Code No. **042**

Roll No. | | | | | | | |

- Please check that this question paper contains **5** printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains **33** questions.
- **Please write down the Serial Number of the question before attempting it.**
- 15 minutes time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

PHYSICS–XII

Sample Paper (Solved)

Time allowed : 3 hours *Maximum marks : 70*

General Instructions:

SECTION-A

All questions are compulsory. In case of internal choices, attempt any one of them.

Q.1. Which orientation of an electric dipole in a uniform electric field would correspond to stable equilibrium?

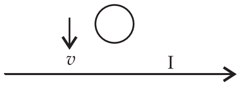
Q.2. Which part of electromagnetic spectrum is absorbed from sunlight by ozone layer?

Or

Do electromagnetic waves carry energy and momentum?

Q.3. Write the condition under which an electron will move undeflected in the presence of crossed electric and magnetic fields.

Q.4. Predict the direction of induced current in a metal ring when the ring is moved towards a straight conductor with constant speed v. The conductor is carrying current I in the direction shown in the figure.



Or

A heating element is marked 210 V, 630 W. Find the resistance of the element when connected to a 210 V dc source.

Q.5. What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atom?

Q.6. State *one* reason to explain why wave theory of light does not suppo rt photoelectric effect.

Q.7. Two nuclei have mass numbers in the ratio 8 : 125. What is the ratio of their nuclear radii?

Or

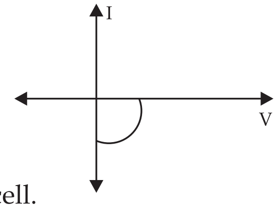
Write any *two* characteristic properties of nuclear force.

Q.8. What is the function of a photodiode?

Or

What happens to the width of depletion layer of a *p-n* junction when it is (*i*) forward biased, (*ii*) reverse biased?

Q.9. Name the junction diode whose I-V characteristics are drawn here:



Q.10. State the reason, why GaAs is most commonly used in making of a solar cell.

For questions number 11, 12, 13 and 14, two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) ***Both A and R are true and R is the correct explanation of A.***
(b) ***Both A and R are true but R is NOT the correct explanation of A.***
(c) ***A is true but R is false.***
(d) ***A is false and R is also false.***

Q.11. ***Assertion (A):*** The whole charge of a conductor cannot be transferred to another isolated conductor.
Reason (R): The total transfer of charge from one to another is possible.

Q.12. ***Assertion (A):*** Dieletric polarisation means formation of positive and negative charges inside the dielectric.
Reason (R): Free electrons are formed in this process.

Q.13. ***Assertion (A):*** Angle of deviation depends upon the angle of incidence.
Reason (R): For a thin prism $\delta = (\mu - 1)A$.

Q.14. ***Assertion (A):*** In interference and diffraction, light energy is redistributed.
Reason (R): There is no gain or loss of energy, which is consistent with the principle of conservation of energy.

SECTION-B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

Q.15. **Kirchhoff's Laws**

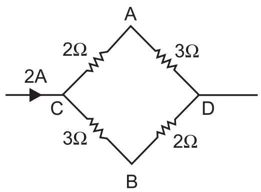
Two rules called Kirchhoff's laws are very useful to find out currents and potential differences in complicated circuits having a large number of resistors and cells, in different combinations.

(*a*) **Junction Rule.** At any junction, the sum of all the currents entering the junction is equal to sum of currents leaving the junction.

(*b*) **Loop Rule.** The algebraic sum of charges in potential around any closed loop involving resistances and cells in the loop is zero.

(*i*) **Point out the right statements about the validity of Kirchhoff's junction rule It is based on:**
(*a*) conservation of charge.
(*b*) outgoing currents add up and are equal to incoming currents at a junction.
(*c*) bending or reorienting the wire does not change the validity of Kirchhoff's junction rule.
(*d*) all of the above

(*ii*) **The potential difference between A and B as shown in figure is**



(*a*) 1 V (*b*) 2 V
(*c*) 3 V (*d*) 4 V

(*iii*) **In the series combination of two or more than two resistances**
(*a*) the current through each resistance is same.
(*b*) the voltage through each resistance is same.
(*c*) neither current nor voltage through each resistance is same.
(*d*) both current and voltage through each resistance are same.

(*iv*) ***n*** **resistors each of resistance R first combine to give maximum effective resistance and then combine to give minimum effective resistance. The ratio of the maximum to minimum resistance is**
(*a*) n (*b*) n^2 (*c*) $n^2 - 1$ (*d*) n^3

(*v*) **Two cells ε_1 and ε_2 connected in opposition to each other. The cell ε_1 is of emf 9 V and internal resistance 3Ω the cell ε_2 is of emf 7 V and internal resistance 7 Ω. The potential difference between the points A and B is**

(*a*) 8.4 V (*b*) 5.6 V (*c*) 7.8 V (*d*) 6.6 V

Q.16. **Phenomenon of Interference**

Entire field of interference is based on the superimposition principle. It is evident that a path difference of λ corresponds to a phase difference of 2π. We obtain constructive and destructive interference depending upon the path difference or consequently phase difference.

We can have a stable interference pattern with two coherent sources.

A British Physicist Thomas Young (1773 - 1829) demonstrated the interference pattern for light waves. The dark and bright bands called **fringes** were shown on the screen by him. Thus wave nature of light was demonstrated convincingly for the first time in 1801 by Thomas Young with the help of a wonderfully simple experiment.

