R1025

No. of Printed Pages : 4

Register Number | | | | | | |

12

PART – III

, awgpay; / PHYSICS

(English Version)

Time Allowed : 3.00 Hours] [Maximum Marks : 70

Instructions :
(1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately
(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

PART – I

Note :
(i) Answer **all** the questions. **15x1=15**
(ii) Choose the most appropriate answer from the given **four** alternatives and write the option code and the corresponding answer.

1. An electric dipole is placed at an alignment angle of 30^0 with an electric field of 2×10^5 N C^{-1}. It experiences a torque equal to 8 N m. The charge on the dipole if the dipole length is 1 cm is
   (a) 4 mC (b) 8 mC (c) 5 mC (d) 7 mc
2. What is the value of resistance of the resistor having color coding of Brown, Black and Yellow?
   (a) 100 k Ω (b) 10 k Ω (c) 1k Ω (d) 1000 k Ω
3. The vertical component of Earth's magnetic field at a place is equal to the horizontal component. What is the value of angle of dip at this place?
   (a) 30^o (b) 45^o (c) 60^o (d) 90^o
4. In a transformer, the number of turns in the primary and the secondary are 410 and 1230 respectively. If the current in primary is 6A, then that in the secondary coil is
   (a) 2 A (b) 18 A (c) 12 A (d) 1 A
5. The electric and magnetic fields of an electromagnetic wave are
   (a) in phase and perpendicular to each other
   (b) out of phase and not perpendicular to each other
   (c) in phase and not perpendicular to each other
   (d) out of phase and perpendicular to each other
6. The speed of light in an isotropic medium depends on,
   (a) its intensity (b) its wavelength
   (c) the nature of propagation
   (d) the motion of the source w.r.t medium

[Turn Over

7. In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to,

(a) 2D (b) $\frac{D}{2}$ (c) $\sqrt{2D}$ (d) $\frac{D}{\sqrt{2}}$

8. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de Broglie wavelength associated with the electrons would

(a) increase by 2 times (b) decrease by 2 times
(c) decrease by 4 times (d) increase by 4 times

9. The ratio of the wavelengths radiation emitted for the transition from n =2 to n = 1 in Li^{++}, He^{+} and H is

(a)1: 2: 3 (b) 1: 4: 9 (c) 3:2:1 (d) 4:9:36

10. The zener diode is primarily used as

(a) Rectifier (b) Amplifier (c) Oscillator (d) Voltage regulator

11. The alloys used for muscle wires in Robots are

(a) Shape memory alloys (b) Gold copper alloys
(c) Gold silver alloys (d) Two dimensional alloys

12. A light emitting diode (LED) has a voltage drop of 2 V across it and passes a current of 10 mA. When it operates with a 6 V battery through a limiting resistor R, the value of R is

(a) 4 kΩ (b) 40 kΩ (c) 400 kΩ (d) 200 kΩ

13. An emf of 0.08 V is induced in a metal rod of length 10 cm held normal to a uniform magnetic field of 0.4 T, when move with a velocity of:

(a) 3.2 ms^{-1} (b) 20 ms^{-1} (c) 2 ms^{-1} (d) 0.5 ms^{-1}

14. By a monochromatic wave, we mean

(a) a single ray (b) A single ray of a single colour
(c) Wave having a single wavelength (d) Many rays of a single colour

15. Assertion: (A)

Electric energy consumption is measured in commercial units.

Reason: (R) Kilovolt-ampere and kilowatt-hour have the same dimensions.

(a) Both (A) and (R) are true and the reason is not the correct explanation of the assertion.
(b) Both (A) and (R) are true but the Reason is not the correct explanation of the Assertion.
(c) (A) is true statement but Reason is false.
(d) Both (A) and (R) are false statements.

PART – II

Note : Answer **any six** questions. Question No. **19** is **compulsory.** **6x2=12**

16. Define displacement current.
17. Why is it safer to be inside a car than sanding under a tree during lighting?
18. Distinguish between ohmic and non-ohmic materials.
19. compute the magnitude of the magnetic field of a long straight wire carrying a current of 1 A at distance of 1 m from it.
20. State Lenz's law.
21. What is optical path?
22. Find the polarizing angle for glass of refractive index 1.5.
23. Give the Barkhausen conditions for sustained oscillations.
24. Write any four properties of the cathode ray.

PART – III

Note : Answer **any six** questions. Question No. **29** is **compulsory.** **6x3=18**

25. Write uses of the polaroid's.
26. State the postulates of Bohr atom model.
27. What is the necessity of modulation?
28. Obtain the macroscopic form of ohm's law from its microscopic form.
29. What is the focal length of the combination if the lenses of focal lengths – 70 cm and 150 cm are in contact? What is the power of the combination?
30. Mention the various energy losses in a transformer. How it is minimized?
31. Calculate the torque acting on a bar magnet in uniform magnetic field.
32. Derive an expression for the energy stored in capacitor.
33. Write a note on continuous X-ray spectrum.

[Turn Over

PART – IV

Note : Answer **all** the questions. **5x5=25**

34. (a) Derive an expression for electrostatic potential due to electric dipole.

(OR)

(b) Draw the circuit diagram of a full wave rectifier and explain its working.

35. (a) Explain the determination of the internal resistance of a cell using voltmeter.

(OR)

(b) Describe the Fizeau's method to determine speed of light.

36. (a) What do you mean by electron emission? Explain briefly various methods of electron emission.

