# BANGALORE SAHODAYA SCHOOLS COMPLEX ASSOCIATION
# PRE-BOARD EXAMINATION -1 (2024-2025)

Class: XII
Time: 3 Hours

**SUBJECT: PHYSICS**
**CODE:(042) SET 1**

Date: 18.12.2024
Marks: 70 Marks

**General Instructions:**

- *The duration of the exam mentioned is the writing time. In addition, 15 minutes are assigned for reading. The first 15 minutes must be utilized for reading the QP alone and nothing must be written in the answer sheet during this period.*
- *Answer the questions neatly and in the same order.*
- *This question paper has a total of **33 questions** under **5 sections.***
  - ***Section A** contains 12 MCQs and 4 AR questions of 1 mark each;*
  - ***Section B** contains 5 very short answer questions of 2 marks each;*
  - ***Section C** contains 7 short answer questions of 3 marks each;*
  - ***Section D** contains 2 CBQs of 4 marks each, and*
  - ***Section E** contains 3 long answer questions of 5 marks each.*
- *There is no overall choice. However, one questions each, under **Sections B** and **C** and all three questions under **Section E** have internal choices. One question in each of the CBQs has internal choice. You must attempt only one of the choices in such questions.*
- *You must show the details of your work for **sections B, C** and **E** to earn full credit.*
- *Calculators are not permitted.*
- *A table of useful natural constants is given below.*

| TABLE OF NATURAL CONSTANTS | |
|---|---|
| **Permittivity Constant** | $\epsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2$ |
| **Permeability Constant** | $\mu_0 = 4\pi \times 10^{-7} Tm/A$ |
| **Electrostatic Constant** | $k = 1/4\pi\epsilon_0 = 8.99 \times 10^9 Nm^2$ |
| **Speed of light in vacuum** | $c = 2.9979 \times 10^8 m.s^{-1}$ |
| **Fundamental Unit of Charge** | $e = 1.60217 \times 10^{-19} C$ |
| **Mass of electron** | $m_e = 5.48597 \times 10^{-4} u$ |
| **Mass of proton** | $m_p = 1.007276\ u$ |
| **Mass of neutron** | $m_n = 1.008665\ u$ |
| **Atomic Mass Unit** | $1u = 1.660539 \times 10^{-27} kg$ |
| **Energy equivalent of 1amu** | $1uc^2 = 931.5\ MeV$ |
| **Planck's Constant** | $h = 6.626 \times 10^{-34} J.s^{-1}$ |

## SECTION A

**(16 x 1 Mark = 16 Marks)**

**(Answer all the questions)**

1) The electrostatic interaction between the point charges $q_1$ and $q_2$ is attractive if,
(A) $q_1 + q_2 < 0$ (B) $q_1 + q_2 > 0$ (C) $q_1 \times q_2 > 0$ (D) $q_1 \times q_2 < 0$

2) Two metal spheres, whose radii are in the ratio $r_1 : r_2 = 1:4$, are kept far away and are put in electrical contact by connecting them by means of a copper wire. what is the ratio of the electrical fluxes on their surface?
(A) $\Phi_{E1} : \Phi_{E2} = 1:2$ (B) $\Phi_{E1} : \Phi_{E2} = 2:1$
(C) $\Phi_{E1} : \Phi_{E2} = 1:4$ (D) $\Phi_{E1} : \Phi_{E2} = 4:1$

3) A charged particle is in uniform circular motion inside a magnetic field. If its velocity is doubled,
(A) its orbital period quadruples. (C) its orbital radius quadruples.
(B) its orbital period remains unchanged. (D) its orbital radius remains unchanged.

4) The magnetic susceptibility of a superconductor is:
(A) $0 > \chi_B > 1$ (B) $-1 < \chi_B < 0$ (C) $\chi_B = -1$ (D) $\chi_B = +1$

5) Transformer cores are laminated to minimize:
(A) Eddy loss (B) Hysteresis loss (C) Flux leakage (D) Ohmic loss.

6) The resonant frequency of water molecules is within the frequency range of which of the following kind of electromagnetic radiation?
(A) Gamma Rays (B) UV Rays (C) IR Rays (D) Microwaves.

