

PHYSICS PAPER 1

(THEORY)

Maximum Marks: 70

Time Allowed: Three Hours

*(Candidates are allowed **additional 15 minutes** for **only** reading the paper.*

*They must **NOT** start writing during this time.)*

*This paper is divided into **four** sections – A, B, C and D.*

*Answer **all** questions.*

Section A consists of **one** question **having sub-parts** of **one** mark each.

Section B consists of **seven** questions of **two** marks each.

Section C consists of **nine** questions of **three** marks each, and

Section D consists of **three** questions of **five** marks each.

Internal choices have been provided in two questions each in Section B, Section C and Section D.

The intended marks for questions are given in brackets [].

All working, including rough work, should be done on the same sheet as and adjacent to the rest of the answer.

Answers to sub parts of the same question must be given in one place only. A list of useful physical constants is given at the end of this paper.

A simple scientific calculator without a programmable memory may be used for calculations.

SECTION A – 14 MARKS

Question 1

- (A) In questions (i) to (vii) below, choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

- (i) Two bulbs of power ratings 100 W and 40 W, designed to operate on the same voltage, are connected in **parallel** to a battery source as shown in **Figure 1** below. Currents flowing across points 1, 2 and 3 are I_1 , I_2 and I_3 respectively. [1]

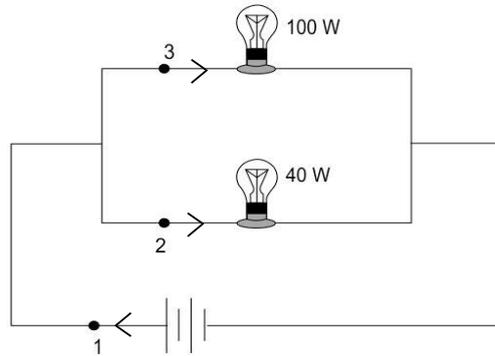


Figure 1

Choose the correct option.

- (a) $I_1 > I_2 > I_3$
- (b) $I_1 > I_2 < I_3$
- (c) $I_1 < I_2 = I_3$
- (d) $I_1 > I_2 = I_3$
- (ii) A circular coil having N turns of radius R carries a current I and produces a magnetic field T at its centre O . [1]
If this coil is opened and rewound such that the radius of the newly formed coil is $2R$, and the same current I passed through it, the magnetic field at the centre O will be:
- (a) $2T$
- (b) T
- (c) $T/2$
- (d) $T/4$

- (iii) **Assertion:** Magnetic lines of force do not intersect each other. [1]
Reason: At the point of intersection, the magnetic field will have two directions.
- (a) Both Assertion and Reason are correct, and Reason is the correct explanation for Assertion.
 - (b) Both Assertion and Reason are correct, 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.
- (iv) The focal length of a double convex lens is equal to the radius of curvature of either surface. The **refractive index** of its material is: [1]
- (a) $3/2$
 - (b) 1
 - (c) $4/3$
 - (d) Zero
- (v) Which one of the following statements is correct in case of **Fraunhofer's single slit diffraction experiment**? [1]
- (a) All bright fringes are of same intensity.
 - (b) Central bright fringe is the brightest.
 - (c) Central fringe is a dark fringe.
 - (d) Angular width of central fringe increases with an increase in wavelength of the incident monochromatic light.
- (vi) The **de Broglie wavelength** of a moving particle varies: [1]
- (a) directly with its velocity.
 - (b) directly with its momentum.
 - (c) directly with its kinetic energy.
 - (d) inversely with its linear momentum.

(vii) Which one of the following statements is correct with reference to **Semiconductor Physics**? [1]

- (a) N type semiconductor has a majority of holes.
- (b) To convert a pure semiconductor into a P type semiconductor, Phosphorous is used as a dopant.
- (c) In energy band diagram of a metal, forbidden band is absent.
- (d) Resistance of a semiconductor increases on increasing its temperature.

(B) Answer the following questions **briefly**:

- (i) State **any one** advantage of a full wave rectifier over that of a half wave rectifier. [1]
- (ii) State the condition for a **balanced Wheatstone bridge**. [1]
- (iii) **Name** the rule used to determine the direction of induced current in the case of a straight conductor moving in a magnetic field. [1]
- (iv) With what type of source of light are plane wavefronts associated? [1]
- (v) Write an expression for the torque acting on an electric dipole kept in a uniform electric field in **vector form**. [1]
- (vi) In **Young's double slit experiment**, what should be the path difference between two overlapping waves to form a bright band / fringe? [1]
- (vii) What are **isotones**? [1]

SECTION B – 14 MARKS

Question 2 [2]

- (i) (a) State **Gauss' theorem**.
- (b) What is the SI unit of electric flux?