(OR)

(b) Derive an expression for phase angle between the applied voltage and current in a series RLC circuit.

37. (a) (i) Write down any six properties of electromagnetic waves.

(ii) The relative permeability of the medium is 2.5 and the relative electrical permittivity of the medium is 2.25. Compute the refractive index of the medium.

(OR)

(b) Discuss about astronomical microscope and obtain the equation for magnification.

38. (a) Obtain the law of radioactivity.

(OR)

(b) Obtain a force between two long parallel current carrying conductors and hence define ampere.

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HIGHER SECONDARY - SECOND YEAR FIRST REVISION EXAMINATION – JANUARY 2025

PHYSICS KEY ANSWER

Note:

1. Answers written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and write the option code and the corresponding answer.
3. For answers 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 changing the concepts and without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining correct steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

PART – I

Answer all the questions. 15x1=15

Q. No.	OPTION	ANSWER	Q. No.	OPTION	ANSWER
1	(b)	8 mc	9	(d)	4:9:36
2	(a)	100 k Ω	10	(d)	Voltage regulator
3	(b)	45^0	11	(a)	Shape memory alloys
4	(a)	2A	12		Mere attempt Correct Answer :400 Ω
5	(a)	in phase and perpendicular to each other	13	(c)	2 ms^{-1}
6	(b)	its wavelength	14	(c)	Wave having a single wavelength
7	(a)	2D	15	(c)	(A) is true statement but Reason is false.
8	(c)	decrease by 4 times			

PART – II

Answer any **six** questions. Question number **24** is compulsory. 6x2=12

16	**Displacement current:** The displacement current can be defined as **the current which comes into play in the region in which the electric field and the electric flux are changing with time.** That is whenever the change in electric field takes place, displacement current is produced.	2
17	The metal body of the car provides electrostatic shielding, where the **electric field is zero.** During lightning the **electric discharge** passes through the body of the car.	2

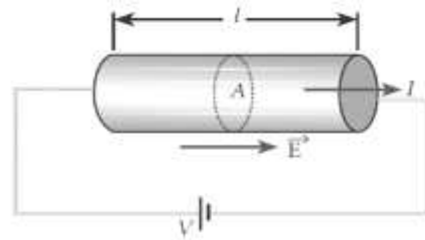
DEPARTMENT OF PHYSICS, SRMHSS, KAVERIYAMPOONDI, TIRUVANNAMALAI.

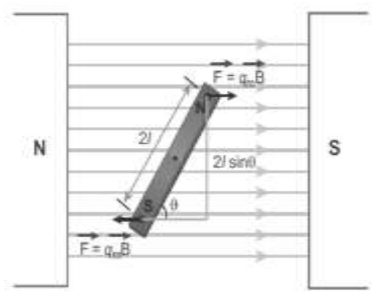
18	**S. No.**	**Ohmic Material**	**Non-Ohmic Material**	2
	1	Substances which **obey ohm's law** are called ohmic substances	Substances which **do not obey ohm's** law are called non-ohmic substances	
	2	Potential difference (V) versus current (I) curve is a **straight line.**	Potential difference (V) versus current (I) curve is **not a straight line.**	
	3	$R = \frac{V}{I}$	$R = \frac{dV}{dI}$	
	4	Examples: Gold , Silver, Copper	Example: Junction diode, Thermistors	
19	$B_{\text{straight wire}} = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 1}{2\pi \times 1} = 2 \times 10^{-7}$ T But the Earth's magnetic field is $B_{Earth} \sim 10^{-5}$T So, $B_{straight\ wire}$ is one hundred times smaller B_{Earth}			2
20	**Lenz's law:** Lenz's law states that the direction of the **induced current** is such that is **always opposes** the cause responsible for its production.			2
21	**Optical path:** Optical path of a medium is defined as **the distance (d') light travels in vacuum in the same time it travels a distance (d) in the medium**. If 'n' is the refractive index of the medium, then optical path is; $\mathbf{d' = n\,d}$			2
22	Brewster's law, $\tan i_P = n$ For glass, $\tan i_P = 1.5$; $i_P = \tan^{-1} 1.5$; i_P **= 56.3⁰**			2
23	**Barkhausen conditions for sustained oscillations:** The loop phase shift must be 0^0 **or integral multiples of 2π.** The loop gain must be unity. $\mathbf{|A\beta| = 1}$ Here, A ⟶ Voltage gain of the amplifier, β ⟶ Feedback ratio			2
24	**Properties of cathode rays: (Any 4)** 1) Cathode rays **possess energy and momentum** 2) They travel in a straight line with **high speed of the order of 10^7m s^{-1}.** 3) It can be **deflected by both electric and magnetic fields.** 4) The direction of deflection indicates that they are negatively charged particles. 5) When the cathode rays are allowed to fall on matter, they **produce heat.** 6) They **affect the photographic plates** 7) They **produce fluorescence** 8) When the cathode rays fall on a material of high atomic weight, x-rays are produced. **Cathode rays ionize the gas through which they pass.** 9) The speed of cathode rays is up to $\left(\frac{1}{10}\right)^{th}$ of the speed of light.			2

