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:

(*i*) ***All*** *questions are compulsory. There are* **33** *questions in all.*

(*ii*) *This question paper has five sections:* ***Section A, Section B, Section C, Section D*** *and* ***Section E****.*

(*iii*) ***Section A*** *contains* ***ten*** *very short answer questions and four assertion reasoning MCQs of* ***one*** *mark each,* ***Section B*** *has two case based questions of* ***four*** *marks each,* ***Section C*** *contains nine short answer questions of* ***two*** *marks each,* ***Section D*** *contains* ***five*** *short answer questions of* ***three*** *marks each and* ***Section E*** *contains* ***three*** *long answer questions of* ***five*** *marks each.*

(*iv*) *There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.*

SECTION-A

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

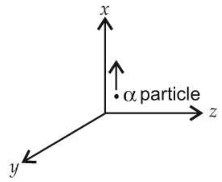
Q.1. If the radius of the Gaussian surface enclosing a charge is halved, how does the electric flux through the Gaussian surface change?

Q.2. Name the physical quantity which remains same for microwaves of wavelength 1 mm and UV radiations of 1600 Å in vacuum.

Or

The speed of an electromagnetic wave in a material medium is given by $v = \frac{1}{\sqrt{\mu\varepsilon}}$, μ being the permeability of the medium and ε its permittivity. How does its frequency change?

Q.3. A beam of α particles projected along +*x*-axis, experiences a force due to a magnetic field along the +*y*-axis. What is the direction of the magnetic field?



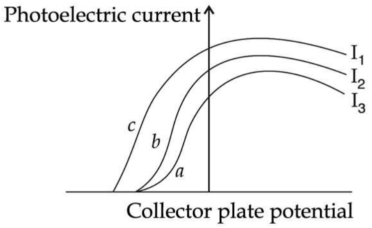
Q.4. Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why?

Or

Why is the use of a.c. voltage preferred over d.c. voltage? Give *two* reasons.

Q.5. Why is the classical (Rutherford) model for an atom—of electron orbiting around the nucleus—not able to explain the atomic structure?

Q.6. The figure shows a plot of three curves *a*, *b*, *c*, showing the variation of photocurrent *vs.* collector plate potential for three different intensities I_1, I_2 and I_3 having frequencies v_1, v_2 and v_3 respectively incident on a photosensitive surface.
Point out the two curves for which the incident radiations have same frequency but different intensities.



Q.7. State the reason, why heavy water is generally used as a moderator in a nuclear reactor.

Or

Name the absorbing material used to control the reaction rate of neutrons in a nuclear reactor.

Q.8. State the reason, why GaAs is most commonly used in making of a solar cell.

Or

Why should a photodiode be operated at a reverse bias?

Q.9. What happens to the width of depletion layer of a *p-n* junction when it is (*i*) forward biased, (*ii*) reverse biased?

Q.10. What is the difference between an *n*-type and a *p*-type intrinsic semiconductor?

For question numbers 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):* Surface charge density of an irregularity shaped conductor is non-uniform.
Reason (R): Surface density is defined as charge per unit area.

Q.12. *Assertion (A):* In a series combination of capacitors, charge on each capacitor is the same.
Reason (R): In such a combination, voltage across each capacitor is same.

Q.13. *Assertion (A):* The images formed by total internal reflections are much brighter than those formed by mirrors or lenses.
Reason (R): There is no loss of intensity in total internal reflection.

Q.14. *Assertion (A):* Wavefronts obtained from light emitted by a point source in an isotropic medium are always spherical.
Reason (R): Speed of light in isotropic medium is constant.

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. **Electric Field Lines**

The electric field line in an electric field is an imaginary smooth curve along which an isolated free positive test charge tends to move. The electric field strength at any point is defined as a vector quantity, whose magnitude is measured by the number of electric field lines passing normally per unit small area around that point and whose direction is along the tangent on field line drawn on that point.

(*i*) The work done in bringing a unit positive charge from infinite distance to a point at distance *x* from a positive charge Q is W. Then the potential ϕ at that point is

(*a*) $\frac{WQ}{x}$ (*b*) W (*c*) $\frac{W}{x}$ (*d*) WQ

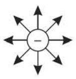
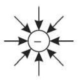
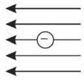
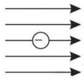
(*ii*) The force per unit charge is known as

(*a*) electric flux (*b*) electric field (*c*) electric potential (*d*) electric current

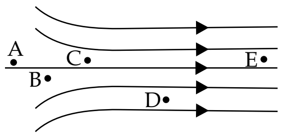
(*iii*) Electric field lines provide information about

(*a*) field strength (*b*) direction (*c*) nature of charge (*d*) all of these

(*iv*) Which of the following figures represent the electric field lines due to a single negative charge?

(*a*)    (*b*)    (*c*)    (*d*) 

(*v*) A non-uniform electric field is represented by the diagram. At which of the following points the electric field is greatest in magnitude?



(*a*) A   (*b*) B
(*c*) C   (*d*) D

Q.16. Optical Instruments

Nature has endowed the human eye (retina) as a valuable ***optical instrument***, with the sensitivity to detect electromagnetic waves within a small range of electromagnetic spectrum of about 400 nm to 750 nm, which is termed as **LIGHT.** It is mainly through light and the sense of vision that we know and interpret the world around us. A number of optical devices and instruments like periscopes, kaleidoscopes, binoculars, telescopes, microscopes are in common use.

In modern microscopes, multi-component lenses are used for both the objective and eyepiece to improve the image quality by minimising various spherical aberrations (defects) in lenses. The wave properties of electrons have been utilised in the design of electron microscope, which is a great improvement, with higher resolution, over the optical microscope.

The telescopes, both of refracting and reflecting types are used to provide angular magnification of distant objects. The largest telescope in India is in Kavalur, Tamil Nadu. It is a 2.34 m diameter reflecting telescope and is being used by Indian Institute of Physics, Bangalore. The largest reflecting telescopes in the world is the Gran Telescopio Canarias in La Palma, Spain with a mirror diameter of 34.2 feet (10.4 meters).