(*i*) **In young's double slit experiment two disturbances arriving at a point P have phase difference of $\frac{\pi}{3}$. The intensity of this point expressed as a fraction of maximum intensity I_0 is**

(*a*) $\frac{3}{2}I_0$ (*b*) $\frac{1}{2}I_0$ (*c*) $\frac{4}{3}I_0$ (*d*) $\frac{3}{4}I_0$

(*ii*) **The intensity ratio of the maxima and minima in an interference pattern produced by two coherent sources of light is 9 : 1. The intensities of the used light sources are in ratio.**

(*a*) 3 : 1 (*b*) 4 : 1 (*c*) 9 : 1 (*d*) 10 : 1

(*iii*) **When interference of light takes place**

(*a*) energy is created in the region of maximum intensity
(*b*) energy is destroyed in the region of maximum intensity
(*c*) conservation of energy holds good and energy is redistributed
(*d*) conservation of energy does not hold good

(*iv*) **In a Young's double slit experiment, let S_1 and S_2 be the two slits, and C be the centre of the screen. If $\angle SCS_2 = \theta$ and λ is the wavelength, the fringe width will be**

(*a*) $\frac{\lambda}{\theta}$ (*b*) $\theta\,\lambda$ (*c*) $\frac{2\lambda}{\theta}$ (*d*) $\frac{\lambda}{2\theta}$

(*v*) **On introduction a thin film in the path of one of the two interfering beams, the central fringe will shift by one fringe width. If μ = 1.5, the thickness of the film is (wavelength of monochromatic light is λ).**

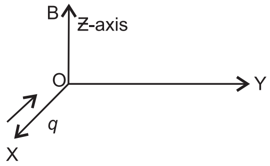
(*a*) 4λ (*b*) 3λ (*c*) 2λ (*d*) λ

SECTION-C

All questions are compulsory. In case of internal choice, attempt any one.

Q.17. A charge '*q*' moving along the X-axis with a velocity $\vec{v}$ is subjected to a uniform magnetic field B acting along the Z-axis as it crosses the origin O.

(*i*) Trace its trajectory.
(*ii*) Does the charge gain kinetic energy as it enters the magnetic field? Justify your answer.



Q.18. State *two* conditions required for obtaining coherent sources. In Young's arrangement to produce interference pattern, show that dark and bright fringes appearing on the screen are equally spaced.

Q.19. Net capacitance of three identical capacitors in series is 3 μF. What will be their net capacitance if connected in parallel? Find the ratio of energy stored in the two configurations if they are both connected to the same source.

Or

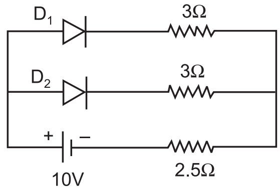
Draw a plot showing the variation of (*i*) electric field (E) and (*ii*) electric potential (V) with distance *r* due to a point charge Q.

Q.20. Explain, with the help of a circuit diagram, the working of a *p-n* junction diode as a half-wave rectifier.

Q.21. A metallic rod of 'L' length is rotated with angular frequency of 'ω' with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Deduce the expression for the emf between the centre and the metallic ring.

Q.22. Yellow light (λ = 6000$\mathring{A}$) illuminates a single slit of width 1×10^{-4} m. Calculate—(*i*) the distance between the two dark lines on either side of the central maxium, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit; (*ii*) the angular spread of the first diffraction minimum.

Q.23. Assuming that the two diodes D_1 and D_2 used in the electric circuit shown in the figure are ideal, find out the value of the current flowing through 2.5 Ω resistor.



Q.24. At a place, the horizontal component of earth's magnetic field is B and angle of dip is 60°. What is the value of horizontal component of the earth's magnetic field at the equator?

Or

A coil of 'N' turns and radius 'R' carries a current 'I'. It is unwound and rewound to make a square coil of side '*a*' having same number of turns (N). Keeping the current 'I' same, find the ratio of the magnetic moments of the square coil and the circular coil.

Q.25. You are given two converging lenses of focal lengths 1.25 cm and 5 cm to design a compound microscope. If it is desired to have a magnification of 30, find out the separation between the objective and the eyepiece.

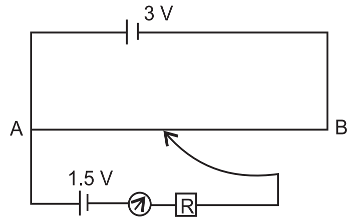
SECTION-D

All questions are compulsory. In case of internal choices, attempt any one.

Q.26. (*i*) State Faraday's law of electromagnetic induction.

(*ii*) A jet plane is travelling towards west at a speed of 1800 km/h. What is the voltage difference developed between the ends of the wing having a span of 25 m, if the Earth's magnetic field at the location has a magnitude of 5×10^{-4} T and the dip angle is 30°?

Q.27. A potentiometer wire of length 1 m is connected to a driver cell of emf 3 V as shown in the figure. When a cell of 1.5 V emf is used in the secondary circuit, the balance point is found to be 60 cm. On replacing this cell and using a cell of unknown emf, the balance point shifts to 80 cm.



(*i*) Calculate unknown emf of the cell.

(*ii*) Explain with reason, whether the circuit works, if the driver cell is replaced with a cell of emf 1 V.

(*iii*) Does the high resistance R, used in the secondary circuit affect the balance point? Justify your answer.

Or

Define resistivity of a conductor. Plot a graph showing the variation of resistivity with temperature for a metallic conductor. How does one explain such a behaviour, using the mathematical expression of the resistivity of a material.

Q.28. (*a*) Using de-Broglie's hypothesis, explain with the help of a suitable diagram, Bohr's second postulate of quantization of energy levels in a hydrogen atom.

(*b*) The ground state energy of hydrogen atom is –13.6 eV. What are the kinetic and potential energies of the electron in this state?

Or

An electron microscope uses electrons accelerated by a potential difference 50 kV. Calculate the de Broglie wavelength of the electrons. Compare the resolving power of an electron microscope with that of an optical microscope, which uses visible light of wavelength 550 nm. Assume the numerical apertures of the objective lens of both the microscopes are the same.

Q.29. The ground state energy of hydrogen atom is –13.6 *e*V.

(*i*) What is the kinetic energy of an electron in the 2^{nd} excited state?

(*ii*) If the electron jumps to the ground state from the 2nd excited state, calculate the wavelength of the spectral line emitted.

Q.30. Distinguish between nuclear fission and fusion. Show how in both these processes energy is released. Calculate the energy release in MeV in the deuterium-tritium fusion reaction:

$${}_1^2\mathrm{H} + {}_1^3\mathrm{H} \longrightarrow {}_2^4\mathrm{He} + n$$

Using the data: $m({}_1^2\mathrm{H}) = 2.014102\ u$ $\quad m({}_1^3\mathrm{H}) = 3.016049\ u$

$m({}_2^4\mathrm{He}) = 4.002603\ u$ $\quad m_n = 1.008665\ u$ $\quad 1\ u = 931.5\ \mathrm{MeV/c^2}$

SECTION-E

All questions are compulsory. In case of internal choices, attempt any one.

