

PHYSICS

PAPER 1

(THEORY)

Maximum Marks: 70

Time Allotted: Three Hours

Reading Time: Additional Fifteen Minutes

Instructions to Candidates

1. You are allowed an **additional fifteen minutes** for **only** reading the question paper.
2. You must **NOT** start writing during reading time.
3. This question paper has **11 printed pages and one blank page**.
4. There are **twenty questions** in this paper. Answer *all* questions.
5. There are **four** sections in the paper: **A, B, C and D**. **Internal choices** have been provided in **two questions** each in **Sections B, C and D**.
6. **Section A** consists of one question having fourteen subparts of **one mark** each.
7. While attempting **Multiple Choice Questions** in Section A, you are required to **write only ONE option as the answer**.
8. **Section B** consists of **seven questions** of **two marks** each.
9. **Section C** consists of **nine questions** of **three marks** each.
10. **Section D** consists of **three questions** of **five marks** each.
11. The intended marks for questions are given in brackets [].
12. A list of useful constants and relations is given at the end of this paper.
13. A simple scientific calculator without a programmable memory may be used for calculations.

Instruction to Supervising Examiner

1. Kindly read **aloud** the Instructions given above to all the candidates present in the examination hall.

SECTION A – 14 MARKS

Question 1

- (A) In questions (i) to (vii) given below, choose the correct alternative (a), (b), (c) or (d).
- (i) A fish called an electric eel can generate a voltage up to 800V. If it can supply a current of 5mA, the maximum power it can deliver is: [1]
- (a) 4000W
 - (b) 400W
 - (c) 40W
 - (d) 4W
- (ii) A collimated beam of protons is travelling with a constant velocity along X-axis. There is a current carrying solenoid whose axis is also X-axis. If the beam now enters the solenoid along its axis, it will: [1]
- (a) describe a circular path.
 - (b) get deflected along Z-axis.
 - (c) get deflected along Y-axis.
 - (d) continue to travel undeflected.
- (iii) An electron, a proton, a deuteron and an alpha particle are all accelerated from rest through the same potential difference. Which one will have the maximum de Broglie wavelength? [1]
- (a) Proton
 - (b) Deuteron
 - (c) Electron
 - (d) Alpha particle
- (iv) Magnetic susceptibility (χ) of a material is found to decrease with the rise in its temperature. The material is: [1]
- (a) diamagnetic.
 - (b) paramagnetic.
 - (c) ferromagnetic.
 - (d) not magnetic.
- (v) When a p-n junction diode is forward-biased: [1]
- (a) it acts as an insulator and no current flows through it.
 - (b) it offers a low resistance and a large current flows through it.
 - (c) it offers a high resistance and a small current flows through it.
 - (d) the width of depletion region increases.

(vi) When a biconvex lens of glass of refractive index 1.6 was dipped in a certain transparent liquid, it was found to behave like a plane sheet of glass. So, the refractive index of the liquid is: [1]

- (a) 1.0
- (b) 1.4
- (c) 1.5
- (d) 1.6

(vii) Given below are two statements marked, Assertion and Reason. Read the two statements and choose the correct option. [1]

Assertion: In Young's double slit experiment, the first bright band for blue light is closer to the centre than the first bright band for green light.

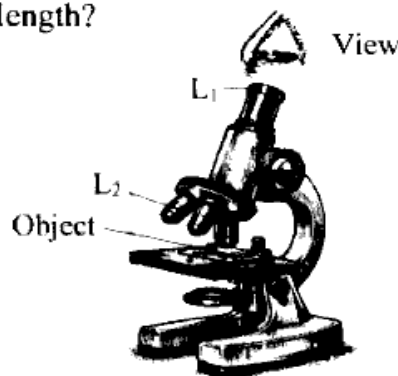
Reason: Blue light has a longer wavelength than green light.

- (a) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
- (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.
- (c) Assertion is true and Reason is false.
- (d) Assertion is false and Reason is true.

