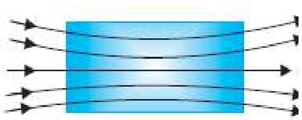
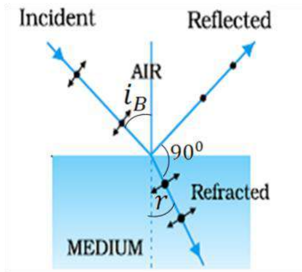
	$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l}[-4+2-8]$ $= \frac{(-10)}{4\pi\epsilon_0}\frac{q^2}{l}$ $\therefore$ Work done = $\frac{10\,q^2}{4\pi\epsilon_0 l} = \frac{5q^2}{2\pi\epsilon_0 l}$	½ ½	3
12	a) Definition and SI unit of conductivity ½ + ½ marks b) Derivation of the expression for conductivity 1 ½ marks Relation between current density and electric field ½ mark a) The conductivity of a material equals the reciprocal of the resistance of its wire of unit length and unit area of cross section. **[Alternatively**: The conductivity (σ) of a material is the reciprocal of its resistivity (ρ)] (Also accept $\sigma = \frac{1}{\rho}$) Its SI unit is $\left(\frac{1}{ohm-metre}\right)/ohm^{-1}m^{-1}/(mho\ \mathrm{m}^{-1})/\mathrm{siemen\ m^{-1}}$ b) The acceleration, $\vec{a} = -\frac{e}{m}\vec{E}$ The average drift velocity, v_d, is given by $v_d = -\frac{eE}{m}\tau$ (τ = average time between collisions/ relaxation time) If n is the number of free electrons per unit volume, the current I is given by $I = neA\|v_d\|$ $= \frac{e^2 A}{m}\tau n\|E\|$ But $I = \|j\|A$ (j= current density) We, therefore, get $\|j\| = \frac{ne^2}{m}\tau\|E\|$, The term $\frac{ne^2}{m}\tau$ is conductivity. $\therefore \sigma = \frac{ne^2\tau}{m}$ ⇨ $J = \sigma E$	½ ½ ½ ½ ½ ½	3
13	a) Formula and Calculation of work done in the two cases (1+ 1) marks b) Calculation of torque in case (ii) 1 mark **(a)** Work done = $m\mathrm{B}(\cos\theta_1 - \cos\theta_2)$ (i) $\theta_1 = 60^0, \theta_2 = 90^0$ $\therefore$work done = $m\mathrm{B}(\cos 60^0 - \cos 90^0)$ $= m\mathrm{B}\left(\frac{1}{2} - 0\right) = \frac{1}{2}m\mathrm{B}$	½	

	$= \frac{1}{2} \times 6 \times 0.44$ J =1.32J (ii) $\theta_1 = 60^0, \theta_2 = 180^0$ ∴work done = mB(cos$60^0 -$ cos180^0) $= m\text{B}\left(\frac{1}{2} - (-1)\right) = \frac{3}{2}\, m\text{B}$ $= \frac{3}{2} \times 6 \times 0.44$ J =3.96J [Also accept calculations done through changes in potential energy.] **(b)** Torque = $\lvert\vec{m} \times \vec{B}\rvert = m\text{B}\sin\theta$ For $\theta = 180^0$, we have Torque = $6 \times 0.44 \sin 180^0 = 0$ [If the student straight away writes that the torque is zero since magnetic moment and magnetic field are anti parallel in this orientation, award full 1mark]	½ ½ ½ ½ ½	**3**
14	a) Expression for Ampere's circuital law — ½ mark Derivation of magnetic field inside the ring — 1 mark b) Identification of the material — ½ mark Drawing the modification of the field pattern — 1 mark a) From Ampere's circuital law, we have, $\oint \vec{B}.d\vec{l} = \mu_o \mu_r I_{enclosed}$ (i) For the field inside the ring, we can write $\oint \vec{B}.d\vec{l} = \oint Bdl = B.2\pi r$ (r = radius of the ring) Also, $I_{enclosed} = (2\pi rn)I$ using equation (i) ∴ $B.2\pi r = \mu_o \mu_r.(n.2\pi r)I$ ∴ $B = \mu_o \mu_r nI$ [Award these $\left(\frac{1}{2}+\frac{1}{2}\right)$ marks even if the result is written without giving the derivation] b) The material is paramagnetic. The field pattern gets modified as shown in the figure below. 	½ ½ ½ ½ **1**	**3**
15	a) Diagram — ½ mark Polarisation by reflection — 1 mark b) Justification — 1 mark Writing yes/no — ½ mark a) The diagram, showing polarisation by reflection is as shown. [Here the reflected and refracted rays are at right angle to each other.]		