PART – II

Answer **any six** questions. Question number **33 is compulsory.** 6x3=18

25	**Uses of Polaroid's:** Used in goggles and **cameras to avoid glare of light** Used in **holography** (three dimensional motion pictures) Used to improve contrast in **old oil paintings** Used in optical **stress analysis**. Used as **window glasses to control the intensity of incoming light** Polarized laser beam acts as **needle to read/write** in compact discs (CDs) **Polarized lights to be used in liquid crystal display (LCD)**	3
26	**Postulates of Bohr's atom model:** **Postulate (1):** **The electron in an atom moves around nucleus in circular orbits** under the influence of **Coulomb electrostatic force of attraction**. This Coulomb force gives necessary centripetal force for the electron to undergo circular motion. **Postulate (2):** **Electrons in an atom revolve around the nucleus only in certain discrete** orbits called stationary orbits. where it does not radiate electromagnetic energy. The angular momentum (l) of the electron in these stationary orbits are quantized (i.e.) **integral multiple of** $\frac{h}{2\pi}$; $l = n\frac{h}{2\pi} = n\hbar$ **Where n → principal quantum number.** This condition is known as angular momentum quantization condition. **Postulate (3) :** **Energy of orbits are not continuous but discrete**. This is called the **quantization of energy**. An electron can jump from one orbit to another orbit by absorbing or emitting a photon whose energy is equal to the difference in energy (ΔE) between the two orbital levels. $\Delta E = E_f - E_i = h\nu = h\frac{c}{\lambda}$; Where c → speed of light λ → wavelength of the radiation used and ν → frequency of the radiation	3
27	**Necessity of modulation:** When the information signal of low frequency is transmitted over a long distance, there will be information loss occurs. As the frequency of the carrier signal is very high, it can be transmitted to long distances with less attenuation. Thus in the modulation process, carrier signal of very high frequency signal (radio signal) is used to carry the baseband signal (information)	3

28	**Macroscopic form of Ohm's law:**  Consider a segment of wire of length l and cross sectional area A. When a potential difference V is applied across the wire, a net electric field is created in the wire which constitutes the current. If assume that the electric field is uniform in the entire length of the wire, the potential difference is given by, V = El (or) $E = \frac{V}{l}$ From the microscopic form of Ohm's law, $J = \sigma E$; $= \sigma\frac{V}{l}$ By definition, the Current density is $J = \frac{I}{A}$ Hence, $\frac{I}{A} = \sigma\frac{V}{l}$; $\therefore V = I\left[\frac{l}{\sigma A}\right]$; V = IR Where, $\frac{l}{\sigma A} = R \rightarrow$ Resistance of the conductor. This is called macroscopic form of Ohm's law. The resistance is the **ratio of potential difference across** the given conductor to the current passing through the conductor.	3
29	Focal length of lenses in contact, $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$; $= \frac{1}{-70} + \frac{1}{150}; = -\frac{1}{70} + \frac{1}{150}$ $\frac{1}{F} = \frac{-150+70}{70 \text{ x } 150}; = \frac{-80}{70 \text{ x } 150}$; $= -\frac{80}{10500}$; $F = -\frac{1050}{8}; = -131.25$ cm As the focal length is negative, the combination of two lenses is a diverging system of lenses. The power of combination is, $P = \frac{1}{F} = \frac{1}{-1.3125 \text{ m}}$; **P = −0.76 diopter**	3
30	**Energy losses in a transformer:** **(i) Core loss or Iron loss:** Hysteresis loss and eddy **current loss** are known as **core loss or Iron loss.** When transformer core is magnetized or demagnetized repeatedly by the alternating voltage applied across primary coil, hysteresis takes place and some energy lost in the form of heat. It is **minimized by using silicone steel in making transformer core.** Alternating magnetic flux in the core induces eddy currents in it. Therefore, there is energy loss due to the flow of eddy current called **eddy current loss.** It is **minimized by using very thin laminations of transformer core.** **(ii) Copper loss:** The primary and secondary coils in transformer have electrical resistance. When an electric current flows through them, some amount of energy is dissipated due to **Joule's heating** and it is known as **copper loss.**	3

<table>
<tr><td></td><td>It is minimized by using wires of larger diameter (thick wire)
(iii) Flux leakage:
The magnetic flux linked with primary coil is not completely linked with secondary. Energy loss due to this flux leakage is minimize by winding coils one over the other.</td><td></td></tr>
<tr><td>31</td><td><u>Torque acting on a bar magnet in uniform magnetic field:</u>
Consider a magnet of length '$2l$' of pole strength 'q_m' kept in uniform magnetic field $\vec{B}$.
Force experienced by the North Pole along the direction of the field.
$\vec{F}_N = q_m \vec{B}$
Force experienced by the South Pole opposite to the direction of the field
$\vec{F}_S = -q_m \vec{B}$. Hence total force; $\vec{F} = \vec{F}_N + \vec{F}_S = \vec{0}$