(B) Answer the following questions briefly:

- (i) Calculate the **momentum** of a photon having an energy of 4.8×10^{-19} J. [1]
- (ii) What is motional emf? [1]
- (iii) Calculate **work done** in moving a point charge 'q' through a distance 'd' along perpendicular bisector of an electric dipole, which consists of two-point charges $-Q$ and $+Q$ separated by a distance 'L'. [1]
- (iv) Draw the symbol of a **Zener diode**. [1]
- (v) A thin convex lens of power 5D is kept in contact with a thin concave lens of power 8D. Calculate the **focal length** of the **combination**. [1]

- (vi) The image below shows a compound microscope. Which one of the two lenses L_1 or L_2 has a **larger** focal length? [1]



- (vii) Radius of the first Bohr orbit of hydrogen atom is 0.05nm . Calculate the radius of the **third** orbit. [1]

SECTION B – 14 MARKS

Question 2

- (i) Four-point charges $Q_1 = +17.7\mu\text{C}$, $Q_2 = -8.85\mu\text{C}$, $Q_3 = -17.7\mu\text{C}$ and $Q_4 = 35.4\mu\text{C}$ are kept as shown in *Figure 1* below. [2]

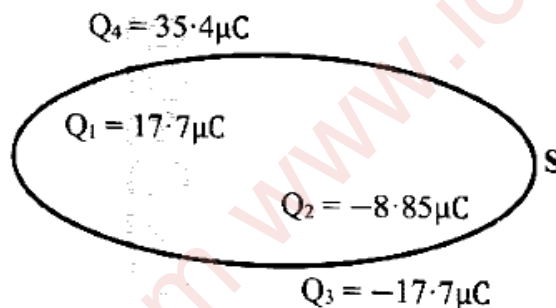


Figure 1

Calculate **electric flux** emanating from the closed surface S .

OR

- (ii) (a) Find the value of current ' I ' in *Figure 2* given below.

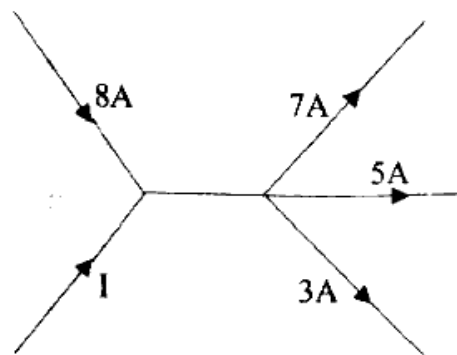


Figure 2

- (b) State the **conservation** principle on which your calculation is based.

Question 3

[2]

You are provided with **three identical** capacitors, each of capacitance 'C'.

If C_p is equivalent capacitance when they are connected in parallel and C_s is equivalent capacitance when they are connected in series, calculate the ratio $\frac{C_s}{C_p}$.

Question 4

[2]

- (i) What is the effect of **doubling** the current flowing through a metallic wire on:
- drift speed of free electrons?
 - relaxation time of free electrons?

OR

- (ii) Draw a **labelled** circuit diagram of a **potentiometer** used to compare emfs of two given cells X and Y. (**Procedure and formula are NOT required.**)

Question 5

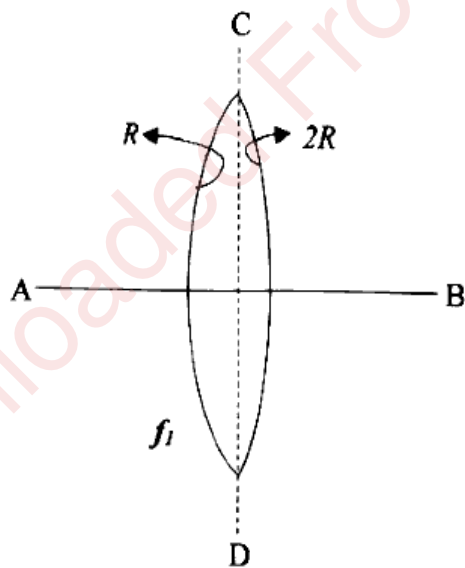
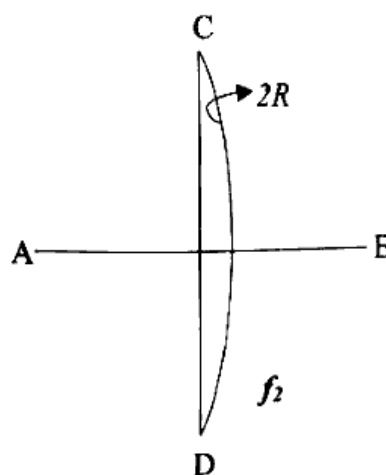
[2]

- Write an expression of Biot-Savart law in **vector** form.
- State Ampere's circuital law.

