HIGHER SECONDARY SECOND YEAR
HALF-YEARLY EXAMINATION - DECEMBER 2024
PHYSICS KEY ANSWER

Note:
1. Answer written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and writethe option code and the corresponding answer.
3. For answer in Part-II, Part-III and Part-IV like reasoning, explanation, narration, description and listing of points, students may write in their own words but without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

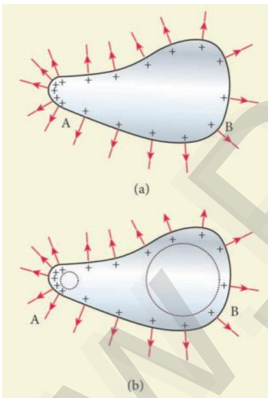
PART A

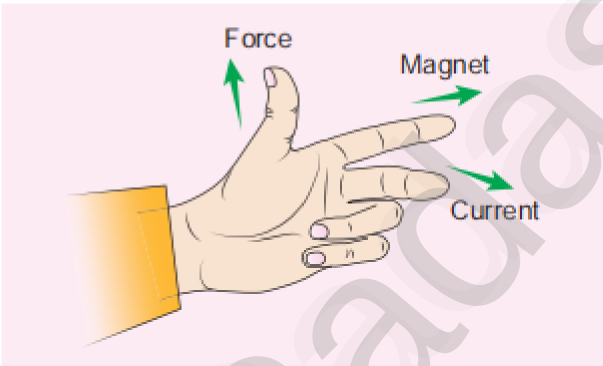
Answer all the question. **15 x 1 = 15**

Q. NO.	OPTION	ANSWER	Q. NO.	OPTION	ANSWER
1.	c)	C remains same, Q doubled	11.	c)	1.5×10^8 m/s
2.	b)	3750 Å	12.	a)	Higgs particle
3.	d)	Voltage regulator	13.	a)	A = 0, B = 0, C = 1, D = 0
4.	c)	(A - Z - 12)/ (Z - 4)	14.	b)	Its wavelength
5.	d)	6.25×10^{18} electrons	15.	b)	4 λ
6.	c)	3.5 Ω			
7.	b)	√(1/3)ßII			
8.	c)	Plane polarised			
9.	a)	16.64 Å			
10.	d)	1/8			

PART - B

II. Answer any 6 questions. (Q.No. 24 is compulsory) **6 x 2 = 12**

Q. NO	ANSWER	MARKS
16.	***Corona discharge:*** 	1
	*We know that smaller the radius of curvature, the larger is the charge density. The end of the conductor which has larger curvature (smaller radius) has a large charge accumulation as shown in Figure. *As a result, the electric field near this edge is very high and it ionizes the surrounding [Page: 1]	1

	air. *The positive ions are repelled at the sharp edge and negative ions are attracted towards the sharper edge. This reduces the total charge of the conductor near the sharp edge. *This is called action of points or corona discharge.	
17.	**Problem:** **Solution:** * Resistance of the coil, $R_{20} = 3\ \Omega$, * Temperature coefficient of resistance, $\alpha = 0.004$°C, * Resistance at 100°C, $R_{100} = R_{20}\ (1 + \alpha\ t)$ $R_{100} = 3\ (\ 1 + 0.004 \times 100)$ $R_{100} = 3\ (\ 1 + 0.4)$ $R_{100} = 3\ (1.4) = 4.2\ \Omega$	1 1
18.	## Fleming's left hand rule * When a current carrying conductor is placed in a magnetic field, the direction of the force experienced by it is given by Fleming's Left Hand Rule (FLHR) as shown  **Figure 3.52** Fleming's Left Hand Rule (FLHR) * Stretch out forefinger, the middle finger and the thumb of the left hand such that they are in three mutually perpendicular directions. *If the forefinger points in the direction of magnetic field, the middle finger in the direction of the electric current, then thumb will point in the direction of the force experienced by the conductor.	1 1
19.	**Ways of producing induced emf:** *Induced emf can be produced by changing magnetic flux in any of the following ways. [Page: 2]	2

	(i) By changing the magnetic field B (ii) By changing the area A of the coil and (iii) By changing the relative orientation θ of the coil with magnetic field.	
20.	**Properties of Cathode rays:** (1) Cathode rays possess energy and \momentum and travel in a straight line with high speed of the order of 10^7 m s^{-1} * It can be deflected by application of electric and magnetic fields. The direction of deflection indicates that they are negatively charged particles. (2) When the cathode rays are allowed to fall on matter, they produce heat. They affect the photographic plates and also produce fluorescence when they fall on certain crystals and minerals.	1 1
21.	**Work function & Unit:** The minimum energy needed for an electron to escape from the metal surface is called work function of that metal. The work function of the metal is denoted by \O and is measured in electron volt (eV).	1 1
22.	**Problem:** **Solution:** * Angle of minimum deviation, D = 37 ° * Angle of an equilateral prism, A = 60° * Refractive index of the material prism, n = sin [(A + D)/2] / (sin A/2) * n = sin [(60° + 37°)/2] / (sin 60°/2) * n = sin [(97°)/2] / (sin 30°) * n = sin [(48.5°] / (1/2) * n = 2 x sin [(48.5°] = 2 x 0.76 = 1.52 (no unit).	1 1
23.	**Problem:** **Solution:** * Applied voltage, V = 10 V * $R_1 = 2\ \Omega$, $R_2 = 3\ \Omega$, $R_3 = 2\ \Omega$, * Since D_1 is reverse biased & D_2 is forward biased * Effective resistance, $R_s = R_1 + R_3 = 2\ \Omega + 2\ \Omega = 4\ \Omega$ * Current, I = V/R = 10 / 4 = 2.5 A	1 1
24.	* **Compulsory Problem:** * **Solution:** * Amplitude of electric field, $E_o = 3 \times 10^4$ N C^{-1} * Amplitude of magnetic field, $B_0 = 2 \times 10^{-4}$ T * Speed of the electromagnetic wave, $v = (E_o / B_o)$ * $v = (3 \times 10^4 / 2 \times 10^{-4})$ * $v = 1.5 \times 10^8$ m s^{-1}	1 1

