

# MARKING SCHEME SET 55/1

Q. No	Expected Answer / Value Points	Marks	Total Marks
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1. **Definition :** One ampere is the value of steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross section and placed one metre apart in vacuum, would produce on each of these conductors a force equal of  $2 \times 10^{-7}$  N/m of its length.

**Alternatively**

If the student writes  $F = \frac{\mu_0}{2\pi} \frac{I_1 I_2 L}{R}$

and says that when  $I_1 = I_2 = 1$  ampere

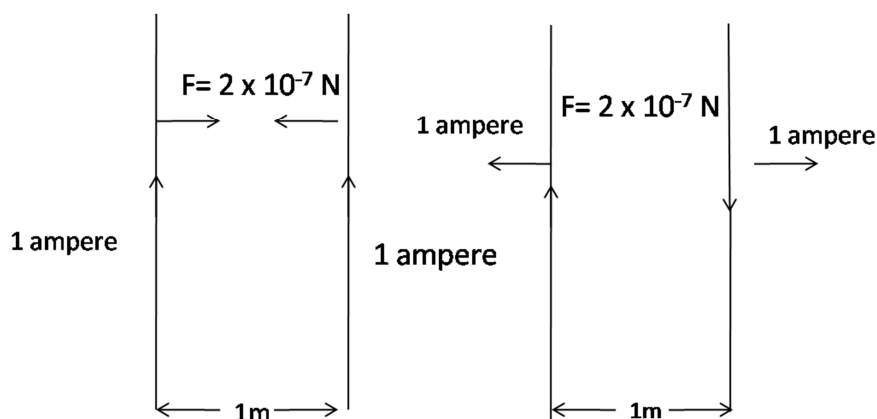
$R = 1$  meter and  $L = 1$  meter, then

$F = 2 \times 10^{-7}$  N

**Award full 1 mark**

**Alternatively**

If the student draws any one of the two diagram, as shown ,



**Award full 1 mark**

2. X – rays /  $\gamma$  – rays
3. Force decreases
4. Intensity of radiation depends on the number of photons incident per unit area per unit time.

[Note: Also accept the definition: ‘number of quanta of radiation per unit area per unit time’. Also accept if the student writes:

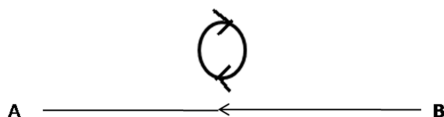
All photons, of a particular frequency, have the same kinetic energy and momentum, irrespective of the intensity of incident radiation.

**Alternatively**

The amount of light energy / Photon energy, incident per metre square per second is called intensity of radiation

**SI Unit :**  $\text{W/m}^2$  or  $\text{J}/(\text{s} \cdot \text{m}^2)$

5. Clockwise
- Alternatively**



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6. Neutrinos are neutral (chargeless), (almost) massless particles that hardly interact with matter. 1

**Alternatively**

The neutrinos can penetrate large quantity of matter without any interaction

**OR**

Neutrinos are chargeless and (almost) massless particles. 1

7. **Any two** of the following (or any other correct) reasons :

- AC can be transmitted with much lower energy losses as compared to DC
- AC voltage can be adjusted (stepped up or stepped down) as per requirement.
- AC current in a circuit can be controlled using (almost) wattless devices like the choke coil.  $\frac{1}{2} + \frac{1}{2}$
- AC is easier to generate. 1

8. As a diverging lens  $\frac{1}{2}$

Light rays diverge on going from a rarer to a denser medium.

[**Alternatively**  $\frac{1}{2}$

Also accept the reason given on the basis of lens maker's formula.] 1

- 9.

Derivation of energy expression	1 $\frac{1}{2}$
Significance of negative sign	$\frac{1}{2}$

As per Rutherford's model

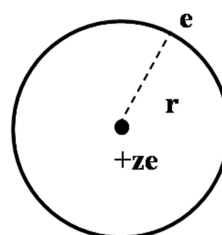
$$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0} \frac{ze^2}{r^2}$$

$$\Rightarrow mv^2 = \frac{1}{4\pi\epsilon_0} \frac{ze^2}{r}$$

Total energy = P.E + K.E.

$$= -\frac{1}{4\pi\epsilon_0} \frac{ze^2}{r} + \frac{1}{2} mv^2$$

$$= -\frac{1}{2} \cdot \frac{1}{4\pi\epsilon_0} \frac{ze^2}{r} = -\frac{1}{8\pi\epsilon_0} \frac{ze^2}{r}$$



$\frac{1}{2}$

$\frac{1}{2}$

$\frac{1}{2}$

Negative Sign implies that

Electron – nucleus form a bound system.  $\frac{1}{2}$

**Alternatively**

Electron – nucleus form an attractive system) 2

**OR**

Bohr's Postulate	$\frac{1}{2}$
Derivation of radius of nth orbit	1
Bohr's radius	$\frac{1}{2}$

For the electron, we have

Bohr's Postulate ( $mvr = \frac{nh}{2\pi}$ )

$\frac{1}{2}$

$$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0} \frac{ze^2}{r^2}$$

$$\text{and } mvr = \frac{nh}{2\pi}$$

$$\therefore m^2 v^2 r^2 = \frac{n^2 h^2}{4\pi^2}$$

$$\text{and } mv^2 r = \frac{1}{4\pi\epsilon_0} ze^2$$

$$\therefore r = \frac{\epsilon_0 n^2 h^2}{\pi ze^2 m}$$

Bohr's radius (for  $n = 1$ ) =  $\epsilon_0 h^2 / \pi ze^2 m$

10.