Q.31. (*a*) Draw a circuit diagram of a meter bridge used to determine the unknown resistance R of a given wire. Hence derive the expression for R in terms of the known resistance S.

(*b*) What does the term 'end error' in a metre bridge circuit mean and how is it corrected? How will the balancing point be affected, if the positions of the battery and galvanometer are interchanged in a metre bridge experiment? Give reason for your answer.

Or

(*a*) Why do the 'free electrons', in a metal wire, 'flowing by themselves', not cause any current flow in the wire? Define 'drift velocity' and obtain an expression for the current flowing in a wire, in terms of the 'drift velocity' of the free electrons.

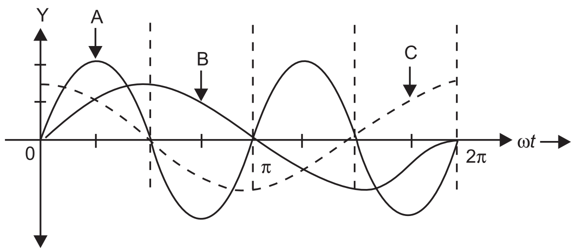
(*b*) Use the above expression to show that the 'resistivity', of the material of a wire, is inversely proportional to the 'relaxation time' for the 'free electrons' in the metal.

Q.32. (*a*) Discuss how Faraday's law of e.m. induction is applied in an ac-generator for converting mechanical energy into electrical energy. Obtain an expression for the instantaneous value of the induced emf in an ac generator.

(*b*) Draw graphs to show the 'phase relationship' between the instantaneous (*i*) magnetic flux (ϕ) linked with the coil and (*ii*) induced emf (ε) in the coil.

Or

A device 'X' is connected to an ac source $V = V_0 \sin \omega t$. The variation of voltage, current and power in one cycle is shown in the given graph:



(*a*) Identify the device 'X'.

(*b*) Which of the curves A, B, and C represent the voltage, current and the power consumed in the circuit? Justify your answer.

(*c*) How does its impedance vary with frequency of the ac source? Show graphically.

(*d*) Obtain an expression for the current in the circuit and its phase relation with ac voltage.

Q.33. Define magnifying power of a telescope. Write its expression.

A small telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm. If this telescope is used to view a 100 m high tower 3 km away, find the height of the final image when it is formed 25 cm away from the eyepiece.

Or

(*a*) Describe briefly how a diffraction pattern is obtained on a screen due to a single narrow slit illuminated by a monochromatic source of light. Hence obtain the conditions for the angular width of secondary maxima and secondary minima.

(*b*) Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of first maxima of the diffractions pattern obtained in the two cases.

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Answer Sheet

S	A	M	P	L	E							P	A	P	E	R		

Code No. 042

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PHYSICS

SECTION – A

1. When dipole moment vector is parallel to electric field vector.

$$\vec{P} \parallel \vec{E}$$

2. ***Ultraviolet rays*** are absorbed from sunlight by ozone layer.

Or

Yes, they do, because of change of magnetic flux associated with circular loop.

3. $V = \frac{E}{B}$ and electric and magnetic fields are mutually perpendicular.

4. Clockwise direction.

Or

Resistance = $\frac{V^2}{P} = \frac{(210)^2}{630} = \frac{210 \times 210}{630}$ = **70 Ω**

5. Radius of Bohr's stationary orbits, $r = \frac{n^2 h}{4\pi^2 m K_e^2}$

Clearly, $r \propto n^2$ and in ground state, $n = 1$

For 1st excited state, $n = 2$ ∴ Ratio of radii of the orbits = $\frac{2^2}{1^2} = \frac{4}{1}$ = **4 : 1**

6. One **reason** why wave theory of light does not support photoelectric effect is that the kinetic energy of photo electrons does not depend on the intensity of incident light.

7. $A_1 : A_2 = 8 : 125$ $\Rightarrow$ $\frac{A_1}{A_2} = \frac{8}{125}$

Since $R = R_0 A^{1/3}$ ∴ $\frac{R_1}{R_2} = \frac{A_1^{1/3}}{A_2^{1/3}} = \frac{8^{1/3}}{125^{1/3}} = \left(\frac{2^3}{5^3}\right)^{1/3} = \left(\frac{2}{5}\right)^{3\times 1/3} = \mathbf{\frac{2}{5}}$

Or

1. Nuclear forces are the strongest forces in nature.
2. Nuclear forces are charge independent.

8. A photodiode is a special purpose p-n junction diode fabricated with a transparent window to allow light to fall on diode. It is operated under reverse bias.

Or

(*i*) In forward biased, the width of depletion layer of a *p-n* junction **decreases**.
(*ii*) In reverse biased, the width of depletion layer of a *p-n* junction **increases**.

9. Solar cell.

10. GaAs in most commonly used in making of a solar cell because:

(*i*) It has high optical absorption (~ 104 cm^{-1}).

(*ii*) It has high electrical conductivity.

11. (*d*) A is false and R is also false.

[Hint: The whole charge of a conductor can be transferred to another isolated conductor, if it is placed inside the hollow insulated conductor and connected with it.

12. (*c*) A is true but R is false.

[Hint: When an electric field is applied to the dielectric, each molecule of dielectric gets polarised, centres of gravity of positive and negative charges get displaced from each other. Electric dipoles are produced inside.

13. (*a*) Both A and R are true and R is the correct explanation of A.

[Hint: For an thin prism, the relation between angle of deviation (δ) and angle of prism (A) and μ is $\boldsymbol{\delta = (\mu - 1)A}$.

14. (*a*) Both A and R are true and R is the correct explanation of A.

SECTION – B

15. (*i*) (*d*) all of the above

(*ii*) (*a*) 1 V ***[Hint: Resistance in both the arms CAD and CBD is equal, and hence same current flows in both the arms.***

(*iii*) (*a*) the current through each resistance is same.