PART - C

III. Answer any 6 questions. (Q.No. 33 is compulsory) 6 x 3 = 18

Q. NO	ANSWER	MARKS
25.	**Applications of capacitors** Capacitors are used in various electronics circuits. A few of the applications. (a) Flash capacitors are used in digital Cameras for taking photographs. The flash which comes from the camera when we take photographs is due to the energy released from the capacitor, called a flash capacitor. (b) During cardiac arrest, a device called heart defibrillator is used to give a sudden surge of a large amount of electrical energy to the patient's chest to retrieve the normal heart function. (c) Capacitors are used in the ignition system of automobile engines to eliminate sparking (d) Capacitors are used to reduce power fluctuations in power supplies and to increase the efficiency of power transmission. However, capacitors have disadvantage as well. Even after the battery or power supply is removed, the capacitor stores charges and energy for some time. For example if the TV is switched off, it is always advisable to not touch the back side of the TV panel.	3
26.	Resistors in parallel Resistors are in parallel when they are connected across the same potential difference as shown in Figure 2.10 (a). In this case, the total current I that leaves the battery is split into three separate components. Let I_1 , I_2 and I_3 be the current through the resistors R_1 , R_2 and R_3 respectively. Due to the conservation of charge, total current in the circuit I is equal to sum of the currents through each of the three resistors. 	3

$$I = I_1 + I_2 + I_3 \quad (2.24)$$

Since the voltage across each resistor is the same, applying Ohm's law to each resistor, we have

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{V}{R_3} \quad (2.25)$$

Substituting these values in equation (2.24),we get

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

$$I = \frac{V}{R_P}$$

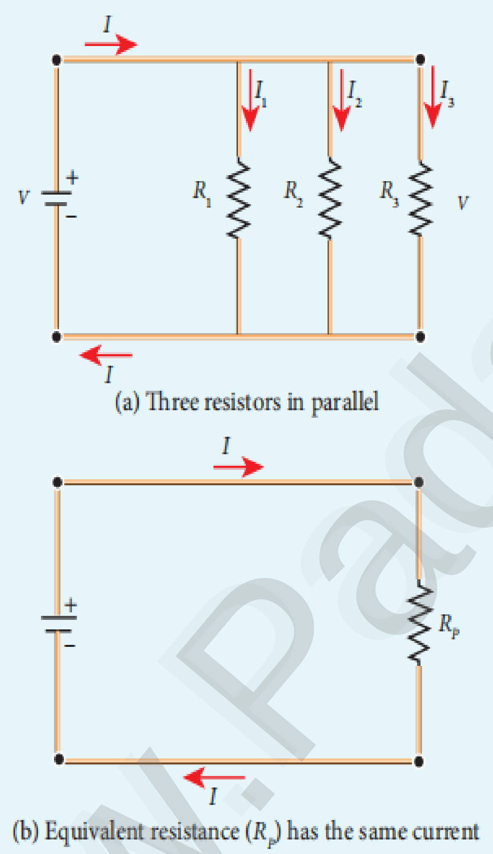


Figure 2.10 Resistors in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad (2.26)$$

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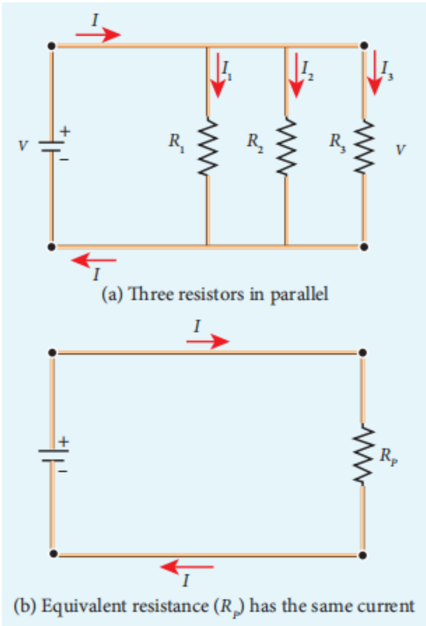

Figure 2.10 Resistors in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad (2.26)$$

* Here RP is the equivalent resistance of the parallel combination of the resistors.
* Thus, when a number of resistors are connected in parallel, the sum of the reciprocals of resistance of the individual resistors is equal to the reciprocal of the effective resistance of the combination as shown in the Figure .
Note: * The value of equivalent resistance in parallel connection will be lesser than each individual resistance.
* House hold appliances are always connected in parallel so that even if one is switched off, the other devices could function properly
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<u>Galvanometer to an Ammeter</u>

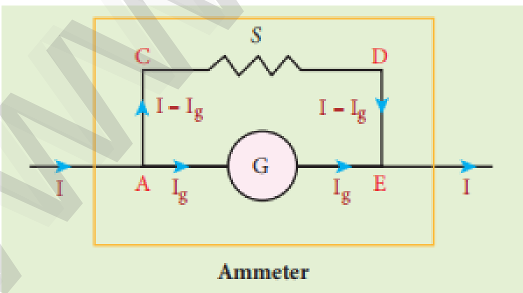

Figure 3.61 Shunt resistance connected in parallel

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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.

<u>Galvanometer to a voltmeter</u>

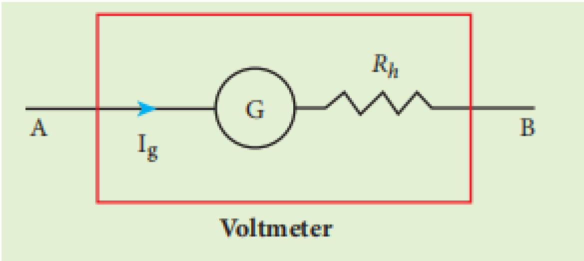

Figure 3.62 High resistance connected in series

A galvanometer is converted into a voltmeter by connecting high resistance *Rh* in series with galvanometer
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Properties of electromagnetic waves
1. Electromagnetic waves are produced by any accelerated charge.
2. Electromagnetic waves do not require any medium for propagation. So electromagnetic wave is a non-mechanical wave.
3. Electromagnetic waves are transverse in nature. The oscillating electric field vector, oscillating magnetic field vector and propagation vector (gives direction of propagation) are mutually perpendicular to

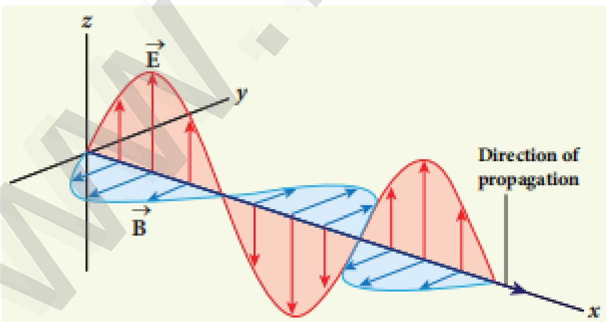

Figure 5.8 Electromagnetic waves – transverse wave

[Page: 7]
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6 x 1/2 = 3</td>
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each other. For example, if the electric and magnetic fields are as shown in Figure 5.8, then the direction of propagation will be along x-direction.

4. Electromagnetic waves travel with speed which is equal to the speed of light in vacuum or free space, $c = 1/\sqrt{(\varepsilon_0 \mu_0)} = 3 \times 10^8\ m\ s^{-1}$, where is the permittivity of free space or vacuum and μo is the permeability of free space or Vacuum.