½

$\therefore\ r = \left(\frac{\pi}{2} - i_B\right)$ ½

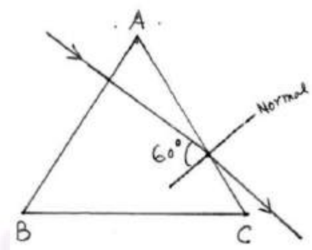
$\therefore\ \mu = \left(\frac{\sin i_B}{\sin r} = \tan i_B\right)$

Thus light gets totally polarised by reflection when it is incident at an angle i_B(Brewster's angle), where $i_B = \tan^{-1}\mu$ ½

b) The angle of incidence, of the ray, on striking the face AC is

i= 60^0(as from figure)

Also, relative refractive index of glass, with respect to the surrounding water, is



$\mu_r = \frac{3/2}{4/3} = \frac{9}{8}$

Also $\sin i = \sin 60^0 = \frac{\sqrt{3}}{2} = \frac{1.732}{2}$

=0.866 ½

For total internal reflection, the required critical angle, in this case, is given by

$\sin i_c = \frac{1}{\mu} = \frac{8}{9} \simeq 0.89$ ½

$\therefore\ i < i_c$

Hence the ray would not suffer total internal reflection on striking the face AC ½

[The student may just write the two conditions needed for total internal reflection without analysis of the given case.

The student may be awarded (½ + ½) mark in such a case.] **3**

16

a) Finding the (modified) ratio of the maximum and minimum intensities	2 marks
b) Fringes obtained with white light	1mark

a) After the introduction of the glass sheet (say, on the second slit), we have

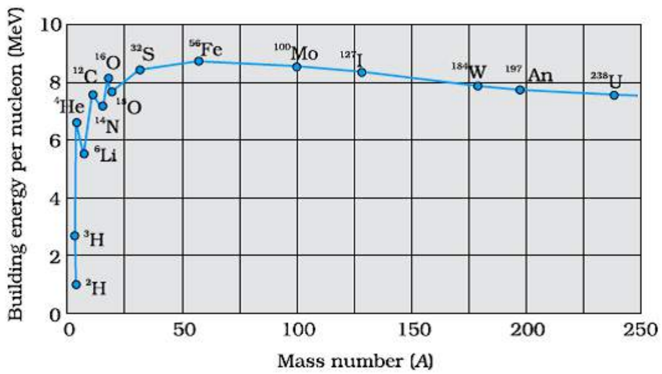
$\frac{I_2}{I_1} = 50\ \% = \frac{1}{2}$