So, that there is no translator motion.
But these two forces constitute a couple, which tends to rotate the magnet along the direction of the field $\vec{B}$.
Hence moment of force or torque about 'O' is
$\vec{\tau} = \overrightarrow{ON} \times \vec{F}_N + \overrightarrow{OS} \times \vec{F}_S$; $= \overrightarrow{ON} \times (q_m \vec{B}) + \overrightarrow{OS} \times (-q_m \vec{B})$
Here, $|\overrightarrow{ON}| = |\overrightarrow{OS}| = l$ and $|q_m \vec{B}| = |(-q_m \vec{B})|$
Hence the magnitude of the torque,
$\tau = lq_m B \sin\theta + lq_m B \sin\theta$
$\tau = 2lq_m B \sin\theta$ $[q_m 2l = pm]$
$\tau = \mathbf{p_m B \sin\theta}$; In vector notation, $\vec{\tau} = \vec{p}_m \times \vec{B}$</td><td>3</td></tr>
<tr><td>32</td><td><u>Energy stored in capacitor:</u>
Capacitor is a device used to store charges and energy.
When a battery is connected to the capacitor, electrons of total charge '-Q' are transferred from one plate to other plate. For this work is done by the battery. This work done is stored as electrostatic energy in capacitor.
To transfer 'dQ' for a potential difference 'V', the work done is
$\mathbf{dW = VdQ} = \frac{Q}{C} dQ$ $[\because V = \frac{Q}{C}]$
The total work done to charge a capacitor, $W = \int_0^Q \frac{Q}{C} dQ$; $= \frac{1}{C}\left[\frac{Q^2}{2}\right]_0^Q = \frac{Q^2}{2C}$ This work done is stored as electrostatic energy of the capacitor, (i.e)
$\mathbf{U_E = \frac{Q^2}{2C} = \frac{1}{2} CV^2}$ $[\because Q = CV]$</td><td>3</td></tr>
</table>

33

Continuous X - ray spectrum:

When a fast-moving electron penetrates and approaches a target nucleus, it gets accelerates or decelerates

It may result in a change of path of the electron.

The radiation produced from such decelerating electron is called Brims strolling or braking radiation.

The energy of the emitted photon (radiation) is equal to the loss of kinetic energy of the electron. So the photons are emitted with all possible energies or frequencies.

The continuous X -ray spectrum is due to such radiations. When an electron gives up all its energy, then the photon is emitted with highest frequency (ν_0) or lowest wavelength (λ_0)

The initial kinetic energy of an electron = eV where, V → accelerating voltage. Thus

$ev = h\nu_0 = h\frac{c}{\lambda_0}$ (or)

$$\lambda_0 = \frac{hc}{eV} = \frac{12400}{V}\mathring{A}$$

This relation is known as Duane - Hunt formula

Marks: 3

PART – IV

Answer **all** the questions. 5x5=25

34 (a)

Electrostatic potential due to dipole:

Consider a dipole AB along X - axis. Its dipole moment be p = 2qa and its direction be along − q to + q

Let 'P' be the point at a distance 'r' from the midpoint 'O'

Let $\angle POA = \theta$, BP = r_1 and AP = r_2

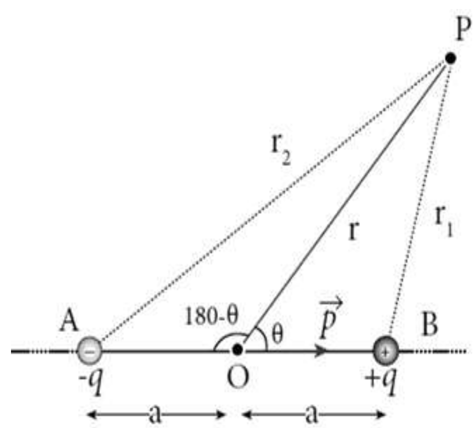
Electric potential at P due to +q $V_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1}$

Electric potential at P due to −q $V_2 = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$

Then total potential at 'P' due to dipole is

$V = V_1 + V_2$

$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{1}{r_1} - \frac{1}{r_2}\right]$ .... (1)



Apply cosine law in Δ BOP

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

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

If a << r then neglecting $\frac{a^2}{r^2}$;

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

$r_1 = r\left[1 - \frac{2a}{r}\cos\theta\right]^{\frac{1}{2}}$;

Marks: 5

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

$\frac{1}{r_1} = \frac{1}{r}\left[1 + \frac{a}{r}\cos\theta\right]$ ....(2)

Apply cosine law in Δ AOP

$r_2^2 = r^2 + a^2 + 2ra\cos(180^0 - \theta)$;

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

If a << r then neglecting $\frac{a^2}{r^2}$;

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

$r_2 = r\left[1 + \frac{2a}{r}\cos\theta\right]^{\frac{1}{2}}$; $\frac{1}{r_2} = \frac{1}{r}\left[1 + \frac{2a}{r}\cos\theta\right]^{-\frac{1}{2}}$

$\frac{1}{r_2} = \frac{1}{r}\left[1 - \frac{a}{r}\cos\theta\right]$ ....(3)

$V = \frac{1}{4\pi\varepsilon_0} q\left(\frac{1}{r}\left[1 + \frac{a}{r}\cos\theta\right] - \frac{1}{r}\left[1 - \frac{a}{r}\cos\theta\right]\right)$

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\left[1 + \frac{a}{r}\cos\theta - \left[1 + \frac{a}{r}\cos\theta\right]\right]$

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\frac{2a}{r}\cos\theta$;

$= \frac{1}{4\pi\varepsilon_0}\frac{2qa}{r^2}\cos\theta$

$= \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}\cos\theta$ [p = 2qa]

Or $V = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\hat{r}}{r^2}$ [$p\cos\theta = \vec{p}.\hat{r}$]

Here $\hat{r}$ is the unit vector along OP

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 $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

Case (ii)

If the point P lies on the **axial line** of the dipole on the side of –q, **then θ = 180⁰**, then $V = -\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

