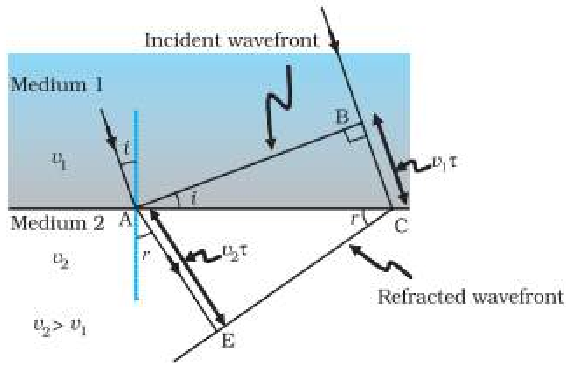


The figure drawn here shows the refracted wave front corresponding to the given incident wave front. — 1

It is seen that

$$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$$ — ½

$$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$$

$$\therefore \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu_{21}$$ — ½

This is Snell's law of refraction. — 3

17.

(a) Definition of mutual inductance and S.I unit	1+½
(b) Obtaining the expression for resultant force on the loop	1½

(a) Mutual inductance equals the magnetic flux associated with a coil when unit current flows in its neighbouring coil.

Alternatively: Mutual inductance equals the induced emf in a coil when the rate of change of current in its neighbouring coil is one ampere/ second. — 1

S.I unit : henry (H) or weber/ampere (or any other correct SI unit) — ½

(b) Force per unit length between two parallel straight conductors

$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$$

Force on the part of the loop which is parallel to infinte straight wire and at a distance x from it.

$$F_1 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{x}$$ (away from the infinte straight wire) ½

Force on the part of the loop which is at a distance (x + a) from it

$$F_2 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{(x + a)}$$ (towards the infinte straight wire) ½

Net force $F = F_1 - F_2$

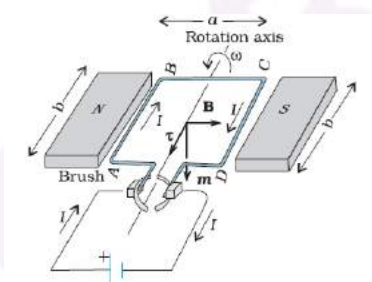
$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{}\left[\frac{1}{x} - \frac{1}{x+a}\right]$$

$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a^2}{x\ (x + a)}$$ (away from the infinte straight wire) ½ | 3

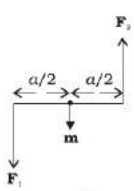
18.

(a) Derivation of the expression for torque	2
(b) Significance of radial magnetic field	1

(a) Consider the simple case when a rectangular loop is placed in a uniform magnetic field B that is in the plane of the loop ½



(a)

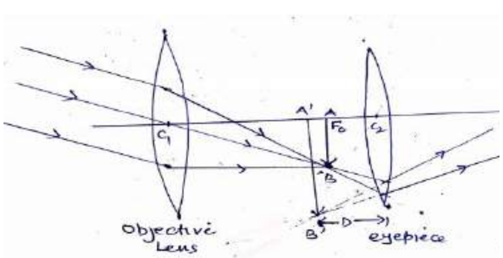


(b)

Force on arm AB = F_1 = IbB (directed into the plane of the loop) ½
Force on arm CD = F_2= IbB   (directed out of the plane of the loop)

Therefore the magnitude of the torque on the loop due to these pair of forces

$$\tau = F_1\frac{a}{2} + F_2\frac{a}{2}$$ ½

	= I (ab) B = IAB = mB (A = ab = area of the loop) <u>Alternatively</u> Also accept if the student does calculations for the general case and obtains the result Torque = IAB sin ϕ Alternatively Also accept if the student says that the euivalent magnetic moment $\vec{}$ (m),associated with a current carrying loop is $\vec{m}$=IA $\hat{n}$ (A = Area of loop) The torque, on a magnetic dipole, in a magnetic field, is given by $\vec{\tau} = \vec{m} \times \vec{B}$ $\therefore \quad \tau = IA(\hat{n} \times \vec{B})$ Hence Magnitude of torque is = IAB sin ϕ (b) When a current carrying coil is kept in a radial magnetic field the corresponding moving coil galvanometer would have a linear scale Alternatively " In a radial magnetic field two sides of the rectangular coil remain parallel to the magnetic field lines while its other two sides remain perpendicular to the magnetic field lines. This holds for all positions of the coil."	½ ½ 1	3
19.	Labelled ray diagram of an astronomical telescope 1 ½ Calculation of the diameter of the image of the moon. 1½ 	1½	

[Note: (i) Deduct ½ mark If arrows are not shown.
(ii) Award one mark of this part if a student draws the ray diagram for normal Adjustment / relaxed eye.]