Formula for energy stored	$\frac{1}{2}$
New value of capacitance	$\frac{1}{2}$
Calculation of ratio	1

Energy stored in a capacitor =  $\frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{Q^2}{C}$  (any one)

Capacitance of the (parallel) combination =  $C+C=2C$

Here, total charge,  $Q$ , remains the same

$$\therefore \text{initial energy} = \frac{1}{2} \frac{Q^2}{C}$$

$$\text{And final energy} = \frac{1}{2} \frac{Q^2}{2C}$$

$$\therefore \frac{\text{final energy}}{\text{initial energy}} = \frac{1}{2}$$

[Note : If the student does the correct calculations by assuming the voltage across the

- (i) Parallel or (ii) Series combination  
to remain constant (=V) and obtain the answers  
as (i) 2:1 or (ii) 1:2 , award full marks ]

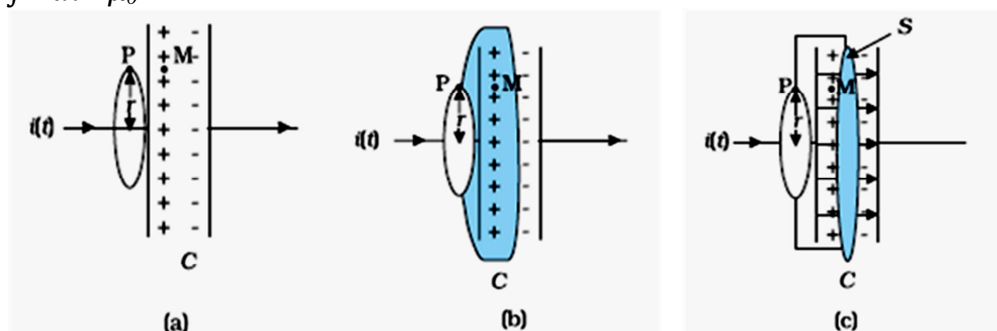
11.

Statement of Ampere's circuital law	$\frac{1}{2}$
Showing inconsistency during the process of charging	1
Displacement Current	$\frac{1}{2}$

According to

Ampere's circuital Law

$$\oint \vec{B} d\vec{l} = \mu_0 I$$



Applying ampere's circuital law to fig (a) we see that, during charging, the right hand side in Ampere's circuital law equals  $\mu_0 I$

However on applying it to the surfaces of the fig (b) or fig (c), the right hand side is zero.

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Hence, there is a contradiction.

We can remove the contradiction by assuming that there exists a current (associated with the changing electric field during charging), known as the displacement current.

1/2

When this current ( $= \frac{d\phi_E}{dt}$ ) is added on the right hand side, Ampere's circuital law, the inconsistency disappears.

It was, therefore necessary, to generalize the Ampere's circuital law, as

$$\oint \vec{B} d\vec{l} = \mu_0 I_c + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$$

[Note : If the student does the reasoning by using the (detailed) mathematics, relevant to displacement current, award full 2 marks ]

2

12.

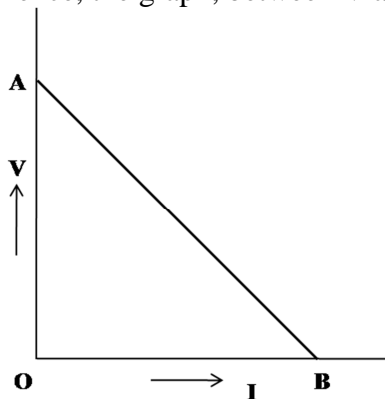
Relation between V and I	1/2
Graph	1/2
Determination of emf and internal resistance	1/2 + 1/2

The relation between V and I is

$$V = E - Ir$$

Hence, the graph, between V and I, has the form shown below.

1/2



1/2

For point A,  $I=0$ , Hence,  $V_A = E$

For point B,  $V=0$ , Hence,  $E = I_B r$

1/2

$$\text{Therefore, } r = \frac{E}{I_B}$$

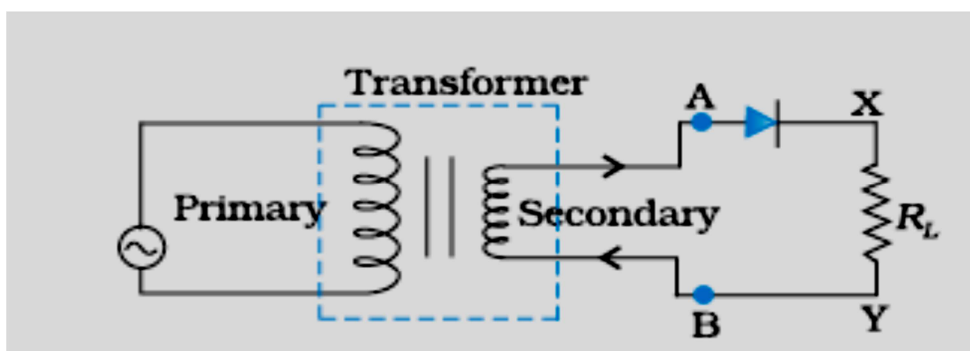
1/2

**Alternatively:** emf (E) equals the intercept on the vertical axis. Internal resistance (r) equals the negative of the slope of the graph.