OR

- (ii) Calculate the **equivalent capacitance** C' if n identical capacitors each of capacitance C are connected in **series**.

Question 3

[2]

A hollow charged metallic sphere of radius R carries a charge Q . How much work has to be done in moving a charge q on its surface through a distance d ? Explain.

Question 4

[2]

- (i) What is meant by **pair annihilation**?
- (ii) Give *any one* example where energy is converted to matter.

Question 5

[2]

- (i) **Figure 2** given below shows a **part** of Wheatstone bridge circuit. With the help of **Kirchhoff's loop rule**, calculate the current flowing through the 4Ω resistor.

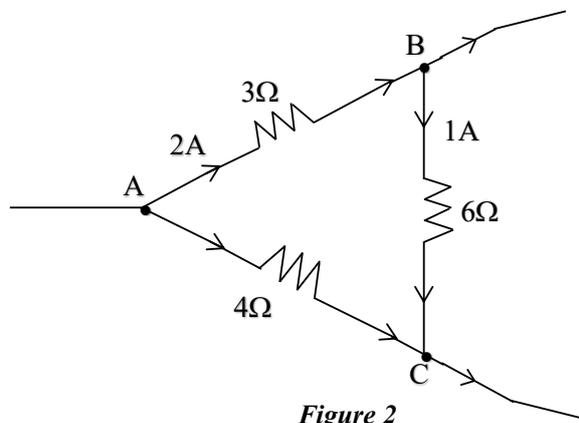


Figure 2

OR

- (ii) In an experiment conducted to determine the **internal resistance** of a cell, its emf is balanced against a p.d. across 110cm of the potentiometer wire. The balancing length becomes 100cm when the cell is **shunted** by a resistance of 10Ω . Calculate the internal resistance of the cell.

Question 6

[2]

- (i) On which principle do optical fibres work?
- (ii) What is a **thin** prism?

Question 7

[2]

- (i) State *any one* application of microwaves.
- (ii) Which one of the following rays/waves is **NOT** an electromagnetic wave?
X rays; UV rays; γ rays; matter waves.

Question 8

[2]

- (i) What is **motional emf**?
- (ii) A 220V ac voltage is to be converted to 33,000V ac voltage. What kind / type of transformer will you use?

SECTION C – 27 MARKS

Question 9

[3]

Obtain an expression for intensity of electric field at a point in **broadside** position of an electric dipole.

Question 10

[3]

- (i) In **Figure 3** shown below, all the cells are **identical**. The external resistance R is also same in both the circuits.

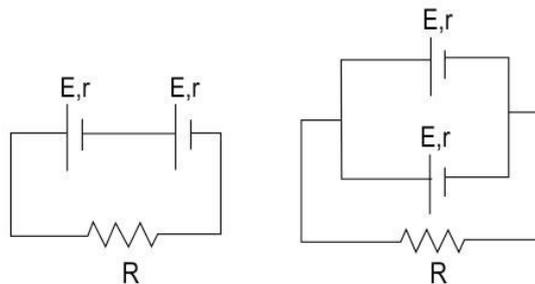


Figure 3

If the same current flows through the resistor R in both the circuits, calculate the relation between **r**, the internal resistance of each cell and the external resistance R.

OR

- (ii) The drift velocity of electrons in a conductor connected to a battery is given by
$$\mathbf{v}_d = -e\mathbf{E}\tau/m.$$

Here, e is the charge of the electron, E is the electric field, τ is the average time between collisions and m is the mass of the electron.

- (a) How does the **drift velocity** change with an increase in the potential difference across the conductor?
- (b) A copper wire of length ' l ' is connected to a source. If the copper wire is replaced by another copper wire of the same area of cross-section but of length ' $4l$ ', how will the drift velocity change? Explain.

Question 11

[3]

A galvanometer of resistance 100Ω gives a **full-scale deflection** for a potential difference of 200 mV .

- (i) How will you convert this galvanometer into an ammeter of the range $0 - 2\text{A}$?
- (ii) Define an **ampere** in terms of force between two current carrying conductors.

Question 12

[3]

- (i) (a) Draw the ray diagram of a compound microscope when the final image lies at the **least distance of distinct vision, D**.
- (b) Write an expression for magnifying power of an astronomical telescope when final image lies at infinity. (No derivation required)

OR

- (ii) For refraction at convex spherical surface of denser medium η_2 surrounded by a rarer medium of refractive index η_1 , derive a formula connecting object distance u , image distance v , and radius of curvature R for the object in rarer medium and a real image formed inside the denser medium.

Question 13

[3]

Using **Huygen's wave theory**, prove **Snell's Law** for refraction of light.

