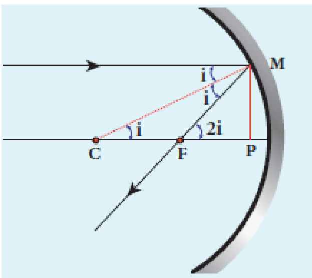
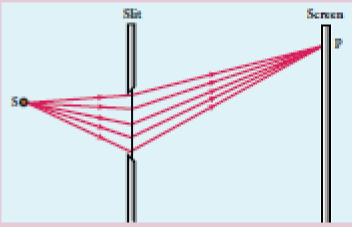
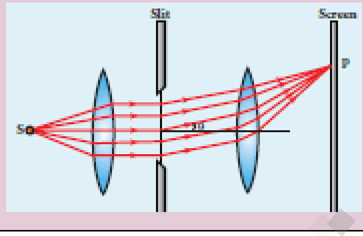
First Revision exam – Jan 2025
Chengalpattu District
XII - Physics Answer Key

Answer all the questions. Choose the correct answer. 15X1=15		
1	For light incident from air on a slab of refractive index 2, the maximum possible angle of reaction is	a) 30^0
2	Which one of the following is the natural nanomaterial.	a) Peacock feather
3	The ratio of magnetic length and geometrical length is	c) 5/6
4	First diffraction minimum due to a single slit of width $1x10^{-5}$ cm is at 30^0. the wavelength of light used is	b) 500 A
5	The barrier potential of a silicon diode is affroximately.	a) 0.7V
6	An electricfield $\vec{E}$ = $10x\hat{\imath}$ exists in a certain region of space. Then the potential difference V= V_0-V_A, where V_0 is the potential at the origin and V_A is the potential at x=2m is	c) +20V
7	If the amplitude of the magnetic field is $3x10^{-6}$T, then amplitude of the electric field for a electromagnetic wave is	d) $900Vm^{-1}$
8	The average binding energy of iron nuclei is	b) 8.8 MeV
9	The internal resistance of a 2.1V cell which gives a current of 0.2A through a resistance of 10Ω is	b) 0.5Ω
10	In an oscillating LC circuit, the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is	c) $\frac{Q}{\sqrt{2}}$
11	The critical angle of diamond is	d) 24.4^0
12	In an electron microscope, the electrons are accelerated by a voltage of 14kv. If the voltage is changed to 224KV, then the de Broglie wavelength associated with the electrons would.	c) decrease by 4 times
13	A circular coil of radius 5cm and 50 turns carries a current of 3 ampere. The magnetic dipole moment of the coil is nearby.	b) 1.2 Am^2
14	The charge of cathode rays particle is	b) negative
15	The dielectric strength of air is	c) $3x10^6$ Vm^{-1}
Part B	**Answer any six in short. Question No. 24 is compulsory**	**6x2=12**
16	What is corona discharge? The leakage of charge from the sharp edges of the charged conductor is called Corona discharge.	
17	Compute the seed of the electromagnetic wave in a medium if the amplitude of electric and magnetic fields are $3x10^4$ NC^{-1} and 2 x 10^{-4}T respectively. C=$\frac{E}{B}$ = $\frac{3x10^4}{2x10^{-4}}$ = $\frac{3}{2}$ x 10^8 = $1.5x10^8$ m/s	
18	Define electrical resistivity. The electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.	

19	State Fleming's right hand rule. The thumb, index finger and middle finger of right hand are stretched out in mutually perpendicular directions. If the index finger points the direction of the magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of the induced current.	
20	What is myopia? What is the remedy? A person suffering from *nearsightedness* (or) *myopia* cannot see distant objects clearly. To overcome this difficulty, the virtual image of the object at infinity should be formed at a distance *x* from the eye using a correcting lens	
21	List out the properties of neutrino. The neutrino has the following properties · It has zero charge · It has an antiparticle called anti-neutrino. · Recent experiments showed that the neutrino has very small mass. · It interacts very weakly with the matter.	
22	What is Bremsstrahlung? When a fast moving electron penetrates and approaches a target nucleus, the interaction between the electron and the nucleus either accelerates or decelerates it which results in a change of path of the electron. The radiation produced from such decelerating electron is called Bremsstrahlung or braking radiation	
23	What do you mean by skip distance? The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the skip distance.	
24	Equation for fringe width, $\beta = \frac{\lambda D}{d}$ Substituting, $\beta = \frac{450\times10^{-9}\times2}{0.15\times10^{-3}}$ $\beta = 6\times10^{-3}\text{m} = 6\text{ mm}$	
Part C	**Answer any six in brief. Question number 33 is compulsory.**	**6x3=18**
25	If MP is the perpendicular from M to the principal axis, then The angles $\angle MCP = i$ and $\angle MFP = 2i$ From right angle triangles ΔMCP and ΔMFP, we can write, $\tan i = \frac{PM}{PC}$ and $\tan 2i = \frac{PM}{PF}$ As the angles are small, $\tan i \simeq i$ and $\tan 2i \simeq 2i$, $i = \frac{PM}{PC}$ and $2i = \frac{PM}{PF}$ Simplifying further, $2\frac{PM}{PC} = \frac{PM}{PF}$; $2PF = PC$ PF is focal length f and PC is the radius of curvature R. $2f = R$ (or) $f = \frac{R}{2}$ (6.4)  (a) Concave mirror	