(*i*) Different objects at different distances are seen by the eye. The parameter that remains constant is

(*a*) the focal length of the eye lens   (*b*) the object distance from the eye lens
(*c*) the radii of curvature of the eye lens   (*d*) the image distance from the eye lens

(*ii*) An under-water swimmer cannot see very clearly even in absolutely clear water because of:

(*a*) absorption of light in water   (*b*) change in focal length of eye lens
(*c*) reduction of speed of light in water   (*d*) scattering of light in water

(*iii*) The final image in an astronomical telescope with respect to object is

(*a*) virtual and erect   (*b*) real and erect
(*c*) real and inverted   (*d*) virtual and inverted

(*iv*) A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eye-piece of focal length 1.0 cm is used, what is the angular magnification of the telescope?

(*a*) 1000   (*b*) 1500   (*c*) 2000   (*d*) 3000

(*v*) A giant telescope in an observatory has an objective of focal length 19 m and an eye-piece of focal length 1.0 cm. In normal adjustment, the telescope is used to view the moon. What is the diameter of the image of the moon formed by the objective? The diameter of the moon is 3.5×10^6 m and the radius of the lunar orbit round the earth is 3.8×10^8 m.

(*a*) 10 cm   (*b*) 12.5 cm   (*c*) 15 cm   (*d*) 17.5 cm

SECTION-C

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

Q.17. A proton and an alpha particle having the same kinetic energy are, in turn, passed through a region of uniform magnetic field, acting normal to the plane of the paper and travel in circular paths. Deduce the ratio of the radii of the circular paths described by them.

Q.18. Draw the intensity pattern for single slit diffraction and double slit interference. Hence, state *two* differences between interference and diffraction patterns.

Q.19. Two point charges 4Q and Q are separated by 1 m in air. At what point on the line joining the charges is the electric field intensity zero? Also calculate the electrostatic potential energy of the system of charges, taking the value of charge, $Q = 2 \times 10^{-7}$ C.

Or

An electric dipole of length 4 cm, when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $4\sqrt{3}$ Nm. Calculate the potential energy of the dipole, if it has charge ± 8 nC.

Q.20. Distinguish between an intrinsic semiconductor and a *p*-type semiconductor. Give reason, why, a *p*-type semiconductor crystal is electrically neutral although $n_h >> n_e$?

Q.21. Derive an expression for the self-inductance of a long air-cored solenoid of length l and number of turns N.

Q.22. Write the distinguishing features between diffraction and interference phenomena.

Q.23. How is forward biasing different from reverse biasing in a *pn* junction diode?

Q.24. A magnetic needle free to rotate in a vertical plane parallel to the magnetic meridian has its north tip down at 60° with the horizontal. The horizontal component of the earth's magnetic field at the place is known to be 0.4 G. Determine the magnitude of the earth's magnetic field at the place.

Or

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

Q.25. Draw a ray diagram of a reflecting type telescope. State *two* advantages of this telescope over a refracting telescope.

SECTION-D

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

Q.26. The current through two inductors of self-inductance 15 mH and 25 mH is increasing with time at the same rate. Draw graphs showing the variation of the

(*a*) emf induced with the rate of change of current.

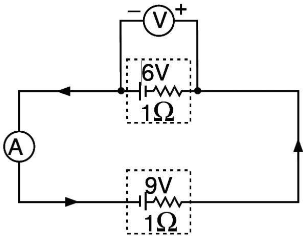
(*b*) energy stored in each inductor with the current flowing through it.

Compare the energy stored in the coils, if the power dissipated in the coils is the same.

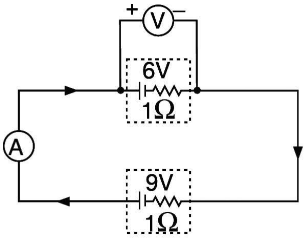
Q.27. State the principle of working of a galvanometer. A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R_1 in series with the coil. If a resistance R_2 is connected in series with it, then it can measure upto V/2 volts. Find the resistance, in terms of R_1 and R_2, required to be connected to convert it into a voltmeter that can read upto 2V. Also find the resistance G of the galvanometer in terms of R_1 and R_2.

Or

In the two electric circuits shown in the figure, determine the reading of ideal ammeter (A) and the ideal voltmeter (V).



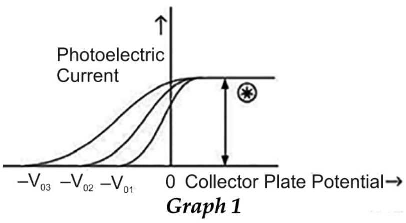
(*a*)



(*b*)

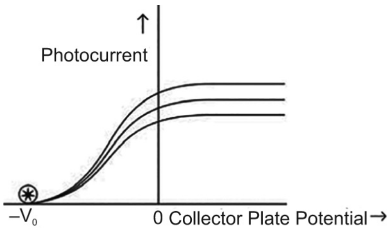
Q.28. The graphs, drawn here, are for the phenomenon of photoelectric effect.

(*a*)



Graph 1

(*b*)



Graph 2

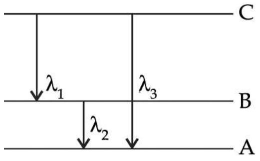
(*i*) Identify which of the two characteristics (intensity/frequency) of incident light, is being kept constant in each case.

(*ii*) Name the quantity, corresponding to the, ⊛ mark in each case.
(*iii*) Justify the existence of a 'threshold frequency' for a given photosensitive surface.

Or

Draw a graph showing the variation of deBroglie wavelength of a particle of charge q and mass m with the accelerating potential. Proton and deuteron have the same de Broglie wave lengths. Explain which has more kinetic energy.