7) When the angle of incidence for a light ray incident on the refracting surface of an equilateral triangular prism is $45^o$ the ray suffers minimum deviation. The angle of minimum deviation and the refractive index of the prism are:
(A) $\delta_{min} = 30^o; \quad n = \sqrt{2}$ (C) $\delta_{min} = 30^o; \quad n = \sqrt{3}$
(B) $\delta_{min} = 45^o; \quad n = \sqrt{2}$ (D) $\delta_{min} = 45^o; \quad n = \sqrt{3}$

8) The ratio of the amplitudes of the waves from the two coherent sources in a Young's Double Slit experiment is $a_1 : a_2 = 1:2$. What is the ratio of the maximum to minimum intensities of the resulting interference fringes?
(A) $I_{max} : I_{min} = 2:1$ (C) $I_{max} : I_{min} = 9:1$
(B) $I_{max} : I_{min} = 8:1$ (D) $I_{max} : I_{min} = 4:1$

9) Which of the following statements regarding the central maxima of a single slit diffraction pattern is correct?
(A) It is wider for a blue light than for a red light.
(B) Its width increases if the slit width decreases.
(C) It is wider in a medium with higher refractive index.
(D) It is independent of the slit width.

10) For an electron accelerated through an electric potential difference of $V$, its *de Broglie* wavelength is related to the potential as:
(A) $\lambda_{dB} \propto \sqrt{V}$ (B) $\lambda_{dB} \propto 1/\sqrt{V}$ (C) $\lambda_{dB} \propto V$ (D) $\lambda_{dB} \propto 1/V$

11) According to the Bohr's atom model, what is the change in the orbital angular momentum of an electron undergoing a Lymann-β emission transition?
(A) $\Delta L = -2\hbar$ (B) $\Delta L = -\hbar$ (C) $\Delta L = +\hbar$ (D) $\Delta L = +2\hbar$

12) A $50\,Hz$ AC signal is input, simultaneously, to a half-wave rectifier and a full-wave rectifier. What are the output frequencies of the half-wave rectifier ($f_{hw}$) and the full-wave rectifier ($f_{fw}$)?
(A) $f_{hw} = 25\,Hz;\quad f_{fw} = 50\,Hz$ (C) $f_{hw} = 50\,Hz;\quad f_{fw} = 100\,Hz$
(B) $f_{hw} = 50\,Hz;\quad f_{fw} = 50\,Hz$ (D) $f_{hw} = 25\,Hz;\quad f_{fw} = 100\,Hz$

Two statements, labeled **Assertion (A)** and **Reason (R)** are given**.** Select the most appropriate answer from the options given below for these statements.

(A) If both **A** and **R** are true and **R** is the correct explanation of **A**
(B) If both **A** and **R** are true but **R** does not explain **A**
(C) If **A** is true but **R** is false
(D) If **A** is false but **R** is true.

13) **Assertion** (**A**): The resistivity of semiconductors decreases with increase in temperature.
**Reason** (**R**): As the temperature increases, the relaxation time decreases.

14) **Assertion** (**A**): A swimming pool appears shallower than it is.
**Reason** (**R**): Refraction of paraxial rays at the water-air boundary creates a virtual image that is closer to the surface than the object from which they originated.

15) **Assertion** (**A**): The nucleus of $^{56}_{26}Fe$ has the highest density.
**Reason** (**R**): Binding energy per nucleon is maximum for a mass number of $A = 56$.

16) **Assertion** (**A**): In a PN Junction diode, the reverse bias current is independent of the bias voltage.
**Reason** (**R**): The reverse bias current is due to the thermally generated electron-hole pairs drifting across the junction.

## SECTION B

**5 × 2 Marks = 10 Marks**

**(Answer all the questions)**

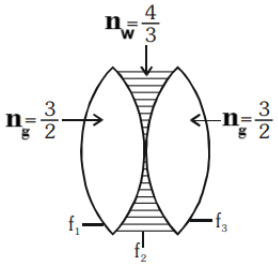
17) Calculate the magnitude of the electrostatic force acting on a $10\,nC$ charge that is $9.0\,cm$ away from an infinitely long uniform charge distribution of linear charge density of $\lambda = 13\,\mu C.m^{-1}$. **(2)**

18) Explain why the kinetic energy of a moving charged particle does not change upon entering a region permeated by a magnetic field. **(2)**

(**OR**)

A small square loop of sides $2.0\,cm$ and resistance $3.2\,m\Omega$ is placed coaxially at the center of a long solenoid with 20 turns per centimeter. Calculate the magnitude of the induced current in the square loop, if the current in the solenoid is increasing as a rate of $10\,A.s^{-1}$. **(2)**