	Equation (6.4) is the relation between *f* and *R*.	
26	The susceptibility of material X is $$\chi_{m,X} = \frac{\lvert\vec{M}\rvert}{\lvert\vec{H}\rvert} = \frac{500}{1000} = 0.5$$ The susceptibility of material Y is $$\chi_{m,Y} = \frac{\lvert\vec{M}\rvert}{\lvert\vec{H}\rvert} = \frac{2000}{1000} = 2$$ Since, susceptibility of material Y is greater than that of material X, which implies that material Y can be easily magnetized.	
27	**Advantages of FM** i) In FM, there is a large decrease in noise. This leads to an increase in signal-noise ratio. ii) The operating range is quite large. iii) The transmission efficiency is very high as all the transmitted power is useful. iv) FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio. **Limitations of FM** i) FM requires a much wider channel. ii) FM transmitters and receivers are more complex and costly. iii) In FM reception, less area is covered compared to AM.	
28	**Postulates of Bohr atom model** (a) The electron in an atom moves around nucleus in circular orbits under the influence of Coulomb electrostatic force of attraction. (b) Electrons in an atom revolve around the nucleus only in certain discrete orbits called stationary orbits and electron in such orbits do not radiate electromagnetic energy. Only those discrete orbits allowed are stable orbits. (c) Energy of the electron in orbits is not continuous but only discrete. This is called the quantization of energy.	

29

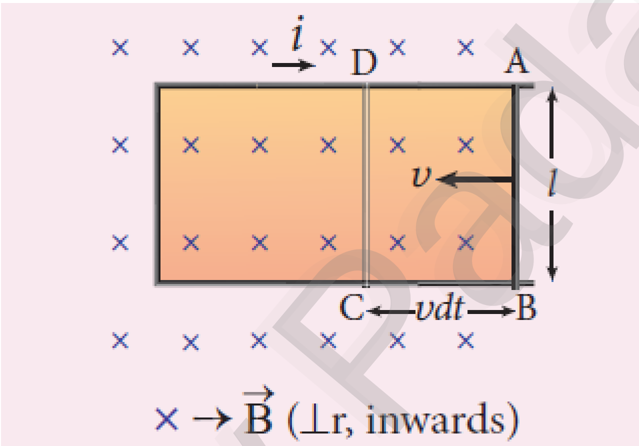
S.No.	Fresnel diffraction	Fraunhofer diffraction
1	Spherical (or) cylindrical wavefront undergoes diffraction	Plane wavefront undergoes diffraction
2	Light wave is from a source at finite distance	Light wave is from a source at infinity
3	Convex lenses need not be used for laboratory conditions	Convex lenses are to be used in laboratory conditions
4	Difficult to observe and analyse	Easy to observe and analyse
5		

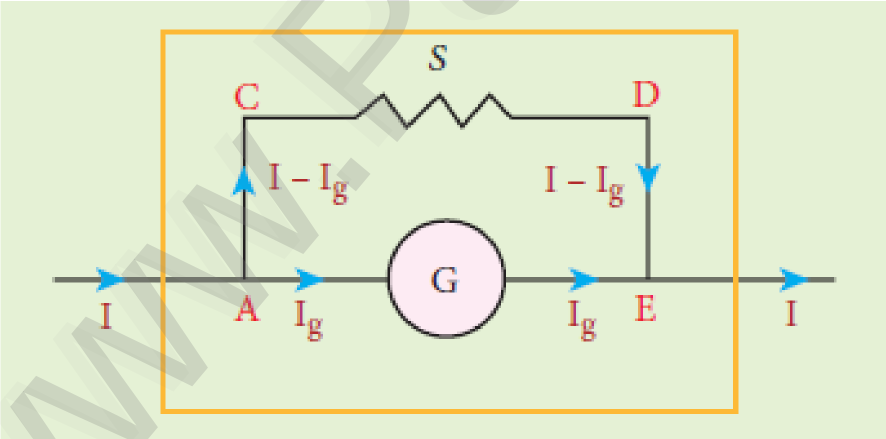
30

Consider a conducting rod of length *l* moving with a velocity *υ* towards left on a rectangular fixed metallic framework.

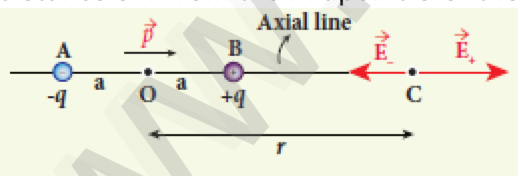
The whole arrangement is placed in a uniform magnetic field $\vec{B}$ whose magnetic lines are perpendicularly directed into the plane of the paper.