Q.29. (*i*) State Bohr's quantization condition for defining stationary orbits. How does de-Broglie hypothesis explain the stationary orbits?
(*ii*) Find the relation between the three wave-lengths λ_1, λ_2 and λ_3 from the energy level diagram shown in the given diagram.



Q.30. (**a**) In a typical nuclear reaction, *e.g.*,

$${}^2_1H + {}^2_1H \rightarrow {}^3_2He + n + 3.27 \text{ MeV}$$

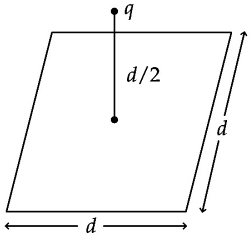
although number of nucleons is conserved, yet energy is released. How? Explain.
(**b**) Show that nuclear density in a given nucleus is independent of mass number A.

SECTION-E

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

Q.31. (**a**) Define electric flux. Is it a scalar or a vector quantity?

A point charge q is at a distance of $\frac{d}{2}$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



(**b**) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

Or

(**a**) Use Gauss' law to derive the expression for the electric field $(\vec{E})$ due to a straight uniformly charged infinite line of charge density λ C/m.
(**b**) Draw a graph to show the variation of E with perpendicular distance r from the line of charge.
(**c**) Find the work done in bringing a charge q from perpendicular distance r_1 to r_2 $(r_2 > r_1)$.

Q.32. An a.c. source generating a voltage $v = v_m \sin \omega t$ is connected to a capacitor of capacitance C. Find the expression for the current, i, flowing through it. Plot a graph of v and i versus ωt to show that the current is $\pi/2$ ahead of the voltage. A resistor of 200 Ω and a capacitor of 15.0 μF are connected in series to a 220 V, 50 Hz a.c. source. Calculate the current in the circuit and the rms voltage across the resistor and the capacitor. Is the algebraic sum of these voltages more than the source voltage? If yes, resolve the paradox.

Or

Explain briefly, with the help of a labelled diagram, the basic principle of the working of an a.c. generator. In an a.c. generator, coil of N turns and area A is rotated at v revolutions per second in a uniform magnetic field B. Write the expression for the emf produced. A 100-turn coil of area 0.1 m^2 rotates at half a revolution per second. It is placed in a magnetic field 0.01 T perpendicular to the axis of rotation of the coil. Calculate the maximum voltage generated in the coil.

Q.33. Draw the labelled ray diagram for the formation of image by a compound microscope.
Derive the expression for the total magnification of a compound microscope. Explain why both the objective and the eyepiece of a compound microscope must have short focal lengths.

Or

(*a*) What are coherent sources of light? Two slits in Young's double slit experiment are illuminated by two different sodium lamps emitting light of the same wavelength. Why is no interference pattern observed?
(*b*) Obtain the condition for getting dark and bright fringes in Young's experiment. Hence write the expression for the fringe width.
(*c*) If s is the size of the source and its distance is a from the plane of the two slits, what should be the criterion for the interference fringes to be seen?

❐ ❐ ❐ ❐

Answer Sheet

S	A	M	P	L	E							P	A	P	E	R		

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PHYSICS

SECTION–A

1. Electric flux ϕ_E is given by

$$\phi_E = \oint \vec{E} \cdot \vec{ds} = \frac{Q}{\varepsilon_0}$$ **...where[Q is total charge inside the closed surface**

$\therefore$ On changing the radius of sphere, the electric flux through the Gaussian surface remains the same.

2. Speed/Velocity of light remains the same.

Or

Frequency remains unchanged.

3. $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$

Direction of the magnetic field is towards negative direction of z-axis.

4. Glass bob would reach earlier because there would be a force acting upward due to eddy currents on metallic bob being conducting, due to earth's magnetic field. This will slow down the metallic bob.

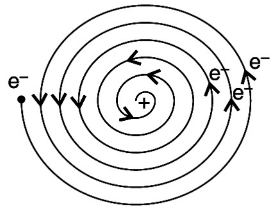
Or

a.c. voltage is preferred over d.c. voltage because of the following reasons:

(*i*) it can be stepped-up or stepped-down by a transformer.

(*ii*) carrying losses are much less.

5. As the revolving electron loses energy continuously, it must spiral inwards and eventually fall into the nucleus. So it is not able to explain the atomic structure.



6. Stopping potential will be same for the same frequency. So its curves '*a*' and '*b*' which have same frequency but different intensities ($I_2 > I_3$).

7. Neutrons produced during fission get slowed if they collide with a nucleus of the same mass. As ordinary water contains hydrogen atoms (of mass nearly that of neutrons), so it can be used as a moderator. But it absorbs neutrons at a fast rate via reaction :

$$n + p \longrightarrow d + \gamma$$

Here d is deuteron. To overcome this difficulty, heavy water is used as a moderator which has negligible cross-section for neutron absorption.

Or

Control rod or cadmium rod.

8. GaAs is 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.

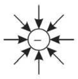
Or

As fractional change in minority charge carriers is more than the fractional change in majority charge carriers, the variation in reverse saturation current is more prominent.

9. (*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*.

10.

n-type semiconductor	*p-type semiconductor*
The electron density (n_e) is much. greater than the hole density (n_h), *i.e.*, $n_e >> n_h$.	The hole density (n_h) is much greater than the electron density (n_e) *i.e.*, $n_h >> n_e$.

