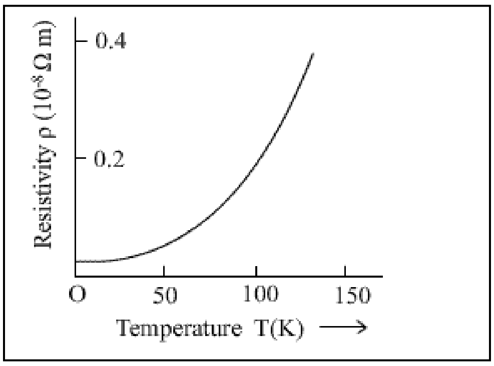
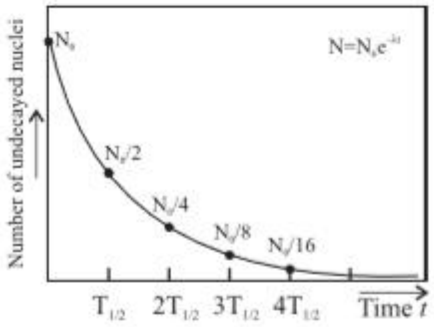
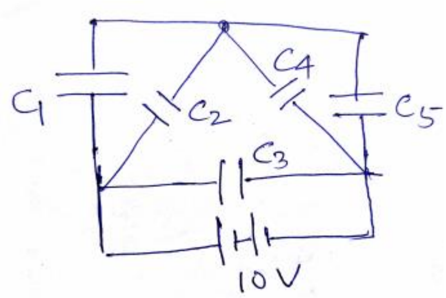
Marking Scheme
55/ 3 / 3

Section - A			
Q. No.	**Value Points / Expected answers**	**Marks**	**Total Marks**
1.	Intensity of radiation is defined as the number of photons incident normally per unit area per unit time.	1	1
2.	$f_0 >> f_e$ Focal length of objective must be much greater than focal length of eyepiece OR Angle of minimum deviation decreases.	1 1	1
3.		1	1
4.	Sphere A will be negatively charged Sphere B will be positively charged Alternatively- B will be similarly charged to the rod and A will be oppositely charged. OR Sphere will be positively charged. Reason - Electrostatic Induction	½ ½ 1 ½ ½	1
5.	Receiver extracts the desired message / modulating signal from received signal at the channel output.	1	1
SECTION - B			

6.	i) Graph showing decay of radioactive nuclei 1 ii) Determination of half life and average life. 1 i)  ii) From figure when $N=\frac{N_0}{2}$ $t = T½$ (half life) Average life $\tau = \frac{T½}{0.6931}$	1 ½ ½	2
7.	a) Explaining Constancy of B.E. per nucleon – 1 b) Completing the nuclear reactions - 1 a) The constancy of the binding energy (B.E) per nucleon in the range 20<A<170 is a consequence of the fact that the nuclear force is short ranged. b) i) $^{32}_{15}P \longrightarrow ^{32}_{16}S + \; _{-1}e^{o} + \bar{v}$ ii) $^{12}_{6}C + ^{12}_{6}C \longrightarrow ^{20}_{10}Ne + ^{4}_{2}He$	1 ½ ½	2
8.	Obtaining Bohr's quantization condition using deBroglie hypothesis 2 Let λ be the deBroglie wavelength associated with electron orbiting (with speed v) in the with n[th] orbit (of radius r) in hydrogen atom. $\therefore \lambda = \frac{h}{mv}$ Also $2\pi r = n\lambda$ $= \frac{nh}{mv}$ $\therefore L = mvr = \frac{nh}{2\pi}$	½ ½ 1	2

9.

a) Calculation of equivalent capacitance	- 1
b) Calculating of charge on 5 μF	- 1



Net capacitance of parallel C_1 & C_2

C_{12} = 15 + 5 = 20 μF — ½

Net capacitance of parallel C_4 & C_5

C_{45} = 10 + 10 = 20 μF

C_{12}, C_{45} in series $C_{1245} = \frac{20 \times 20}{20 + 20} = 10\ \mu F$

C_3 in parallel with C_{1245} = 10 + 20 = 30 μF — ½

P.D. across C_{1245} 10 V

P.D. across C_{12} = C_{45} = 5 V — ½

Charge on 5 μF Q = CV

= 5 x 10^{-6} x 5

= 25 x 10^{-6} C — ½

Total: 2

10.