As the rod moves from *AB* to *DC* in a time *dt*, the area enclosed by the loop and hence the magnetic flux through the loop decreases.



	The change in magnetic flux in time dt is $d\Phi_B = B \times$ Change in area (dA) $= B \times$ Area $ABCD$ Since Area $ABCD = l(vdt)$ $d\Phi_B = Blvdt$ (or) $\frac{d\Phi_B}{dt} = Blv$ As a result of change in flux, an emf is generated in the loop. The magnitude of the induced emf is $\varepsilon = \frac{d\Phi_B}{dt}$ $\varepsilon = Blv \quad (4.18)$	
31	**Galvanometer to an Ammeter** Ammeter is an instrument used to measure current flowing in the electrical circuit. The ammeter must offer low resistance such that it will not change the current passing through it. So ammeter is connected in series to measure the circuit current. A galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer. This low resistance is called shunt resistance S. The scale is now calibrated in ampere and the range of ammeter depends on the values of the shunt resistance.  Ammeter	

	$V_{galvanometer} = V_{shunt}$ $\Rightarrow I_g R_g = (I - I_g) S$ $S = \frac{I_g}{(I - I_g)} R_g$ or $I_g = \frac{S}{S + R_g} I$ Since, the deflection in the galvanometer is proportional to the current passing through it, $\theta = \frac{1}{G} I_g \Rightarrow \theta \propto I_g \Rightarrow \theta \propto I$ So, the deflection produced in the galvanometer is a measure of the current I passing through the circuit. Shunt resistance is connected in parallel to galvanometer. Therefore, resistance of ammeter (R_a) can be determined by computing the effective resistance, which is $\frac{1}{R_{eff}} = \frac{1}{R_g} + \frac{1}{S} \Rightarrow R_{eff} = \frac{R_g S}{R_g + S} = R_a$ Since, the shunt resistance is a very low resistance and the ratio $\frac{S}{R_g}$ is also small. This means, R_a is also small, i.e., the resistance offered by the ammeter is small. So, when we connect ammeter in series, the ammeter will not change appreciably the current in the circuit. For an ideal ammeter, the resistance must be equal to zero. But in reality, the reading in ammeter is always less than the actual current in the circuit. Let I_{ideal} be the current measured by ideal ammeter and I_{actual} be the actual current in the circuit. Then, the percentage error in measuring a current through an ammeter is $\frac{\Delta I}{I} \times 100\% = \frac{I_{ideal} - I_{actual}}{I_{ideal}} \times 100\%$	
32	Capacitor not only stores the charge but also it stores energy. When a battery is connected to the capacitor, electrons of total charge $-Q$ are transferred from one plate to the other plate. To transfer the charge, work is done by the	

<table>
<tr><td></td><td>battery. This work done is stored as electrostatic potential energy in the capacitor.
To transfer an infinitesimal charge dQ for a potential difference V, the work done is given by
$dW = V\,dQ$
where $V = \frac{Q}{C}$
The total work done to charge a capacitor is
$W = \int_0^Q \frac{Q}{C} dQ = \frac{Q^2}{2C}$ (1.86)
This work done is stored as electrostatic potential energy (U_E) in the capacitor.
$U_E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 \quad (\because Q = CV)$ (1.87)</td><td></td></tr>
<tr><td>33</td><td>In a transistor connected in the common base configuration, $\alpha = 0.95$, $I_E = 1\ mA$. Calculate the values of I_C and I_B.
Solution
$\alpha = \frac{I_C}{I_E}$
$I_C = \alpha I_E = 0.95 \times 1 = 0.95$ mA
$I_E = I_B + I_C$
$\therefore I_B = I_E - I_C = 1 - 0.95 = 0.05$ mA</td><td></td></tr>
<tr><td>Part D</td><td>Answer all the questions</td><td>5x5=25</td></tr>
<tr><td>34. a)</td><td>Electric field due to a dipole
Case (i) Electric field due to an electric dipole at points on the axial line
Consider an electric dipole placed on the x-axis. A point C is located at a distance of r from the midpoint O of the dipole on the axial line.

</td><td></td></tr>
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The electric field at a point C due to $+q$ is

$$\vec{E}_{+} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r-a)^2} \text{ along BC}$$

Since the electric dipole moment vector $\vec{p}$ is from $-q$ to $+q$ and is directed along BC, the above equation is rewritten as

$$\vec{E}_{+} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r-a)^2}\hat{p} \qquad (1.13)$$

where $\hat{p}$ is the electric dipole moment unit vector from $-q$ to $+q$.