(*iv*) (*b*) n^2

[Hint: To get maximum value of equivalent resistance, all resistances must be connected in series. ∴ R′ = nR. To get minimum value of equivalent resistance all resistance must be connected in parallel.

$$\therefore R'' = \frac{n}{R}\frac{R^{IF}}{R''} = \frac{nr}{r/n} = n^2$$

(*v*) (*a*) 8.4 V ***[Hint:*** $I = \frac{\Delta E}{r_1 + r_2} = \frac{9-7}{3+7} = \frac{2}{10} = 0.2A$

$(V)E_1 = 9 - (0.2 \times 3) = 8.4;\ (V)E_2 = 7 + (0.2 \times 7) = 8.4\ V$

16. (*i*) (*d*) $\frac{3}{4}I_0$ ***[Hint: The resultant intensity*** $I = I_0 \cos^2 \frac{\phi}{2}$ · ***The*** I_0 ***is the maximum intensity and*** $\theta = \pi/3$; ***Here*** $I = I_0 \cos^2\left(\frac{\pi}{3} \times \frac{1}{2}\right) = I_0 \cos^2 \frac{\pi}{6} = \frac{3}{4}I_0$

(*ii*) (*b*) 4 : 1 ***[Hint:*** $\frac{I_{max}}{I_{min}} = \frac{(A+B)^2}{(A-B)^2}$ $\therefore \frac{9}{1} = \frac{(A+B)^2}{(A-B)^2}$ or $\frac{3}{1} = \frac{A+B}{A-B} \Rightarrow A = 2B$

Now, $\frac{I_1}{I_2} = \frac{A^2}{B^2} = \frac{(2B)^2}{B^2} = \frac{\mathbf{4}}{\mathbf{1}}$

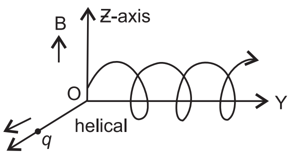
(*iii*) (*c*) conservation of energy holds good and energy is redistributed

(*iv*) (*a*) $\frac{\lambda}{\theta}$ ***[Hint: Fringe width (β) =*** $\frac{\lambda D}{d}$ *and* $\theta = \frac{d}{D}$ $\therefore \beta = \frac{\lambda}{\theta}$

(*v*) (*c*) 2λ

SECTION – C

17. (*i*)



(*ii*) K.E. does not change irrespective of the direction of the charge as

Power delivered, $\vec{F} \cdot \vec{v} = q\left(\vec{v} \times \vec{B}\right) \cdot \vec{v} = 0$ **...[∵ scalar triple product** $\left(\vec{v} \times \vec{\mathbf{B}}\right) \cdot \vec{v} = \mathbf{0}$ **]**

18. ***Two conditions for obtaining coherent sources:***

(*i*) Two sources should give monochromatic light.

(*ii*) Coherent sources of light should be obtained from a single source by some device.

The fringe width (dark and bright) is given by $\beta = \frac{\lambda D}{d}$

Hence, it is same for both dark and bright fringes. So they are equally spaced on the screen.

19. Let C_1, C_2 and C_3 be the capacitances of three capacitors. But these three capacitors are of same capacitance, so C is the capacitance of each capacitor.

$$C_1 = C_2 = C_3 = C$$

When C_1, C_2 and C_3 are connected in series:

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\Rightarrow \frac{1}{C_S} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C} \qquad \Rightarrow \qquad C_S = \frac{C}{3} = 3\mu F \qquad \text{...[}\because C_S = 3\ \mu F$$

$\therefore$ $C = 9\ \mu F$

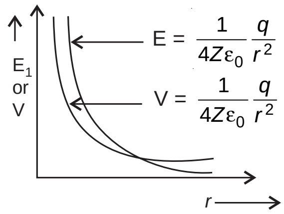
When C_1, C_2 and C_3 are connected in parallel.

$$C_p = 3C = 3 \times 9\ \mu F = 27\ \mu F$$

Energy stored in capacitor is, $E = \frac{1}{2}CV^2$

$$\therefore \frac{E_S}{E_p} = \frac{C_s}{C_p} = \frac{3}{27} = \frac{1}{9} \qquad \therefore \qquad \textbf{Ratio = 1 : 9}$$

Or



20. ***Rectifier.*** A rectifier is a circuit which converts an alternating current into direct current.

p-n diode as a half wave rectifier. A half wave rectifier consists of a single diode as shown in the circuit diagram. The secondary of the transformer gives the desired a.c. voltage across A and B. In the positive half cycle of a.c., the voltage at A is positive, the diode is forward biased and it conducts current.

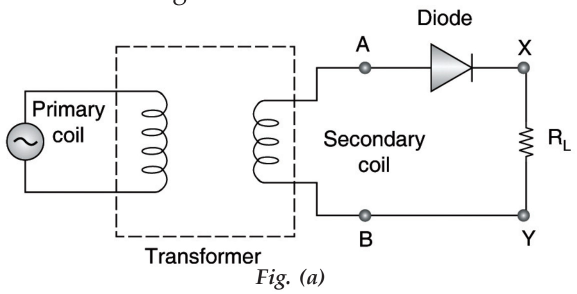


Fig. (a)

In the negative half cycle of a.c., the voltage at A is negative, the diode is reversed biased and it does not conduct current. Thus, we get output across R_L during positive half cycles only. The output is unidirectional but varying.

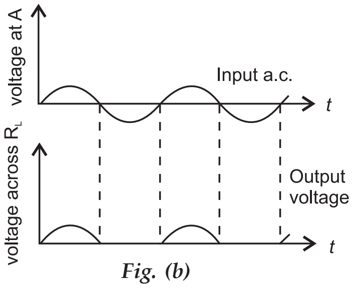
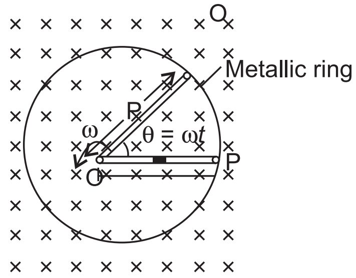


Fig. (b)

21. The magnitude of the emf, generated across a length dr of the rod, as it moves at right angles to the magnetic field, is given by

$d\varepsilon = Bvdr$



$$\therefore \quad \varepsilon = \int d\varepsilon = \int_0^R Bvdr = \int_0^R B\omega r dr = \frac{B\omega R^2}{2}$$