11. (***a***) Both A and R are true and R is the correct explanation of A.
12. (***c***) A is true but R is false.
13. (***a***) Both A and R are true and R is the correct explanation of A.
14. (***a***) Both A and R are true and R is the correct explanation of A.
15. (***i***) (*b*); W
    (***ii***) (*b*); electric field
    (***iii***) (*d*); all of these
    (***iv***) (*b*); 
    (***v***) (*d*) D ***...[Hint: Electric field strength is maximum where the electric field lines are closer***
16. (***i***) (*d*); the image distance from the eye lens.
    ...[Hint: The image formed by the eye lens is always on the retina and the image distance is fixed
    (***ii***) (*d*); Change in the focal length of eye lens.
    ...[Hint: The eye lens is surrounded by a different medium than air. This will change the focal length of eye lens. The eye cannot accommodate all images, as it would do in air.
    (***iii***) (*d*); virtual and inverted
    (***iv***) (*b*); 1500 ***...[Hint:*** $F_0 = 15$ ***cm*** $= 15 \times 10^2$ ***cm;*** $F_e = 1.0$ ***cm As we know,*** $m = \frac{f_0}{f_e} = \frac{15\times10^2}{1.0} = 1500$
    (***v***) (*d*); 17.5 ***...[Hint:*** $\mu >>> F_0$; $v = f_0 = 19$ ***m;*** $u = -3.8 \times 10^8$ ***m As we know,*** $m_0 = \frac{v}{u} = \frac{19}{-3.8\times10^8} = 0.5 \times 10^{-7}$
    Diameter of image of moon is $(3.5 \times 10^6) \times (0.5 \times 10^{-7}) = 17.5$ ***cm***
17. **Given:** $E_p = E$

We know, $\frac{mv^2}{r} = qvB$

or $\quad r = \frac{\sqrt{2mE}}{qB} \qquad \because E = \frac{1}{2}mv^2$

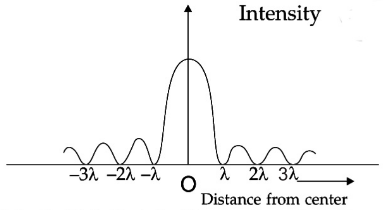
$$r_p = \frac{\sqrt{2m_pE}}{q_pB} \text{ and } r_\alpha = \frac{\sqrt{2m_\alpha E}}{q_\alpha B} \qquad \left[\begin{array}{l}\because m_\alpha = 4m_p \\ q_\alpha = 2q_p\end{array}\right.$$

$$\frac{r_p}{r_\alpha} = \frac{\sqrt{2m_pE}}{q_pB} \times \frac{q_\alpha B}{\sqrt{2m_\alpha E}} = \sqrt{\frac{m_p}{m_\alpha}} \times \frac{q_\alpha}{q_p}$$

$$\frac{r_p}{r_\alpha} = \sqrt{\frac{m_p}{4m_p} \times \frac{2q_p}{q_p}} = \frac{1}{2} \times 2 = 1$$

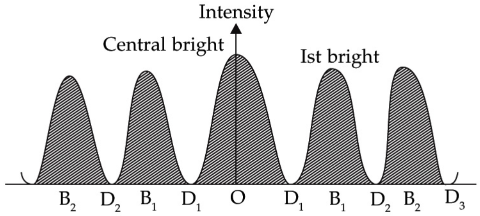
$\therefore$ $\quad r_p : r_\alpha :: \mathbf{1 : 1}$

18. (*i*) **Intensity distribution in the diffraction due to single slit**



Intensity distribution in the diffraction due to single slit

(*ii*) **Intensity pattern for double slit interference**



Basic features of distinction between interference and diffraction patterns :

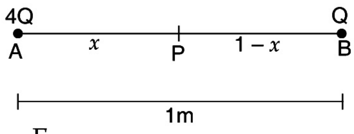
(*i*) The interference pattern has a number of equally spaced bright and dark bands while diffraction pattern has a central bright maximum which is twice as wide as the other maxima.

(*ii*) Interference pattern is the superimposition of two wave slits originating from two narrow slits. The diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit.

(*iii*) For a single slit of width '*a*' the first null of diffraction pattern occurs at an angle of $\frac{\lambda}{a}$.

At the same angle of $\frac{\lambda}{a}$, we get a maxima for two narrow slits separated by a distance '*a*'.

19. (*i*) **Given :** r = 1m, $\quad q_1 = 4Q, \quad q_2 = Q$



$E_{PA} = E_{PB}$

$$\frac{K(4Q)}{x^2} = \frac{KQ}{(1-x)^2} \quad \Rightarrow \quad \frac{4}{x^2} = \frac{1}{(1-x)^2} \quad \Rightarrow \quad \frac{2}{x} = \frac{1}{1-x}$$

$\Rightarrow 2 - 2x = x \quad \Rightarrow \quad 3x = 2 \quad \therefore \quad \boldsymbol{x = \frac{2}{3}}$

(*ii*) Electrostatic potential energy of the system is

$$U = K\frac{q_1 q_2}{r} = \frac{9 \times 10^9 \times 4Q \times Q}{1}$$

$= 36 \times 10^9 \times (2 \times 10^{-7})^2 = \mathbf{1.44 \times 10^{-3}\ J}$

Or

1st method:

Given : $2a = 4$ cm $= 4 \times 10^{-2}$ m; $\theta = 60°$; $\tau = 4 \times \sqrt{3}$ Nm; $q = \pm 8$ nC $= \pm 8 \times 10^{-9}$ C

P.E. $= |p|\ |E|\cos\theta$; $\tau = |p|\ |E|\sin\theta$

As we know, $\frac{\text{P.E.}}{\tau} = \frac{|P||E|\cos\theta}{|P||E|\sin\theta} = \cot\theta = \cot 60°$

$$\text{P.E} = \tau\cot\theta = 4 \times \sqrt{3} \times \frac{1}{\sqrt{3}}$$

$\therefore$ **P.E. = –4 Joules**

2nd method:

$\therefore\ \tau = pE\sin\theta$

$\therefore\ E = \frac{\tau}{p\sin\theta} \qquad \Rightarrow\ p = q \times 2a$

$$\therefore\ E = \frac{4\times\sqrt{3}}{8\times10^{-9}\times4\times10^{-2}\times\frac{\sqrt{3}}{2}} = \frac{1}{4}\times10^{11}$$

Now, P.E. $= |p|\ |E|\cos\theta$

$= (q \times 2a)(E)\cos\theta$

$= (8 \times 10^{-9} \times 4 \times 10^{-2}) \times \left(\frac{1}{4}\times10^{11}\right)\times\frac{1}{2}$

$= -4$ Joules $\qquad [\because \cos 60° = \frac{1}{2}$

(**Note:** However, the first method is preferred because it saves a lot of time from unnecessary calculations)

20. (*i*)

Intrinsic semiconductor	*p-type semiconductor*
1. The pure semiconductors (Ge or Si) in which the electrical conductivity is totally governed by electrons thermally excited from the valence bond to the conduction bond are called intrinsic semiconductors.	A tetravent semiconductor of Si or Ge doped with trivalent impurity atoms of B, Al or In is called a *p*-type semiconductor.
2. They have equal number of densities of free electrons and holes *i.e.* $n_e = n_h$.	It has more density of holes than density of free electrons *i.e.* $n_h >> n_e$.