The electric field at a point C due to $-q$ is

$$\vec{E}_{-} = -\frac{1}{4\pi\epsilon_0}\frac{q}{(r+a)^2}\hat{p} \qquad (1.14)$$

Since $+q$ is located closer to the point C than $-q$, $\vec{E}_{+}$ is stronger than $\vec{E}_{-}$. Therefore, the length of the $\vec{E}_{+}$ vector is drawn larger than that of $\vec{E}_{-}$ vector.

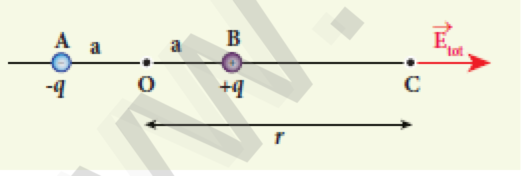
The total electric field at point C is calculated using the superposition principle of the electric field.

$$\vec{E}_{tot} = \vec{E}_{+} + \vec{E}_{-}$$
$$= \frac{1}{4\pi\epsilon_0}\frac{q}{(r-a)^2}\hat{p} - \frac{1}{4\pi\epsilon_0}\frac{q}{(r+a)^2}\hat{p}$$

$$\vec{E}_{tot} = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right)\hat{p} \qquad (1.15)$$

$$\vec{E}_{tot} = \frac{1}{4\pi\epsilon_0}q\left(\frac{4ra}{(r^2-a^2)^2}\right)\hat{p} \qquad (1.16)$$

Note that the total electric field is along $\vec{E}_{+}$, since $+q$ is closer to C than $-q$. The direction of $\vec{E}_{tot}$ is shown in Figure 1.16.



If the point C is very far away from the dipole ($r >> a$). Then under this limit the term $(r^2-a^2)^2 \simeq r^4$. Substituting this into equation (1.16), we get

$$\vec{E}_{tot} = \frac{1}{4\pi\epsilon_0}\left(\frac{4aq}{r^3}\right)\hat{p} \quad (r >> a)$$

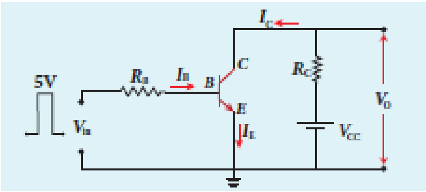
since $2aq\,\hat{p} = \vec{p}$

$$\vec{E}_{tot} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3} \quad (r >> a) \qquad (1.17)$$

If the point C is chosen on the left side of the dipole, the total electric field is still in the direction of $\vec{p}$. We infer this result by examining the electric field lines of the dipole

34. b) **Transistor as a switch**

A transistor in saturation region acts as a closed switch while in cut-off region; it acts as an open switch. It functions like an electronic switch that helps to turn ON or OFF a given circuit by a small control signal which keeps the transistor either in saturation region or in cut-off region.



- **When the input is low:**

When the input is low (say 0V), the base current is zero and transistor is not properly forward biased. It is in cut off region. As a result, the collector current is zero and correspondingly the voltage drop across R_C also becomes nearly zero. The output voltage is high and is equal to V_{CC}. It means that the no current flows through the transistor and it is said to be switched off. The transistor acts as an open switch.

- **When the input is high:**

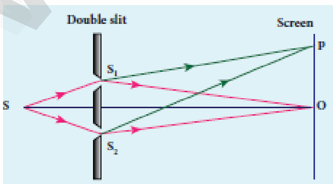
When the input voltage is increased to a certain high value (say +5 V), the base current (I_B) increases and in turn increases the collector current to its maximum. The transistor will move into the saturation region. The increase in collector current (I_C) increases the voltage drop across R_C, thereby lowering the output voltage, close to zero (since $V_o = V_{CC} - I_C R_C$). It means that maximum current flows through the transistor and it is said to be switched on. The transistor acts as a closed switch.

It is manifested that a high input to the transistor gives a low output and a low input gives a high output. In addition, we can say that the output voltage is opposite to the applied input voltage. Therefore, a transistor can be used as an inverter (NOT gate) in computer logic circuitry.

35. a) **Young's double slit experiment**

Experimental setup

Thomas Young, a British Physicist in 1801 used an opaque screen with two small openings called double slit S_1 and S_2 kept equidistance from a source S as shown in Figure 7.12. The width of each slit is about 0.03 mm and they are separated by a distance of about 0.3 mm. As S_1 and S_2 are equidistant from S the same wavefront is cut by S_1 and S_2. The light waves at S_1 and S_2 are in-phase. So, S_1 and S_2 act as coherent sources which is the requirement for obtaining interference pattern.



Wavefronts from S_1 and S_2 spread out and overlap on the other side of the double slit. When a screen is placed at a distance of about 1 m from the slits, alternate bright and dark fringes which are equally spaced appear on the screen. These are called interference fringes (or) bands. Using an eyepiece, the fringes can be seen directly. At the center point O on the screen, the waves from S_1 and S_2 travel equal distances and arrive in-phase as shown in Figure 7.12. These two waves constructively interfere and a bright fringe is observed at O. This is called central bright fringe. When one of the slits is closed, the fringes disappear and there is uniform illumination on the screen. This shows clearly that the bands are due to interference.