19) Two identical equiconvex lenses made of glass ($n_g = 3/2$) each with focal length of $f = 30\,cm$, are kept in contact. The gap between the two is filled with water ($n_w = 4/3$). Find the focal length of the combination. **(2)**



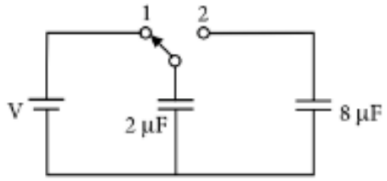
Question 19

20) Answer the following related to the Bohr atom model:
(a) State any two limitations of the Bohr atom model. **(1)**
(b) Explain how Bohr's third postulate explains absorption and emission line spectra. **(1)**

21) Draw the energy band diagrams of
(a) an intrinsic semiconductor (for $T > 0\,K$) and **(1)**
(b) a P type semiconductor, showing the acceptor energy level. **(1)**

## SECTION C
**7 × 3 Marks = 21 Marks**
**(Answer all the questions)**

22) A $2.0\,\mu F$ and a $8.0\,\mu F$ capacitors are connected to a battery of emf $V = 12\,V$ through a toggle switch. The $2.0\mu F$ capacitor is first charged by connecting the toggle switch to position 1. What percentage of the stored electrostatic energy is lost when the toggle switch is turned to position 2? **(3)**



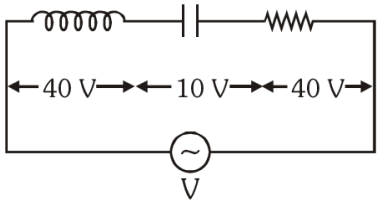
Question 22

23) Answer the following regarding the mobility of a charge carrier:
(a) Define the term **mobility** of a charge carrier and write down its SI unit. **(1 + 1/2)**
(b) When a constant potential difference is maintained across an electrolyte made of sodium and chlorine ions, the drift speed of sodium ions is found to be $70 \times 10^{-6}\,ms^{-1}$. If the sodium to chlorine mass ratio is $27:35$, what is the drift speed of chlorine ions? **(1 + 1/2)**

24) The rms voltages across an inductor, a capacitor and a resistor in a series LCR circuit (shown in the figure) are, respectively, $V_L^{rms} = 40\,V$, $V_C^{rms} = 10\,V$ and $V_R^{rms} = 40\,V$. If the amplitude of the current oscillations is $I_m = 10\sqrt{2}\,A$, calculate the following

(a) Impedance of the circuit. **(1+1/2)**

(b) Average power over a cycle. **(1+1/2)**



Question 24

25) Answer the following related to displacement current:
(a) What is meant by the term **displacement current**? Write the mathematical expression for it. **(1)**
(b) For a parallel plate capacitor connected to a DC source through a wire, show that during the charging and discharging of the capacitor, the displacement current between the plates is equal to the conduction current through the wire. **(2)**

26) A compound microscope is constructed with convex lenses of focal lengths $0.5\,cm$ and $5.0\,cm$. An amoeba of size $0.25\,mm$ is viewed through the microscope by placing it at a distance of $0.75\,cm$ in front of the objective. Taking the least distance of distinct vision as $D = 25\,cm$, find the following:

(a) magnifying power achieved for a relaxed vision (normal adjustment). **(2)**

(b) angular size of the amoeba, when it is seen through the microscope. **(1)**

(**OR**)

(a) State the **Huygen's Principle** on the propagation of wavefronts. **(1)**

(b) With the aid of a neat diagram, derive the **Snell's law** for the refraction of a plane wavefront at a plane boundary with the wave propagating from an optically denser medium into an optically rarer medium. **(2)**

27) The ***Lenard-Hallwachs*** experiment on photoelectric effect is performed by irradiating six different metal targets with a monochromatic visible light of wavelength $\lambda = 400\,nm$. The work functions of the different target metal surfaces are given in the Table shown aside. Answer the following:

(a) Which of these metal surfaces display photoelectric effect for this wavelength? **(1)**

(b) Calculate the stopping potential for sodium. **(1)**

(c) Calculate the threshold wavelength for photoelectric emission in gold. **(1)**

| METAL | WORK FUNCTION |
|---|---|
| CESIUM | 2.10 eV |
| SODIUM | 2.30 eV |
| LITHIUM | 2.50 eV |
| MAGNESIUM | 3.70 eV |
| SILVER | 4.13 eV |
| GOLD | 5.00 eV |