Question 14**[3]**

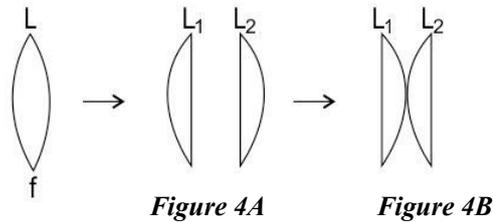
- (i) A certain metal emits **photoelectrons** with a green light but not with a yellow light. If this surface is illuminated with blue light and red light, which one of the two will cause photoelectric emission? Give a reason for your answer.
- (ii) What conclusion can be drawn from this phenomenon regarding the **nature** of light?

Question 15**[3]**

A lens of focal length f is divided into two equal parts as shown in **Figure 4A** below. These parts are then arranged as shown in **Figure 4B** below.

In terms of the original focal length f ,

- (i) What is the focal length of the lens L_1 ?
- (ii) What is the focal length of the final combination?

**Question 16****[3]**

Using **Ampere circuital law**, obtain an expression for magnetic field **B** near a long current carrying straight conductor.

Question 17**[3]**

Young's double-slit experiment is performed by a student. The examiner gives the following instructions to the student. State whether the responses of the student, in each case, are correct or incorrect. Give a reason for your answer.

- (i) EXAMINER: The fringes on the screen are too crowded. **Increase** the distance between the fringes.

STUDENT increases the distance between the two slits (thinking that distance between the fringes increases on increasing the distance between slits).

(ii) EXAMINER: Bright fringes are **not** very bright. Increase their **brightness**.

STUDENT moves the source of light towards the two slits.

(iii) EXAMINER: Compare the distance between central and first maxima with the distance between second and third maxima.

STUDENT measures and states that the distance between central and first maxima is **MORE** than that between second and third maxima

SECTION D – 15 MARKS

Question 18

[5]

- (i) (a) A closed loop of area 1 m^2 and resistance of 10Ω is free to rotate about an axis passing through its plane and the centre. If the loop is placed at right angles to a magnetic field $B = 0.2 \text{ Wb/m}^2$ and turned through 180° in 0.02 second, then determine (I) induced emf and (II) induced current in the loop.
- (b) A wire is wound into a solenoid of length l and radius r . It has a self-inductance of L . By what factor does the self-inductance change, if the same wire is wound into a solenoid of half the length and half the radius?

OR

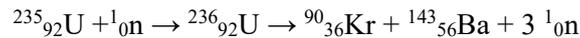
- (ii) (a) In a **series** LCR circuit connected to an alternating voltage source of 220V-50Hz, the readings of voltmeters across resistor, capacitor and inductor are 70V, 415V, 210V respectively.

If the value of the resistance $R = 100\Omega$, calculate

- (1) current in the circuit.
- (2) value of L .
- (3) value of C .
- (b) If the capacitance in an LC series circuit is doubled, by what value should the inductance be changed to keep its **resonant frequency** constant?

Question 19**[5]**

- (i) (a) Uranium undergoes **nuclear fission** as shown in the following nuclear reaction.



Calculate the energy released during the fission reaction.

- (b) Write *any one* balanced equation to represent **nuclear fusion**.
- (c) In **Rutherford's α -particle scattering experiment**, it was observed that most of the α -particles did not deflect; some showed a deflection of more than 90° and some were deflected by even 180° .
- (1) What hypothesis was made to justify the deflection of α -particle by more than 90° ?
- (2) State *any one* postulate of **Bohr's theory**.

OR

- (ii) (a)

- (1) Define **unified atomic mass unit**.
- (2) Write its energy equivalent.
- (3) What is the physical significance of binding energy per nucleon of a nucleus?
- (b) The wavelength of the first line of Balmer series (H_α) is 656.3nm . Calculate the value of the **Rydberg's constant**.

Question 20**[5]**

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

A rain sensor is a device used for sensing rain. They are used to automatically activate windscreen wipers to remove water from the windshields. An IR LED is used to shine infrared light onto the windshield at an angle of 45° , which is then detected using an IR photodiode.

- (i) Name the two semiconductor diodes used in the rain sensor.
- (ii) What kind of biasing is used in each of these diodes?
- (iii) Draw the symbol of LED.

Useful Constants & Relations:

S.No	Planck's Constant	
1	Mass of a proton	1.0073u
2	Mass of a neutron	1.0087u
3	Mass of ²³⁵ U	235.0439u
4	Mass of ⁹⁰ Kr	89.9195u
5	Mass of ¹⁴³ Ba	142.9206u
6	1u =	931.5MeV
7	1nm =	10 ⁻⁹ m