Formula	½
Calculation of Induced Voltage	1½

Induced voltage

$$|V| = L\frac{dI}{dt}$$ — ½

$$\therefore |V| = \mu_0 n^2 la \frac{dI}{dt}$$ — ½

$$= 4\pi\times10^{-7}\times\left(\frac{10}{10^{-2}}\right)^2 \times 0.5 \times 1 \times 10^{-4} \times \frac{(2-1)}{0.1}$$ — ½

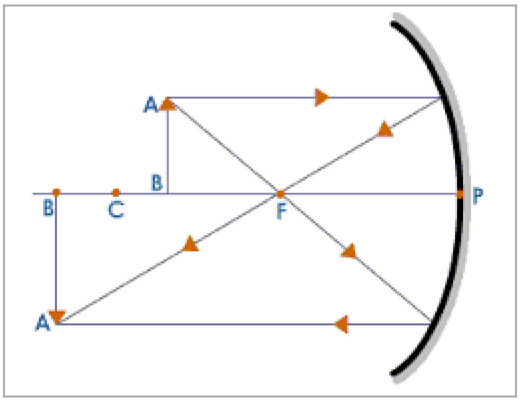
$$= 6.28 \times 10^{-4}\text{V or } 0.628\text{mV}$$ — ½

OR

Calculation of	(i) change of magnetic flux	1
	(ii) induced emf	1

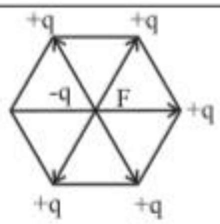
i) $\Delta\phi = \phi_2 - \phi_1 = 0 - NBA\cos\theta$

$= 140 \times 0.09 \times 5 \times 10^{-4} \cos 0 = 63 \times 10^{-4}$ Wb — 1

	Alternatively If student assumes that the coil was initially kept with its plane parallel to the field, i.e. $\varphi = 90°$, $\Delta\phi = (0 - 0) = 0$ Wb award 1 mark ii) $e = \frac{-\Delta\phi}{\Delta t} = \frac{-63\times10^{-4}}{\Delta t}$ V Alternatively, if the student takes $\Delta\phi = 0$, then e = o, [Note: Award this 1 mark, If a student writes that induced emf cannot be calculated as value of time interval Δt it is not given.]	½ +½	2
11.	Let u = -(2f – x) , x < f, x > 0 , f < 0 By mirror equation = $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ ⇨ $\frac{1}{v} = \frac{1}{-f} + \frac{1}{(2f-x)} = \frac{1}{(2f-x)} - \frac{1}{f} = \frac{f-2f+x}{f(2f-x)} = \frac{-(f-x)}{f(2f-x)}$ v = $\frac{-(f-x)}{f(2f-x)}$ > 2f as x < f The image is real and enlarged. Alternatively, a student can explain with the help of the ray diagram.  OR They can explain with specific values of u and f and find v by using mirror equation. Award full marks for correct answer.	1 1	2

12.

i) Diagram(or statement) for justification	1
ii) Net force (expression)	1

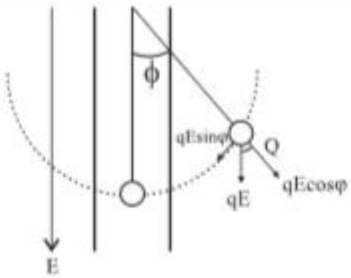


Alternatively
The forces due to the charges placed diagonally opposite at the vertices of hexagon, on the charge -q cancel in pairs. Hence net force is due to one charge only. — 1

Net Force $|\vec{F}| = \frac{1}{4\pi\varepsilon_0}\,\frac{q^2}{l^2}$ — 1 — 2
Ne

OR

I) Diagram ½	
ii) Derivation of period of oscillation	1½



½

Derivation — ½

F_r=-qEsinφ (Restoring force)

ma=-qEsinφ

when φ is small

ma = -qEφ

$$m\frac{d^2x}{dt^2} = -qE\ \frac{x}{l}$$

$$\frac{d^2x}{dt^2} = -q\frac{E}{m}\ \frac{x}{l}$$ — ½

comparing with equation of linear SHM.

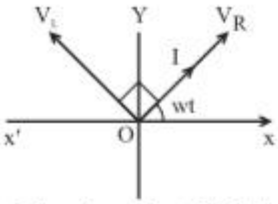
$$\frac{d^2x}{dt^2} = -\omega^2 x$$

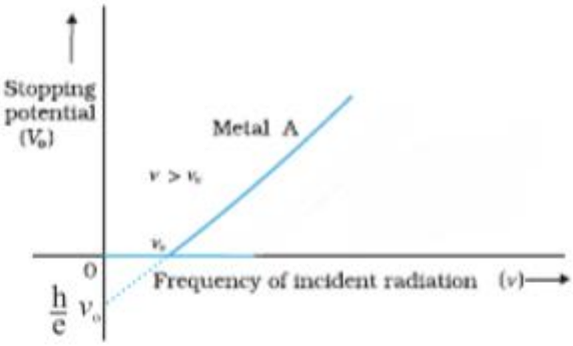
$$\omega = \sqrt{\frac{qE}{ml}}$$

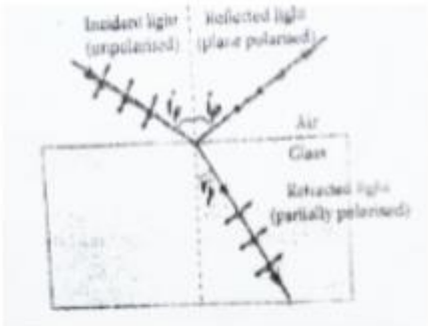
$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{ml}{qE}}$$ — ½