(*ii*) In a *p*-type semiconductor, the trivalent impurity atom shares its three valence electrons with the three tetravalent host atoms while the fourth bond remains unbounded. The impurity atom as a whole is electrical neutral. Hence the *p*-type semiconductor is also neutral.

21. Consider a long solenoid of length l and radius r with $r << l$ and having n turns per unit length. If a current I flows through the coil, then the magnetic field inside the coil is almost constant and is given by

$$B = \mu_0 n I$$

Magnetic flux linked with each turn = BA = $\mu_0 n I A$

...where [A = πr^2 = cross-sectional area of the solenoid

$\therefore$ Magnetic flux linked with the entire solenoid is

ϕ = Flux linked with each turn × Total number of turns

$= \mu_0 n I A \times nl = \mu_0 n^2 I A l$

But $\phi = LI$

$\therefore$ Self-inductance of the long solenoid is

$$L = \mu_0 n^2 l A$$

If N is the total number of turns in the solenoid then $n = \frac{N}{l}$.

$\therefore \quad \mathbf{L = \frac{\mu_0 N^2 A}{l}}$

22. **Difference between Interference and Diffraction of light**

Interference	*Diffraction*
1. Interference is due to superposition of two distinct waves coming from two coherent sources.	Diffraction is due to superposition of the secondary wavelets coming from different parts of the same wavefront.
2. Interference fringes may or may not be of the same width.	Diffraction fringes are not to be of the same width.
3. The intensity of minima is generally zero.	The intensity of minima is never zero.
4. All bright fringes are of uniform intensity.	All bright fringes are not of uniform intensity.

23. ***Forward biasing.*** If the positive terminal of a battery is connected to a *p*-side and the negative terminal to the *n*-side, then the *p-n* junction is said to be forward biased. Here the applied voltage V opposes the barrier voltage V_B. As a result of this

- the effective resistance across the *p-n* junction decreases.
- the diffusion of electrons and holes into the depletion layer which decreases its width.

Reverse biasing. If the positive terminal of a battery is connected to the *n*-side and negative terminal to the *p*-side, then the *p-n* junction is said to be reverse biased.

The applied voltage V and the barrier potential V_B are in the same direction. As a result of this

- the resistance of the *p-n* junction becomes very large.
- the majority charge carriers move away from the junction, increasing the width of the depletion layer.

24. **Given :** $\delta = 60$; $H = 0.4$ G; $R = ?$

As $H = R \cos \delta$

As we know, $R = \frac{H}{\cos\delta} = \frac{0.4}{\cos 60^\circ}$ $\quad \therefore \quad R = \frac{0.4}{\frac{1}{2}} = \mathbf{0.8\ G}$

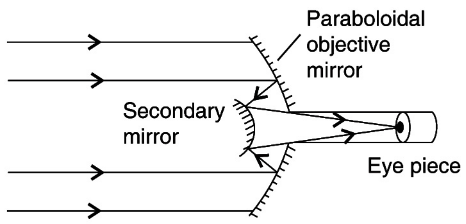
Or

$B_H = B \cos \delta$; $\quad B_V = B \sin \delta$

$B_V = B_H \tan \delta = B \tan 60° = B \times \sqrt{3} = \sqrt{3}\, B$

$\therefore$ **At equator**, $B_V = \mathbf{0}$ (zero) **[$\therefore$ $\delta = 0$ at equator**

25. (*i*)



Cassegrain reflecting type telescope

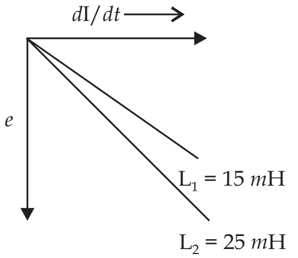
(*ii*) ***Advantages of reflecting telescope over a refracting telescope:***

1. Due to large aperture of the mirror used, the reflecting telescopes have high resolving power.
2. This type of telescope is free from chromatic aberration (formation of coloured image of a white object).

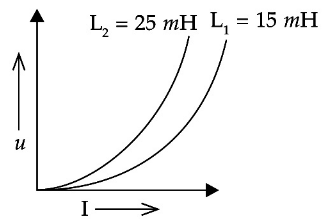
3. The use of paraboloidal mirror reduces the spherical aberration (formation of non-point, blurred image of a point object).
4. Image formed by reflecting telescope is brighter than refracting telescope.
5. A lens of large aperture tends to be very heavy and therefore difficult to make and support by its edges. On the other hand, a mirror of equivalent optical quality weighs less and can be supported over its entire back surface.

26. **Given:** L_1 = 15 mH and L_2 = 25 mH

(*a*)



(*b*)



$$\frac{u_1}{u_2} = \frac{\frac{1}{2}L_1 i_1^2}{\frac{1}{2}L_2 i_1^2}$$

But $\varepsilon_1 i_1 = \varepsilon_2 i_2$ (∵ power dissipated is same)

$$\therefore \quad \frac{i_1}{i_2} = \frac{\varepsilon_2}{\varepsilon_1} = \frac{L_2}{L_1} \qquad \left(\because \frac{dl}{dt} \text{ is same and } \varepsilon = -L\frac{dl}{dt}\right)$$

$$\therefore \quad \frac{u_1}{u_2} = \frac{L_1}{L_2}\left(\frac{L_2}{L_1}\right)^2 = \frac{L_2}{L_3} = \frac{25}{15} = \mathbf{1.66}$$

27. (*a*) **Working principle of a galvanometer:** A current carrying coil experiences a torque when placed in a magnetic field which tends to rotate the coil and produces an angular deflection.