5. In a medium with permittivity ε and permeability μ, the speed of electromagnetic wave v is less than that in free space or vacuum (v < c).

6. Electromagnetic waves are not deflected by electric field or magnetic field.

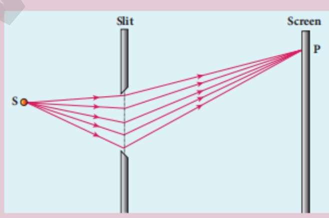
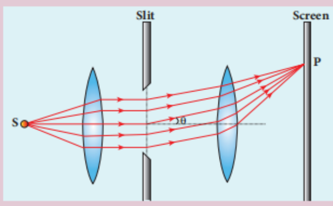
29. **Problem:**

Solution:

* Focal length of convex lens, f = + 20 cm
* Let object distance be 'u'
* Image distance 'v' is 4 times 'u'. ie v = 4u. — 1
* Lens formula is 1/v + 1/u = 1/f
* i.e (1/4u - 1/u)= 1/20
*(1 - 4)/ 4u =1/20
* (-3/4u) = 1/20 — 1
* 4u = - 60
* u = - 60 / 4 = - 15 cm
* ie Object distance, 'u' is 15 cm from the convex lens. — 1

30. — 3

Table 6.4 Difference between Fresnel and Fraunhofer diffractions

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	For laboratory conditions, convex lenses need not be used	In laboratory conditions, convex lenses are to be used
4	Difficult to observe and analyse	Easy to observe and analyse
5		

31.	Laws of photoelectric effect: i) For a given frequency of incident light, the number of photo electrons emitted is directly proportional to the intensity of the incident light. The saturation current is also directly proportional to the intensity of incident light. ii) Maximum kinetic energy of the photo electrons is independent of intensity of the incident light. iii) Maximum kinetic energy of the photo electrons from a given metal is directly proportional to the frequency of incident light. iv) For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the threshold frequency. v) There is no time lag between incidence of light and ejection of photo electrons.	3
32.	**Problem:** * **Solution:** * Self inductance of an air-core solenoid, L_1 = 4.8 mH 4.8 x 10^{-3} H * Self inductance of an Iron core solenoid, L_2 = 1.8 H * Relative permeability, $\mu_r = L_2/L_1$ = [1.8 /(4.8 x 10^{-3})] = 1000/3 = 333.	
33.	**Compulsory Problem:** * **Solution:** * $1/\lambda = R(1/n^2 - 1/m^2)$ * Minimum wavelength in Balmer series, $1/\lambda_m = R(1/2^2 - 1/3^2)$ * $1/\lambda_m$ = R(1/4 - 1/9) where n is 2 and m is 3 * $1/\lambda_m$ = R(9/36 - 4/36) = R (5/36) * λ_m = (36 /5 R) Maximum wavelength in Balmer series, $1/\lambda_\infty = R(1/2^2 - 1/\infty^2)$ *$1/\lambda_\infty$= R(1/4 - 0) where n is 2 and m is ∞ and $1/\infty^2 = 0$. * $1/\lambda_\infty$ = R(1/4) = R/4) * λ_∞ = 4/R * The ratio of minimum to maximum wavelength in Balmer series is (λ_m / λ_∞) = (36 /5R) / (4/R) = (36 R) /(5R x 4) = 36/20 = 9/4 * $\lambda_m : \lambda_\infty$ = 9 : 4	 1 1 1

PART - D

II. Answer all the questions. 5 x 5 = 25

Q. NO	ANSWER	MARKS
34. a)	**Electrostatic potentialat a point due to an electric dipole** * Consider two equal and opposite charges separated by a small distance 2a as shown in Figure. * The point P is located at a distance r from the midpoint of the dipole. [Page: 9]	

Let θ be the angle between the line OP and dipole axis AB. 1

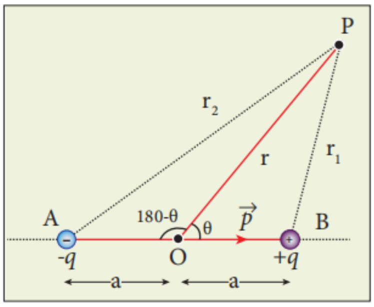


Figure 1.25 Potential due to electric dipole

Let r_1 be the distance of point P from $+q$ and r_2 be the distance of point P from $-q$.

Potential at P due to charge $+q = \frac{1}{4\pi\epsilon_o}\frac{q}{r_1}$

Potential at P due to charge $-q = -\frac{1}{4\pi\epsilon_o}\frac{q}{r_2}$

Total potential at the point P

$$V = \frac{1}{4\pi\epsilon_o} q\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad (1.35)$$ 1

Suppose if the point P is far away from the dipole, such that r>>a, then equation can be expressed in terms of r.

By the cosine law for triangle BOP

$$r_1^2 = r^2 + a^2 - 2ra\cos\theta$$

$$r_1^2 = r^2\left(1 + \frac{a^2}{r^2} - \frac{2a}{r}\cos\theta\right)$$

Since the point P is very far from the dipole ($r>>a$). As a result the term $\frac{a^2}{r^2}$ is very small and can be neglected. Therefore

1

$$r_1^2 = r^2\left(1 - 2a\frac{\cos\theta}{r}\right)$$

$$\text{(or)}\quad r_1 = r\left(1 - \frac{2a}{r}\cos\theta\right)^{\frac{1}{2}}$$

$$\frac{1}{r_1} = \frac{1}{r}\left(1 - \frac{2a}{r}\cos\theta\right)^{-\frac{1}{2}}$$

Since $\frac{a}{r} << 1$, we can use binomial theorem and retain the terms up to first order

$$\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{a}{r}\cos\theta\right) \qquad (1.36)$$

Similarly applying the cosine law for triangle AOP,

$$r_2^2 = r^2 + a^2 - 2ra\cos(180-\theta)$$

since $\cos(180-\theta) = -\cos\theta$ we get

$$r_2^2 = r^2 + a^2 + 2ra\cos\theta$$

Neglecting the term $\frac{a^2}{r^2}$ (because $r >> a$)

$$r_2^2 = r^2\left(1 + \frac{2a\cos\theta}{r}\right)$$

$$r_2 = r\left(1 + \frac{2a\cos\theta}{r}\right)^{\frac{1}{2}}$$

Using Binomial theorem, we get

$$\frac{1}{r_2} = \frac{1}{r}\left(1 - a\frac{\cos\theta}{r}\right) \qquad (1.37)$$