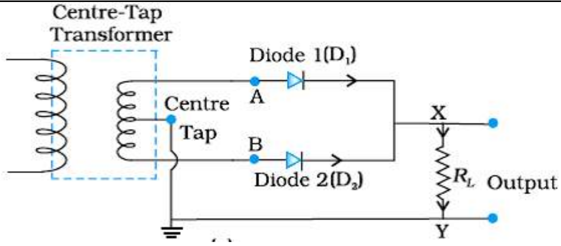
$\therefore$ Ratio of the amplitudes

$= \frac{a_2}{a_1} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$ ½

	Hence $\frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2$	½	
	$= \left(\frac{1+\frac{1}{\sqrt{2}}}{1-\frac{1}{\sqrt{2}}}\right)^2$	½	
	$=\left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2$		
	$(\simeq 34)$	½	
	b) The central fringe remains white. No clear fringe pattern is seen after a few (coloured) fringes on either side of the central fringe.	1	
	[Note : For part (a) of this question, The student may (i) Just draw the diagram for the Young's double slit experiment. Or (ii) Just state that the introduction of the glass sheet would introduce an additional phase difference and the position of the central fringe would shift. For all such answers, the student may be awarded the full (2) marks for this part of this question.]		3
17	Lens maker's formula — ½ mark Formula for 'combination of lenses' — ½ mark Obtaining the expression for μ — 2 marks		
	Let μ_l denote the refractive index of the liquid. When the image of the needle coincides with the lens itself ; its distance from the lens, equals the relevant focal length.	½	
	With liquid layer present, the given set up, is equivalent to a combination of the given (convex) lens and a concavo plane / plano concave 'liquid lens'.		
	We have $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	½	
	and $\frac{1}{f} = \left(\frac{1}{f_1} + \frac{1}{f_2}\right)$	½	
	as per the given data, we then have $\frac{1}{f_2} = \frac{1}{y} = (1.5 - 1)\left(\frac{1}{R} - \frac{1}{(-R)}\right)$ $= \frac{1}{R}$	½	
	$\therefore \frac{1}{x} = (\mu_l - 1)\left(-\frac{1}{R}\right) + \frac{1}{y} = \frac{-\mu_l}{y} + \frac{2}{y}$	½	
	$\therefore \frac{\mu_l}{y} = \frac{2}{y} - \frac{1}{x} = \left(\frac{2x-y}{xy}\right)$ $or\ \mu_l = \left(\frac{2x-y}{x}\right)$	½	3

18	a) Statement of Bohr's postulate — 1 mark Explanation in terms of de Broglie hypothesis — ½ mark b) Finding the energy in the n = 4 level — 1 mark Estimating the frequency of the photon — ½ mark		
	a) Bohr's postulate, for stable orbits, states "The electron, in an atom, revolves around the nucleus only in those orbits for which its angular momentum is an integral multiple of $\frac{h}{2\pi}$ (h = Planck's constant),"	½	
	[Also accept $mvr = n.\frac{h}{2\pi}$ $(n = 1,2,3, \dots \dots)$ As per de Broglie's hypothesis $\lambda = \frac{h}{p} = \frac{h}{mv}$ For a stable orbit, we must have circumference of the orbit= $n\lambda$ $(n = 1,2,3, \dots \dots)$ $\therefore 2\pi r = n.mv$ or $mvr = \frac{nh}{2\pi}$	½	
	Thus de –Broglie showed that formation of stationary pattern for intergral 'n' gives rise to stability of the atom. This is nothing but the Bohr's postulate	½	
	b) Energy in the n = 4 level = $\frac{-E_o}{4^2} = -\frac{E_o}{16}$	½	
	$\therefore$ Energy required to take the electron from the ground state, to the n = 4 level = $\left(-\frac{E_o}{16}\right) - (-E_o)$ $= \frac{-1+16}{16}$ $= \frac{15}{16}E_o$ $= \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19}$J	½	
	Let the frequency of the photon be v, we have $hv = \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19}$ $\therefore v = \frac{15 \times 13.6 \times 1.6 \times 10^{-19}}{16 \times 6.63 \times 10^{-34}}$Hz $\simeq 3.1 \times 10^{15}$Hz (Also accept 3×10^{15}Hz)	½	3
19	a) Drawing the plot — 1 mark Explaining the process of Nuclear fission and Nuclear fusion — ½ + ½ marks b) Finding the required time — 1 mark		
	a) The plot of (B.E / nucleon) verses mass number is as shown.		