2

13.

Circuit diagram	1
Working	1



1

**Working:**

During one half of the input AC, the diode is forward biased and a current flows through  $R_L$ .

1/2

During the other half of the input AC, the diode is reverse biased and no current flows through the load  $R_L$ .

1/2

Hence, the given AC input is rectified

[**Note** : If the student just draws the waveforms, for the input AC voltage and output voltage (without giving any explanation)  
(award 1/2 mark only for “working”)]

2

14.

Formula	1/2
Substitution and calculation	1/2 + 1

$$I = neA V_d$$

1/2

$$V_d = \frac{I}{neA} = \frac{1.5}{9 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.0 \times 10^{-7}} \text{ m/s}$$

1/2

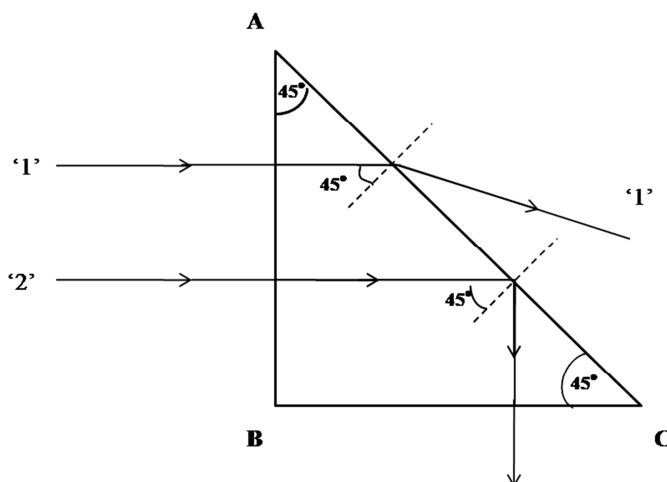
$$= 1.048 \times 10^{-3} \text{ m/s } (\approx 1 \text{ mm/s})$$

1

2

15.

Tracing of Path of Ray 1	1
Tracing of Path of Ray 2	1



1

1

[**Note** : If the student just writes (without drawing any diagram) that angle of incidence for both rays ‘1’ and ‘2’ on face AC equals  $45^\circ$ , and says that it is less than critical angle for ray ‘1’ (which therefore gets refracted) and more than critical angle for ray ‘2’ (which undergoes total internal reflection), award only 1/2 + 1/2 marks.]

2

16.

Function of Transducer	1
Function of Repeater	1

**Transducer** : Any device that converts one form of energy to another.

1

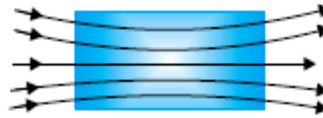
**Repeater** : A repeater accepts the signal from the transmitter, amplifies and retransmits it to the receiver.

1

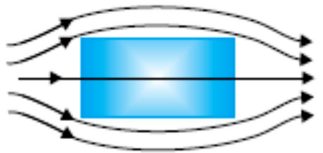
2

17.

Diagrams	1/2 + 1/2
Explanations	1/2 + 1/2



1/2



1/2

A paramagnetic material tends to move from weaker to stronger regions of the magnetic field and hence increases the number of lines of magnetic field passing through it.

[**Alternatively:** A paramagnetic material, dipole moments are induced in the direction of the field.]

A diamagnetic material tends to move from stronger to weaker regions of the magnetic field and hence, decreases the number of lines of magnetic field passing through it.

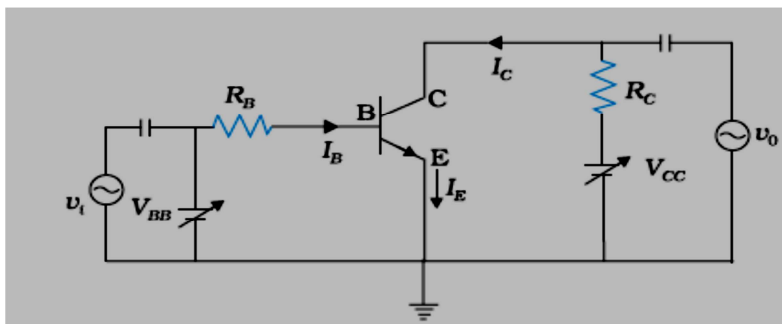
[**Alternatively:** A diamagnetic material, dipole moments are induced in the opposite direction of the field.]

[**Note:** If the student just writes that a paramagnetic material has a small positive susceptibility ( $0 < X < \epsilon$ ) and a diamagnetic material has a negative susceptibility ( $-1 \leq X < 0$ ), award the 1/2 mark for the second part of the question.]

2

18.

Circuit diagram	1 1/2
Condition	1/2



1 1/2

**Condition :** The transistor must be operated close to the centre of its active region.

**Alternatively**

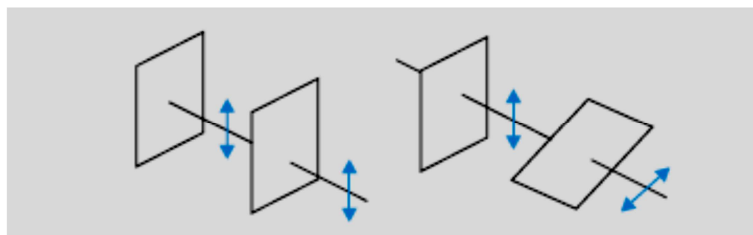
The base- emitter junction of the transistor must be (suitably) forward biased and the collector – emitter junction must be (suitably) reverse biased.