Substituting equation (1.37) and (1.36) in equation (1.35),

$$V = \frac{1}{4\pi\epsilon_\circ}q\left(\frac{1}{r}\left(1 + a\frac{\cos\theta}{r}\right) - \frac{1}{r}\left(1 - a\frac{\cos\theta}{r}\right)\right)$$

$$V = \frac{q}{4\pi\epsilon_\circ}\left(\frac{1}{r}\left(1 + a\frac{\cos\theta}{r} - 1 + a\frac{\cos\theta}{r}\right)\right)$$

$$V = \frac{1}{4\pi\epsilon_\circ}\frac{2aq}{r^2}\cos\theta$$

[Page: 11]

	But the electric dipole moment $p = 2qa$ and we get, $$V = \frac{1}{4\pi\epsilon_0}\left(\frac{p\cos\theta}{r^2}\right)$$ Now we can write p $\cos\theta = \vec{p}\cdot\hat{r}$, where $\hat{r}$ is the unit vector from the point O to point P. Hence the electric potential at a point P due to an electric dipole is given by $$V = \frac{1}{4\pi\epsilon_\circ}\frac{\vec{p}\cdot\hat{r}}{r^2} \quad (r>>a) \qquad (1.38)$$ Equation (1.38) is valid for distances very large compared to the size of the dipole. But for a point dipole, the equation (1.38) is valid for any distance. Special cases Case (i) If the point P lies on the axial line of the dipole on the side of +q, then θ = 0. Then the electric potential becomes $$V = \frac{1}{4\pi\epsilon_\circ}\frac{p}{r^2} \qquad (1.39)$$ **Case (ii)** If the point P lies on the axial line of the dipole on the side of $-q$, then θ = 180°. Then $$V = -\frac{1}{4\pi\epsilon_\circ}\frac{p}{r^2} \qquad (1.40)$$ **Case (iii)** If the point P lies on the equatorial line of the dipole, then θ = 90°. Hence $$V = 0 \qquad (1.41)$$ -- (OR)	1 1

34.b)

Force on a current carrying conductor placed in a magnetic field

* When a current carrying conductor is placed in a magnetic field, the force experienced by the conductor is equal to the sum of Lorentz forces on the individual charge carriers in the conductor. 1

* Consider a small segment of conductor of length dl, with cross-sectional area A and current I as shown in Figure.

* The free electrons drift opposite to the direction of current. So the relation between current I and magnitude of drift velocity v_d

* $I = neAv_d$

* If the conductor is kept in a magnetic field B, then average force experienced by the charge (electron) in the conductor is

$$\vec{f} = -e(\vec{v}_d \times \vec{B})$$

*If n is the number of free electrons present in unit volume, then $n = N/V$

where N is the number of free electrons in the small element of volume $V = Adl$. 1

* Hence Lorentz force on the elementary section of length dl is the product of the number of the electrons ($N = nAdl$) and the force acting on each electron.

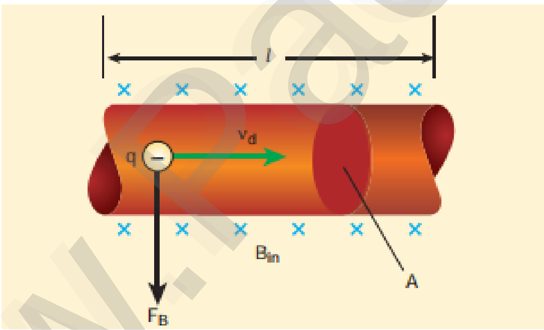


Figure 3.51 Current carrying conductor in a magnetic field 1

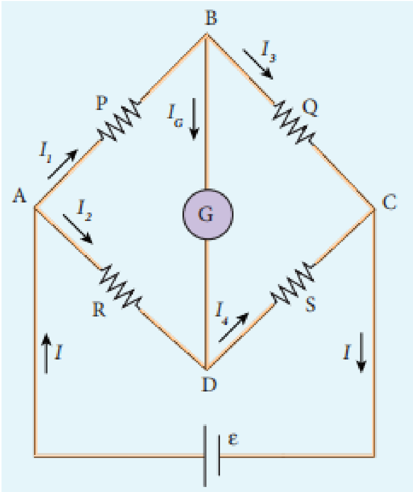
$$d\vec{F} = -enAdl(\vec{v}_d \times \vec{B})$$

The current element in the conductor is $Id\vec{l} = -enA\vec{v}_d dl$. Therefore the force on the small elemental section of the current-carrying conductor is 1

$$d\vec{F} = (I\,d\vec{l} \times \vec{B}) \quad (3.66)$$

[Page:13]

	* Thus the force on a straight current carrying conductor of length l placed in a uniform magnetic field is $\vec{F}_{total} = (I\vec{l} \times \vec{B})$ In magnitude, $F_{total} = BIl\sin\theta$ (a) If the conductor is placed along the direction of the magnetic field, the angle then $\theta = 0^o$. * Hence, the force experienced by the conductor is zero. (b) If the conductor is placed perpendicular to the magnetic field, then the angle $\theta = 90^o$ * Hence, the force experienced by the conductor is maximum, which is $F_{total} = BIl$.	1
35. a)	**Wheatstone's bridge** * An important application of Kirchhoff 's rules is the Wheatstone's bridge. It is used to compare resistances and in determining the unknown resistance in electrical network. * The bridge consists of four resistances P, Q, R and S connected as shown in Figure. * A galvanometer G is connected between the points B and D. The battery is connected between the points A and C. * The current through the galvanometer is I_G and its resistance is G. * Applying Kirchhoff 's current rule to junction B and D respectively Applying Kirchhoff's voltage rule to loop $ABDA$, $I_1P + I_GG - I_2R = 0$ (2.47) Applying Kirchhoff's voltage rule to loop $ABCDA$, $I_1P + I_3Q - I_4S - I_2R = 0$ (2.48) When the points B and D are at the same potential, the bridge is said to be balanced. As there is no potential difference between B and D, no current [Page:14]	1 1

		1
	Figure 2.25 Wheatstone's bridge	
	flows through galvanometer (I_G = 0). Substituting I_G = 0 in equation (2.45), (2.46) and (2.47), we get	
	$I_1 = I_3$ (2.49)	1
	$I_2 = I_4$ (2.50) $I_1 P = I_2 R$ (2.51)	
	Using equation (2.51) in equation (2.48)	
	$I_3 Q = I_4 S$ (2.52)	
	Dividing equation (2.52) by equation (2.51), we get	1
	$\frac{P}{Q} = \frac{R}{S}$ (2.53)	
	* This is the condition for bridge balance. * Only under this condition, galvanometer shows null deflection. * * Suppose we know the values of two adjacent resistances, the other two resistances can be compared. * If three of the resistances are known, the value of unknown resistance (fourth one) can be determined. --- [OR]	

[Page:15]

35.b)

AC circuit containing a resistor, an inductor and a capacitor in series – Series RLC circuit