Question 27

28) Answer the following related to a full wave rectifier:

(a) With the aid of a neat circuit diagram, explain (briefly) the working of a full wave rectifier. **(2)**

(b) For a sinusoidally oscillating AC input, draw the output forms of a full wave rectifier with and without a capacitor filter. **(1)**

## SECTION D

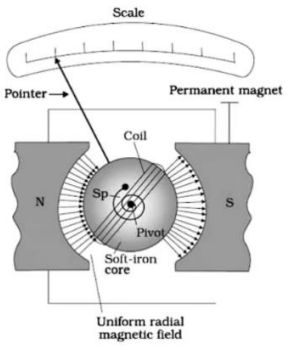
**$2 \times 4$ Marks = 08 Marks**

**(Answer all the questions)**

29) A current loop acts as a magnetic dipole with a dipole moment whose magnitude is equal to the product of the current and the loop area ($m = IA$). When a magnetic dipole is placed in an external magnetic field it experiences a torque given by $\vec{\tau} = \vec{m} \times \vec{B}$.

A moving coil galvanometer is a coil with a large number of turns ($N$) placed in an external uniform radial magnetic field (an isotropic configuration such that the magnetic field is always perpendicular to the plane of the loop). The coil is connected to a pointer attached to a spring which provides a restoring torque that is proportional to the angle of deflection.

$\tau_{res} \propto \phi$; $\tau_{\text{res}} = \kappa\,\phi$, where $\kappa$ is the torsional constant of the spring.




Question 29

For a uniform radial magnetic field, the torque produced is proportional to the current through the coil ($\tau_m \propto I$). The deflection stabilizes when the torque due to the interaction of the current with magnetic field equilibrates with the restoring torque of the spring.

Therefore, the angle of deflection at equilibrium is proportional to the current through the coil.

$$\tau_m = \tau_{res} \implies \phi \propto I; \implies \phi = S_I I$$

The constant of proportionality, $S_I$ , is called the **Current Sensitivity** of the galvanometer.

A galvanometer is made of a coil with $N$ turns and has a loop area $A$. It is placed in a uniform radial magnetic field of strength $B$. The torsional constant of the spring used is $\kappa$.

I. What is the torque exerted by the magnetic field on the coil, if a current $I$ flows through it? **(1)**
(A) $\tau = NI/AB$ (B) $\tau = NIA/B$ (C) $\tau = IA/NB$ (D) $\tau = NIAB$

II. Which of the following is an accurate definition of current sensitivity? **(1)**
(A) Current required to produce unit deflection.
(B) Deflection produced per unit current.
(C) Torque produced per unit current.
(D) Torque produced per unit deflection.

III. The correct expression for the current sensitivity of the galvanometer is: **(1)**
(A) $S_I = NIAB/\kappa$ (B) $S_I = IA/N\kappa B$ (C) $S_I = NAB/\kappa$ (D) $S_I = NA\phi/\kappa B$

IV. The SI unit for current sensitivity is: **(1)**
(A) $rad.A^{-1}$ (B) $T.A^{-1}$ (C) $A.T^{-1}$ (D) $A.rad^{-1}$

**(OR)**

The current sensitivity of a galvanometer:
(A) decreases with increasing current in the coil.
(B) decreases with increasing magnetic field strength of the radial magnetic field.
(C) is independent of the current through the coil.
(D) is independent of the field strength of the radial magnetic field.

30) Two kinds of particles constitute atomic nuclei, positively charged **protons** and a electrically neutral **neutrons**. The mass of neutron is almost equal to the mass of proton. The word nucleon is a collective term to refer to either of the nuclear particle. The number of protons in a nucleus is called **atomic number** and is represented by the symbol $Z$. The atomic number determines the chemical and physical properties of a particular nuclide. The mass of a nucleus is directly proportional to the number of nucleons in it. Therefore, the total number of nucleons in a nucleus is called **mass number** and is represented by the symbol $A$. Alpha particle and electron scattering experiments show that the radius of a nucleus is proportional to the cube-root of the mass number. $R \propto A^{1/3}$. The **neutron number** ($N$) of a nucleus is just the difference between its mass number and the atomic number. i.e. $N = A - Z$.