Alternatively, The potential difference across the resistor is equal to the induced emf and equal B × (rate of change of area of loop). If θ is the angle between the rod and the radius of the circle at P at time t, the area of the sector OPQ (as shown in the figure) is given by—

$$\pi R^2 \times \frac{\theta}{2\pi} = \frac{1}{2}R^2\theta$$ **...where [R is the radius of the circle**

$$\varepsilon = B \times \frac{d}{dt}\left[\frac{1}{2}R^2\theta\right] = \frac{1}{2}BR^2\frac{d\theta}{dt} = \frac{B\omega R^2}{2}$$

22. (i) Distance between two dark lines, on either side of central maxima $= 2\frac{\lambda D}{a}$

$$= \frac{2 \times 6000 \times 10^{-10} \times 1.5}{1 \times 10^{-4}} = 18000 \times 10^{-6} = 18 \times 10^{-3}\text{m} = \mathbf{18\ mm}$$

(ii) Angular spread of the first diffraction minimum (on either side)

$$= \theta = \frac{\lambda}{a} = \frac{6 \times 10^{-7}}{1 \times 10^{-4}} = \mathbf{6 \times 10^{-3}\ radians}$$

23. D_1 and D_2 both are forward biased and allow current to flow through them

$R_1 = 3\Omega$ and $R_2 = 3\Omega$ are in parallel,

$R_{net} = \frac{3}{2} = 1.5\ \Omega$ ...$\left[\therefore \mathbf{R\rho = \frac{R_1 \times R_2}{R_1 + R_2}}\right.$

R_{net} and 2.5 Ω are in series

Total Resistance = 1.5 Ω + 2.5 Ω = 4 Ω

$\therefore \quad I = \frac{10V}{4\Omega} = 2.5\ A$

∴ **Value of the current flowing through 2.5 Ω resistor = 2.5 A**

24. $B_H = B_E \cos\delta$ $\quad\therefore\quad 4B_H = B$ **...[Given**

$B = B_E \cos 60^\circ$ $\quad\Rightarrow\quad B = B_E \times \frac{1}{2}$

$\Rightarrow \quad B_E = 2B$

At equator, $\delta = 0^\circ$ $\quad\therefore\quad B_H = 2B(\cos 0) = 2B(1) = \mathbf{2B}$

Or

Magnetic moment due to a circular coil, NIA = NI (πR^2)

Magnetic moment due to square coil, NIA = NI $\left(\frac{2\pi R}{4}\right)^2$

∵ Circumference of a circle of radius is 2πR, which makes 4 sides of a square.

Hence one side of a square $= \frac{2\pi R}{4} = \frac{\pi R}{2}$

$$\text{Ratio} = \frac{(M)_{sq.}}{(M)_{cir}} = \frac{\frac{NI(\pi^2R^2)}{4}}{NI(\pi R^2)} = \frac{\pi}{4} = \frac{3.14}{4} = \frac{32}{40} = \frac{4}{5} = \mathbf{4 : 5}$$ **...[3.14 ≈ 3.2]**

25. (a) ***When the image lies at infinity:***

Given: $f_1 = 1.25$ cm, $\quad f_2 = 5$ cm, $\quad m = 30$, $\quad D = 25$ cm

We know that, $m = \frac{L}{f_1} \times \frac{D}{f_2}$ $\quad$ or $\quad L = \frac{m(f_1 \times f_2)}{D} = \frac{30 \times 1.25 \times 5}{25} = \mathbf{7.5\ cm}$

(*b*) ***When the image is formed at the near point:***

$$M = m_0 \times m_e = \frac{L}{f_0}\left(1+\frac{D}{f_e}\right) \qquad \Rightarrow \qquad 30 = \frac{L}{1.25}\left(1+\frac{25}{5}\right)$$

$$\Rightarrow \quad 30 \times 1.25 = L \times 6 \qquad \therefore \qquad L = 5 \times 1.25 = \mathbf{6.25\ cm}$$

SECTION – D

26. (*i*) ***First law:*** *Whenever the magnetic flux linked with a closed circuit changes, an emf (and hence a current) is induced in it which lasts only so long as the change in flux is taking place. This phenomenon is called electromagnetic induction.*

Second law: *The magnitude of the induced emf is equal to the rate of change of magnetic flux linked with the closed circuit.*

Mathematically $|\varepsilon| = \frac{d\phi}{dt}$

(*ii*) $v = 1800$ km/h in the west, $l = 25$ m, $B_R = 5 \times 10^{-4}$ tesla, $\delta = 30°$

Since v, l and B are to be perpendicular to get induced emf, the vertical component alone will contribute to the induction

$B_V = B_R \sin\delta = 5 \times 10^{-4} \times \sin 30° = 2.5 \times 10^{-4}$ tesla

The induced emf = $-B_V vl$

$$= -2.5 \times 10^{-4} \times \frac{1800 \times 10^3}{3600} \times 25 = -\frac{62.5}{2} \times 10^{-1} = -3.125 \text{ volt}$$

– ve sign signifies that the emf will oppose the change in magnetic flux causing it.

27. (*i*) $\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$ $\qquad \therefore \qquad \varepsilon_2 = \frac{l_2}{l_1} \times \varepsilon_1 = \frac{80}{60} \times 1.5 = \mathbf{2.0\ V}$

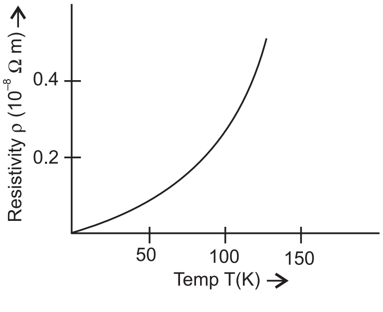
(*ii*) The circuit will not work. If emf of auxiliary battery is greater than the emf of the driver cell of the potentiometer, there will be no balance point on the wire AB. The maximum potential drop across the wire will be of 1 V and will not be able to balance 1.5 V emf.

(*iii*) **No,** the balance point is not affected by the high resistance R because no current flows through the cell at the balance point.

Or

(*i*) ***Resistivity of conductor.*** It is the resistance of a conductor of unit length and unit area of cross-section.

The S.I. unit of resistivity is Ω (ohm-metre), $\rho = R\frac{A}{l}$



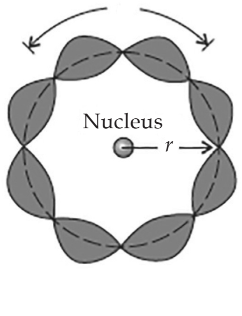
(*ii*) ***Variation of resistivity with temperature.***

The resistivity of a material is given by

$$\rho = \frac{m}{ne^2\tau}$$

On increasing temperature, average speed of drifting electrons increases. As a result collisions are more frequent. Average relaxation time 'τ' decreases, hence 'ρ' increases.