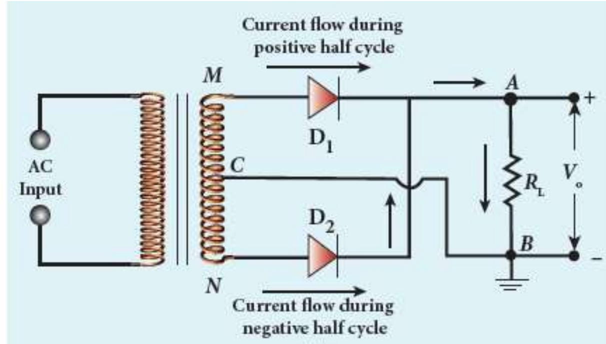
Case (iii)

If the point P lies on the **equatorial line** of the dipole, the **θ = 90⁰.** Hence V = 0

34 (b)

Full wave rectifier:

The positive and negative half cycles of the AC input signal pass through this circuit and hence it is called the full wave rectifier.



(a)

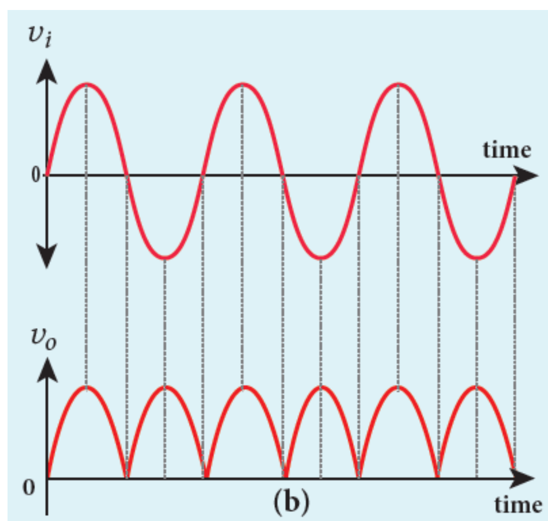
It consists of two P-N junction diodes, a center tapped transformer, and a load resistor (R_L).

The centre (C) is usually taken as the ground or zero voltage reference point. Due to the centre tap transformer, the output voltage rectified by each diode is only one half of the total secondary voltage.

During positive half cycle of input AC	During negative half cycle of input AC
Terminal **M is positive**, C is at zero potential and **N is at negative** potential.	Terminal **M is negative**, C is at zero potential and **N is at positive** potential.
Diode **D_1** is **forward biased.** Diode **D_2** is **reverse biased.**	Diode **D_1** is **reverse biased.** Diode **D_2** is **forward biased.**
D_1 conducts and current flows along the **path MD_1ABC**	D_2 conducts and current flows along the **path ND_2ABC**

Hence in a full wave rectifier both positive and negative half cycles of the input signal pass through the circuit in the same direction. The output waveform is shown below.

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 %.**



(b)

5

35 (a)

Internal resistance of a cell using voltmeter:

A real battery is made of electrodes and electrolyte. There is resistance to the flow of charges within the battery and this resistance is called internal resistance (r)

The **emf of the cell** is measured by **connecting high resistance** voltmeter across it without connecting the external resistance R. This circuit may be considered as open, the voltmeter reading gives the emf (ξ) of the cell. Then external resistance is included in the circuit and current 'I' is established in the circuit.

This circuit is then considered as close, the voltmeter reading gives the potential difference (V) across 'R'

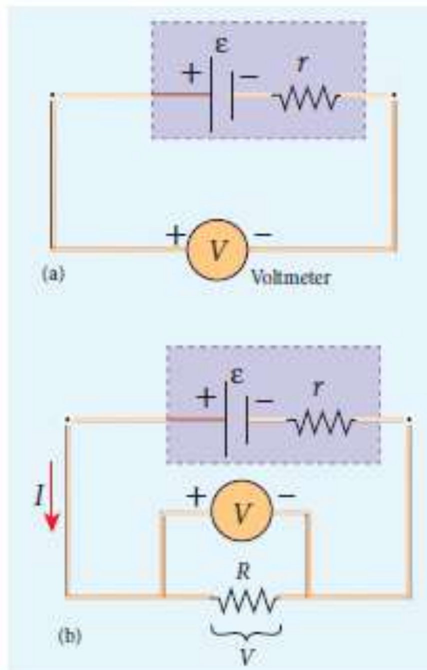
By Ohm's law, = IR (or) $I = \frac{V}{R}$ ....(1)

Due to internal resistance of the cell, the voltmeter reads the value "V" which is less than the emf (ξ). It is because, certain amount of voltage (Ir) has dropped across the internal resistance 'r'. Hence

$V = \xi - Ir$ – – – – (2) (or)

$Ir = \xi - V$

$\therefore \quad r = \frac{\xi - V}{I}$; $= \left[\frac{\xi - V}{V}\right] R$



Since ξ, V and R are known, internal resistance 'r' and total current 'I' can be determined.