(*b*) $V = I(G + R_1)$ ...(*i*) $\quad \frac{V}{2} = I(G + R_2)$ ...(*ii*)

Dividing (*i*) by (*ii*), we have

$$\Rightarrow \quad 2 = \frac{G+R_1}{G+R_2} \qquad \Rightarrow \quad 2G + 2R_2 = G + R_1 \qquad \Rightarrow \quad G = R_1 - 2R_2$$

Let R_3 be the resistance required for conversion into voltmeter of range 2V.

$\therefore \quad 2V = I_g(G + R_3)$ ...(*iii*)

Also, $V = I_g(G + R_1)$ ...(*iv*)

Dividing (*iii*) by (*iv*), we have

$$\therefore \quad 2 = \frac{G+R_3}{G+R_1}$$

$\therefore \quad R_3 = G + 2R_1 = (R_1 - 2R_2) + 2R_1$

$\mathbf{R_3 = 3R_1 - 2R_2}$ **...[From value of G**

Or

(*i*) In circuit (*a*)

Total emf = 15 V, Total Resistance = 2Ω

Current, $\boldsymbol{i} = \left(\frac{\mathbf{15}}{\mathbf{2}}\right)$ **A = 7.5 A**

Potential difference between the terminals of 6 V battery

$V = E - iR = [6 - (7.5 \times 1) = \mathbf{-1.5\ V}$

(*ii*) In circuit (*b*)
Effective emf = (9 – 6)V = 3V,
Total Resistance = 2Ω

Current, $i = \left(\frac{3}{2}\right)$ **A= 1.5 A**

Potential Difference across 6V cell,
V = E – (–I)R = V + IR (∵ **Current is in opposite direction to 6 V cell)**
= 6 + 1.5 × 1 = 7.5V

28. (*i*) (*a*) In graph 1 : **intensity** is being kept constant.
(*b*) In graph 2 : **frequency** is being kept constant.
(*ii*) (*a*) In graph 1 : Saturation current
(*b*) In graph 2 : Stopping potential.
(*iii*) For a given photo-sensitive surface electrons need a minimum energy to be emitted, this is called work function of the surface W.
∴ Photons energy $h\nu$ should be greater/equal to the work function.

∴ $h\nu \geq W$ or $\nu \geq \frac{W}{h}$

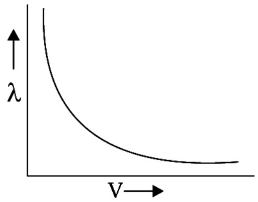
∴ Minimum frequency for photo emission $\nu_0 = \frac{W}{h}$

Which is justified to be called as **threshold frequency.**

Or

We have, $\lambda = \frac{h}{\sqrt{2mqV}} = \frac{h}{\sqrt{2mK}}$ ...[∵ K = qV = K.E.

∵ Mass of deuteron is more than that of proton,



i.e., $m_d > m_p$

∴ For same λ, we must have $K_p > K_d$, *i.e.,* **the proton has more kinetic energy.**

29. (*i*) **Bohr's quantisation condition for stationary orbits:** Only those orbits are stable for which the angular momentum of revolving electron is an integral multiple of $\frac{h}{2\pi}$.

$L = \frac{nh}{2\pi}$, *i.e.* angular momentum of orbiting electron is quantized.
According to *de Broglie hypothesis,*

Linear momentum (p) = $\frac{h}{\lambda}$

and for circular orbit $L = r_n p$ **...where**['r_n' is the radius of quantized orbits.

$L = \frac{r_n h}{\lambda}$ Also $L = \frac{nh}{2\pi}$

∴ $\frac{r_n h}{\lambda} = \frac{nh}{2\pi}$ ⇒ $2\pi r_n = n\lambda$

∴ **Circumference of permitted orbits are integral multiples of the wavelength λ.**

(*ii*) Let E_A, E_B and E_C be the energy of three given energy levels A, B and C respectively.

$E_C - E_B = \frac{hc}{\lambda_1}$ ...(*i*)

$$E_B - E_A = \frac{hc}{\lambda_2} \quad ...(ii)$$

$$E_C - E_A = \frac{hc}{\lambda_3} \quad ...(iii)$$

Adding (*i*) and (*ii*), we have

$$E_C - E_A = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \quad ...(iv)$$

Using equation (*iii*) and (*iv*), we have

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{\mathbf{1}}{\lambda_3} = \frac{\mathbf{1}}{\lambda_1} + \frac{\mathbf{1}}{\lambda_2}$$

30. (*a*) In all types of nuclear reactions, the law of conservation of number of nucleons is followed. But during the reaction, the mass of the final product is found to be slightly less than the sum of the masses of the reactant components. This difference in mass of a nucleus and its constituents is called mass defect. So, as per mass energy relation $E = (\Delta m)c^2$, energy is released. In the given reaction the sum of the masses of two deuterons is more than the mass of helium and neutron. Energy equivalent of mass defect is released.

(*b*) Nuclear density $= \dfrac{\text{Mass of nucleus}}{\text{Volume}} = \dfrac{mA}{\frac{4}{3}\pi R^3}$ **...[*m* = mass of each nucleon**

As $R = R_0 A^{1/3}$ **...where [$R_0 = 1.2 \times 10^{-15}$ m**

$$\therefore \text{ Nuclear density} = \frac{3mA}{4\pi R_0^3 A} = \frac{3m}{4\pi R_0^3}$$

i.e. independent of Mass Number A.

31. (*a*) • Electric flux through a given surface is defined as the dot product of electric field and area vector over that surface.