	 [Note : Also accept the diagram that just shows the general shape of the graph.] From the plot we note that i) <u>During nuclear fission</u> A heavy nucleus in the larger mass region (A>200) breaks into two middle level nuclei, resulting in an increase in B.E/ nucleon. This results in a release of energy. ii) <u>During nuclear fusion</u> Light nuclei in the lower mass region (A<20) fuse to form a nucleus having higher B.E / nucleon. Hence Energy gets released. [Alternatively: As per the plot: During nuclear fission as well as nuclear fusion, the final value of B.E/ nucleon is more than its initial value. Hence energy gets released in both these processes.] b) We have $3.125\% = \frac{3.125}{100} = \frac{1}{32} = \frac{1}{2^5}$ Half life = 10 years ∴ Required time = 5x 10 years = 50 Years	1 ½ ½ ½ ½	3
20	a) Drawing the labeled circuit diagram — 1 mark Explanation of working — 1 mark b) Circuit Symbol and — ½ + ½ marks Truth table of NAND gate a) The labeled circuit diagram, for the required circuit is as shown.		



1

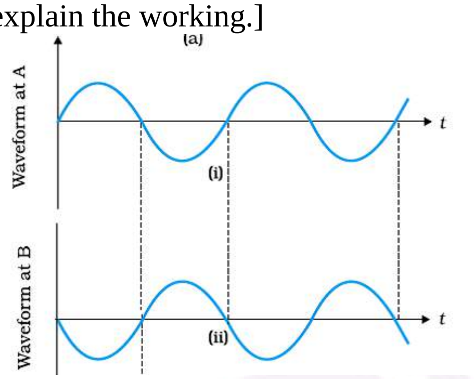
The working of this circuit is as follows:

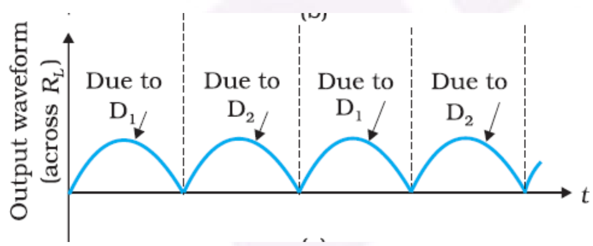
i) During one half cycle(of the input ac) diode D_1 alone gets forward biased and conducts. During the other half cycle, it is diode D_2 (alone) that conducts. ½

ii) Because of the use of the center tapped transformer the current though the load flows in the same direction in both the half cycles. ½

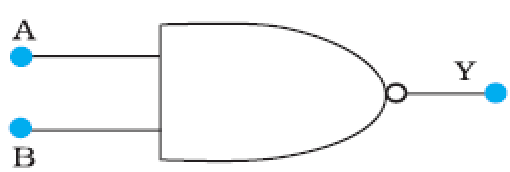
Hence we get a unidirectional/ direct current through the load, when the input is alternating current.

[Alternatively: The student may just use the following diagrams to explain the working.]





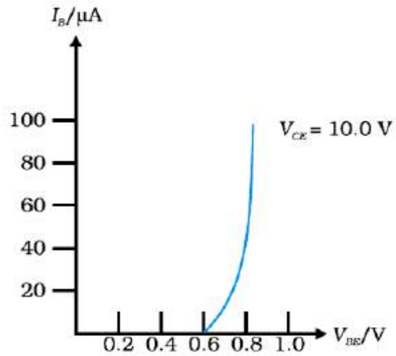
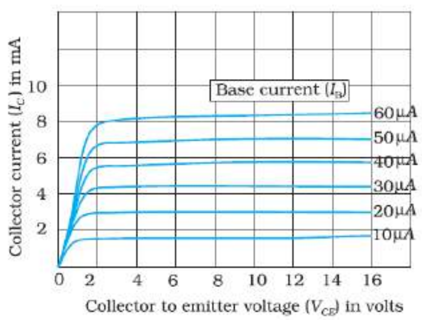
b) The circuit symbol, and the truth table, for the NAND gate, are given below.