2

19.

a) Demonstration of transverse nature of light	1 ½
b) Calculation of intensity through P <sub>1</sub> P <sub>2</sub> & P <sub>3</sub>	½ + ½ + ½

a)



Light from the sodium lamp passing through the single Polaroid sheet ( P<sub>1</sub>) does not show any variation in intensity when this sheet is rotated. However, if the light, transmitted by P<sub>1</sub>, is made to pass through another Polaroid sheet (P<sub>2</sub>) the light intensity, coming out of P<sub>2</sub>, varies from a maximum to zero, and again to maximum, when P<sub>2</sub> is rotated. These observations are consistent only with the transverse nature of light waves.

b) Intensity of light transmitted through P<sub>1</sub> = I<sub>0</sub> / 2

$$\text{Intensity of light transmitted through P}_3 = (I_0 / 2) \times \cos^2 30^\circ = 3 I_0 / 8$$

$$\text{Intensity of light transmitted through P}_2 = \frac{3}{8} I_0 \cos^2 60^\circ$$

$$= \frac{3}{32} I_0$$

[**Note** : If the student takes the intensity of light transmitted through P<sub>1</sub> as I<sub>0</sub> and calculates the intensity through P<sub>3</sub> and P<sub>2</sub> as  $\frac{3}{4} I_0$  and  $\frac{3}{16} I_0$  award ½ + ½ = 1 mark for part (b) ]

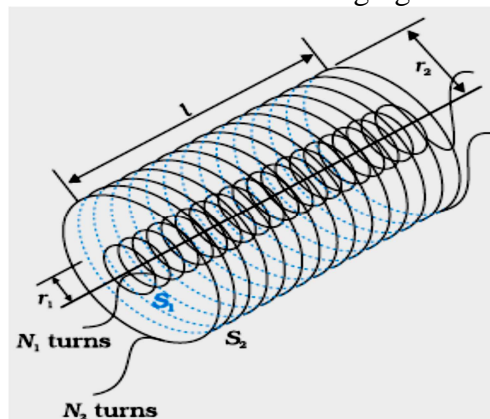
20.

Definition of mutual induction	1
Obtaining the expression	2

Mutual inductance, between a pair of coils, equals the magnetic flux, linked with one of them, due to a unit current flowing in the other.

**Alternatively**

The mutual inductance, for a pair of coils, equals the emf induced, in one of them, when the current in the other coil is changing at a unit rate.



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Let a current  $I_2$  flow through the outer coil.

The magnetic field due to this current

$$= \mu_o \frac{N_2}{l} \times I_2 \quad \frac{1}{2}$$

The resulting magnetic flux linked with the inner coil

$$\begin{aligned} \phi_{12} &= N_1 \cdot \left( \mu_o \frac{N_2}{l} \times I_2 \right) \times \pi r_1^2 \\ &= \left( \mu_o \frac{N_1 N_2}{l} \cdot \pi r_1^2 \right) I_2 \end{aligned} \quad \frac{1}{2}$$

$$\begin{aligned} &= M_{12} I_2 \\ \therefore M_{12} &= \mu_o \frac{N_1 N_2}{l} \cdot \pi r_1^2 \end{aligned} \quad \frac{1}{2} \quad 3$$

21.

Answers to each of the three parts      1+1+1=3

a) This is to ensure that the connections do not contribute any extra, unknown, resistances in the circuit.      1

b) This is done to minimize the percentage error in the value of the unknown resistance.

[**Alternatively:** This is done to have a better “balancing out” of the effects of any irregularity or non-uniformity in the metre bridge wire.

**Or**

This can help in increasing the sensitivity of the metre bridge circuit.]      1

c) Manganian / constantan / Nichrome

This material has a low temperature (**any one**) of coefficient of resistance/ high resistivity.       $\frac{1}{2} + \frac{1}{2} \quad 3$

**OR**

Calculation of total resistance of the circuit	1
Calculation of total current drawn from the voltage Source	$\frac{1}{2}$
Calculation of current through R	1
Calculation of potential drop across R	$\frac{1}{2}$

$$\begin{aligned} R_{total} &= \frac{R_o}{2} + \frac{\frac{R_o}{2} \cdot R}{\frac{R_o}{2} + R} \\ &= \frac{R(R_o + 4R)}{2(R_o + 2R)} \end{aligned} \quad \frac{1}{2}$$

$$I_{(total)} = \frac{V}{R_{total}} \quad \frac{1}{2}$$

$$\text{Current through R} = I_2 = I_{total} \times \frac{\frac{R_o}{2}}{\frac{R_o}{2} + R} \quad \frac{1}{2}$$

$$\begin{aligned} &= I_{total} \times \frac{R_o}{R_o + 2R} \\ &= \frac{V \cdot 2(R_o + 2R)}{R(R_o + 4R)} \times \frac{R_o}{R_o + 2R} \\ &= \frac{2VR_o}{R(R_o + 4R)} \end{aligned} \quad \frac{1}{2}$$

