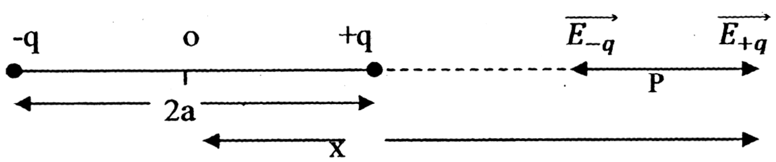
$$\Rightarrow \frac{n_1}{-u}+\frac{n_1}{v}=(n_2-n_1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

$$\Rightarrow n_1\left(\frac{1}{v}+\frac{1}{u}\right)=(n_2-n_1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$ ½ 5

26.	a)	Derivation of the expression for the electric field E and its limiting value	3
	b)	Finding the net electric flux	2

a)



½

Electric field intensity at point P due to charge -q

$$\overrightarrow{E_{-q}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x+a)^2}(\hat{x})$$

Due to charge +q

$$\overrightarrow{E_{+q}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x-a)^2}(\hat{x})$$ ½

Net electric field at point P

$$\vec{E} = \overrightarrow{E_{-q}} + \overrightarrow{E_{+q}}$$

$$= \frac{q}{4\pi\varepsilon_0} \times \left[\frac{1}{(x-a)^2} - \frac{1}{(x+a)^2}\right](\hat{x})$$

$$= \frac{q}{4\pi\varepsilon_0} \times \left[\frac{4aqx}{(x^2-a^2)^2}\right](\hat{x})$$ ½

$$= \frac{1}{4\pi\varepsilon_0} \frac{(q \times 2a)2x}{(x^2-a^2)^2}(\hat{x})$$

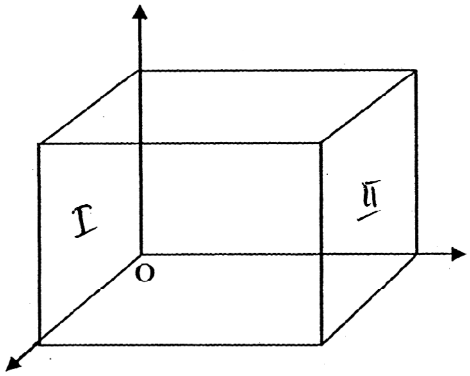
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{2px}{(x^2-a^2)^2}(\hat{x})$$ ½

For x >> a

$(x^2 - a^2)^2 \simeq x^4$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2p}{x^3}\hat{x}$$ ½

b) Only the faces perpendicular to the direction of x-axis, contribute to the electric flux. The remaining faces of the cube give zero contribution. ½



	½	

Total flux $\phi = \phi_I + \phi_{II}$

$$= \oint_I \vec{E} \cdot \vec{ds} + \oint_{II} \vec{E} \cdot \vec{ds}$$

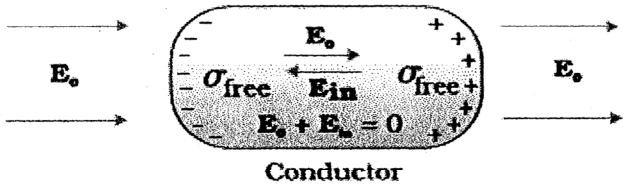
$= 0 + 2(a).a^2$ ½

$\therefore \quad \phi = 2a^3$ ½ 5

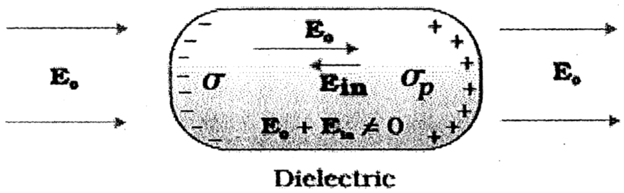
OR

a)	Explanation of difference in behaviour of		
	(i) conductor (ii) dielectric		1+1
	Definition of polarization and its relation with susceptibility		½+½
b)	(i)	Finding the force on the charge at centre and the charge at point A	½+½
	(ii)	Finding Electric flux through the shell	1

(a)



½



½

In the presence of electric field, the free charge carriers, in a conductor, move the charge distribution in the conductor readjusts itself so that the net electric field within the conductor becomes zero. ½

In a dielectric, the external electric field induces a net dipole moment, by stretching / reorienting the molecules. The electric field, due to this induced dipole moment, opposes ,but does not exactly cancel, the external electric field. ½

Polarisation: Induced dipole moment, per unit volume, is called the polarization. For linear isotropic dielectrics having a susceptibility X_c, we have

$P = X_e E$ ½

(b) (i) Net Force on the charge $\frac{Q}{2}$, placed at the centre of the shell, is zero. ½

Force on charge '$2Q$' kept at point A

$$F = E \times 2Q = \frac{1\left(\frac{3Q}{2}\right)2Q}{4\pi\varepsilon_0 r^2} = \frac{(K)3Q^2}{r^2}$$ ½

Electric flux through the shell

$$\phi = \frac{Q}{\varepsilon_0}$$ 1 5