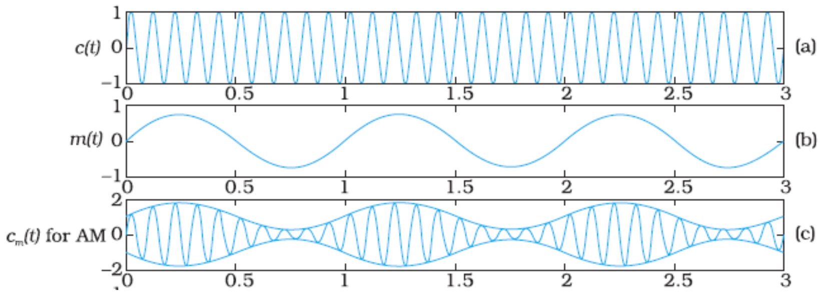
Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

½ + ½

3

21	Input and Output characteristics — 1+1marks Determination of a) Input resistance — ½ mark b) Current amplification factor — ½ mark		
	The input and output characteristics, of a *n-p-n* transistor, in its CE configuration, are as shown.		
		1	
	Input resistance $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$	½	
		1	
	The relevant values can be read from the input characteristics. Current amplification factor $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$	½	
	The relevant values can be read from the output characteristics, corresponding to a given value of V_{CE}.		3
22	a) Stating the three reasons — ½ + ½ + ½ mark b) Graphical representation of the audio signal, carrier wave and the amplitude modulated wave — ½ + ½ + ½ mark		
	a) The required three reasons are :		
	(i) A reasonable length of the transmission antenna.	½	
	(ii) Increase in effective power radiated by the antenna.	½	
	(iii)Reduction in the possibility of 'mix-up' of different signals.	½	

<table>
<tr><td></td><td>b) The required graphical representation is as shown below



</td><td>½
½
½</td><td>3</td></tr>
<tr><td></td><td>SECTION D</td><td></td><td></td></tr>
<tr><td>23</td><td>

a)	Name of device	½ mark
	One cause for power dissipation	½ mark
b)	Reduction of power loss in long distance transmission	1 mark
c)	Two values each displayed by teacher and Geeta	(½ x 4=2)marks

a) Transformer
Cause of power dissipation
i) Joule heating in the windings.
ii) Leakage of magnetic flux between the coils.
iii) Production of eddy currents in the core.
iv) Energy loss due to hysteresis.
[Any one / any other correct reason of power loss]
b) ac voltage can be stepped up to high value, which reduces the current in the line during transmission, hence the power loss(I^2R) is reduced considerably while such stepping up is not possible for direct current.
[Also accept if the student explains this through a relevant example.]
c) Teacher : Concerned, caring, ready to share knowledge .
Geeta : Inquisitive, scientific temper, Good listener, keen learner (any other two values for the teacher and Geeta)
</td><td>½
½
1
½+ ½
½+ ½</td><td>4</td></tr>
<tr><td></td><td>SECTION E</td><td></td><td></td></tr>
<tr><td>24</td><td>

a)	Definition of electric flux	1 mark
	Stating scalar/ vector	½ mark
	Gauss's Theorem	½ mark
	Derivation of the expression for electric flux	1 marks
b)	Explanation of change in electric flux	2 marks

a) Electric flux through a given surface is defined as the dot product of electric field and area vector over that surface.
Alternatively $\phi = \int_s \vec{E}.\vec{dS}$

Also accept
Electric flux, through a surface equals the surface integral of the
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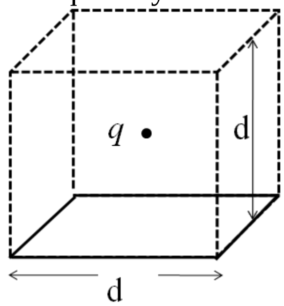
</table>

electric field over that surface.

It is a scalar quantity ½



½

Constructing a cube of side ‘d’ so that charge ‘q’ gets placed within of this cube (Gaussian surface)

According to Gauss ‘s law the Electric flux $\emptyset = \frac{Charge\ enclosed}{\varepsilon_0}$

$= \frac{q}{\varepsilon_0}$ ½

This is the total flux through all the six faces of the cube.