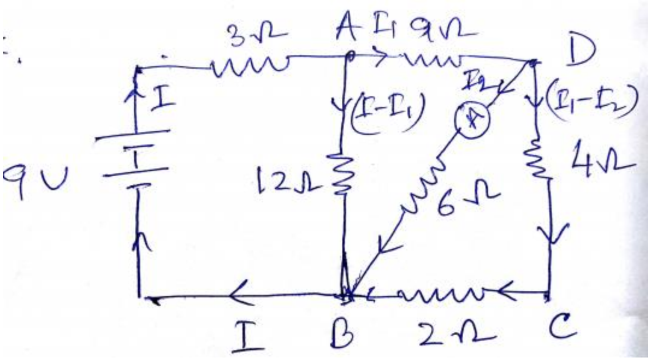
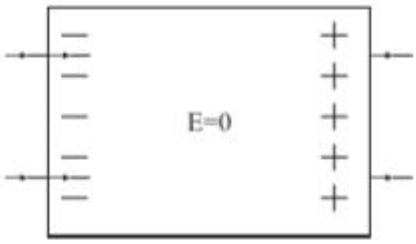
Alternatively - The student can use angular SHM expression also. Full marks to be awarded for correct answer even without intermediate steps.

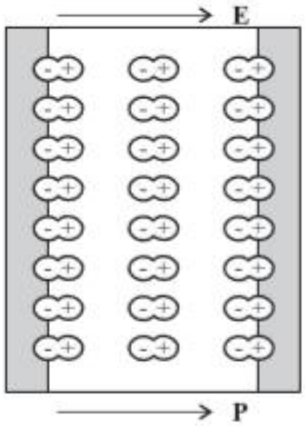
SECTION - C

13.	i) Explanation using phasor diagram — 1 ii) Calculation of impedance — 1½ iii) Calculation of potential difference — ½		3
			
	a) From phasor diagram it is clear that V_R is in phase with I and V_L is ahead of I in phase by $\pi/2$.	1	
	Hence the resultant voltage (= voltage in the circuit) will lead V_R and, therefore, the current in the circuit.	½+½	
	b) Let V be the effective potential difference across L-R circuit, therefore $V = \sqrt{V_R^2+V_L^2} = \sqrt{(160)^2+(120)^2} = 200V$	½	
	$\therefore$ Impedance of the circuit, $Z = \frac{V}{I} = \frac{200}{1} = 200\Omega$		
	c) For d.c. (constant voltage source) V_L=0, therefore Potential difference in the circuit = V_R = potential difference across the resistor	½	
	(Alternatively, if the student takes the d.c. also as 1A, the potential difference will be = 160V = V_R)		
	OR		
	i) Naming the circuit element Y — ½ ii) Calculation of r.m.s value of current — 1½ iii) Effect of replacing a.c source by d.c source — 1		
	a) Y is a capacitor.	½	
	b) Phase angle, $\varphi = \pi/4$, Also $\cos\varphi = \frac{R}{Z}$	½	
	$\Rightarrow Z = \frac{R}{\cos\phi} = \frac{R}{\cos(\pi/4)} = \frac{100}{1/\sqrt{2}} = 100\sqrt{2} = 141.4\Omega$	½	
	$I_{r.m.s} = \frac{V_{r.m.s}}{Z} = \frac{141V}{141.4\Omega} \cong 1A$	½	
	c) The current becomes zero.	1	
14.	a) Wavelength range of electromagnetic radiations - ½ + ½ + ½ b) One use of each e.m. radiations - ½ + ½ + ½		
	a) Infrared rays - 10^{-4}m to 10^{-5}m	½	
	Ultraviolet rays - 10^{-7}m to 10^{-9}m	½	
	ɣ- rays - 10^{-11}m to 10^{-14}m	½	3
	b) Use (Any one) Infrayed rays – Pain reliever / night photography / remote control	½	