Equation for bandwidth

The *bandwidth* β is defined as the distance between any two consecutive bright (or) dark fringes.

The distance between $(n+1)^{th}$ and n^{th} consecutive bright fringes from O is given by,

$$\beta = y_{(n+1)} - y_n = \left((n+1)\frac{\lambda D}{d}\right) - \left(n\frac{\lambda D}{d}\right)$$

$$\beta \text{ for bright,} \quad \beta = \frac{\lambda D}{d} \qquad (7.31)$$

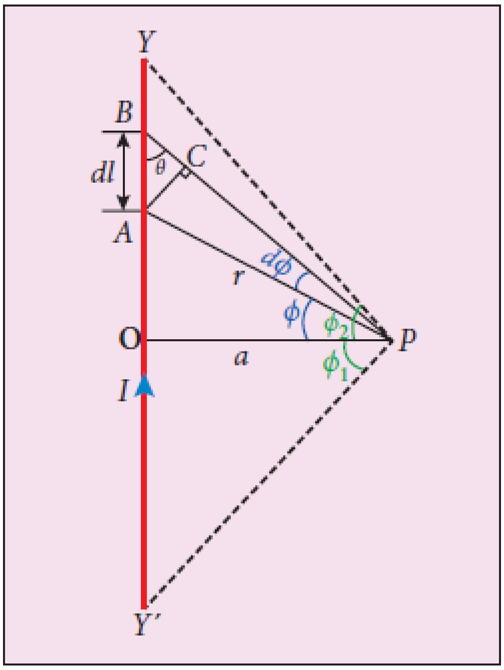
Similarly, the distance between $(n+1)^{th}$ and n^{th} consecutive dark fringes from O is given by,

$$\beta = y_{(n+1)} - y_n = \left(\frac{(2(n+1)-1)}{2}\frac{\lambda D}{d}\right) - \left(\frac{(2n-1)}{2}\frac{\lambda D}{d}\right)$$

$$\beta \text{ for dark,} \quad \beta = \frac{\lambda D}{d} \qquad (7.32)$$

From Equations (7.31) and (7.32) we understand that the bright and dark fringes are of same width equally spaced on either side of the central bright fringe.

35. b)	**Magnetic field due to long straight conductor carrying current**	



Let YY′ be an infinitely long straight conductor and I be the steady current through the conductor as shown in Figure 3.32. In order to calculate magnetic field at a point P which is at a distance a from the wire, let us consider a small line element dl (segment AB).

The magnetic field at a point P due to current element Idl can be calculated from Biot-Savart's law, which is

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}\hat{n}$$

where $\hat{n}$ is the unit vector which points into the page at P, θ is the angle between current element Idl and line joining dl and the point P. Let r be the distance between line element at A to the point P.

To apply trigonometry, draw a perpendicular line from A to BP as shown in Figure 3.32.

In triangle ΔABC, $\sin\theta = \frac{AC}{AB}$

$\Rightarrow AC = AB\sin\theta$

But AB = $dl \Rightarrow AC = dl\sin\theta$

Let $d\phi$ be the angle subtended between AP and BP

	i.e., $\angle APB = \angle APC = d\phi$ In a triangle $\Delta APC, \sin(d\phi) = \frac{AC}{AP}$ Since $d\phi$ is very small, $\sin(d\phi) \simeq d\phi$ But $AP = r \Rightarrow AC = rd\phi$ $\therefore AC = dl\sin\theta = rd\phi$ $\therefore d\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{r^2}(rd\phi)\,\hat{n} = \frac{\mu_0}{4\pi}\frac{Id\phi}{r}\,\hat{n}$ Let ϕ be the angle between AP and OP In a ΔOPA, $\cos\phi = \frac{OP}{AP} = \frac{a}{r}$ $\Rightarrow r = \frac{a}{\cos\phi}$ $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{a/\cos\phi}d\phi\,\hat{n}$ $\Rightarrow d\vec{B} = \frac{\mu_0 I}{4\pi a}\cos\phi\, d\phi\,\hat{n}$ The total magnetic field at P due to the conductor YY′ is $\vec{B} = \int_{-\phi_1}^{\phi_2} d\vec{B} = \int_{-\phi_1}^{\phi_2} \frac{\mu_0 I}{4\pi a}\cos\phi\, d\phi\,\hat{n}$ $= \frac{\mu_0 I}{4\pi a}[\sin\phi]_{-\phi_1}^{\phi_2}\,\hat{n}$ $= \vec{B} = \frac{\mu_0 I}{4\pi a}(\sin\phi_1 + \sin\phi_2)\,\hat{n}$ For infinitely long conductor, $\phi_1 = \phi_2 = 90°$ $\therefore \vec{B} = \frac{\mu_0 I}{4\pi a}\times 2\,\hat{n} \Rightarrow \vec{B} = \frac{\mu_0 I}{2\pi a}\,\hat{n}$ (3.36)	
36. a)	**Maxwell's equations in integral form** Electrodynamics can be summarized in four basic equations, known as Maxwell's equations. These equations are analogous to Newton's equations in mechanics. Maxwell's equations completely explain the behaviour of charges, currents and properties of electric and magnetic fields. These equations can be written in integral form (or integration form) or derivative form (or differential form). The differential form of Maxwell's equation is beyond higher secondary level. So we focus only the integral form of Maxwell's equations.	