1

* Consider a circuit containing a resistor of resistance R, an inductor of inductance L and a capacitor of capacitance C connected across an alternating voltage source.
* The instantaneous value of the alternating voltage is given by

$$v = V_m \sin\omega t$$

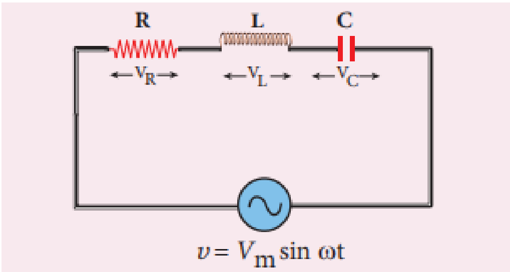


Figure 4.46 AC circuit containing *R*, *L* and *C*

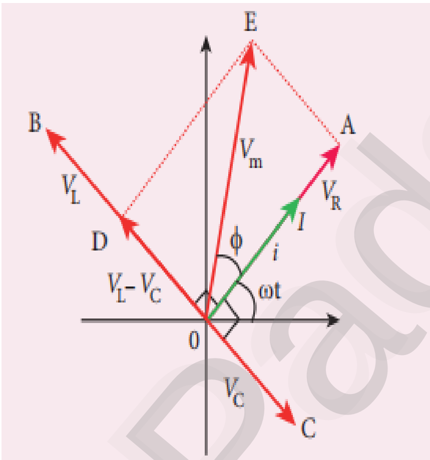


Figure 4.47 Phasor diagram for a series *RLC* – circuit when $V_L > V_C$

1

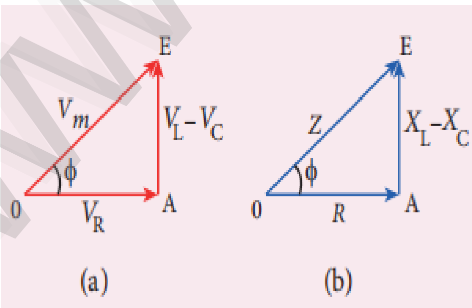


Figure 4.48 Voltage and impedance triangle when $X_L > X_C$

[Page:16]

Let i be the resulting current in the circuit at that instant. As a result, the voltage is developed across R, L and C. 1

We know that voltage across R (V_R) is in phase with i, voltage across L (V_L) leads i by $\pi/2$ and voltage across C (V_C) lags behind i by $\pi/2$.

The phasor diagram is drawn with current as the reference phasor. The current is represented by the phasor $\overline{OI}$, V_R by $\overline{OA}$; V_L by $\overline{OB}$ and V_C by $\overline{OC}$ as shown in Figure 4.47.

The length of these phasors are

$$OI = I_m,\ OA = I_mR,\ OB = I_mX_L;\ OC = I_mX_C$$

The circuit is either effectively inductive or capacitive or resistive depending on the value of V_L or V_C. Let us assume that $V_L > V_C$. Therefore, net voltage drop across L-C combination is $V_L - V_C$ which is represented by a phasor $\overline{OD}$. 1

By parallelogram law, the diagonal $\overline{OE}$ gives the resultant voltage v of V_R and $(V_L - V_C)$ and its length OE is equal to V_m. Therefore,

$$V_m^2 = V_R^2 + (V_L - V_C)^2$$

$$V_m = \sqrt{(I_mR)^2 + (I_mX_L - I_mX_C)^2}$$

$$= I_m\sqrt{R^2 + (X_L - X_C)^2} \text{ or}$$

$$I_m = \frac{V_m}{\sqrt{R^2 + (X_L - X_C)^2}} \text{ or} \qquad (4.46)$$

$$I_m = \frac{V_m}{Z}$$

where $$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad (4.47)$$

	[Page:17] * Z is called impedance of the circuit which refers to the effective opposition to the current by the series *RLC* circuit. * The voltage triangle and impedance triangle are given. * From phasor diagram, the phase angle between *v* and *i* is found out from the following relation. $\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$ **Special cases** (i) If $X_L > X_C$, $(X_L - X_C)$ is positive and phase angle ϕ is also positive. It means that the applied voltage leads the current by ϕ (or current lags behind voltage by ϕ). The circuit is inductive. $\therefore i = I_m \sin\omega t;\ v = V_m \sin(\omega t + \phi)$ (ii) If $X_L < X_C$, $(X_L - X_C)$ is negative and ϕ is also negative. Therefore current leads voltage by ϕ (or voltage lags behind current by ϕ) and the circuit is capacitive. $\therefore i = I_m \sin\omega t;\ v = V_m \sin(\omega t - \phi)$ (iii) If $X_L = X_C$, ϕ is zero. Therefore current and voltage are in the same phase and the circuit is resistive. $\therefore v = V_m \sin\omega t;\quad i = I_m \sin\omega t$	1
36.a)	(a)Emission spectra * When the spectrum of self luminous source is taken, we get emission spectrum. * Each source has its own characteristic emission spectrum. *The emission spectrum can be divided into three types: (i) Continuous emission spectrum (or continuous spectrum) If the light from incandescent lamp (filament bulb) is allowed to	1

pass through prism (simplest spectroscope), it splits up into seven colours. [Page: 18] 1

* Thus, it consists of wavelengths containing all the visible colours ranging from violet to red.

* Examples: spectrum obtained from carbon arc and incandescent solids.

(ii) Line emission spectrum (or line spectrum):

* Suppose light from hot gas is allowed to pass through prism, line spectrum is observed (Figure 5.14). Line spectra are also known as discontinuous spectra.

* The line spectra consists of sharp lines of definite wavelengths or frequencies.

* Such spectra arise due to excited atoms of elements. 1

*These lines are the characteristics of the element and are different for different elements.

* Examples: spectra of atomic hydrogen, helium, etc.

(iii) Band emission spectrum (or band spectrum)

* Band spectrum consists of several number of very closely spaced spectral lines which overlap together forming specific bands which are separated by dark spaces.

* This spectrum has a sharp edge at one end and fades out at the other end. 1

* Such spectra arise when the molecules are excited.

* Band spectrum is the characteristic of the molecule and hence the structure of the molecules can be studied using their band spectra.

* Example: spectra of ammonia gas in the discharge tube etc.