	Ultravoilert rays – water purifier / sterlizer ɣ -ray - cancer treatment	½ ½	
15.	a) Graph showing variation of stopping potential with frequency - 1 b) Showing the determination of (i) Threshold frequency - 1 (ii) Planck's constant (from the graph) - 1		
	a. 	1	
	b. From Einstein's Equation $eV_o = h\nu - h\nu_o$ $V_o = \frac{h}{e}\nu - \frac{h}{e}\nu_o$ comparing $y = mx + c$		
	(i) Threshold frequency ν_o is the intercept along ν axis. (Alternatively, intercept on V_o axis, $c = \frac{h}{e}\ \nu_o$ $\nu_o = \frac{ec}{h}$)	1	3
	(ii) Planck's constant h = e x slope	1	
	OR		
	a. Explanation of emission of electron from a photosensitive surface - 1 b. Explanation and justification - 1 c. Finding the maximum KE - 1		

	a. When a photon of the energy $h\nu$ is absorbed by an electron in the photosensitive material, a part of the energy absorbed is used up in liberating it from the surface (the work function). The remaining energy appears as KE of the photoelectron.	1	
	Alternatively: $K_{max} = h\nu - \phi_o$ if $h\nu \geq \phi_o$, k_{max} is positive and electron is emitted	½	
	b. Emission of electron will not take place. Energy $h\nu$, of a single photon, is less than the work function ϕ_o (Alternatively - $k_{max} = h\nu - \phi_o$ $h\nu < \phi_o$ so k_{max} is negative; Hence no emission will take place.)	½	
	c. $V_o = 1.5$ V $k_{max} = eV_o = 1.6 \times 10^{-19} \times 1.5 = 2.4 \times 10^{-19}$ J [If a student just writes, $k_{max} = 1.5$ eV award ½ mark]	1	
16.	a. Diagram - ½ Explaination - 1 b. Calculation of (i) Polarizing angle - ½ (ii) Refractive index - 1		
		½	3
	When unpolarized light propagates from a rarer into a denser medium, it gets partly reflected and partly refracted. If the reflected and refracted lights are perpendicular to each other, the reflected light gets polarized. (Alternatively if the student explains using Brewster's law award full marks.)	1	
	(i) $i_p = 90 - r_p$ $i_p = 90 - 30 = 60°$	½	
	(ii) $\mu = \tan i_p = \tan 60° = \sqrt{3}$	1	
17.	a) Calculation of Equivalent resistance – 1 ½ b) Determination of current through Ammeter 1 ½		

	 		
	Total effective resistance		3
	$R_{DB} = \frac{(4+2)\ 6}{6+6} = 3\ \Omega$	½	
	$R_{AB} = \frac{(9+3)\ x\ 12}{12+12} = 6\ \Omega$		
	Total resistance R = 6 + 3 = 9 Ω	1	
	Current drawn from battery = $\frac{9}{9}$ = 1 A	1	
	I_1 = 0.5 A , I_2 = I_1 / 2 = 0.25 A	½	
	Give full marks if the student uses Khirchoff 's law to get the value of the current.		
18.	i) Explanation with diagram 2 ii) Definition of polarization and its expression for linear isotropic dielectric in terms of electric field. 1		
	 	½	
	For conductor Due to induction the free electrons collect on the left face of slab creating equal positive charge on the right face. Internal electric field is equal and opposite to external field; hence net electric field (inside the conductor) is zero.	½	3



½

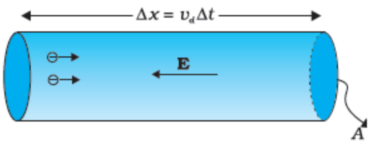
For dielectric
Due to alignment of atomic dipoles (permanent or induced) along $\vec{E}$, the net electric field within the dielectric decreases. ½

ii) The net dipole moment developed per unit volume in the presence of external electric field is called polarization vector $\vec{P}$. ½

Expression :.
$\vec{P} = \chi_e \vec{E}$ ½

19.

a) Obtaining expression for current through a conductor	2
b) Explaining variation of resistivity of a semiconductor wire with rise of temp.	1



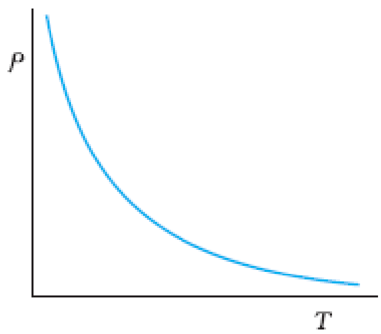
1

a) Drift Velocity , Vd = $(V_i)_{av}$ $= 0 - \frac{eE}{m}\tau$ where τ = relaxation time

$$I = \frac{\Delta q}{\Delta t} = \frac{enA|v_d|\Delta t}{\Delta t} = enAv_d$$ 1

$I = n\,e\,A\,v_d$

(b) Clearly resistivity decreases with rise in temperatur. As temperature coefficient of resistivity of a semi conductor is negative