First equation

It is nothing but the Gauss's law of electricity. It relates the net electric flux to net electric charge enclosed in a surface. Mathematically, it is expressed as

$$\oint_S \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\epsilon_o} \quad \text{(Gauss's law for electricity)} \quad (5.7)$$

where $\vec{E}$ is the electric field and Q enclosed is the net charge enclosed by the surface S. This equation is true for both discrete and continuous distribution of charges.

It also indicates that the electric field lines start from positive charge and terminate at negative charge. This implies that the electric field lines do not form a continuous closed path. In other words, it means that an isolated positive charge or negative charge can exist.

Second equation

This law is similar to Gauss's law for electricity. So this law can also be called as Gauss's law for magnetism. The surface integral of magnetic field over a closed surface is zero. Mathematically,

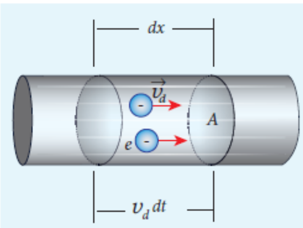
$$\oint_S \vec{B} \cdot d\vec{A} = 0 \quad \text{(Gauss's law for magnetism)} \quad (5.8)$$

where $\vec{B}$ is the magnetic field.

This equation implies that the magnetic lines of force form a continuous closed path. In other words, it means that no isolated magnetic monopole exists.

Third equation

It is Faraday's law of electromagnetic induction. This law relates electric field with the changing magnetic flux which is mathematically written as

	$$\oint_l \vec{E}\cdot d\vec{l} = -\frac{d}{dt}\Phi_B \quad \text{(Faraday's law)} \quad (5.9)$$ where $\vec{E}$ is the electric field. This equation implies that the line integral of the electric field around any closed path is equal to the rate of change of magnetic flux through the closed path bounded by the surface. Our modern technological revolution is due to Faraday's laws of electromagnetic induction. **Fourth equation** It is modified Ampere's circuital law. This is also known as Ampere – Maxwell law. This law relates the magnetic field around any closed path to the conduction current and displacement current through that path. $$\oint_l \vec{B}.d\vec{l} = \mu_0 i_C + \mu_0 \epsilon_0 \frac{d}{dt}\oint_s \vec{E}.d\vec{A}$$ (Ampere-Maxwell law) (5.10) where $\vec{B}$ is the magnetic field. This equation shows that both conduction current and displacement current produce magnetic field. These four equations are known as Maxwell's equations in electrodynamics. This equation ensures the existence of electromagnetic waves. The entire communication system in the world depends on electromagnetic waves. In fact our understanding of stars, galaxy, planets etc come by analysing the electromagnetic waves emitted by these astronomical objects.	
36. b)	**Microscopic model of current** Consider a conductor with area of cross section A and let an electric field $\vec{E}$ be applied to it from right to left. Suppose there are n electrons per unit volume in the conductor and assume that all the electrons move with the same drift velocity $\vec{v}_d$ as shown in Figure 2.5.  	

The drift velocity of the electrons = v_d

If the electrons move through a distance dx within a small interval of dt, then

$$v_d = \frac{dx}{dt}\ ; \quad dx = v_d\, dt \qquad (2.7)$$

Since A is the area of cross section of the conductor, the electrons available in the volume of length dx is

= volume × number of electrons per unit volume

$$= A\,dx \times n \qquad (2.8)$$

Substituting for dx from equation (2.7) in (2.8)

$$= (A\ v_d\, dt)\ n$$

Total charge in the volume element dQ = (charge) × (number of electrons in the volume element)

$$dQ = (e)(A v_d dt) n$$

Hence the current $I = \frac{dQ}{dt}$

$$I = neAv_d \qquad (2.9)$$

Current density (J)

The current density (J) is defined as the current per unit area of cross section of the conductor.