Nuclides (nuclear species) are represented by the symbol ${}^{A}_{Z}X$, where $X$ is the chemical symbol of the species. All nuclides which differ in mass number and neutron number but have the same atomic number are called **isotopes**. All nuclides that differ in atomic number and neutron number but have the same mass number are called **isobars**. All nuclides that differ in atomic number and mass number but have the same neutron number are called **isotones**.

I. If the radius of $^{27}_{13}Al$ nucleus is 3.6 $fm$, what is the radius of $^{125}_{51}Sb$ nucleus?
(A) 6.0 $fm$ (B) 12.0 $fm$ (C) 17 $fm$ (D) 18 $fm$

II. If the density of $^{27}_{13}Al$ nucleus is $2.2 \times 10^{17}\ kg.m^{-3}$, what is the density of $^{125}_{51}Sb$ nucleus?
(A) $3.6 \times 10^{16}\ kg.m^{-3}$ (C) $3.6 \times 10^{17}\ kg.m^{-3}$
(B) $2.2 \times 10^{17}\ kg.m^{-3}$ (D) $10 \times 10^{17}\ kg.m^{-3}$

III. Beta-minus particles are emitted when a neutron inside a nucleus is converted to proton. If nuclide **X** emits a beta-minus particle and becomes nuclide **Y**, then **X** and **Y** are related to each other as:
(A) isotopes (B) isotones (C) isobars (D) either isotopes or isotones

IV. Which of the following pairs are **isobars**?
(A) $^{13}_{6}C$ and $^{14}_{7}N$ (B) $^{14}_{6}C$ and $^{14}_{7}N$ (C) $^{13}_{6}C$ and $^{12}_{6}C$ (D) $^{4}_{2}He$ and $^{3}_{2}He$

**(OR)**

Which of the following pairs are **isotones**?
(A) $^{14}_{6}C$ and $^{14}_{7}N$ (B) $^{13}_{6}C$ and $^{14}_{7}N$ (C) $^{40}_{18}Ar$ and $^{40}_{19}K$ (D) $^{40}_{18}Ar$ and $^{40}_{20}Ca$

## SECTION E

**3 × 5 Marks = 15 Marks**

**(Answer all the questions)**

31) (a) Define the term capacitance of a capacitor and state its SI unit. **(1)**

(b) What happens to the capacitance of the capacitor, **(1)**

(i) if the distance between the plates is doubled?

(ii) If the voltage across the plates is doubled?

(c) A parallel plate capacitor is made of circular plates of radius 60 $cm$ separated by a distance of 1.0 $mm$. The capacitor is first charged by connecting its plates to a 12 $V$ battery. Calculate the charge stored in the capacitor. **(2)**

(d) With the capacitor still connected to the battery, a dielectric slab of dielectric constant $\kappa = 5$ and thickness 1.0 $mm$ is inserted until all the space between the plates is filled. Calculate the charge that will be drawn from the battery when the dielectric slab is introduced. **(1)**

(**OR**)

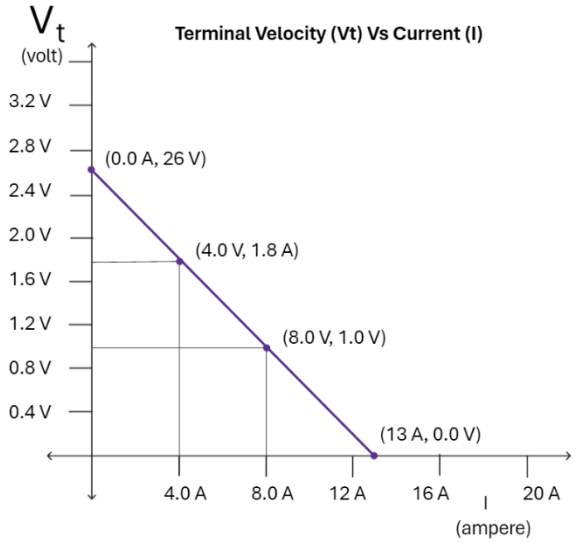
(a) Explain why the resistivity of metals increase with temperature while that of semiconductors decrease with temperature. **(1)**

(b) Two cells are connected in parallel. The emf's and internal resistances of the two cells are given as $(\varepsilon_1, r_1) = (3.0\,V, 0.1\Omega)$ and $(\varepsilon_2, r_2) = (2.0\,V, 0.2\,\Omega)$. Calculate the effective internal resistance and effective emf of the battery. **(2)**