Hence electric flux through the square $\frac{1}{6} \times \frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$ ½

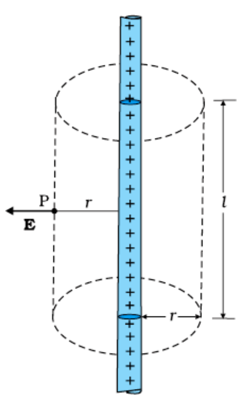
b) If the charge is moved to a distance d and the side of the square is doubled the cube will be constructed to have a side 2d but the total charge enclosed in it will remain the same. Hence the total flux through the cube and therefore the flux through the square will remain the same as before. **1+1** **5**

[Deduct 1 mark if the student just writes No change /not affected without giving any explanation.]

OR

a)	Derivation of the expression for electric field $\vec{E}$	3 marks
b)	Graph to show the required variation of the electric field	1 mark
c)	Calculation of work done	1 mark

a)



½

To calculate the electric field, imagine a cylindrical Gaussian surface, since the field is everywhere radial, flux through two ends of the cylindrical Gaussian surface is zero. ½

At cylindrical part of the surface electric field $\vec{E}$ is normal to the surface at every point and its magnitude is constant.
Therefore flux through the Gaussian surface.

= Flux through the curved cylindrical part of the surface.

= E× $2\pi rl$ ------------------(i) ½

Applying Gauss's Law

Flux $\phi = \frac{q_{enclosed}}{\varepsilon_0}$

Total charge enclosed

= Linear charge density × l

= λl

$\therefore \phi = \frac{\lambda L}{\varepsilon_0}$ ------------------(ii) ½

Using Equations (i) & ii

$E \times 2\pi rl = \frac{\lambda l}{\varepsilon_o}$

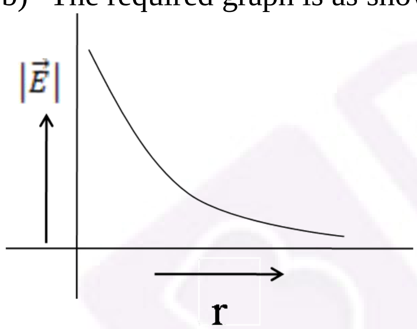
⇨ $E = \frac{\lambda}{2\pi\varepsilon_o r}$ ½

In vector notation ½

$\vec{E} = \frac{\lambda}{2\pi\varepsilon_o r}\hat{n}$

(where $\hat{n}$ is a unit vector normal to the line charge)

b) The required graph is as shown:



1

a) Work done in moving the charge 'q'. Through a small displacement 'dr'

$dW = \vec{F}.\vec{dr}$

$dW = q\vec{E}.\vec{dr}$

$= qEdrcos0$

$dW = q \times \frac{\lambda}{2\pi\varepsilon_o r}dr$ ½

Work done in moving the given charge from r_1 to $r_2 (r_2 > r_1)$

$W = \int_{r_1}^{r_2} dW \int = \int_{r_1}^{r_2} \frac{\lambda q dr}{2\pi\varepsilon_o r}$

$W = \frac{\lambda q}{2\pi\varepsilon_o}[log_e r_2 - log_e r_1]$ ½

	$W = \frac{\lambda q}{2\pi\varepsilon_o}\left[log_e \frac{r_2}{r_1}\right]$		5

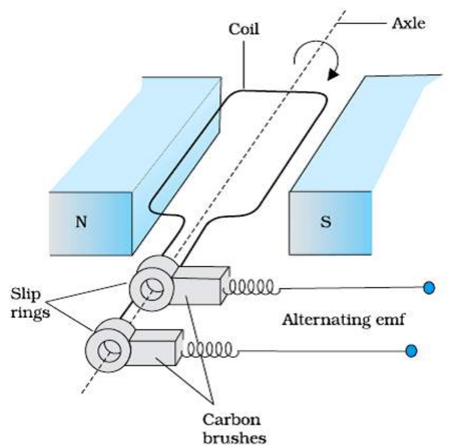
25

a) Principle of ac generator	½ mark
working	½ mark
Labeled diagram	1 mark
Derivation of the expression for induced emf	1 ½ mark
b) Calculation of potential difference	1 ½ mark

a) The AC Generator works on the principle of electromagnetic induction. — ½

when the magnetic flux through a coil changes, an emf is induced in it.