$$J = \frac{I}{A}$$

The S.I unit of current density is $\frac{A}{m^2}$ (or) $A\,m^{-2}$

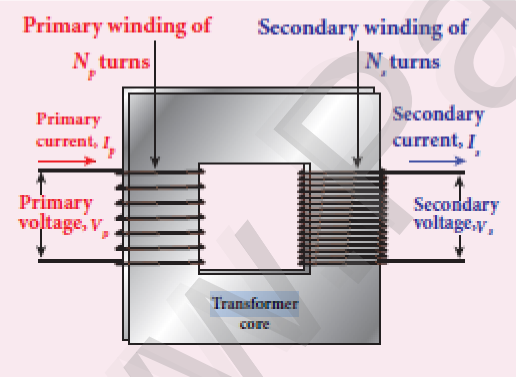
$$J = \frac{neAv_d}{A} \text{ (from equation 2.9)}$$

$$J = nev_d \qquad (2.10)$$

The above expression is valid only when the direction of the current is perpendicular to the area A. In general, the current density is a vector quantity and it is given by

$$\vec{J} = ne\vec{v}_d$$

Substituting $\vec{v}_d$ from equation (2.4)

	$$\vec{J} = -\frac{n \cdot e^2 \tau}{m}\vec{E} \quad (2.11)$$ $$\vec{J} = -\sigma\vec{E}$$ But conventionally, we take the direction of (conventional) current density as the direction of electric field. So the above equation becomes $$\vec{J} = \sigma\vec{E} \quad (2.12)$$ where $\sigma = \frac{ne^2\tau}{m}$ is called conductivity. The equation (2.12) is called microscopic form of ohm's law. The inverse of conductivity is called resistivity (ρ) [Refer section 2.2.1]. $$\rho = \frac{1}{\sigma} = \frac{m}{ne^2\tau} \quad (2.13)$$	
37. a)	**Construction and working of transformer** **Construction** In the simple construction of transformers, there are two coils of high mutual inductance wound over the same transformer core. The core is generally laminated and is made up of a good magnetic material like silicon steel. Coils are electrically insulated but magnetically linked via transformer core The coil across which alternating voltage is applied is called primary coil *P* and the coil from which output power is drawn out is called secondary coil *S*. The assembled core and coils are kept in a container which is filled with suitable medium for better insulation and cooling purpose.  **Working** If the primary coil is connected to a source of alternating voltage, an alternating magnetic flux is set up in the laminated core. If there is no magnetic flux leakage, then whole of magnetic flux linked with primary coil is also linked with secondary coil. This means that rate at which magnetic flux changes through each turn is same for both primary and secondary coils.	

As a result of flux change, emf is induced in both primary and secondary coils. The emf induced in the primary coil or back emf ε_p is given by

$$\varepsilon_p = -N_p \frac{d\Phi_B}{dt}$$

But the voltage applied v_p across the primary is equal to the back emf. Then

$$v_p = -N_p \frac{d\Phi_B}{dt} \quad (4.24)$$

The frequency of alternating magnetic flux in the core is same as the frequency of the applied voltage. Therefore, induced emf in secondary will also have same frequency as that of applied voltage. The emf induced in the secondary coil ε_s is given by

$$\varepsilon_s = -N_s \frac{d\Phi_B}{dt}$$

where N_p and N_s are the number of turns in the primary and secondary coil respectively. If the secondary circuit is open, then $\varepsilon_s = v_s$ where v_s is the voltage across secondary coil.

$$v_s = -N_s \frac{d\Phi_B}{dt} \quad (4.25)$$

From equations (4.24) and (4.25),

$$\frac{v_s}{v_p} = \frac{N_s}{N_p} = K \quad (4.26)$$

This constant K is known as voltage transformation ratio. For an ideal transformer,

Input power $v_p i_p$ = Output power $v_s i_s$

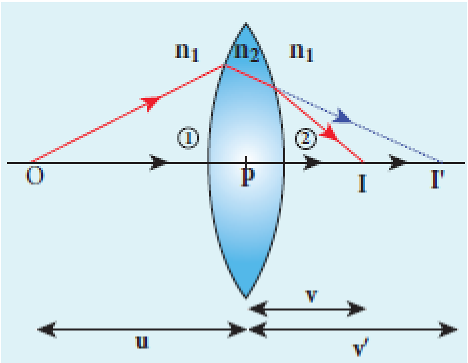
where i_p and i_s are the currents in the primary and secondary coil respectively. Therefore,

$$\frac{v_s}{v_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} \quad (4.27)$$