Question 6

[2]

A bi-convex lens of focal length f_1 is placed in air as shown in **Figure 3(a)** below. The radii of curvature of its first and second surfaces are R and $2R$ respectively. The lens is cut along the plane CD. Compare the focal length f_2 of the resulting lens shown in **Figure 3(b)** with that of the original lens shown in **Figure 3(a)**.

**Figure 3(a)****Figure 3(b)**

Question 7

[2]

- (i) Name the electromagnetic wave that **scans** the contents of the luggage of a traveller during a security check.
- (ii) Which physical quantity is the **same** for UV rays, red light and radio waves when they are travelling in **vacuum**?

Question 8

[2]

The work functions for metals M_1 and M_2 are 1.9eV and 5.0eV respectively. Perform necessary calculations to find out which metal emits photoelectrons, when monochromatic light of **wavelength** 410nm is incident on them.

SECTION C – 27 MARKS**Question 9**

[3]

Show that the **intensity** of electric field at a point in end on position i.e., **axial** position of an electric dipole is given by:

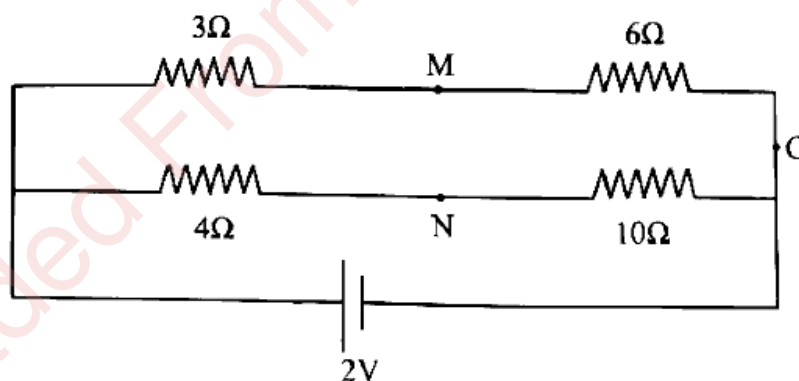
$$E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{2pr}{(r^2 - l^2)^2}$$

where the terms have their usual meaning.

Question 10

[3]

- (i) In the circuit shown in **Figure 4** below, how much resistance should be connected to a 10Ω resistor so that the points **M** and **N** are at the **same** potential?

**Figure 4****OR**

- (ii) **Figure 5** below shows a battery consisting of three cells. Their emfs and internal resistances are also shown.

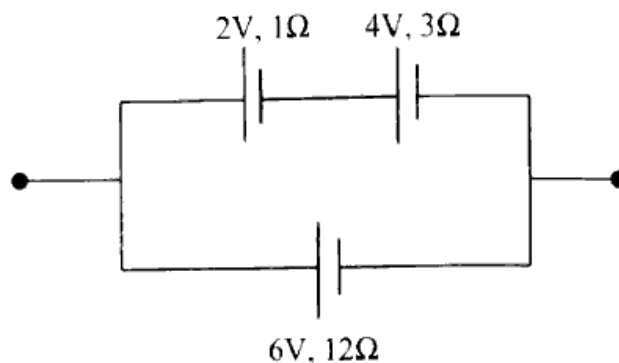


Figure 5

Calculate:

- emf of the battery.
- internal resistance of the battery.

Question 11

[3]

- Obtain an expression for **magnetic field (B)** at the centre of a circular coil having '**n**' turns of radius '**R**' when it is carrying a current '**I**'.

OR

- (a) Two moving coil galvanometers **G₁** and **G₂** are identical **except** for the following features:

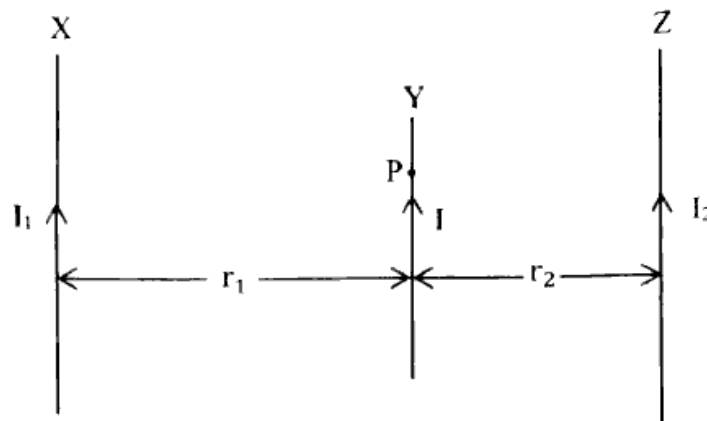
Features	G₁	G₂
Number of turns	50	60
Area of the coil	30cm ²	40cm ²
Resistance of the coil	4Ω	6Ω

Perform calculations to determine which galvanometer has greater **current sensitivity**.