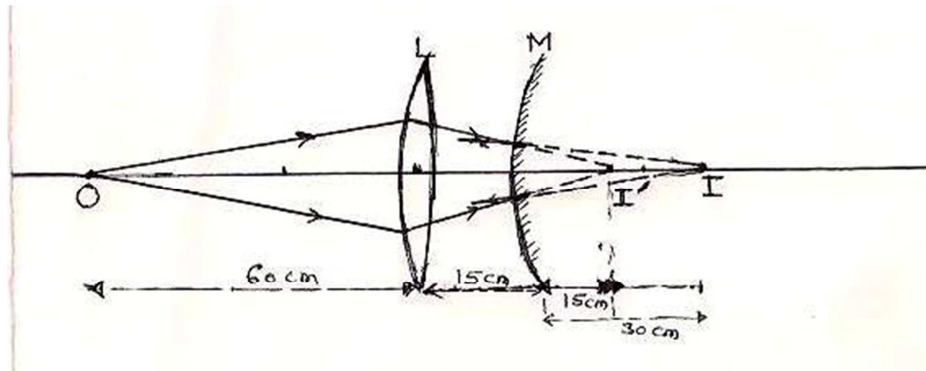
$$\text{Voltage across R} = I_2 R = \left( \frac{2VR_o}{R_o + 4R} \right) \quad \frac{1}{2} \quad 3$$

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22.

Ray diagram	1
Nature of final image	$\frac{1}{2}$
Position of final image	$1\frac{1}{2}$



1

For the convex lens

$$u = -60 \text{ cm}, f = +20 \text{ cm}$$

 $\frac{1}{2}$ 

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ gives } v = +30 \text{ cm}$$

For the convex mirror

$$u = + (30 - 15) \text{ cm} = 15 \text{ cm}, f = +\frac{20}{2} \text{ cm} = 10 \text{ cm}$$

 $\frac{1}{2}$ 

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \text{ gives } v = +30 \text{ cm}$$

Final image is formed at the distance of 30 cm from the convex mirror  
(or 45 cm from the convex lens) to the right of the convex mirror.

 $\frac{1}{2}$ 

The final image formed is a virtual image.

 $\frac{1}{2}$ 

3

23.

Deriving the expression for average power	2
Condition for no power dissipation	$\frac{1}{2}$
Condition for maximum power dissipation	$\frac{1}{2}$

$$\text{Applied voltage} = V_0 \sin \omega t$$

 $\frac{1}{2}$ 

$$\text{Current in the circuit} = I_0 \sin (\omega t - \phi)$$

where  $\phi$  is the phase lag of the current with respect to the voltage applied ,

Hence instantaneous power dissipation

$$= V_0 \sin \omega t \times I_0 \sin (\omega t - \phi)$$

$$= \frac{V_0 I_0}{2} [2 \sin \omega t \cdot \sin (\omega t - \phi)]$$

$$= \frac{V_0 I_0}{2} [\cos \phi - \cos(2\omega t - \phi)]$$

 $\frac{1}{2}$ 

Therefore, average power for one complete cycle

$$= \text{average of } \left[ \frac{V_0 I_0}{2} [\cos \phi - \cos(2\omega t - \phi)] \right]$$

The average of the second term over a complete cycle is zero .

 $\frac{1}{2}$ 

$$\text{Hence, average power dissipated over one complete cycle} = \frac{V_0 I_0}{2} \cos \phi$$

 $\frac{1}{2}$ 

[Note : Please also accept alternative correct approach.]

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Conditions

- (i) No power is dissipated when  $R = 0$  (or  $\phi = 90^\circ$ )

1/2

[**Note:** Also accepts if the student writes ‘This condition cannot be satisfied for a series LCR circuit’.]

- (ii) Maximum power is dissipated when  $X_L = X_C$

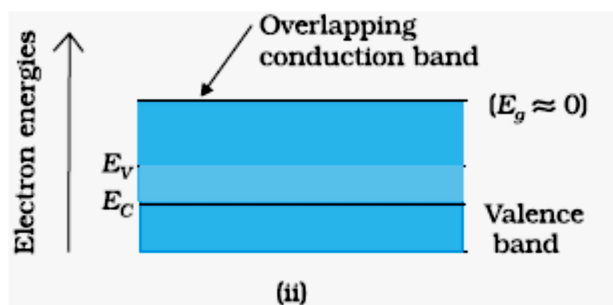
1/2

or  $\omega L = \frac{1}{\omega C}$  (or  $\phi = 0$ )

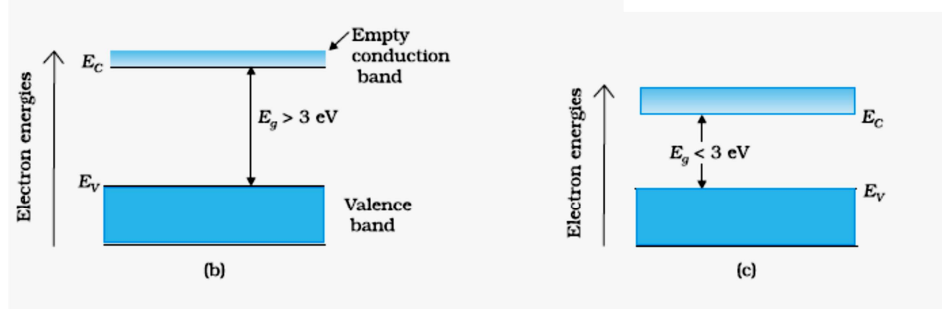
3

24.