Angular magnification of the telescope = $\frac{f_o}{f_e} = \frac{15}{0.01} = 1500$ ½

3

For objective lens, $\tan\alpha = \frac{3.48X\,10^6}{3.8X10^8}$

For eyepiece $\tan\beta = \frac{h_i}{f_e} = \frac{h_i}{10^{-2}}$ ½

∴ Magnifying power $= \frac{\beta}{\alpha} = \frac{\frac{h_i}{10^{-2}}}{\frac{3.48\,X10^6}{3.8\,X\,10^8}}$

$= \frac{h_i X 3.8 X 10^8}{3.48 X 10^6 X 10^{-2}} = 1500$

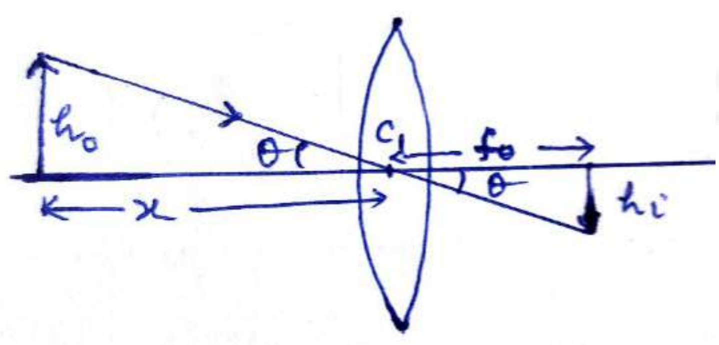
h_i = 13.73 cm ½

Also accept angular magnification of the telescope

$= \frac{f_o}{f_e}\left(1 + \frac{f_e}{d}\right) = \frac{15}{0.01}\left(1 + \frac{0.01}{0.25}\right) = 1560$

So, h_i = 14.29 cm

Alternatively



½

From figure:

$\frac{h_0}{x} = \frac{h_i}{f_0}$ [Where h_o and h_i are the diameter of the moon and diameter of the image of the moon respectively.] ½

$h_i = \frac{h_0 f_o}{x}$ ½

$= \frac{3.48 \times 10^6}{3.8 \times 10^8} \times 15$

= 13.73cm ½

3

20.

(a)statement of Gauss's law in magnetism	½
Its significance	½
(b)Four Important properties	½ x4

(a) Gauss's law for magnetism states that "The total flux of the magnetic field, through any closed surface, is always zero. ½

Alternatively

$$= \oint_S \vec{B}.\vec{d}.s = 0$$

This law implies that magnetic monopoles do not exist" / magnetic field lines form closed loops ½

[Note: Award this I mark if the student just attempts it]

(b) Four properties of magnetic field lines ½

(i) Magnetic field lines always form continuous closed loops.

(ii) The tangent to the magnetic field line at a given point represents the direction of the net magnetic field at that point. ½

(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field. ½

(iv) Magnetic field lines do not intersect. ½

OR

Three points of difference	3 x ½
One example of each	1½

	Diamagnetic	Paramagnetic	Ferromagnetic	
1	$-1 \le \chi < 0$	$0 < \chi < \varepsilon$	$\chi \gg 1$	½
2	$0 \le \mu_r < 1$	$1 \le \mu_r < 1+\varepsilon)$	$\mu_r \gg 1$	½
3	$\mu < \mu_0$	$\mu > \mu_0$	$\mu \gg \mu_0$	½

Where ε is any positive constant.