- (b) In a moving coil galvanometer, how is magnetic field made **radial**?

Question 12

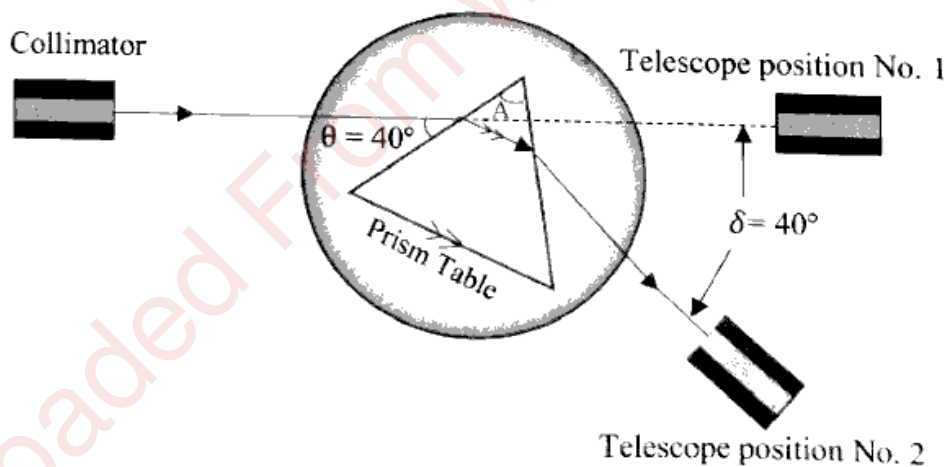
Figure 6 below shows a long straight conductor X carrying a current I_1 . A point P is at a perpendicular distance ' r_1 ' from it.

**Figure 6**

- How much force conductor X exerts on a **short** conductor Y of length ' l ' which is carrying a current ' I ' and is kept at point P parallel to the conductor X?
- Another long wire Z carrying a current I_2 is **now** kept parallel to X and Y at a distance ' r_2 ' from Y such that the conductor Y remains at rest. Obtain the relation between the currents I_1 and I_2 .

Question 13

A monochromatic ray of light incident on one refracting surface of an **equilateral** prism, suffers a deviation as shown in the **Figure 7** below:

**Figure 7**

- Calculate the **refractive index** of the material of the prism.
- What is meant by **dispersive power** of a transparent material?

Question 14

Draw a **labelled** diagram of an astronomical telescope when its final image lies at infinity.

Question 15

[3]

Kabir and Neha conducted experiments on light as part of their school project. Both of them worked with the same source of monochromatic yellow light. Both obtained patterns on the screen which consisted of alternate bright and dark bands.

The images below depict their results.



Kabir's result



Neha's result

- Identify the **phenomenon** observed by Neha.
- The teacher asked Kabir to replace monochromatic yellow light with **white light**. What would be Kabir's observation now?
- What conclusion would be drawn by Kabir and Neha about the **nature** of light?

Question 16

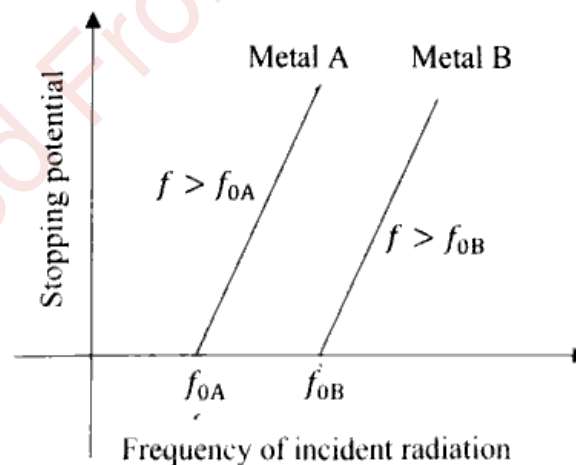
[3]

Using **Huygen's** wave theory and a labelled diagram, show that angle of reflection (r) is equal to angle of incidence (i).