Figure 5.13 continuous emission spectra

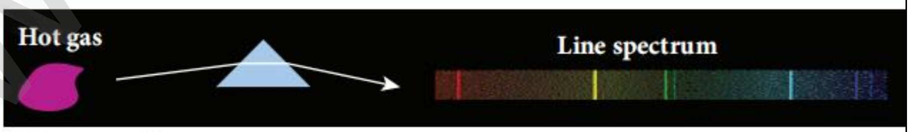


Figure 5.14 line emission spectra 1

[OR]

	\ [Page:19]	
36. a)	Lens maker's formula and lens equation: * Let us consider a thin lens made up of a medium of refractive index n_2 is 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. * Consider a point object O on the principal axis. The ray 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 spherical surface is given from Equation	1
	$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$ For the refracting surface ①, the light goes from n_1 to n_2. $\frac{n_2}{v'} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R_1}$ (6.64) For the refracting surface ②, the light goes from medium n_2 to n_1. $\frac{n_1}{v} - \frac{n_2}{v'} = \frac{(n_1 - n_2)}{R_2}$ (6.65)	1
	Adding the above two equations (6.64) and (6.65) $\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	1
	Further simplifying and rearranging,	

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

1

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

[Page:20]

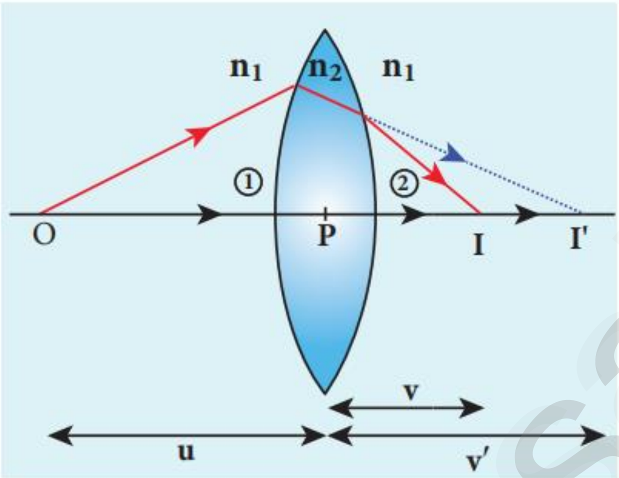


Figure 6.34 Refraction through thin lens

* 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.

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

1

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

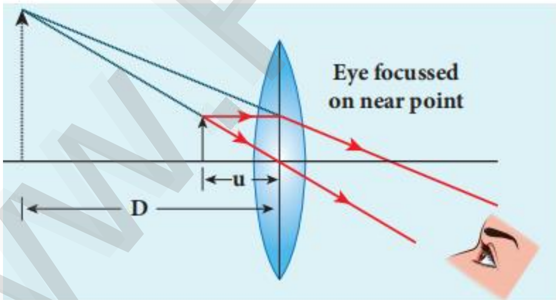
* If the refractive index of the lens is n_2 and it is placed in air, then $n_2 = n$ and $n_1 = 1$. So the equation becomes,

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

*The above equation is called the *lens maker's formula*, because it tells the lens manufactures what curvature is needed to make a lens of desired focal length with a material of particular refractive index.

* This formula holds good also for a concave lens.

* By comparing the equations, we can write,

	$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$ * This equation is known as *lens equation* which relates the object distance *u* and image distance *v* with the focal length *f* of the lens. * This formula holds good for a any type of lenS.	
37.a)	[Page: 21] * A simple microscope is a single magnifying (converging) lens of small focal length. * The idea is to get an erect, magnified and virtual image of the object. * For this the object is placed between F and P on one side of the lens and viewed from other side of the lens. * There are two magnifications to be discussed for two kinds of focussing. (1) *Near point focusing* – * The image is formed at near point, i.e. 25 cm for normal eye. * This distance is also called as *least distance D* of distinct vision. In this position, the eye feels comfortable but there is little strain on the eye. (2) *Normal focusing* – * The image is formed at infinity. In this position the eye is most relaxed to view the image. * Magnification in near point focusing  Figure 6.83 Near point focusing	1 1

	$$m = \frac{v}{u} \quad (6.172)$$ With the help of lens equation, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ he magnification can further be written as, $$m = 1 - \frac{v}{f} \quad (6.173)$$ Substituting for v with sign convention, $v = -D$ $$m = 1 + \frac{D}{f} \quad (6.174)$$ [Page: 22] * The near point focusing is the Object distance u is less than f. * The image distance is the near point D. * The magnification m is given by the relation,	1 1
	* **Magnification in normal focusing (angular magnification)** * We will now find the magnification for the image formed at infinity. * If we take the ratio of height of image to height of object $m = h'/h$ to find the magnification, we will not get a practical relation, as the image will also be of infinite size when the image is formed at infinity. * Hence, we can practically use the angular magnification. * The angular magnification is defined as the ratio of angle θ_i subtended by the image with aided eye to the angle θ_o subtended by the object with unaided eye.	1

$$m = \frac{\theta_i}{\theta_0} \quad (6.175)$$

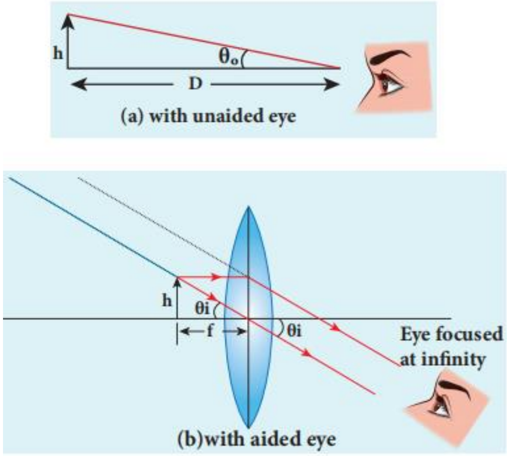


Figure 6.84 Normal focusing

* The magnification for normal focusing is one less than that for near point focusing.
* But, the viewing is more comfortable in normal focusing than near point focusing.
* For large values of D/f, the difference in magnification is usually small.

[Page: 23]