The power delivered to the circuit is,

$I = I\xi$; $= I(V + Ir)$; $= I(IR + Ir)$

$P = I^2R + I^2r$

where, $I^2R \longrightarrow$ power delivered to R

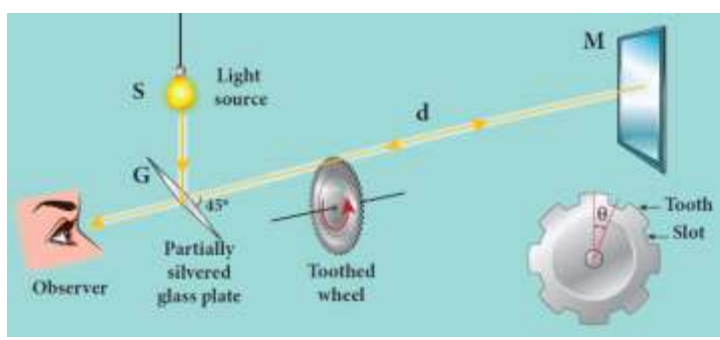
$I^2r \longrightarrow$ power delivered to r

5

35 (b)

Fizeau's method:

The light from the source S was first allowed to fall on a partially silvered glass plate G kept at an **angle of 45⁰** to the vertical. The light then allowed to pass through a rotating toothed-wheel with N - teeth and N - cuts.



The speed of rotation of the wheel could be varied through an external mechanism. The light passing through one cut in the wheel get reflected by a mirror M kept at a long distance 'd' **(about 8 km) from the toothed wheel**. If the

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	toothed wheel was not rotating, the reflected light from the mirror would again pass through the same cut and reach the observer through G. **Working:** The angular speed of the rotation of the toothed wheel was increased until light passing through one cut would completely be blocked by the adjacent tooth. Let that angular speed be ω The **total distance traveled by the light from the toothed wheel to the mirror and back to the wheel is '2d' and the time taken be 't'.** Then the speed of light in air, $v = \frac{2\,d}{t}$ But the angular speed is, $\omega = \frac{\theta}{t}$ Here θ is angle between the tooth and the slot which is rotated by the toothed wheel within that time "t". Then, $\theta = \frac{\text{Total angle of the circle in radian}}{\text{Number of teeth+Number of cuts}}\ ;\ \theta = \frac{2\pi}{2N} = \frac{\pi}{N}$ Hence, angular speed, $\omega = \frac{\left(\frac{\pi}{N}\right)}{t} = \frac{\pi}{Nt}$ (or) $t = \frac{\pi}{N\omega}$ Therefore the speed of light in air, $v = \frac{2\,d}{t} = \frac{2d}{\left(\frac{\pi}{N\omega}\right)}\ ;\ v = \frac{\mathbf{2\,d\,N\omega}}{\boldsymbol{\pi}}$ **The speed of light in air was determined as , v = 2.99792 x 10^8 ms^{-1}**	
36 (a)	**Electron emission:** The **liberation of electrons from any surface of a substance** is called electron emission. The **minimum energy needed to liberate the electrons** from the metal surface is called **work function** of that metal. Depending upon the energy source, the electron emission is classified as four types which are explained below. **(1) Thermionic emission:** When a metal is **heated to a high temperature, the free electrons on the surface get sufficient energy in the form of heat**, so that they are emitted from the metallic surface. This type of emission is known as thermionic emission. The intensity of the thermionic emission depends on the metal used and its temperature. (e.g.) **electron microscopes, X-ray tubes.** **(2) Field emission:** When a **very strong electric field is applied across the metal,** this strong field pulls the free electrons and helps to overcome the surface barrier of the metal. This type of emission of electron is called field emission. (e.g.) **Field emission display** **(3) Photo electric emission:** When an **electromagnetic radiation of suitable frequency is incident on the surface of the metal**, the energy is transferred from the radiation to free electrons. Hence the free electrons get sufficient energy to cross the surface barrier and this type is called photo electric emission. (e.g.) **photo electric cells, photo diodes**	5

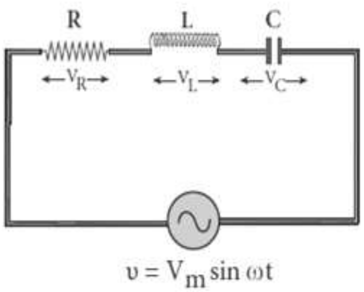
(4) Secondary emission:

When a beam of **fast-moving electrons strikes the surface of the metal**, the kinetic energy is transferred to the free electrons on the metal surface called secondary emission. (e.g.) **Photo multiplier tube.**

36 (b)

Series RLC circuit:

Consider a circuit containing a resistor of resistance 'R', a inductor of inductance 'L' and a capacitor of capacitance 'C' connected across an alternating voltage source.



The **applied alternating voltage** is given by,

$$\mathbf{v} = \mathbf{v_m} \sin \omega t \qquad ------(1)$$

Let 'i' be the current in the circuit at that instant.

Hence the voltage developed across R, L and C

$V_R = iR$ (V_R is in phase withi)

$V_L = iX_L$ (V_L leads i by $\frac{\pi}{2}$)

$V_C = iX_C$ (V_C lags i by $\frac{\pi}{2}$)

The Phasor diagram is drawn by representing current along $\overrightarrow{OI}$, V_R along $\overrightarrow{OA}$, V_L along $\overrightarrow{OB}$ and V_C along $\overrightarrow{OC}$,

If $V_L > V_C$ then the net voltage drop across LC combination is ($V_L - V_C$) which is represented by $\overrightarrow{AD}$

By parallogram law, the diagonal $\overrightarrow{OE}$ gives the resultant voltage"v"

$$v = \sqrt{V_R^2 + (V_L - V_C)^2}\ ;$$

$$v = \sqrt{i^2R^2 + (iX_L - iX_C)^2}$$

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

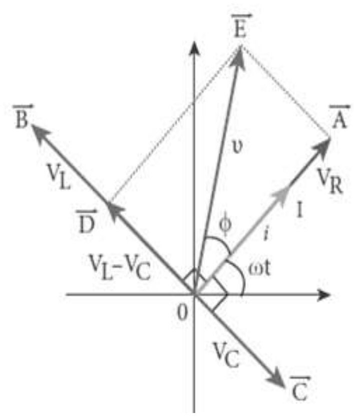
$$\mathbf{i} = \frac{\mathbf{v}}{\sqrt{\mathbf{R^2 + (X_L - X_C)^2}}} \text{ (or)}$$

$$i = \frac{v}{Z}$$

Where, $Z = \sqrt{R^2 + (X_L - X_C)^2}$ is called **impedance of the circuit**, which refers to the effective opposition to the circuit current by the series RLC circuit.