28. (*a*) Consider the motion of an electron in a circular orbit of radius r around the nucleus of the atom. According to de-Broglie hypothesis, this electron is also associated with wave character. Hence a circular orbit can be taken to be a stationary orbit. If it contains an integral number of de-Broglie wavelength, *i.e.,*



$2\pi r_n = n\lambda$ ...[n = 1, 2, 3

But de-Broglie wavelength, $\lambda = \frac{h}{mv}$ $\qquad \therefore \qquad 2\pi r = \frac{nh}{mv}$

The angular momentum C of the electron must be $L = mvr = \frac{nh}{2\pi}$ **...Here [n = 1, 2, 3 ...**

The electrons are permitted to circulate only in those orbits in which the angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$; h being Planck's constant.

(*b*) Total energy, E = – 13.6 eV

(*i*) *Kinetic energy*: T = – E = –(–13.6) eV = **13.6 eV**

(*ii*) *Potential energy:* V = – 2T = –2 × 13.6 eV = **–27.2 eV**

Or

Given. V = 50 kV, $(a)_{EM} = (a)_{OM'}$

λ for optical microscope $(\lambda)_{OM}$ = 550nm = 550 $\times 10^{-9}$ m

$$\therefore \quad \lambda_{DB} = ?, \ \frac{(R)_{EM}}{(R)_{OM}} = ?$$

we know that,

$$\lambda_{DB} = \frac{1.227}{\sqrt{V}} = \frac{1.227}{\sqrt{50 \times 10^3}} = \mathbf{0.005\ nm}$$

Resolving power of telescope is given by

$$RP = \frac{2n\sin\beta}{1.22\lambda}$$

$$\frac{(R)_{EM}}{(R)_{OM}} = \frac{2n\sin\beta}{1.22(\lambda)_{EM}} \Big/ \frac{2n\sin\beta}{1.22(\lambda)_{OM}}$$

$$= \frac{(\lambda)_{OM}}{(\lambda)_{EM}} = \frac{(550 \times 10^{-9})}{(0.005 \times 10^{-9})} = \mathbf{1{,}10{,}000}$$

29. (*i*) K.E. of electron in the 2nd excited state,

$$E_n = -\frac{13.6}{n^2} eV$$

$$\therefore E_n = -\frac{13.6}{3^2} = -1.51\,eV$$ **...[∵ for 2nd excited state n = 3**

(*ii*) $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) \quad \Rightarrow \quad \frac{1}{\lambda} = R\left(1 - \frac{1}{9}\right)$

$\Rightarrow \quad \frac{1}{\lambda} = R\left(\frac{8}{9}\right) \quad \Rightarrow \quad \frac{1}{\lambda} = \frac{8}{9}R$

$$\lambda = \frac{9}{8R} = \frac{9}{8 \times 1.1 \times 10^7 m^{-1}}$$ **...[∵ Rydberg constant, R = 1.1 × 10^7 m^{-1}**

$\therefore \quad \boldsymbol{\lambda = 1.02 \times 10^{-7}}$ **m**

30. (*a*) The breaking of heavy nucleus into smaller fragments is called **nuclear fission**; while the joining of lighter nuclei to form a heavy nucleus is called **nuclear fusion**.

(*b*) Binding energy per nucleon of the daugher nuclei, in both processes, is more than that of the parent nuclei. The difference in binding energy is released in the form of energy in both processes some mass gets converted into energy.

(*c*) **Energy released :** $Q = \left[m\left({}^2_1H\right) + m\left({}^3_1H\right) - m\left({}^4_2He\right) - m(n)\right] \times 931.5$ MeV

= [2.014102 + 3.016049 – 4.002603 – 1.008665] × 931.5 MeV

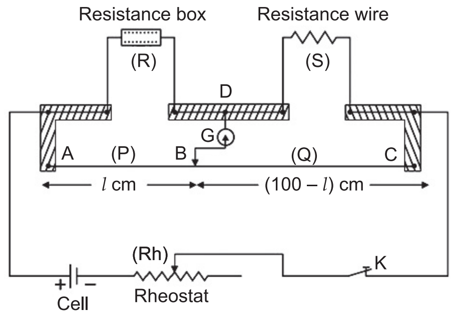
= 0.018883 × 931.5 MeV = **17.59 MeV**

SECTION – E

31. (*a*) **Metre Bridge is special case of Wheatstone Bridge.** It is a device based on Wheatstone bridge to determine the unknown resistance of a wire.

Principle: Meter bridge is based on the principle of wheatstone bridge, *i.e.,* when bridge is balanced.

$$\frac{l}{(100-l)} = \frac{R}{S} \quad or \quad S = \frac{R(100-l)}{l}$$



Circuit: To find the unknown resistance S, the circuit is completed as shown in the figure. The unknown resistance wire of resistance S is connected across the gap between points C and D and a resistance box (R) is connected across the gap between the points A and D. A cell, a rheostat and a key (K) is connected between the point A and C by means of connecting screws. In the experiment when the sliding jockey touches the wire AC at any point, then the wire is divided into two parts. These two parts AB and BC act as the resistances P and Q of the Wheatstone bridge. In this way the resistances of arms AB, BC, AD and DC form the resistances P, Q, R and S of Wheatstone bridge. Thus the circuit of meter bridge is the same as that of Wheatstone bridge.