Question 17

[3]

- The graphs below show variation of **stopping potential** versus **frequency** of incident radiation for metals A and B.



UV radiation of appropriate wavelength is allowed to fall on both the metals. Which metal will emit photoelectrons with higher **maximum kinetic energy** (E_{\max})? Give a reason.

- State the conclusion that was drawn from **Davisson-Germer's** experiment.

SECTION D – 15 MARKS

Question 18

[5]

- (i) (a) When a coil is connected to a 200V dc supply, the current flowing through it is found to be 1A. However, when it is connected to the 200V, 50Hz ac supply, the current is found to be 0.5A.
- (1) Explain why current flowing is less when the coil is connected to an ac supply.
- (2) Calculate **coefficient of self-inductance** (L) of the coil.
- (b) If the power factor in an ac circuit is 0.5, what is the **phase difference** between the voltage and the current in the circuit?

OR

- (ii) (a) A 70Ω resistor is connected to an ac source generating an emf 'e' given by
$$e(V) = 495 \sin(100\pi t).$$
Calculate **rms** value of the current (I_{rms}) flowing through the resistor.
- (b) A 20cm length of a long **iron cored** solenoid has 25 turns. If the area of cross section of the solenoid is $1 \times 10^{-4}m^2$, calculate its **coefficient of self-inductance** (L).
- (c) State why soft iron is **preferred** to steel as a material for the core of a transformer.

Question 19



[5]

Answer either subparts (i) to (iii) or (iv) to (vii).

- (i) Draw a **labelled** graph showing the variation of **binding energy per nucleon** with the **mass number (A)** of the nucleus. On it, mark the nucleus that is **most** stable.
- (ii) What is meant by the following statement?
'Angular momentum of an orbiting electron is quantised.'
- (iii) Calculate the **shortest** wavelength of **Balmer** series.

OR

- (iv) Calculate the **minimum** amount of energy which a gamma ray photon should possess in order to produce a proton and an anti-proton pair.
- (v) Why is a nuclear fusion reaction also **known** as a thermonuclear reaction?
- (vi) What is the **physical significance** of the fact that total energy of an orbiting electron is negative?
- (vii) State **any one** limitation of **Bohr's** theory of hydrogen atom.

Question 20

[5]

Read the scenario given below and answer the questions that follow.

Annie, a student of Physics, began her experiment by fabricating a **p-n junction** diode from an **extrinsic** semiconductor crystal, leading to the formation of a **depletion region** and a **potential barrier** at the interface. She then measured resistance of the diode in the **linear region** of the V-I characteristic curve. She also studied its characteristics during forward bias and reverse bias. Finally, she designed a circuit to convert ac voltage to dc voltage.

- (i) Which instrument was used by Annie to measure current flowing through the diode during its reverse bias?
- (ii) How did Annie obtain an extrinsic semiconductor from an intrinsic semiconductor?
- (iii) What is meant by **potential barrier**?
- (iv) Draw a labelled circuit diagram of a **half wave** rectifier.

USEFUL CONSTANTS AND RELATIONS

1.	Speed of light in vacuum	c	=	$3 \times 10^8 \text{ ms}^{-1}$
2.	Charge of a proton	e	=	$1.6 \times 10^{-19} \text{ C}$
3.	Mass of a proton	m_p	=	$1.67 \times 10^{-27} \text{ kg}$
4.	Permeability of vacuum	μ_0	=	$4\pi \times 10^{-7} \text{ Hm}^{-1}$
5.	Permittivity of vacuum	ϵ_0	=	$8.85 \times 10^{-12} \text{ Fm}^{-1}$
6.	Planck's constant	h	=	$6.6 \times 10^{-34} \text{ Js}$
7.	Rydberg's constant	R_H	=	$1.097 \times 10^7 \text{ m}^{-1}$
8.	Relative permeability of iron	μ_r	=	3000
9.	1nm		=	$1 \times 10^{-9} \text{ m}$
10.	1eV		=	$1.6 \times 10^{-19} \text{ J}$
11.	π		=	3.14

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