From the Phasor diagram, the phase angle between 'v' and 'i' is found out by

$$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$$



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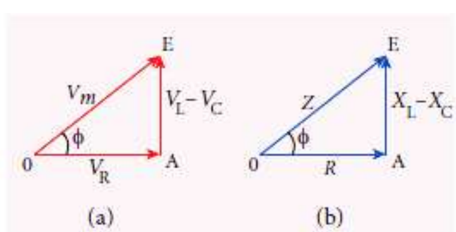
Special cases:

(i) When $X_L > X_C$, $X_L - X_C$ the phase angle ϕ is **Positive.**

It means that $\boldsymbol{v}$ leads $\boldsymbol{i}$ by ϕ.

(*i. e.*) $i = I_m \sin \omega t$; $v = v_m \sin(\omega t + \phi)$

This circuit is inductive.

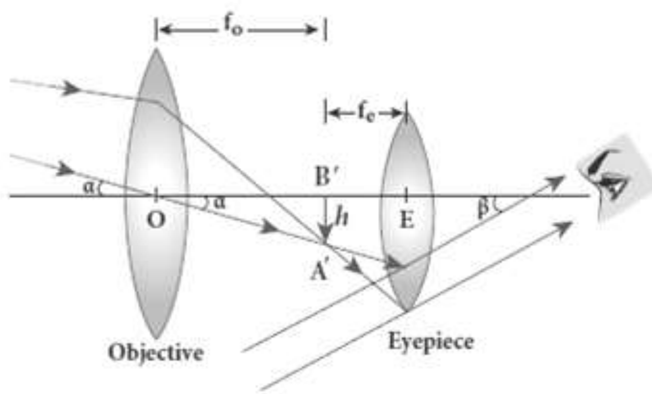


	(ii) When $X_L < X_C$, $X_L - X_C$ the phase angle ϕ is **negative.** It means that v lags behind i by ϕ. $(i.e.)$ $i = I_m \sin \omega t$; $v = v_m \sin(\omega t - \phi)$ **This circuit is capacitive** (iii) When $X_L = X_C$ the phase angle ϕ **is zero.** It means that v in-phase with i $(i.e.)$ $v = V_m \sin \omega t$ & $i = I_m \sin \omega t$ **This circuit is resistive**	
37(a)	**(i) Properties of electromagnetic waves:** 1) Electromagnetic waves are **produced by any accelerated charge.** 2) They **do not require any medium** for propagation. So **electromagnetic waves are non-mechanical wave.** 3) They are **transverse in nature**, (i.e) the oscillating electric field vector, oscillation magnetic field vector and direction of propagation are mutually perpendicular to each other. 4) They **travel with speed of light in vacuum or free space** and it is given by, $C = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 3x10^8 ms^{-1}$ 5) In a medium with permittivity 'ε' and permeability 'μ', the speed of electromagnetic wave is less than speed in free space or vacuum. (i.e.) $(v < c)$ Hence**, refractive index of the medium** is, $\mu = \frac{C}{v} = \frac{1/\sqrt{\varepsilon_0\mu_0}}{1/\sqrt{\varepsilon\mu}}$ $\therefore n = \sqrt{\varepsilon_r\mu_r}$ where ε_r is the relative permittivity of the medium (also known as dielectric constant) and μ_r is the relative permeability of the medium. 6) They are **not deflected by electric or magnetic field.** 7) They **show interference, diffraction and polarization.** 8) Like other waves, electromagnetic waves also **carry energy, linear momentum and angular momentum.** 9) If the electromagnetic wave incident on a material surface is **completely absorbed, then the energy delivered** is 'U' and the **momentum imparted on the surface** is $p = \frac{U}{C}$, 10) If the incident electromagnetic wave of energy 'U' is **totally reflected from the surface, then the momentum delivered to the surface** is $\Delta p = \frac{U}{c} - \left(-\frac{U}{c}\right) = 2\frac{U}{c}$ (ii) Refractive index of the medium, n = $\sqrt{\epsilon_r \mu_r}$; = $\sqrt{2.25 \text{ x } 2.5}$; = $\sqrt{5.625}$; **n =2.37 (No unit)**	5

37 (b)

Astronomical telescope:

An **astronomical telescope is used to get the magnification of distant astronomical objects like stars, planets.** The image formed by this will be inverted. It has an objective of long focal length and a much larger aperture than eye piece. Light from a distant object enters the objective and a real image is formed in the tube at its second focal point.



The eye piece magnifies this image producing a final inverted image.