Method: To determine the unknown resistance first of all key K is closed and a resistance R is taken in the resistance box in such a way that on pressing jockey B at end points A and C, the deflection in galvanometer is on both the sides. Now jockey is slided on wire at such a position that on pressing the jockey on the wire at that point, there is no deflection in the galvanometer G. In this position the points B and D are at the same potential, therefore the bridge is balanced. The point B is called the null point. The length of both parts AB and BC of the wire are read on the scale. The condition of balance of Wheatstone bridge is,

$$\frac{P}{Q} = \frac{R}{S}$$

$\therefore$ Unknown resistance, $S = \left(\frac{Q}{P}\right)R$ ...(*i*)

If r is the resistance per cm length of wire AC and l cm is the length of wire AB, then length of wire BC will be $(100 - l)$ cm

$\therefore$ P = resistance of wire AB = lr

Q = resistance of wire BC = $(100 - l)r$

Substituting these values in equation (*i*), we get,

$$S = \frac{(100-l)r}{lr} \times R \qquad \Rightarrow \qquad S = \frac{100-l}{l}R \qquad ...(ii)$$

As the resistance (R) of wire (AB) is known, the resistance S may be calculated. A number of observations are taken for different resistances taken in resistance box and S is calculated each time and the mean value of S is found.

Precautions:

(*i*) In this experiment the resistance of the copper strips and connecting screws have not been taken into account. These resistances are called end-resistances. Therefore very small resistances cannot be found accurately by metre bridge. The resistance S should not be very small.

(*ii*) The current should not flow in the metre bridge wire for a long time, otherwise the wire will become hot and its resistance will change.

(*b*) The error which arises on account of resistance of copper strips and the connecting wire at both ends of the meter bridge is called ***end error***.

It is minimized by adjusting the balance point near the middle point of the bridge.

• The balancing point will **not** be affected, as the bridge remains balanced.

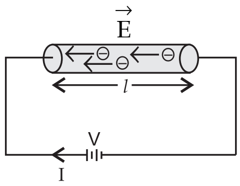
Or

(*a*) (*i*) The free electrons, in a metal, (flowing by themselves), have a random distribution of their velocities. Hence the net charge crossing any cross section in a unit time is **zero.**

(*ii*) The **drift velocity** equals the average (time dependent) velocity acquired by free electrons, under the action of an applied (external) electric field.

(*iii*) ***Expression for current in terms of drift velocity:*** Drift velocity is defined as the velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied field. Its unit is m^{-1}s and dimensions [LT^{-1}]

Expression. The magnitude of electric field set up across the conductor is given by



$$E = \frac{V}{l}$$

Let n be the number of free electrons per unit volume of the conductor.

Then, total number of free electrons in the conductor = n × volume of the conductor

Hence, $Q = (nAl)e$

Time taken by the charge to cross the conductor length l is given by

$$t = \frac{1}{v_d}$$ **...where [v_d is drift velocity of electrons**

$$\therefore \quad \mathbf{I} = \frac{Q}{t} = \frac{nAle}{\frac{l}{v_d}} = neAv_d \qquad \therefore \qquad I = neAv_d$$

(*b*) We know from above

$$I = -neA\, v_d \qquad ...(i)$$

Also we know, $$v_d = \left(\frac{e\vec{E}}{m}\right)\tau \qquad ...(ii)$$

Putting the value of v_d in equation (*i*) from equation (*ii*) we have

$$I = -neA\frac{eE}{m}\tau \qquad ...\left[\because \mathbf{E} = \frac{V}{l}\right.$$

or $$\frac{E}{I} = -\frac{m}{ne^2A\tau} \qquad ...\left[\because \rho = \frac{\mathbf{RA}}{l}\right.$$

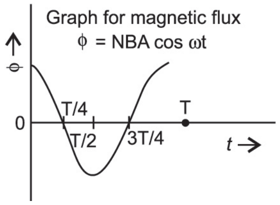
$$\rho = -\frac{m}{ne^2\tau} \qquad \therefore \qquad \rho \propto \frac{\mathbf{1}}{\tau}$$

32. ***Faraday's law of e.m. induction is a basic law of electromagnetism predictions now a magnetic field will interact with an electric circuit to produce an electromotive force.***

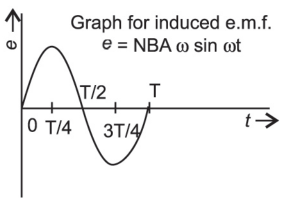
(*a*) When a closed coil is rotated in a uniform magnetic field with its axis perpendicular to the magnetic field, the magnetic flux linked with the coil changes and an induced emf and hence a current is set up in it. The working of an a.c. generator is based on the principle of electromagnetic induction.

Graph:

(*i*)



(*ii*)



(*b*) Let N = number of turns in the coil

A = area of face of each turn

B = magnitude of the magnetic field

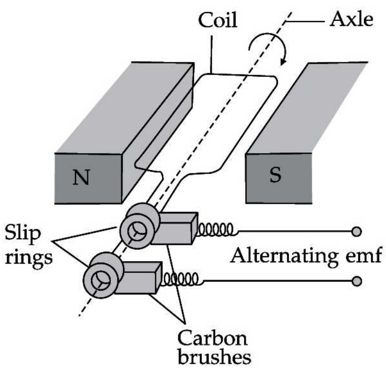
θ = angle which normal to the coil makes with field $\vec{B}$ at any instant t

ω = the angular velocity with which the coil rotates

The magnetic flux linked with the coil at any instant t will be,

$\phi = NAB\cos\theta = NAB\cos\omega t$

By *Faraday's flux rule*, the induced emf is given by,



$$E = -\frac{d\phi}{dt} = \frac{-d}{dt}NAB(\cos\omega t)$$

$$E = NAB(\sin\omega t) \cdot \omega$$

$$E = E_0 \sin\omega t$$ **...where [$E_0 = NAB\omega$**

When a load of resistance R is connected across the terminals, a current I flows in the external circuit.

$$I = \frac{E}{R} = \frac{E_0\sin\omega t}{R} = I_0\sin\omega t$$ **...where $\left[I_0 = \frac{E_0}{R}\right.$**

Or

(*a*) The device X is a **capacitor**.

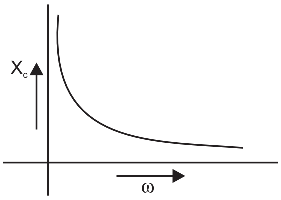
(*b*) Curve B $\longrightarrow$ voltage

Curve C $\longrightarrow$ current

Curve A $\longrightarrow$ power consumption over a full cycle.

Reason. The current leads the voltage in phase, by a plane angle of $\frac{\pi}{2}$ for a capacitor.