Energy band diagrams	1 1/2
Two distinguishing features	1 1/2



1/2



1/2 + 1/2

**Two distinguishing features:**

- (i) In conductors, the valency band and conduction band tend to overlap ( or nearly overlap ) while in insulators they are separated by a large energy gap and in semiconductors are separated by a small energy gap.

1

- (ii) The conduction band, of a conductor, has a large number of electrons available for electrical conduction. However the conduction band of insulators is almost empty while that of the semi- conductor has only a ( very ) small number of such electrons available for electrical conduction.

1/2

3

25.

Values displayed	2
Diagnosis	1

- (a) keen observer/ helpful/ concerned / responsible/ respectful towards elders.

1+1

(**Any two**)

- (b) The doctor can trace and observe, the difference between the movement of an appropriate radio- isotope through a normal brain and a brain having tumor in it.

1

[**Note :** Also accept any other appropriate explanation.]

3

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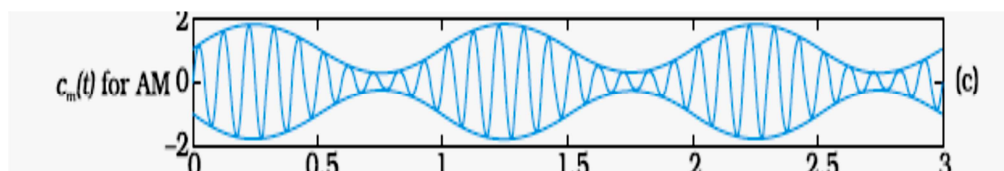
26.

Two basic modes of communication	$\frac{1}{2} + \frac{1}{2}$
Process of Amplitude Modulation	1
Schematic Sketch	1

Two basic modes of communication are

- Point – to –point
- Broadcast

In Amplitude modulation the amplitude of a carrier wave is made to vary, with time, in the same way as the modulating signal varies with time



27.

Formula	$\frac{1}{2}$
Calculation of debroglie wavelength	2
Comparison	$\frac{1}{2}$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \quad \text{or} \quad \lambda = \frac{12.27}{\sqrt{V}} \text{ \AA}$$

$$\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 50 \times 10^3)}}$$

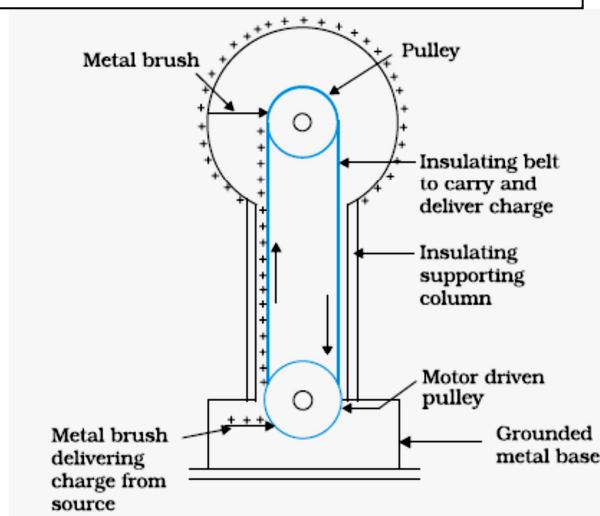
$$\lambda = 5.33 \times 10^{-12} \text{ m}$$

The resolving power of an electron microscope is much better than that of optical microscope.

[Note : If the student writes R.P  $\propto \frac{1}{\lambda}$ , award this  $\frac{1}{2}$  mark]

28.

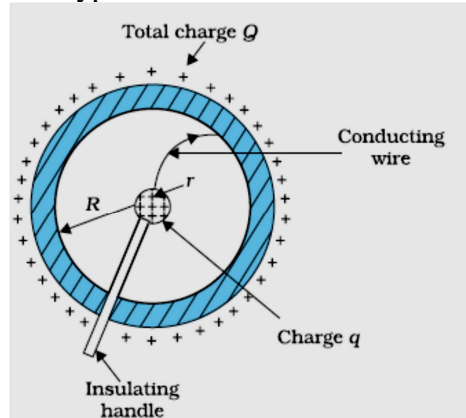
Diagram	2
Principle and working	2
Use and limitation	$\frac{1}{2} + \frac{1}{2}$



[Note : Award 1 mark only if the diagram is not labelled]

### Principle & working

Consider a set up of the type shown here



- i. Potential inside and on the surface, of the conducting sphere of radius 'R':

$$V'_R = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$$

- ii. Potential due to small sphere of radius 'r' carrying a charge 'q':

At the surface of the smaller sphere :  $V'_r = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$  1/2

At the surface of the larger sphere :  $V''_R = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$

■ The difference of potential between the smaller and the larger sphere:

$$=\Delta V = \frac{1}{4\pi\epsilon_0} \cdot \left[ \left( \frac{Q}{R} + \frac{q}{r} \right) - \left( \frac{Q}{R} + \frac{q}{r} \right) \right]$$
 1/2

$$= \frac{q}{4\pi\epsilon_0} \left( \frac{1}{r} - \frac{1}{R} \right)$$

When 'q' is positive, the inner sphere would always be at a higher potential with respect to outer sphere, irrespective of the amount of charges on the two. 1/2