1

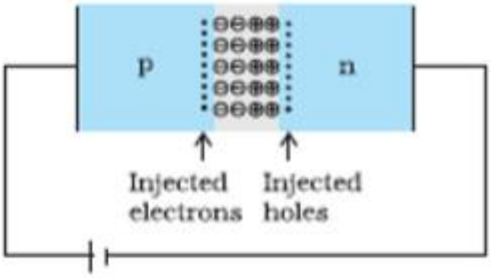
3

	Alternatively Give full marks (1/2 + ½) if the student use $\rho = \frac{m}{ne^2\tau}$ to explain decrease of resistivity with rise in temperature.		
20.	a. (i) Truth tables for P and Q - ½ + ½ (ii) Truth tables for circuit - 1 b. Explanation for why NOR gates are considered as universal gates - 1		3
	a. P (I) | A | Y | | 0 | 1 | | 1 | 0 | Q | A | B | Y | | 0 | 0 | 1 | | 0 | 1 | 0 | | 1 | 0 | 0 | | I | I | 0 |	½ +½	
	(ii) | A | B | Y | | 0 | 0 | 0 | | 0 | 1 | 0 | | 1 | 0 | 1 | | I | I | 0 |	1	
	b. All basic logic gates can be realized by using NOR gates (Also accept if the student draws the diagrams for getting OR & AND gates using NOR gates.)	1	

OR

a. Formation of potential barrier (with diagram) - 1½
b. Circuit diagram and plotting graph - 1½

a.

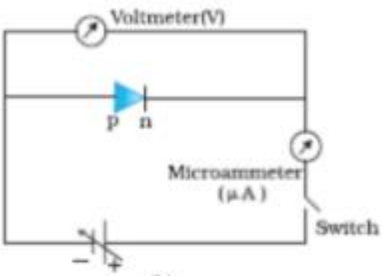


½

During the formation of p - n junction diode: due to the concentration gradient across p and n sides of a diode, holes diffuse from p side to n side and electrons diffuse from n side to p side giving rise to development of immobile positive charges on the n side and the negative charges on the p side across the junction. Thus a potential barrier is formed at the junction. 1

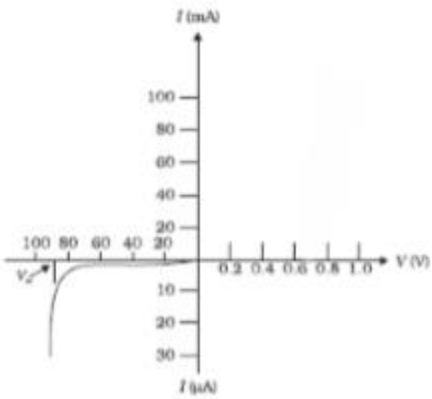
Alternatively: if a student explains with depletion region, award this 1 mark.

b.

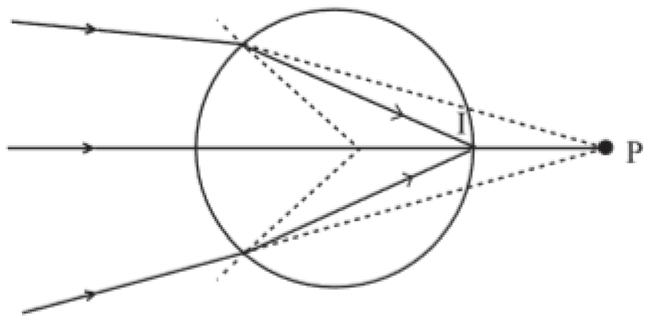


1

c.



½

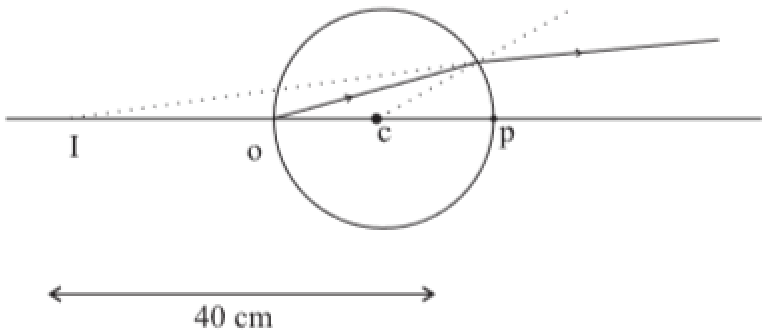
21.	i) Generation of Eddy Current — 1 ii) Two examples of application — ½+½ iii) Method of minimizing — 1 a) When the magnetic flux linked with a conductor changes with time, induced currents are set up inside the conductor. b) Induction furnace / Induction stove/Induction breaks/dead beat galvanometer (any two) c) By lamination/cutting shots (any one) eddy current can be minimized.	1 ½ +½ 1	3
22.	i) Calculation of new image position — 2 ii) Ray diagram — 1 a) $u = 20\text{cm}, n_2 = 1.5, n_1 = 1, R = 5\text{cm}$ Using $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ $\frac{1.5}{v} - \frac{1}{20} = \frac{1.5-1}{5}$ $v = 10$ cm  OR	½ 1 ½ 1	3