(c) A graph of the potential difference across a cell is plotted as a function of the current drawn from it. Answer the following:

(i) Determine the emf of the cell. **(1)**

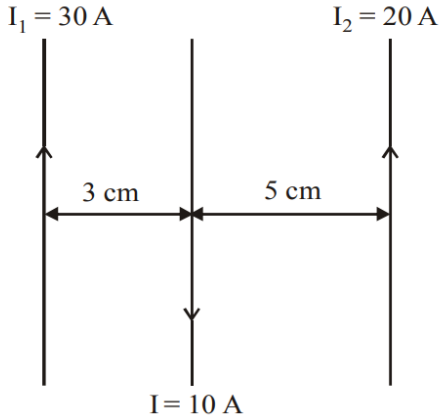
(ii) Determine the internal resistance of the cell. **(1)**




32) (a) State the Ampere's circuital law. **(1)**

(b) Use the Ampere's law to derive an expression for the magnetic field at the centre of the axis of a long solenoid with $N$ turns within a length $L$ carrying a current $I$. **(2)**

(c) Three straight parallel current carrying conductors that are long are as shown in the figure. Determine the direction and magnitude of the force acting per unit length, on the conductor that is in the middle. **(2)**




Question 32(c)

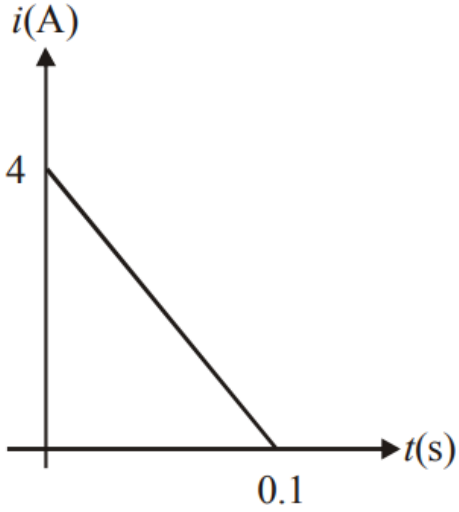
**(OR)**

(a) A metal rod of length $50\ cm$ is rotated anticlockwise on a horizontal plane with a frequency of $120\ rpm$ , with its one end hinged at the centre. A uniform magnetic field of $15\ T$ is parallel to the axis of rotation and is directed upward.

(i) What is the potential difference across the length of the rod? **(2)**

(ii) Which end of the rod (hinged end? Or free end?) is at a higher potential? Why? (1)

(b) A circular coil of resistance $10\ \Omega$ is placed in a time varying magnetic flux. The magnetic flux starts with an initial value of $0.0\ Wb$ and changes for a period of $100\ ms$, before it reaches a steady value. A graph of the variation of the induced current with time over this time interval of flux change is as shown in the figure. What is the value of the magnetic flux, when its value stabilized? **(2)**

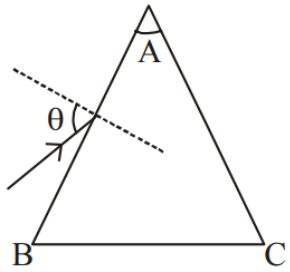



Question 32-b(Choice 2)

33) (a) State the two conditions for the occurrence of Total Internal Reflection (**TIR**). **(1)**

(b) The refractive index of water is $n_w = 4/3$. A transparent gas has a refractive index of $2/\sqrt{3}$. What is the critical angle for the water-gas interface? **(1)**

(c) A monochromatic ray of light is incident (from air) at an angle θ with the normal on the face **AB** of an equilateral prism made of a material of refractive index $\sqrt{2}$. What is the condition on θ so that the light ray emerges through face **AC**? **(3)**



Question 33(c)

**(OR)**

(a) Draw a wavefront diagram showing a plane wave passing through a symmetric bi-convex lens. In the same diagram mark the focal point of the lens and show the light rays. **(2)**

(b) In a Young's double slit experiment, a screen is placed at a distance of $50\ cm$ from two slits that are separated by $0.5\ mm$ and are illuminated by monochromatic light of wavelength $500\ nm$. Find the distance between the $3^{rd}$ bright fringe to the left of the centre to the $2^{nd}$ dark fringe to the right of the centre. **(3)**

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