For unaided eye shown in Figu

$$\tan\theta_0 \approx \theta_0 = \frac{h}{D}$$

For aided eye shown in Figure

$$\tan\theta_i \approx \theta_i = \frac{h}{f}$$

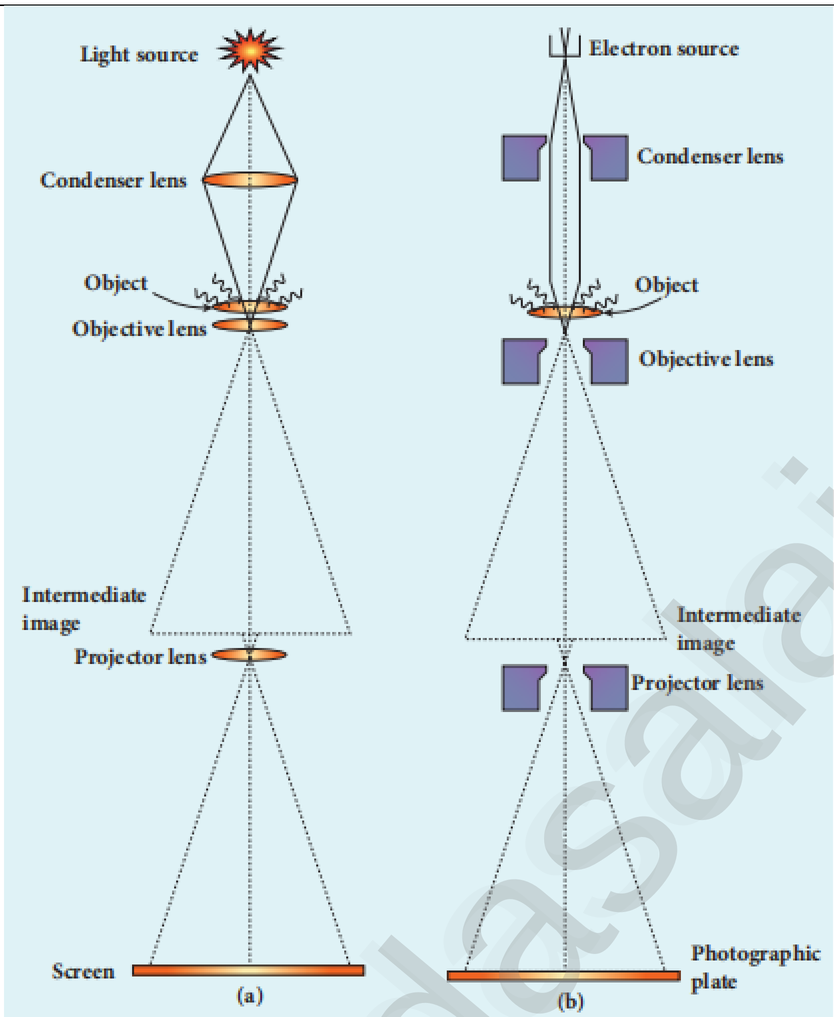
The angular magnification is,

$$m = \frac{\theta_i}{\theta_0} = \frac{h/f}{h/D}$$

$$m = \frac{D}{f}$$

* The magnification for normal focusing is one less than that for near point focusing.

	* But, the viewing is more comfortable in normal focusing than near point focusing. * For large values of D/f, the difference in magnification is usually small. --- **[OR]**	
37. b)	Electron Microscope Principle * This is the direct application of wave nature of particles. * The wave nature of the electron is used in the construction of microscope called electron microscope. * The resolving power of a microscope is inversely proportional to the wavelength of the radiation used for illuminating the object under study. * Higher magnification as well as higher resolving power can be obtained by employing the waves of shorter wavelengths. * De Broglie wavelength of electron is very much less than (a few thousands less) that of the visible light being used in optical microscopes. [Page: 24]	**1** **1**



* As a result, the microscopes employing de Broglie waves of electrons have very much higher resolving power than optical microscope. Electron microscopes giving magnification more than 2,00,000 times are common in research laboratories. 1

Working

* The construction and working of an electron microscope is similar to that of an optical microscope except that in electron microscope focussing of electron beam is done by the electrostatic or magnetic lenses.

* The electron beam passing across a suitably arranged either electric or magnetic fields undergoes divergence or convergence thereby focussing of the beam is done.

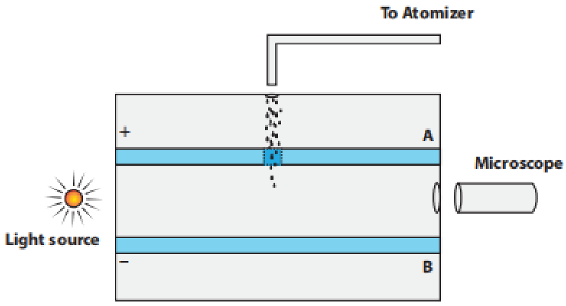
* The electrons emitted from the source are accelerated by high potentials.

* The beam is made parallel by magnetic condenser lens.

* When the beam passes through the sample whose magnified

1

1

	image is needed, the beam carries the image of the sample. * With the help of magnetic objective lens and magnetic projector lens system, themagnified image is obtained on the screen. * These electron microscopes are being used in almost all branches of science.	
38. a)	**Determination of charge of an electron – Millikan's oil drop experiment.**  * Millikan's oil drop experiment is another important experiment in modern physics which is used to determine one of the fundamental constants of nature known as charge of an electron. * By adjusting electric field suitably, the motion of oil drop inside the chamber can be controlled – that is, it can be made to move up or down or even kept balanced in the field of view for sufficiently long time. *The apparatus consists of two horizontal circular metal plates A and B each with diameter around 20 cm and are separated by a small distance 1.5 cm. * These two parallel plates are enclosed in a chamber with glass walls. Further, plates A and B are given a high potential difference around 10 kV such that electric field acts vertically downward. * A small hole is made at the centre of the upper plate A and atomizer is kept exactly above the hole to spray the liquid. When a fine droplet of highly viscous liquid (like glycerine) is sprayed using atomizer, it falls freely downward through the hole of the top plate only under the influence of gravity. * Few oil drops in the chamber can acquire electric charge (negative charge) because of friction with air or passage of x-rays in between the parallel plates. [Page: 26]	1 1

* Further the chamber is illuminated by light which is passed horizontally and oil drops can be seen clearly using microscope placed perpendicular to the light beam.

* These drops can move either upwards or downward. Let m be the mass of the oil drop and q be its charge.

* Then the forces acting on the droplet are

(a) gravitational force $F_g = mg$ (b) electric force $F_e = qE$

(c) buoyant force F_b (d) viscous force F_v

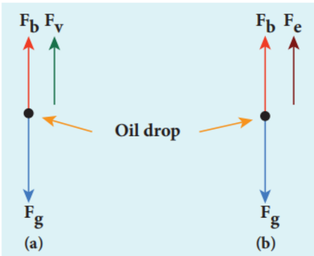


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Figure 8.7 Free body diagram of the oil drop – (a) without electric field (b) with electric field

(a) Determination of radius of the droplet

* When the electric field is switched off, the oil drop accelerates downwards.

* Due to the presence of air drag forces, the oil drops easily attain its terminal velocity and moves with constant velocity.

* This velocity can be carefully measured by noting down the time taken by the oil drop to fall through a predetermined distance.

* The free body diagram of the oil drop is shown in Figure.

* we note that viscous force and buoyant force balance the gravitational force.

* Let the gravitational force acting on the oil drop (downward) be $F_g = mg$

* Let us assume that oil drop to be spherical in shape.