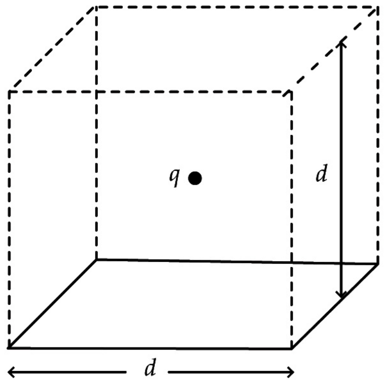
Alternatively $\phi = \int_s \vec{E}.\vec{ds}$

• It is a **scalar** quantity.

• Constructing a cube of side '*d*' so that charge '*q*' gets placed within this cube (Gaussian surface)

According to Gauss's law,

Electric flux $\phi = \dfrac{\text{charge enclosed}}{\varepsilon_0} = \dfrac{q}{\varepsilon_0}$



This is the total flux through all the six faces of the cube. Hence electric flux through the square

$$= \frac{1}{6} \times \frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$$

(*b*) If the charge is moved to a distance *d* and the side of the square is doubled, the cube will be constructed to have a side 2*d* but the total charge enclosed in it will remain the same. Hence the total flux through the cube and therefore the flux through the square **will remain the same** as before.

Or

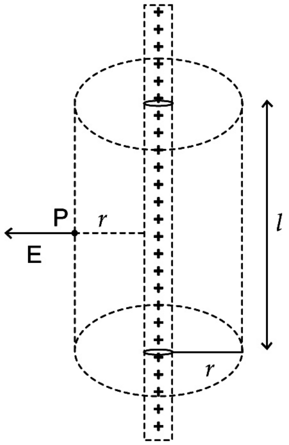
(*a*) To calculate the electric field, imagine a cylindrical Gaussian surface, since the field is everywhere radial, flux through two ends of the cylindrical Gaussian surface is zero.

At cylindrical part of the surface, electric field $\vec{E}$ is normal to the surface at every point and its magnitude is constant.

Therefore, Flux through the Gaussian surface

= Flux through the curved cylindrical part of the surface.

$= E \times 2\pi rl$ ...(*i*)



Applying Gauss's Law, Flux $\phi = \frac{q\ enclosed}{\varepsilon_0}$

Total charge enclosed = Linear charge density × $l = \lambda l$

$$\phi = \frac{\lambda l}{\varepsilon_0} \qquad ...(ii)$$

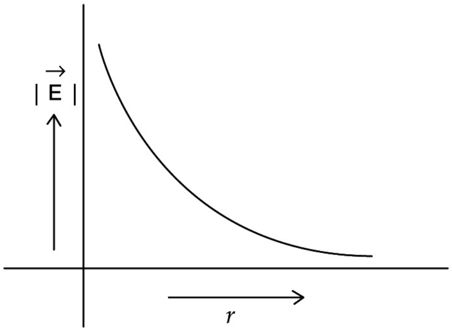
Using Equation (*i*) and (*ii*),

$$E \times 2\pi rl = \frac{\lambda l}{\varepsilon_0} \qquad \Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

In vector notation,

$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$ **...[where $\hat{n}$ is a unit vector normal to the line charge**

(*b*) Then required graph is as shown:



(*c*) Work done in moving the charge '*q*' through a small displacement '*dr*'

$$dW = \vec{F}.\vec{dr}$$

$$dW = q\vec{E}.\vec{dr} = q\,(E\cos\theta)\,dr$$

$$dW = q \times \left(\frac{\lambda}{2\pi\varepsilon_0 r}\right)dr \qquad \left[\because E = \frac{\lambda}{2\pi\varepsilon_0 r}\right]$$

Work done in moving the given charge from r_1 to r_2 $(r_2 > r_1)$

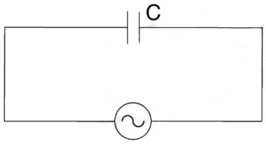
$$W = \int_{r_1}^{r_2} dW = \int_{r_1}^{r_2} \frac{\lambda q dr}{2\pi\varepsilon_0 r} = \int_{r}^{r_2} \frac{\lambda q}{2\pi\varepsilon_0}\left(\frac{1}{r}dr\right)$$

$$W = \frac{\lambda q}{2\pi\varepsilon_0}\ [\log_e r_2 - \log_e r_1]$$

32. (*a*) Voltage applied to the capacitor, $V = V_m \sin \omega t$ ...(*i*)

Let instantaneous voltage across the capacitor = v

We have, $V = \frac{q}{C}$



According to *Kirchhoff's loop rule*, the voltage across the source and the capacitor are equal at any instant of time.

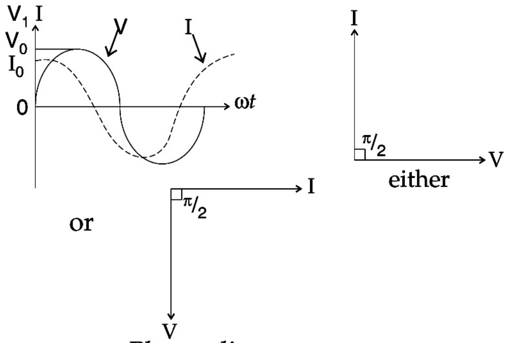
$\therefore \quad V_m \sin \omega t = \frac{q}{C} \qquad \Rightarrow q = CV_m \sin \omega t$

$$\frac{dq}{dt} = \omega\, CV_m \cos \omega t$$

$$\Rightarrow \frac{dq}{dt} = \frac{V_m}{1/\omega C} \cos \omega t \qquad [\because \textbf{Cos } \omega t = \sin (\omega t + \pi/2)$$

$$i = i_m \sin (\omega t + \pi/2) \qquad \ldots \textbf{where} \left[i_m = \frac{V_m}{1/\omega C} \right.$$

From equations (*i*) and (*ii*) we conclude that current leads the voltage by a phase angle of $\pi/2$,