As the coil rotates in magnetic field the effective area of the loop, (i.e. A cos θ) exposed to the magnetic field keeps on changing, hence magnetic flux changes and an emf is induced. — ½



— 1

When a coil is rotated with a constant angular speed 'ω' , the angle 'θ' between the magnetic field vector $\vec{B}$ and the area vector $\vec{A}$, of the coil at any instant 't' equals ωt; (assuming θ = O^0 at t=o) — ½

As a result, the effective area of the coil exposed to the magnetic field changes with time ; The flux at any instant 't' is given by

$\phi_B = NBA \cos\theta$ = NBA $\cos\omega t$

∴ The induced emf e = - N $\frac{d\phi}{dt}$ — ½

= -NBA$\frac{d\phi}{dt}$ $(\cos \omega t)$

e = NBAω sin ωt — ½

b) Potential difference developed between the ends of the wings

'e' = Blv — ½

Given Velocity v= 900km/hour

= 250m/s

Wing span (l) = 20 m

Vertical component of Earth's magnetic field

$B_V = B_H \tan\delta$

$= 5\times10^{-4}\,(\tan 30^o)$ tesla — ½

∴ Potential difference

$= 5\times10^{-4}\,(\tan 30^o)\times 20\times 250$

$= \frac{5\times20\times250\times10^{-4}}{\sqrt{3}}\,V$

= 1.44 volt — ½ — **5**

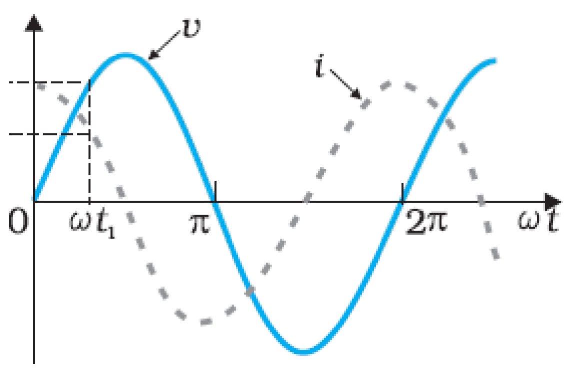
Or

a)	Identification of the device X	½
	Expression for reactance	½
b)	Graphs of voltage and current with time	1+1
c)	Variation of reactance with frequency	½
	(Graphical variation)	½
	d) Phasor Diagram	1

a) X : capacitor — ½

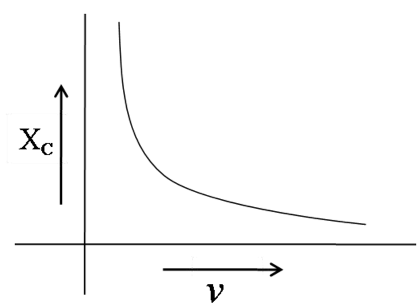
Reactance $X_c = \frac{1}{\omega C} = \frac{1}{2\pi\upsilon C}$ — ½

b)



½ + ½

c) Reactance of the capacitor varies in inverse proportion to the frequency i.e. , $X_c \propto \frac{1}{\upsilon}$ — **1**



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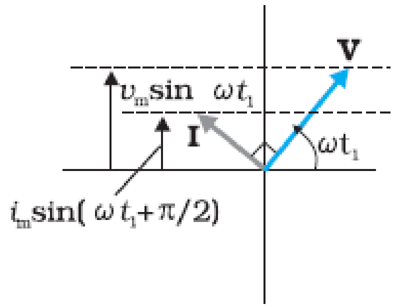