* Let) be the density of the oil drop, and r be the radius of the oil drop, then the mass of the oil drop can be expressed in terms of its density as

* Once the oil drop attains a terminal velocity v, the net downward force acting on the oil drop is equal to the viscous force acting opposite to the direction of motion of the oil drop. [Page: 27]

1

$$\rho = \frac{m}{V}$$

$$\Rightarrow m = \rho\left(\frac{4}{3}\pi r^3\right) \qquad \left(\because \text{volume of the sphere}, V = \frac{4}{3}\pi r^3\right)$$

The gravitational force can be written in erms of density as

$$F_g = mg \Rightarrow F_g = \rho\left(\frac{4}{3}\pi r^3\right)g$$

Let σ be the density of the air, the ιpthrust force experienced by the oil drop lue to displaced air is

$$F_b = \sigma\left(\frac{4}{3}\pi r^3\right)g$$

* From Stokes law, the viscous force on the oil drop is

$F_v = 6$□r J|

From the free body diagram as shown in Figure 8.7 (a), the force balancing equation is

$$F_g = F_b + F_v$$

$$\rho\left(\frac{4}{3}\pi r^3\right)g = \sigma\left(\frac{4}{3}\pi r^3\right)g + 6\pi r\upsilon\eta$$

$$\frac{4}{3}\pi r^3(\rho - \sigma)g = 6\pi r\upsilon\eta$$

$$\frac{2}{3}\pi r^3(\rho - \sigma)g = 3\pi r\upsilon\eta$$

$$r = \left[\frac{9\eta\upsilon}{2(\rho - \sigma)g}\right]^{\frac{1}{2}} \qquad (8.11)$$

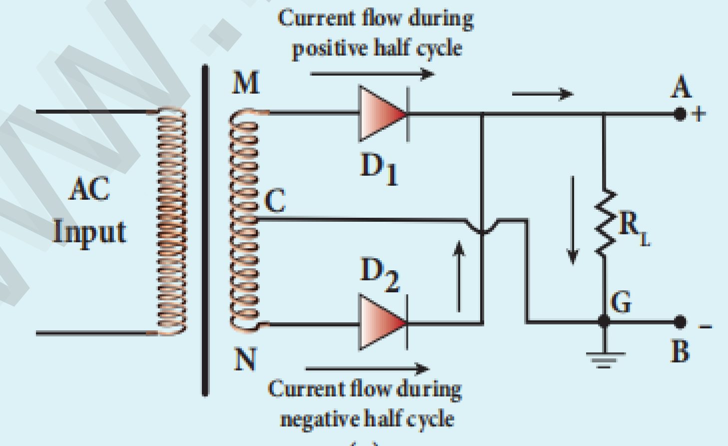
* Thus, equation (8.11) gives the radius of the oil drop.

(b) Determination of electric charge

* When the electric field is switched on, charged oil drops experience an upward electric force (qE).

* Among many drops, one particular drop can be chosen in the field of view of microscope and strength of the electric field is adjusted to make that particular drop to be stationary.

* Under these circumstances, there will be no viscous force acting on the oil drop.

	* Then, from the free body diagram shown Figure, the net force acting on the oil droplet is $F_e + F_b = F_g$ $\Rightarrow qE + \frac{4}{3}\pi r^3 \sigma g = \frac{4}{3}\pi r^3 \rho g$ $\Rightarrow qE = \frac{4}{3}\pi r^3 (\rho - \sigma) g$ $\Rightarrow q = \frac{4}{3E}\pi r^3 (\rho - \sigma) g \quad (8.12)$ Substituting equation (8.11) in equation (8.12), we get $q = \frac{18\pi}{E}\left(\frac{\eta^3 \upsilon^3}{2(\rho - \sigma) g}\right)^{\frac{1}{2}}$ * Millikan repeated this experiment several times and computed the charges on oil drops. * He found that the charge of any oil drop can be written as integral multiple of a basic value, $Q = -1.6 \times 10^{-19}$ coulomb which is nothing but the charge of an electron. --- [OR]	1
39. B)	**Full wave rectifier** * The positive and negative half cycles of the AC input signal pass through the full wave rectifier circuit and hence it is called the full wave rectifier. * The circuit is shown in Figure. * It consists of two p-n junction diodes, a center tapped.  (a) [Page: 29]	1 1

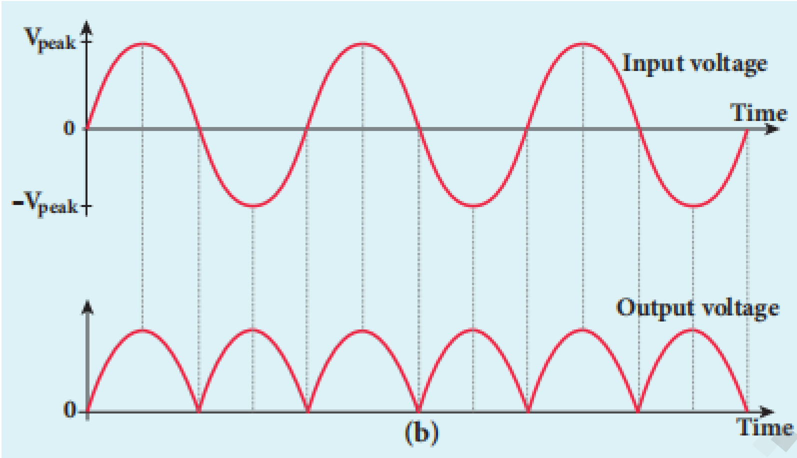


Figure 9.18 (a) Full wave rectifier circuit (b) Input and output waveforms

transformer, and a load resistor (R_L)

. The centre is usually taken as the ground or zero voltage reference point. 1

* Due to the centre tap transformer, the output voltage rectified by each diode is only one half of the total secondary voltage. 1

* *During positive half cycle* When the positive half cycle of the ac input signal passes through the circuit, terminal M is positive, G is at zero potential and N is at negative potential.

* This forward biases diode D1 and reverse biases diode D_2 .

* Hence, being forward biased, diode D_1 conducts and current flows along the path MD_1AGC.

* As a result, positive half cycle of the voltage appears across R_L in the direction G to C

* *During negative half cycle* When the negative half cycle of the ac input signal passes through the circuit, terminal N is positive, G is at zero potential and M is at negative potential.

* This forward biases diode D2 and reverse biases diode D_1 . Hence, being forward biased, diode D_2 conducts and current flows along the path ND_2BGC.

* As a result, negative half cycle of the voltage appears across R_L in the same direction from G to C

* Hence in a full wave rectifier both positive and negative half cycles of the input signal pass through the load in the same direction

* Though both positive and negative half cycles of ac input are rectified, the output is still pulsating in nature.
* The efficiency (η) of full wave rectifier is twice that of a half wave rectifier and is found to be 81.2 %. It is because both the positive and negative half cycles of the ac input source are rectified. 1

'ALL IS WELL THAT ENDS WELL'

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