■ When both the spheres are connected, charge will flow from the smaller sphere to the larger sphere. Thus for a set up of the type shown, charge would keep on piling up on the larger sphere. 1/2

**Use :** This machine is used to accelerate charged particles (electron, protons, ions) to high energies. 1/2

**Limitation:** It can build up potentials upto a few million volts only. 1/2

5

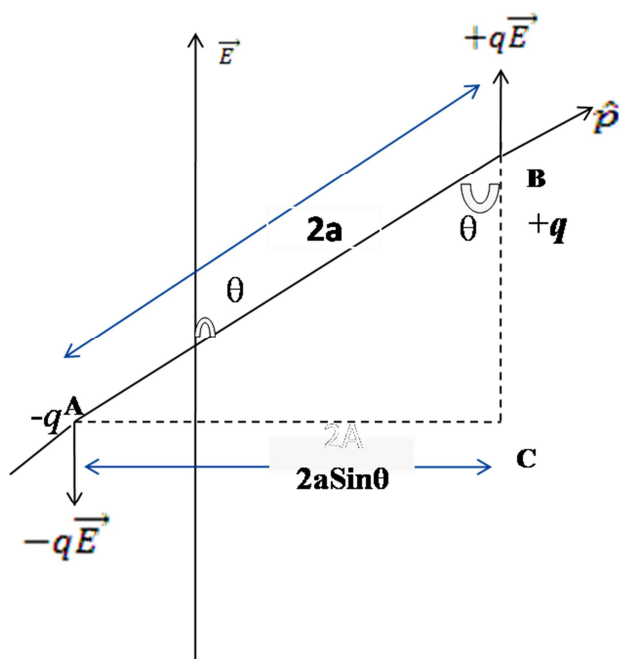
**OR**

(a)	Deducing the expression for torque	2
(b)	Finding the ratio of the flux through the two spheres	2
(c)	Finding the change in flux	1

(a)

The forces, acting on the two charges of the dipole, are  $+q\vec{E}$  and  $-q\vec{E}$

1/2



1/2

The net force on the dipole is zero.

The two forces are, however, equivalent to a torque having a magnitude

$$\begin{aligned}\tau &= (qE)AC \\ &= qE \cdot 2a \sin \theta \\ &= pE \sin \theta\end{aligned}$$

1/2

The direction of this torque is that of the cross product  $(\vec{p} \times \vec{E})$ . Hence, the torque acting on the dipole, is given by

$$\vec{\tau} = \vec{p} \times \vec{E}$$

1/2

1/2

(b)

As per Gauss's Theorem

$$\text{Electric Flux} = \oint_s \vec{E} \cdot d\vec{S} = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

1/2

1/2

■ For sphere  $S_1$ , flux enclosed  $= \phi_1 = \frac{2Q}{\epsilon_0}$

For sphere  $S_2$ , flux enclosed  $= \phi_2 = \frac{2Q+4Q}{\epsilon_0} = \frac{6Q}{\epsilon_0}$

1/2

$$\therefore \frac{\phi_1}{\phi_2} = \frac{1}{3}$$

1

When a medium of dielectric consistent  $\epsilon_r$  is introduced in sphere  $S_1$  the flux through  $S_1$  would be  $\phi'_1 = \frac{2Q}{\epsilon_r}$

[Also award this mark if the student writes  $\phi_1 = \frac{2Q}{\epsilon_0 \epsilon_r}$ ]

[**Note** : If the student just writes that the flux through  $S_1$  decreases, award 1/2 mark only.]

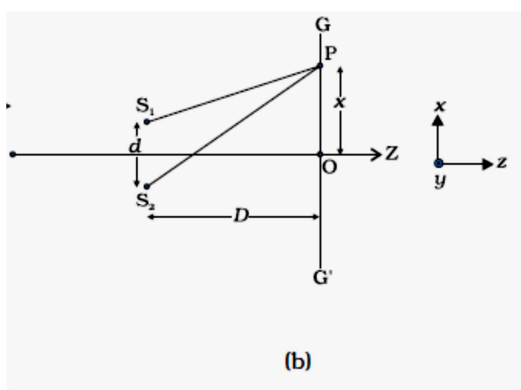
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29.

(a) Formation of bright and dark fringes	1
Obtaining the expression for fringe width	3
(b) Finding the ratio	1

(a) The light rays from the two (coherent) slits, reaching a point 'P' on the screen, have a path difference ( $S_2P - S_1P$ ). The point 'P' would, therefore be a

- Point of maxima (bright fringe), if  $S_2P - S_1P = n\lambda$  1/2
- Point of minima (dark fringe), if  $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$  1/2



We have

$$(S_2P)^2 - (S_1P)^2 = \left\{ D^2 - \left( x + \frac{d}{2} \right)^2 \right\} - \left\{ D^2 + \left( x - \frac{d}{2} \right)^2 \right\}$$

$$= 2xd$$

$$S_2P - S_1P = \frac{2xd}{S_2P + S_1P} \approx \frac{2xd}{2D} = \frac{xd}{D}$$

■ We have maxima at points, where

$$\frac{xd}{D} = n\lambda$$

and minima at points where

$$\frac{xd}{D} = \left( \frac{2n+1}{2} \right) \lambda$$

Now, fringe width  $\beta$  = separation between two successive maxima (or two successive minima) =  $x_n - x_{n-1}$

$$\beta = \frac{\lambda D}{d}$$

(b) We have

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$

$$\therefore \frac{a_1}{a_2} = \frac{4}{1}$$

$$\therefore \frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{16}{1}$$

[Note: Give 1/2 mark if the student just writes Intensity  $\propto$  width]

OR

Outside Delhi SET I

(a)

The path difference ( NP-LP ) , between the two edges of the slit, is given by

$$\text{NP-LP} = \frac{3}{2}$$

$$\frac{3(\lambda_2 - \lambda_1)}{a} \times D$$

Outside Delhi SET I

$$= 13.5 \times 10^{-3} \text{ m } (= 13.5 \text{ mm})$$

30.