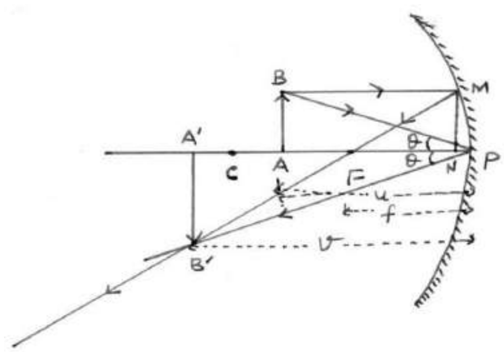
1

5

26

(a) Ray diagram to show the required image formation	1 mark
(b) Derivation of mirror formula	2 ½ marks
Expression for linear magnification	½ mark
(c) Two advantages of a reflecting telescope over a refracting telescope	½+½ marks

a)



1

(b) In the above figure

Δ BAP and ΔB'A'P are similar

$$\Rightarrow \frac{BA}{B'A'} = \frac{PA}{PA'} \qquad \text{(i)}$$ ½

Similarly, Δ MNF and ΔB'A'F are similar

$$\Rightarrow \frac{MN}{B'A'} = \frac{NF}{FA'} \qquad \text{(ii)}$$

As MN = BA

NF≈ PF

FA' = PA' – PF

∴ equation (ii) takes the following form

$$\frac{BA}{B'A'} = \frac{PF}{PA' - PF} \qquad \text{(iii)}$$ ½

Using equation (i) and (iii)

$$\frac{PA}{PA'} = \frac{PF}{PA' - PF}$$ ½

For the given figure, as per the sign convention,

PA =-u

PA' = - v

PF= -f

$$\Rightarrow \frac{-u}{-v} = \frac{-f}{-v-(-f)}$$ ½

$$\frac{u}{v} = \frac{f}{v-f}$$

uv –uf =vf

Dividing each term by uvf, we get

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

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

Linear magnification = - $^{v}/_{u}$, (alternatively m = $\frac{h_i}{h_o}$) ½

c) Advantages of reflecting telescope over refracting telescope

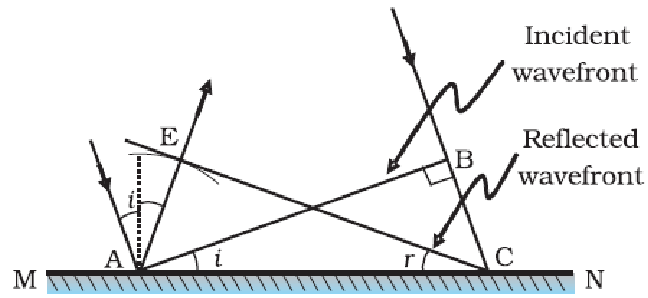
- (i) Mechanical support is easier
- (ii) Magnifying power is large
- (iii) Resolving power is large ½ + ½
- (iv) Spherical aberration is reduced
- (v) Free from chromatic aberration

(any two) **5**

OR

(a)	Definition of wave front	½ mark
	Verification of laws of reflection	2 marks
(b)	Explanation of the effect on the size and intensity of central maxima	1+ 1marks
(c)	Explanation of the bright spot in the shadow of the obstacle	½ mark

(a)The wave front may be defined as a surface of constant phase. (Alternatively: The wave front is the locii of all points that are in the same phase) ½



1

Let speed of the wave in the medium be 'v'

Let the time taken by the wave front, to advance from point B to point C is 'τ'

Hence BC = $v\,\tau$ ½

Let CE represent the reflected wave front

Distance AE = $v\,\tau = BC$

$\Delta\, AEC$ and $\Delta\, ABC$ are congruent

$\therefore\ \angle BAC = \angle ECA$

	$\Rightarrow \angle i \quad = \angle r$ (b) Size of central maxima reduces to half, (∵ Size of central maxima = $\frac{2\lambda D}{a}$) Intensity increases. This is because the amount of light, entering the slit, has increased and the area, over which it falls, decreases. (Also accept if the student just writes that the intensity becomes four fold) (c) This is because of diffraction of light. [Alternatively: Light gets diffracted by the tiny circular obstacle and reaches the centre of the shadow of the obstacle.] [Alternatively: There is a maxima, at the centre of the obstacle, in the diffraction pattern produced by it.]	½ ½ ½ ½ ½ ½	5