Formula - 1
substitution and calculation - 1
Ray diagram - 1

$$\frac{n_1}{-u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$$ 1

$$\frac{1.5}{20} + \frac{1}{v} = \frac{1-1.5}{-10}$$ ½

$v = -40\text{cm}$ ½



1

23.

a. Meaning of bandwidth and importance - 1
b. Differentiation between analog & Digital signal - 1
c. Functions of transducers and repeaters - 1

a. Bandwidth of a signal is the range over which the frequencies in that signal vary. ½

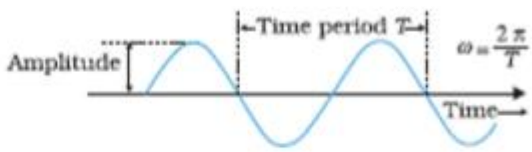
(Also accept bandwidth is the frequency range over which an equipment/device operates)

The knowledge of bandwidth helps in designing equipment used in communication/essential for communication. ½

b. In digital communication, digital signals are used which have two discrete current or voltage values in a signal. ½+½

Analog signals are used which have continuous current or voltage values in a signal.

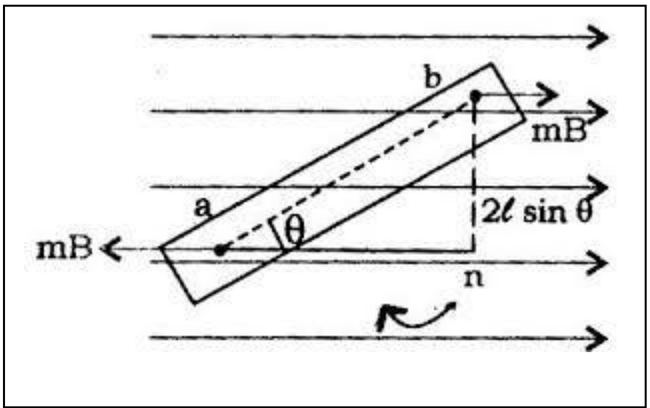
Alternatively, if a student draws the diagram of the digital signals and analog signals give these(½+½) mark.



(a)

3

(b)

	c. A transducer converts one from of energy into another. A repeater enhances the range of a communication system.	½ ½	
24.	(a) Definition of magnetic dipole moment and its SI unit 1 (b) Deriving expression for torque due to external uniform magnetic field 2		
	(a) Magnetic dipole moment is defined as the product of its pole strenth and effective length $\vec{p} = 2ml$	½	
	Its SI unit is Am^2	½	3
	(b) 	½	
	Torque τ = One of the magnetic force x perpendicular distance	½	
	$= m\vec{B}\ .\ 2l\sin\theta$ $= 2m\vec{l}\ .\ \vec{B}\sin\theta$ $= \vec{P}_m \times \vec{B}$	1	

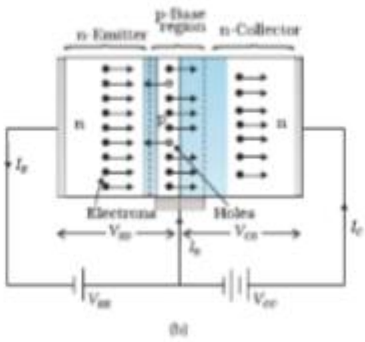
SECTION - D

25.

a. Circuit diagram and its working - 2
Explanation of low and high resistance at input and output respectively - 1

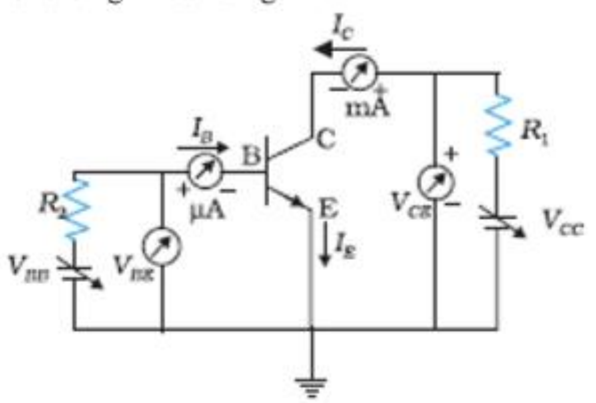
b. Derivation of voltage gain - 1½
Input and output phase relation. - ½

a.



1

(Also accept the following circuit diagram.