(a) Expression for frequency	1 ½
Frequency Independent of 'v' or energy	½
(b) Sketch of cyclotron	1
Construction	1
Working	1

(a) When a particle of mass 'm' and charge 'q', moves with a velocity  $\mathbf{v}$ , in a uniform magnetic field  $\mathbf{B}$ , it experiences a force  $\mathbf{F}$  where

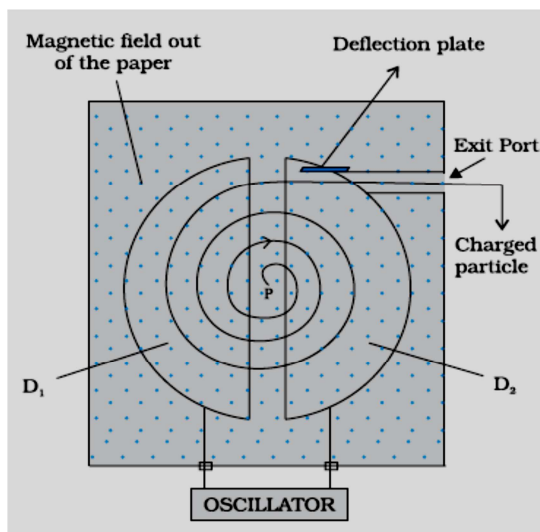
$$\vec{F} = q (\vec{v} \times \vec{B}) \quad \frac{1}{2}$$

$$\therefore \text{Centripetal force } \frac{mv^2}{r} = q v B_{\perp} \quad \frac{1}{2}$$

$$\therefore r = \frac{mv}{qB_{\perp}} \quad \frac{1}{2}$$

$$\therefore \text{frequency} = \frac{v}{2\pi r} = \frac{qB_{\perp}}{2\pi m} \quad \frac{1}{2}$$

$\therefore$  It is independent of the velocity or the energy of the particle. ½



1

**Construction:** The cyclotron is made up of two hollow semi-circular disc like metal containers, D<sub>1</sub> and D<sub>2</sub>, called dees.

It uses crossed electric and magnetic fields. The electric field is provided by an oscillator of adjustable frequency.

[**Note:** Award this mark even if the student labels the diagram properly without writing the details of the construction.]

1

**Working:** In a cyclotron, the frequency of the applied alternating field is adjusted to be equal to the frequency of revolution of the charged particles in the magnetic field. This ensures that the particles get accelerated every time they cross the space between the two dees. The radius of their path increases with increase in energy and they are finally made to leave the system via an

1

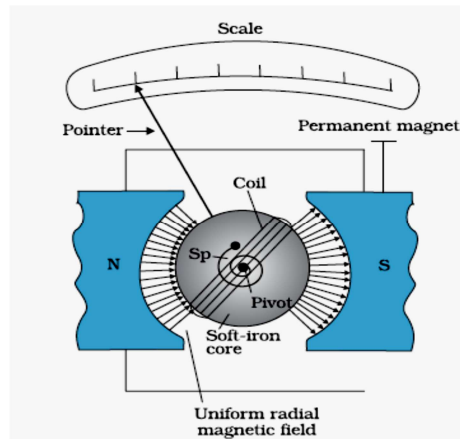
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exit slit.

OR

(a) Labelled diagram	1
Principle and working	2
(b) i) Reason for cylindrical soft iron core	1
ii) Comparison of current sensitivity and voltage sensitivity	1



1

**Principle and working :** A current carrying coil, placed in a uniform magnetic field, (can) experience a torque

1/2

Consider a rectangular coil for which no. of turns = N,

Area of cross- section =  $l \times b = A$ ,

Intensity of the uniform magnetic field = B,

Current through the coil = I

Deflecting torque =  $BIL \times b = BIA$

For N turns  $\tau = NBA$

Restoring torque in the spring =  $k\theta$

1/2

(k = restoring torque per unit twist)

$$\therefore NBA = k\theta$$

$$\therefore I = \left( \frac{k}{NBA} \right) \theta$$

$$\therefore I \propto \theta$$

1/2

The deflection of the coil, is, therefore, proportional to the current flowing through it.

1/2

(b) (i) The soft iron core not only makes the field radial but also increases the strength of the magnetic field.

1

[ **Note:-** Award this one mark even if the student writes just one of the two reasons given above )

(ii) We have

$$\text{Current sensitivity} = \frac{\theta}{I} = NBA/k$$

$$\text{Voltage sensitivity} = \frac{\theta}{V} = \frac{\theta}{IR} = \left( \frac{NBA}{k} \right) \cdot \frac{1}{R}$$

1/2

It follows that an increase in current sensitivity may not necessarily increase the voltage sensitivity.

1/2

5