[Note: Give full credit of this part if student write any other three correct difference]

Examples (Any one example of each type)

Diamagnetic materials: Bi,Cu, Pb,Si, water, NaCl, Nitrogen (at STP) ½

Paramagnetic materials: Al,Na,Ca, Oxygen(at STP), Copper chloride ½

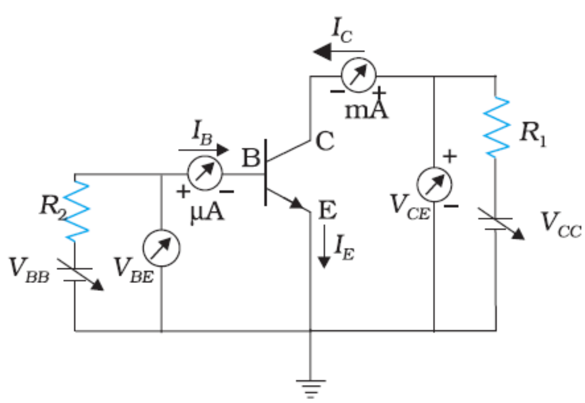
Ferromagnetic materials: Fe,Ni,Co,AlniCo ½ 3

21.

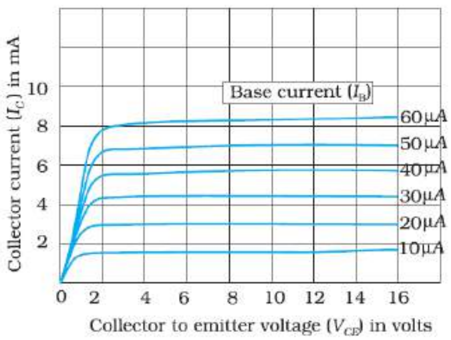
Definition of decay constant	1
Calculation of half life	1
Calculation of initial number of nuclei at t=0	1

	The decay constant (λ) of a radioactive nucleus equals the ratio of the instantaneous rate of decay $\left(\frac{\Delta N}{\Delta t}\right)$ to the corresponding instantaneous number of radioactive nuclei. Alternatively: The decay constant (λ) of a radioactive nucleus is the constant of proportionality in the relation between its rate of decay and number of its nuclei at any given instant. Alternatively: $\frac{\Delta N}{\Delta t} \propto N$ $\frac{\Delta N}{\Delta t} = \lambda N$ The constant (λ) is known as the decay constant Alternatively: The decay constant equals the reciprocal of the mean life of a given radioactive nucleus . $\lambda = \frac{1}{\tau}$ where τ= mean life Alternatively: The decay constant equal the ratio of $\ln_e 2$ to the half life of the given radioactive element. $\lambda = \frac{\ln_e 2}{T_{1/2}}$ Where $T_{1/2}$ = Half life	1	3
	Alternatively: The decay constant of a radioactive element, is the reciprocal of the time in which the number of its nuclei reduces to 1/e of its original number. (**Note: Do not deduct any mark of this definition, if a student does not write the formula in support of the definition)**		
	We have $R = \lambda N$	½	

	R (20 hrs) = 10000 = λN_{20} R (30 hrs) = 5000 = λN_{30} $\therefore \quad \frac{N_{20}}{N_{30}} = 2$		
	This means that the number of nuclei, of the given radioactive nucleus, gets halved in a time of (30 - 20) hours = 10 hours	½	
	$\therefore$ Half life = 10 hours	½	
	This means that in 20 hours (= 2 half lives), the original number of nuclei must have gone down by a factor of 4. Hence Rate of decay at t = 0	½	
	$\lambda N_0 = 4\lambda N_{20}$ =4X10000 = 40,000 disintegration per second (Note : Award full marks of the last part of this question even if student does not calculate initial number of nuclei and calculates correctly rate of disintegration at t=0) i.e R_0 = 40,000 disintegration per second $N_0 = \frac{40000}{\lambda} = \frac{40000}{\ln_e 2} \times 10 \times 60 \times 60$ $N_0 = \frac{144 \times 10^7}{0.693} = 2.08 \times 10^9 \ \ nuclei$		3
22.	(a) Calculation of energy of a photon of light — 1½ (b) Identification of photodiode — 1½ Why photodiode are operated in reverse bias — 1 We have		
	$E = h\nu = \frac{hc}{\lambda}$	½	
	$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{600 \times 10^{-9}}$ J	½	