(*c*) $X_C = \frac{1}{\omega C}\left(X_C \propto \frac{1}{\omega}\right)$

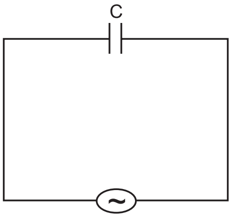


(*d*) $V = V_0 \sin\omega t$

$Q = CV = CV_0 \sin\omega t$

$I = \frac{dq}{dt} = \omega c V_0 \cos\omega t = \mathbf{I_0 \sin\left(\omega t + \frac{\pi}{2}\right)}$

Current leads the voltage, in phase, by $\frac{\pi}{2}$.



33. The magnifying power of a telescope is defined as the ratio of the angle subtended at the eye by the final image formed at the least distance of distance vision to the angle subtended at the eye by the object at infinity, when seen directly

$$m = \frac{\beta}{\alpha} \qquad \therefore \qquad m = \frac{f_0}{f_e}\left(1 + \frac{f_e}{p}\right)$$

Angle subtended by the 100 m tall tower 3 km away is,

$$\alpha = \tan\alpha = \frac{100}{3\times10^3} = \frac{1}{3}\text{ rad.}$$

Let h be the height of the image of tower formed by the objective.

Then angle subtended by the image produced by the objective will also be equal to h and is given by

$$\alpha = \frac{h}{f_0} = \frac{h}{150} \qquad \Rightarrow \frac{h}{150} = \frac{1}{30} \qquad \therefore h = \frac{150}{30} = 5 \text{ cm}$$

Magnification produced by the eyepiece,

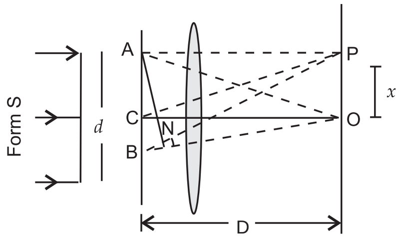
$$m_e = 1 + \frac{D}{f_0} = 1 + \frac{25}{5} = 6$$

$\therefore$ **Height of the final image** = $h \times m_e$ = 5 × 6 = **30 cm**

Or

(*a*) ***Diffraction at a single slit.*** Suppose a parallel beam of monochromatic light of wavelength λ falls normally on a slit AB of width d (of the order of the wavelength of light). The diffraction occurs on passing through the slit. The diffraction pattern is focussed on to the screen by a convex lens. The diffraction pattern consists of a central bright fringe (or band), having alternate dark and bright fringes of decreasing intensity on both sides.

1. **Position of central maximum.** Let C be the centre of the slit AB. According to ***Huygen's principle,*** *"when light falls on the slit, it becomes a source of secondary wavelets."* All the wavelets originating from slit AB are in same phase. These secondary waves reinforce each other resulting the central maximum intensity at O.



2. **Position of secondary maxima and minima.** Consider a point P on the screen. All the secondary waves travelling in a direction making angle θ with CO, reach at a point P. The intensity at P depends on the path difference between secondary waves.

$\therefore$ Path difference between the secondary waves reaching P from points A and B is, BN = $d \sin \theta$.

(*i*) The point P will be the position of n^{th} *secondary maxima*

If path difference, BN = $(2n + 1)\frac{\lambda}{2}$ **...where [n is an integer**

$\therefore d \sin \theta = (2n + 1)\frac{\lambda}{2}$

or $\sin \theta = (2n + 1)\frac{\lambda}{2d}$

When θ is very small, then $\sin \theta \approx \theta$

$\theta = (2n + 1)\frac{\lambda}{2d}$ **...where [n is an integer**

for $n = 1$

$\theta_1 = \frac{3\lambda}{2d}$, first secondary maximum

(*ii*) The point P will be the position of n^{th} *secondary minima*, if path difference BN = $n\lambda$

$d \sin \theta = n\lambda$

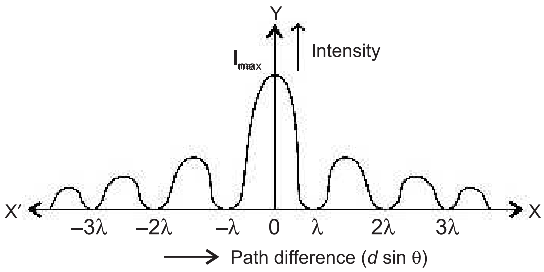
When θ is very small, then $\sin \theta \approx \theta$

$\therefore \theta = \frac{n\lambda}{d}$ **...where [n is an integer**

for $n = 1$, $\theta = \frac{\lambda}{d}$ = first secondary minima.

Hence, the diffraction pattern due to single slit consists of a centre bright maximum at O alongwith secondary maxima and minima on either side.

Intensity distribution curve. The intensity distribution on the screen is represented as shown in the figure.



Width of central maximum. If D is the distance between slit and screen and y_n is the distance of n^{th} minimum from point O, then $\theta_n = \frac{y_n}{D}$. ...(*i*)

But the position of n^{th} secondary minimum is,

$$\theta_n = \frac{n\lambda}{d} \quad ...(ii)$$

$$\therefore \quad \frac{y_n}{D} = \frac{n\lambda}{d} \quad \text{...[From (i) and (ii)}$$

$$y_n = n\lambda\frac{D}{d}$$

Thus width of a secondary minima (and maxima also) (Fringe width) is:

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

$$= \frac{n\lambda D - n\lambda D + \lambda D}{d}$$

$$\therefore \quad \beta = \frac{\lambda D}{d}$$

(*b*) **Given.** $\lambda_1 = 590$ nm, $\lambda_2 = 596$ nm, $d = 2\times 10^{-6}$ m, D = 1. 5 m

First maxima due to $\lambda_1(\beta_1) = \frac{\lambda_1 D}{d}\times\frac{3}{2}$

First maxima due to $\lambda_2(\beta_2) = \frac{\lambda_2 D}{d}\times\frac{3}{2}$

$$\beta_2 - \beta_1 = \frac{3}{2}\frac{\lambda_1 D}{d} - \frac{3}{2}\frac{\lambda_2 D}{d} = \frac{3}{2}\frac{D}{d}(\lambda_2 - \lambda_1)$$

$$= \frac{3}{2}\times\frac{1.5}{(2\times 10^{-6})}(596 - 590)\times 10^{-9} = 6.75\times 10^{-3}\text{ m} = \mathbf{6.75\ mm}$$

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