	Equation 4.27 is written in terms of amplitude of corresponding quantities, $$\frac{V_s}{V_p}=\frac{N_s}{N_p}=\frac{I_p}{I_s}=K$$ i) If $N_s > N_p (K > 1)$, then $V_s > V_p$ and $I_s < I_p$. This is the case of step-up transformer in which voltage is increased and the corresponding current is decreased. ii) If $N_s < N_p (K < 1)$, then $V_s < V_p$ and $I_s > I_p$. This is step-down transformer where voltage is decreased and the current is increased.	
37. b)	At any instant t, the number of decays per unit time, called rate of decay $\left(\frac{dN}{dt}\right)$ is proportional to the number of nuclei (N) at the same instant. $$-\frac{dN}{dt}\propto N$$ The negative sign in the equation implies that N is decreasing with time. By introducing a proportionality constant, the relation can be written as $$\frac{dN}{dt}=-\lambda N \quad (9.32)$$ Here proportionality constant λ is called decay constant which is different for different radioactive sample. By rewriting the equation (9.32), we get $$dN=-\lambda N dt \quad (9.33)$$ Here dN represents the number of nuclei decaying in the time interval dt. Let us assume that at time $t=0$ s, the number of nuclei present in the radioactive sample be N_0. By integrating the equation (9.33), we can calculate the number of undecayed nuclei N present at any time t. From equation (9.33), we get $$\frac{dN}{N}=-\lambda\, dt \quad (9.34)$$ $$\int_{N_0}^{N}\frac{dN}{N}=-\int_0^t \lambda\, dt$$ $$[\ln N]_{N_0}^{N}=-\lambda t$$ $$\ln\left[\frac{N}{N_0}\right]=-\lambda t$$ Taking exponentials on both sides, we get $$N=N_0 e^{-\lambda t} \quad (9.35)$$	

38. a)	**Lens maker's formula and lens equation**	

Let us consider a thin lens made up of a medium of refractive index n_2 placed in a medium of refractive index n_1. Let R_1 and R_2 be the radii of curvature of two spherical surfaces ① and ② respectively and P be the pole as shown in Figure 6.34. Consider a point object O on the principal axis. A paraxial ray from O which falls very close to P, after refraction at the surface ① forms image at I'. Before it does so, it is again refracted by the surface ②. Therefore, the final image is formed at I.



The general equation for the refraction at a single spherical surface is given by the equation (6.56) is,

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$$

For the refracting surface ①, the light goes from n_1 to n_2.

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R_1} \quad (6.58)$$

For the refracting surface ②, the light goes from medium n_2 to n_1.

$$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{(n_1 - n_2)}{R_2} \quad (6.59)$$

For surface ②, I' acts as virtual object.

Adding the above two equations (6.58) and (6.59)

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

On further simplifying and rearranging,

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

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad (6.60)$$

If the object is at infinity, the image is formed at the focus of the lens. Thus, for $u = \infty$, $v = f$. Then the equation becomes.

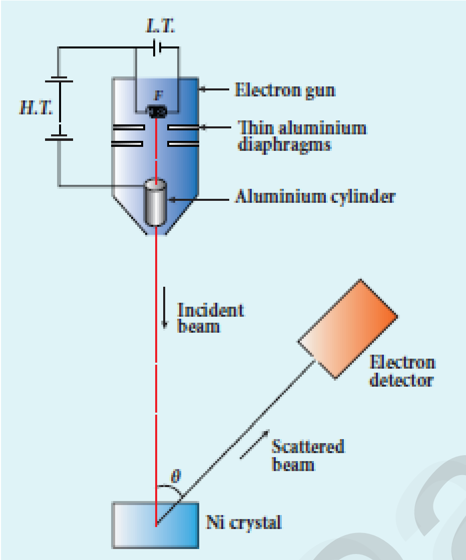
$$\frac{1}{f} - \frac{1}{\infty} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad (6.61)$$

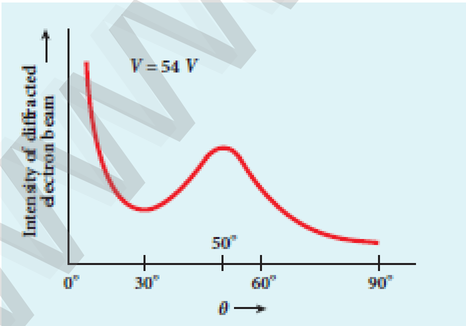
	If the lens is kept in air, then we can take $n_1 = 1$ and $n_2 = n$. So the equation (6.61) becomes, $$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad (6.62)$$	
38. b)	**Davisson – Germer experiment**	

Louis de Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester Germer in 1927. They demonstrated that electron beams are diffracted when they fall on crystalline solids. Since crystal can act as a three-dimensional diffraction grating for matter waves, the electron waves incident on crystals are diffracted off in certain specific directions. Figure 8.17 shows a schematic representation of the apparatus for the experiment.

The filament *F* is heated by a low tension (L.T.) battery. Electrons are emitted from the hot filament by thermionic emission. They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery. Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.



The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam. The detector is capable of rotation in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. The intensity of the scattered electron beam is measured as a function of the angle θ.



The variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of 54*V*. For a given accelerating voltage *V*, the scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam. This peak in intensity is attributed to the constructive

	interference of electrons diffracted from various atomic layers of the target material. From the known value of interplanar spacing of Nickel, the wavelength of the electron wave was experimentally calculated as 1.65Å. The wavelength can also be calculated from de Broglie relation for V = 54 V $\lambda = \frac{12.27}{\sqrt{V}} Å = \frac{12.27}{\sqrt{54}} Å$ $\lambda = 1.67$ Å This value agrees very well with the experimentally observed wavelength of 1.65Å. Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.	