	$= \dfrac{19.89 \times 10^{-26}}{6\times10^{-7} \times 1.6\times10^{-19}}$ eV $= \dfrac{19.89}{9.6}$ eV = 2.08eV	½	
	The band gap energy of diode D_2 (= 2eV) is less than the energy of the photon. Hence diode D_2 will not be able to detect light of wavelength 600 nm. [Note: Some student may take the energy of the photon as 2eV and say that all the three diodes will be able is detect this right , Award them the ½ mark for the last part of identification]	½	
	(b) A photodiode when operated in reverse bias, can measure the fractional change in minority carrier dominated reverse bias current with greater ease Alternatively: It is easier is observe the change in current with change in light intensity , if a reverse bias is applied	1	3
23.	(a) Functions of the three segments $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}$ (b) Circuit diagram for studying the output characteristics 1 obtaining output characteristics ½		
	(i) Emitter : supplies the large number of majority carriers for current flow through the transistor	½	
	(ii) Base: Allows most of the majority charge carriers to go over to the collector Alternatively , It is the very thin lightly doped central segment of the transistor.	½	
	Collector : collects a major portion of the majority charge carriers supplied by the emitter.	½	
	(b) 	1	
	The output characteristics are obtained by observing the variation of I_c when V_{CE} is varied keeping I_B constant .	½	

Note:Award the last ½ mark even if the student just draws the graph for output characteristics



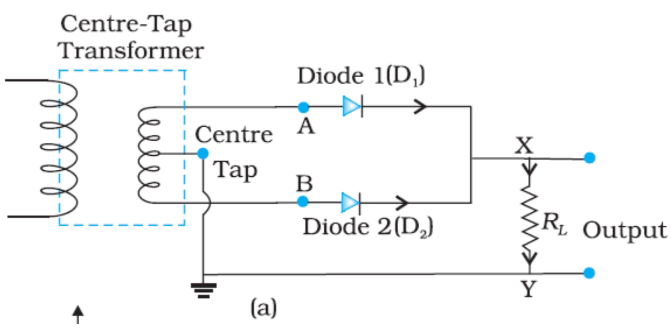
(b)

[Note: Do not deduct marks of this part, for not writing values on the axis]

OR

Circuit diagram of full wave rectifier	½
working	½
Input and output wave forms	½ + ½

The circuit diagram of a full wave rectifier is shown below.



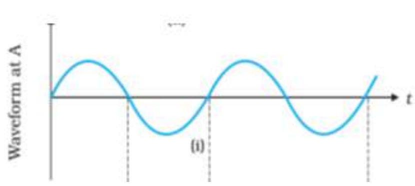
(a)

1

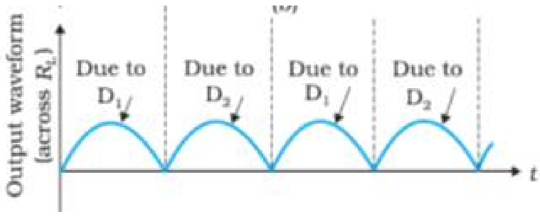
Because of the center tap in the secondary of the transformer, diodes 1 and 2 get forward biased in successive halves of the input ac cycle. However the current through the load flows in the same direction in both the halves of he input ac cycle. We therefore, get a unidirectional (rectified) current through the load for the full cycle of the input ac.

1

The input and output wave forms are as shown below.



½

		½	3
24.	(a)Obtaining the expression for modulation index in terms of A and B 1 ½ (b) calculation of μ 1 Reason ½ We are given that $A = A_c + A_m$ and $B = A_c - A_m$ $A_c = (A + B)/2$ $A_m = (A - B)/2$ $\therefore \quad \mu = \frac{A_m}{A_c}$ $= \frac{A-B}{A+B}$ (b) We have $\mu = \frac{A_m}{A_c}$ $= \frac{10}{15} = 2/3$ μ is kept less than one to avoid distortion	½ ½ ½ ½ ½ ½	3
25.	SECTION D (a) Derivation of the expression for impedance 2 plot of impedance with frequency ½ b) Phase difference between voltage across inductor and capacitor ½ (c) Reason and calculation of self induction $\frac{1}{2}+1\frac{1}{2}$		