Magnification (m) :

The magnification 'm' is the ratio of the angle β subtended at the eye by the final image to the angle α which the object subtends at the lens or the eye. $m = \frac{\beta}{\alpha}$

From figure, $m = \frac{\left[\frac{h}{f_e}\right]}{\left[\frac{h}{f_0}\right]}$; $m = \frac{f_0}{f_e}$

The length of the telescope is approximately, $L = f_0 + f_e$

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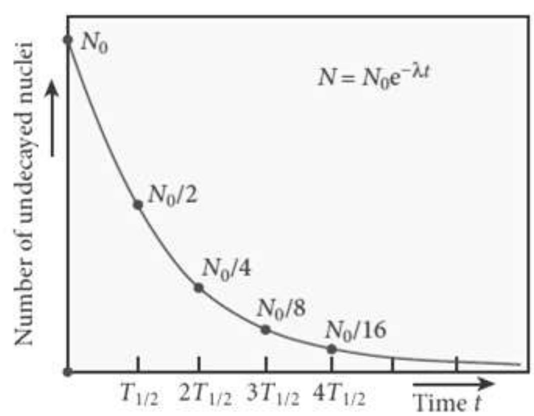
38 (a)

Law of radioactivity:

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. This is called law of radioactive decay.**



Expression:

Let N_0 be the number of nuclei at initial time (t = 0)

Let 'N' be the number of un-decayed nuclei at any time 't'

If 'dN' be the number of nuclei decayed in time 'dt' then,

rate of decay = $\frac{dN}{dt}$

From law of radioactivity, $\frac{dN}{dt} \propto N$ (or) $\frac{dN}{dt} = -\lambda N$ - - - - - (1)

Here, $\lambda \longrightarrow$ **decay constant**

Decay constant (λ) is **different for different radioactive sample and the negative sign in the equation implies that the N is decreasing with time.**

By rewriting the equation (1), we get $\frac{dN}{N} = -\lambda dt$

Integrating on both sides, $\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$; $[\text{In } N]_{N_0}^{N} = -\lambda t$

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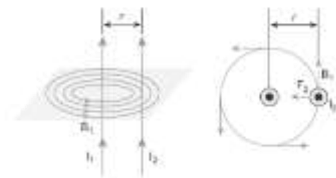
$$[\ln N - \ln N_0] = -\lambda t \; ; \; \ln\left[\frac{N}{N_0} = -\lambda t\right]$$

Taking exponential on both sides, $\frac{N}{N_0} = e^{-\lambda t}$; $N = N_o e^{-\lambda t}$ – – – – – (2)

Equation (2) is called **the law of radioactive decay.** Here the number of atoms is decreasing exponentially over the time.

This implies that **the time taken for all the radioactive nuclei to decay will be infinite.**

38 (b) **Force between two parallel conductors carrying current:** 5



Consider two straight parallel current carrying conductors 'A' and 'B' separated by a distance 'r' kept in air. Let I_1 and I_2 be the currents passing through the A and B in same direction (z-direction) . The net magnetic field due to I_1 at a distance 'r'.

$$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi r}(-\hat{\imath}) = -\frac{\mu_0 I_1}{2\pi r}\,\hat{\imath}$$

Here $\vec{B}_1$ acts perpendicular to plane of paper and inwards.

Then Lorentz force acts on the length element dl in conductor 'B' carrying current I_2 due to this magnetic field $\vec{B}_1$

$$\vec{dF} = I_2\vec{dl} \times \vec{B}_1 = -I_2 dl\,\hat{k} \times \frac{\mu_0 I_1}{2\pi r}\,\hat{\imath} \quad ; \vec{dF} = -\frac{\mu_0 I_1 I_2 dl}{2\pi r}(\hat{k} \times \hat{\imath}) \; ; \vec{dF} = -\frac{\mu_0 I_1 I_2 dl}{2\pi r}\hat{\jmath}$$

By Fleming's left hand rule, this force acts left wards. The force per unit length of the conductor B. $\frac{\vec{F}}{l} = -\frac{\mu_0 I_1 I_2}{2\pi r}\hat{\jmath}$ – – – – – – – (1)

Similarly, net magnetic field due to I_2 at a distance 'r' is $\vec{B}_2 = \frac{\mu_0 I_2}{2\pi r}\hat{\imath}$

Here $\vec{B}_2$ **acts perpendicular to plane of paper and outwards.**

Then Lorentz force acts on the length element dl in conductor 'A' carrying current I_1 due to this magnetic field $\vec{B}_2$.

$$\vec{dF} = I_1\vec{dl} \times \vec{B}_2 = I_1 dl\,\hat{k} \times \frac{\mu_0 I_2}{2\pi r}\,\hat{\imath} \quad ; \vec{dF} = \frac{\mu_0 I_1 I_2 dl}{2\pi r}(\hat{k} \times \hat{\imath}) \; ; \vec{dF} = \frac{\mu_0 I_1 I_2 dl}{2\pi r}\hat{\jmath}$$

By Fleming's left hand rule, this force acts right wards. The force per unit length of the conductor A. $\frac{\vec{F}}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}\hat{\jmath}$ – – – – – – – (2)

Thus the force experienced by two parallel current carrying conductors is attractive if they carry current in same direction. On the other hand, the force experienced by two parallel current carrying conductors is repulsive if they carry current in opposite direction.

Definition of ampere:

One ampere is defined as that current when it is passed through each of two infinitely long parallel conductors kept a distance of one metre apart in vacuum causes each conductor experience a force of **2 x 10^{-7} Newton per meter length of conductor.**