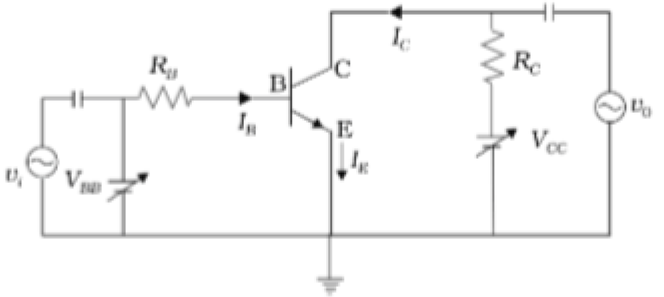


)

When Emitter Base junction is forward biased, electron from emitter enter the base where a few free charge carriers combine with the holes present in the base. As base is thin, most of the electron go into the collector, since collector junction is reverse biased, it gives rise to a collector current. 1

Since Emitter-Base junction is forward biased, input resistance is low and base-collector is reversed biased, so output resistance is high. 1

b.



½ | 5

Applying Kirchoff's loop rule to input loop and taking variation

$\Delta V_{BE} = \Delta I_B (R_B + r_i)$ ....(1)

Output loop and taking variations

$\Delta V_{CE} = - R_L \Delta I_C$ ....(2)

Voltage gain, $A_V = \frac{v_0}{v_i} = \frac{\Delta V_{CE}}{\Delta V_{BE}} - \frac{R_L \Delta I_C}{\Delta I_B (R_B + r_i)} = -\beta_{ac} \frac{R_L}{r}$ 1

Where, $R_B + r_i = r$ ....(3)

and $\beta_{a.c}$ = Current gain in C.E. $= \frac{\Delta I_C}{\Delta I_B}$

The negative sign in equation (3) indicates that the input and output voltages are in opposite phase. ½

OR

a)	Two considerations for fabricating p-n junction diode used as LED	1
	Order of band gap	1
	Circuit diagram and action	1
b)	V-I characteristics of LED	1
	Two advantages of LED lamps over conventional lamps	½+½

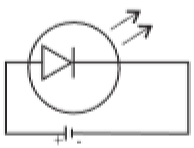
a) Important fabricating consideration

i) Heavily doped ½+ ½

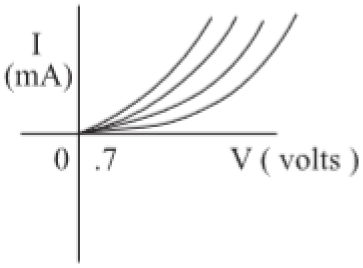
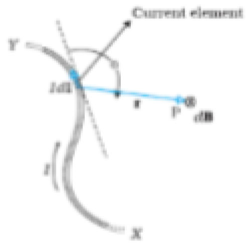
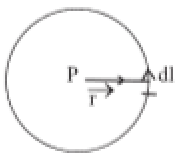
ii) Encapsulated with transparent cover.

<u>For visible light:</u>

order of band gap for LED = 1.8 eV to 3eV 1



½

	When the diode is forward biased, electron are sent from n side to p side and holes are sent from p side to n side and at the junction boundary, the excess minority carrier recombines with the majority carriers releasing energy in the form of photons.  Two advantage of LED over ordinary Lamps Low operational voltage/Less power consumption / fast action / No warm up time required / Nearly monochomatic / Long life / ruggedness / fast switching capacity (Any two)	½ 1 ½ + ½	
26.	a. Statement of the law and expression for the magnetic field - 1+2 b. Finding the magnitude and direction of magnetic field - 1½ +½ a. According to Biot Savart law, the magnetic field due to a current element is given by $d\vec{B} = \frac{\mu_o}{4\pi} I \frac{\vec{dl} \times \vec{r}}{[\vec{r}]^3}$  Alternatively award this 1 mark if a student makes statement of Biot Savart law. Derivation of magnetic field  Magnetic field due to current element dl $\vec{dB} = \frac{\mu_o}{4\pi} I \frac{\vec{dl} \times \hat{r}}{[\vec{r}]^2}$ where $\hat{r}$ is a unit vector along $\vec{r}$	1 ½	

$\vec{r} \perp \vec{dl}$

Direction of $\vec{dB}$ is perpendicular, pointing outward. ½

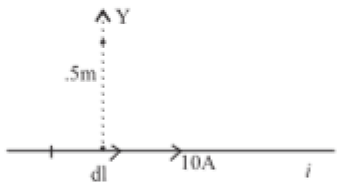
∴ Field due to the whole loop

$$\left|\vec{B}\right| = \int dB = \frac{\mu_o I}{4\pi r^2}\int dl = \frac{\mu_o I}{4\pi r^2} \times 2\pi r$$ ½

$$\left|\vec{B}\right| = \frac{\mu_o I}{2r}$$ ½

b.

$$\left|\vec{dB}\right| = \frac{\mu_0 I}{4\pi}\frac{dl \sin\theta}{[\vec{r}\,]^2}$$ ½ 5