Phasor diagram

(*b*) R = 200 Ω, C = 15.0 μF = 15.0 × 10^{-6} F, V_{rms} = 220V, f = 50 Hz

(*i*) $X_C = \frac{1}{2\pi fC} = \frac{1}{2 \times 3.14 \times 50 \times 15.0 \times 10^{-6}} = 212.3\ \Omega$

$$Z = \sqrt{R^2 + X_C^2} = \sqrt{(200)^2 + (212.3)^2} = 291.5\ \Omega$$

$\therefore$ Current in the circuit, $I_{rms} = \frac{V_{rms}}{Z} = \frac{220V}{291.5\Omega}$ = **0.755 A**

(*ii*) As the current is same throughout the series circuit, we have

$V_{rms}^R = I_{rms}.R = 0.755 \times 200 = 151$ V

$V_{rms}^C = I_{rms}.X_C = 0.755 \times 212.3 = 160.3$ V

The algebraic sum of the two voltages, V_R and V_C is 311.3 V which is more than the source voltage of 220 V. These two voltages are 90° out of phase. These cannot be added like ordinary numbers.

The voltage is obtained by using Pythagoras' theorem,

$$V_R + C = \sqrt{V_R^2 + V_C^2}$$

$$= \sqrt{(151)^2 + (160.3)^2} = 220 \text{ V}$$

Thus if the phase difference between two voltages is properly taken into account, the total voltage across the resistor and the capacitor is equal to the voltage of the source.

Or

(*a*) ***Principle of A.C. generator.*** The working of an a.c. generator is based on the principle of electromagnetic induction. 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.

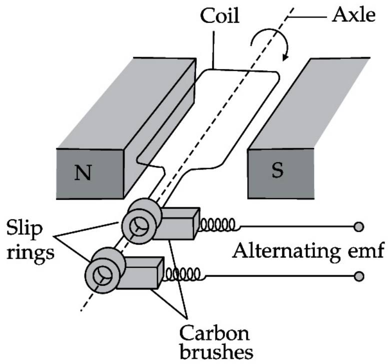
(*b*) Let N = number of turns in the coil

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 coil rotates



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

$$\phi = NAB \cos\theta = NAB \cos wt$$

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

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

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

$\Rightarrow$ $E = E_0 \sin wt$ **...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 $\left[I_0 = \frac{E_0}{R} \right.$**

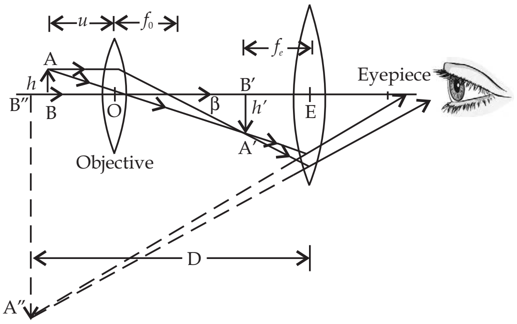
(*c*) v = 0.5 Hz; N = 100; A = 0.1 m^2; B = 0.01 T

$e_{max} = NAB (2\pi v)$

$e_{max} = 100 \times 0.01 \times 0.1 \times (2\pi \times 0.5)$

$\therefore$ e_{max} = **0.314 volt**

33. ***Compound Microscope:***



Magnifying power : The magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final virtual image to the angle subtended at the eye by the object, when both are at the least distance of distinct vision from the eye.

$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} = \frac{h'/u_e}{h/D} = \frac{h'}{h}.\frac{D}{u_e} = m_0 m_e$$

Here, $m_0 = \frac{h'}{h} = \frac{V_0}{u_0}$

As the eye-piece acts as a simple microscope

$\therefore$ $m_e = \frac{D}{u_e} = 1 + \frac{D}{f_e}$ $\qquad$ $\therefore$ $m = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$

As the object AB is placed close to the focus f_0 of the objective

$\therefore\ u_0 = -f_0$

Also image A′B′ is formed close to the eyelens whose focal length is short, therefore v_0 = L = the length of the microscope tube or the distance between the two lenses.

$$\therefore\ m_0 = \frac{v_0}{u_0} = -\frac{L}{f_0}$$

$$\therefore\ m_0 = -\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$$ **...[For final image at D**

(*i*) If the focal lengths are less, then their magnifying power will be more.

(*ii*) To avoid any aberrations in refraction due to larger bend on passing through the eye-piece.

Or

(*a*) Two sources of light having same frequency and a constant or a zero phase difference are said to be **coherent.**

Light wave emitted from an ordinary source (like a sodium lamp) undergoes abrupt phase changes in times of the order of 10^{-10} seconds. Thus two independent sources of light will not have a fixed phase relationship and would be incoherent.

(*b*) For bright fringes (maxima)

Path difference, $\frac{xd}{D} = n\lambda$

$$\therefore\ x = n\lambda\,\frac{D}{d}$$ **...where [n = 0, 1, 2, 3, ...**

For dark fringes (minima)

Path difference, $\frac{xd}{D} = (2n-1)\,\frac{\lambda}{2}$

$$\therefore\ x = (2n-1)\,\frac{\lambda D}{2d}$$ **...where [n = 0, 1, 2, 3, ...**

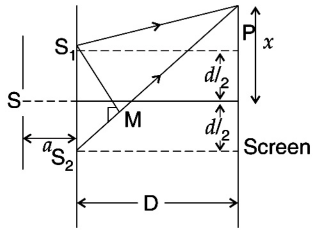
The separation between the centre of two consecutive bright fringes is the width of a dark fringe.

$\therefore$ Fringe width, $\beta = x_n - x_{n-1}$

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

$$\therefore\ \boldsymbol{\beta = \frac{\lambda D}{d}}$$ **...Here [β is fringe width**

(*c*) For interference fringes to be seen, the condition $\frac{S}{a} < \frac{\lambda}{d}$ should be satisfied.



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