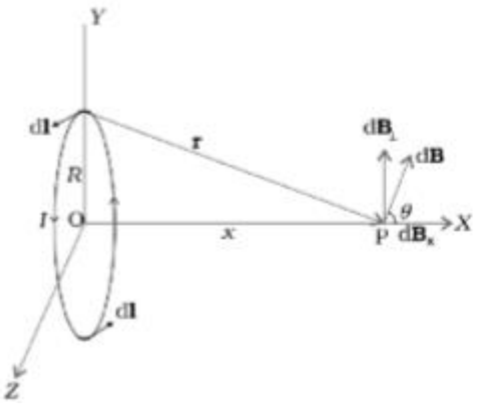


$$= \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{10 \times (1\times10^{-2}) \times \sin 90^0}{(0.5)^2}$$ 1

$$= 4\times10^{-8}\,T$$ ½

OR

a) Derivation of expression with diagram	3
b) Calculation of magnitude of magnetic field at the center of the arc.	1½
Direction of field	½



1

	According to Biot Savart law $\left\|\vec{dB}\right\| = \frac{\mu_0}{4\pi} \frac{I\,dl \sin 90^0}{\left\|\vec{r_1}\right\|^2}$ Where $r_1 = \sqrt{x^2 + r^2}$ $\left\|\vec{dB}\right\| = \frac{\mu_0}{4\pi} \frac{I\,dl}{(x^2+r^2)^{\frac{3}{2}}}$ Direction of $\vec{dB}$ is perpendicular to $\vec{dl}$ and $\vec{r_1}$. It has components dB_x and $dB_\perp$. The components $dB_\perp$ due to the whole coil cancel out in pairs. Net field B = $\int dB_x = \int dB \cos\theta$ $\vec{B} = \frac{\mu_0 I r^2}{2(r^2+x^2)^{\frac{3}{2}}}\hat{i}$ b) $B = \frac{\mu_0 I}{4r}$ $= \frac{4\pi \times 10^{-7} \times 5}{4 \times 2 \times 10^{-2}}$ $= 7.85 \times 10^{-5}\,T$ The field is directed inwards perpendicular to the plane of the page.	½ ½ 1 ½ ½ ½ ½	

27.

i) Production of Interference pattern and explanation.	1+1
ii) Obtaining expression for intensity at the point P	1½
iii) Calculating wavelength of light	1½

a) No. Sustained interference pattern cannot be obtained — 1

Light waves emitted from a source undergoes abrupt phase changes in times of the order of 10^{-10}s. So light from two independent sources will not have fixed phase relationship and will be incoherent. — ½ + ½

b) $x = \frac{\beta}{3}$, path difference $= \frac{\lambda}{3}$ — ½

phase diff $= \frac{2\pi}{3}$ — ½

$$I = I_0 \cos^2 \frac{\phi}{2}$$

$$I = I_0 \cos^2\left(\frac{2\pi}{3\times 2}\right) = I_0 \cos^2\left(\frac{\pi}{3}\right)$$

$$I = I_0 \left(\frac{1}{4}\right) = \frac{I_0}{4}$$ — ½

c) Distance of 5th bright fringe from 2nd dark fringe

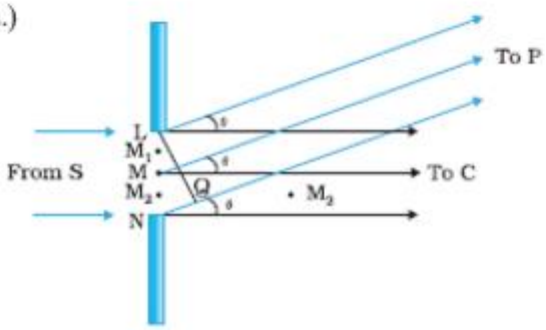
$$x = \frac{5\lambda D}{d} - \frac{3\lambda D}{2\,d} = \frac{7}{2}\frac{\lambda D}{d}$$ — ½

$$\lambda = \frac{2xd}{7D} = \frac{2\times 4.13\times 10^{-3}\times 0.5\times 10^{-3}}{7\times 1}$$ — ½

$$\lambda = 0.59\times 10^{-6}\text{m} = 5900\ \text{Å}$$ — ½

OR

i) Derivation of relation	2
ii) Effect on linear width of central maximum	½+½
iii) Determination of slit width	2

	a.) 	½	
	From diagram path difference between the waves from L and N $= a \sin\theta$	½	
	When first minimum is obtained at P then path difference $= \lambda$	½	
	[imagine the slit be divided into two halves, for each wavelets from first half of the slit has a corresponding wavelet from second half of the slit differing by a path of $\frac{\lambda}{2}$ and cancel each other]		
	Condition for first minimum		
	$\therefore\ \lambda = a \sin\theta$		
	b.) $\beta_{cm} = \frac{2\lambda D}{d}$	½	
	(i) increases	½	
	(ii) increases	½	
	c.) $10\frac{\lambda}{d} = 2\frac{\lambda}{a}$	1	
	$a = \frac{d}{5} = 0.2\text{mm}$	1	