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 sub-parts 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) When a battery is connected between the terminals P and Q, as shown in **[1]** *Figure 1* below, it is found that no current flows through 5Ω resistor. Then, the value of resistor X is:
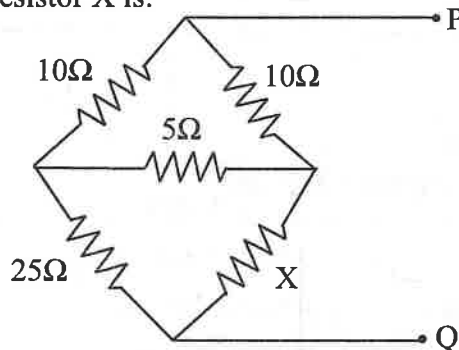

Figure 1

 (a) 10Ω

 (b) 20Ω

 (c) 25Ω

 (d) 45Ω

(ii) The **relative permeability** of substance 'X' is slightly less than one and that **[1]** of substance 'Y' is slightly more than one. Then:

 (a) 'X' is paramagnetic and 'Y' is ferromagnetic.

 (b) 'X' is diamagnetic and 'Y' is ferromagnetic.

 (c) 'X' is paramagnetic and 'Y' is diamagnetic.

 (d) 'X' is diamagnetic and 'Y' is paramagnetic.

(iii) If **kinetic energy** of moving electrons is made four times, then their **[1]** **de Broglie wavelength** becomes:

 (a) eight times.

 (b) four times.

 (c) two times.

 (d) half.

(iv) A student has made connections, as shown in **Figure 2** below, so that the wires [1]
MN and ST **repel** each other. But it is observed that they are attracting each
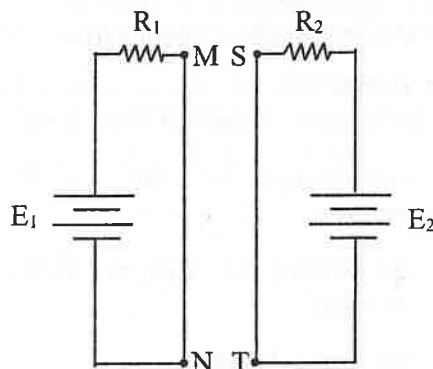other. What change should the student make for the wires to repel each other?

Figure 2

(a) Reverse the terminals of batteries E_1 and E_2.

(b) Reverse the terminals of battery E_1 or E_2.

(c) Choose supply voltage such that $E_1 = E_2$.

(d) Add key and ammeter to the circuit.

(v) N-type semiconductor is that which has: [1]

(a) majority of holes as charge carriers.

(b) majority of free electrons as charge carriers.

(c) trivalent element added as an impurity.

(d) an equal number of holes and free electrons.

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

Assertion: When a convex lens made of glass is completely immersed in
water, its focal length increases.

Reason: Refractive index of glass with respect to water is greater than that of
glass with respect to air.

(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) Both Assertion and Reason are false.

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

Assertion: Diffraction of light is difficult to observe in everyday situations but can be observed in laboratory conditions.

Reason: To produce diffraction of waves, size of an obstacle must be comparable to the wavelength of the waves.

(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) Both Assertion and Reason are false.

(B) Answer the following questions briefly:

(i) How does the resistance of a semiconductor crystal vary with its temperature?   [1]

(ii) *Figure 3* below shows an ideal transformer. Explain why current flowing through secondary coil is greater than that in primary coil.   [1]
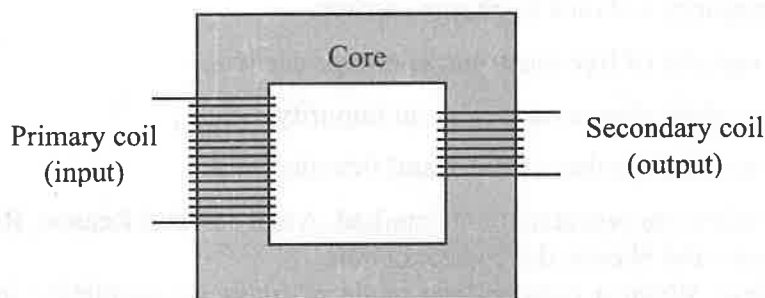

Primary coil (input)   Core   Secondary coil (output)

Figure 3

(iii) State *any one* difference between a primary rainbow and a secondary rainbow.   [1]

(iv) **Hubble** telescope employs a large parabolic mirror as an objective. State *any one* advantage of using a **mirror** in place of a lens in such a telescope.   [1]

(v) Name *any one* phenomenon where moving particles behave like waves.   [1]

(vi) What is the minimum energy a gamma ray (γ) photon should possess to produce an electron - positron pair?   [1]

(vii) In an energy band diagram of a certain material, forbidden band is **absent**. Identify this material.   [1]

SECTION B – 14 MARKS

Question 2   [2]

(i)   (a)   What is the effect on **capacitance** of a **parallel plate** capacitor if the distance between its plates is increased?

(b)   How will **capacitance** of a capacitor change if a dielectric slab is introduced between its plates?

OR

(ii) *Figures 4* and *5* represent the combination of two identical cells having negligible internal resistance.
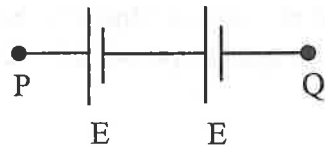

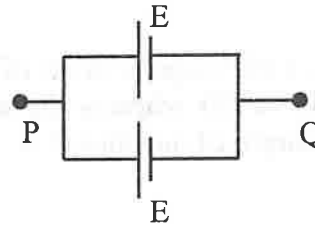*Figure 4*   *Figure 5*

(a)   In which of the two combinations, emf of the battery is **greater**?

(b)   When a resistor 'R' is connected between the terminals P and Q, I_1 and I_2 are the currents flowing through 'R' in *Figure 4* and *Figure 5* respectively. Obtain the ratio $\dfrac{I_1}{I_2}$.

Question 3   [2]

In case of a **short** electric dipole:

(i)   What is the **locus** of a point having zero potential?

(ii) If electric field intensity at a point in axial position is E_1 and at an **equidistant** point in equatorial position is E_2, what is the ratio $\dfrac{E_1}{E_2}$?

Question 4   [2]

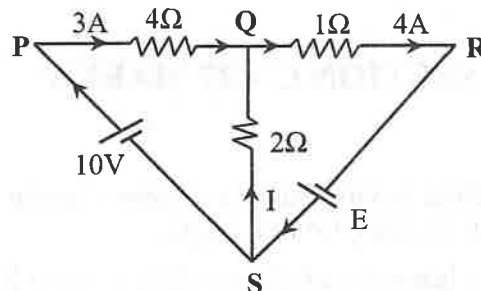(i)   *Figure 6* below shows an electric circuit.

Figure 6

Apply **Kirchhoff's** laws to calculate:

(a)   current 'I' flowing through the 2Ω resistor.

(b)   emf of the cell 'E'.

OR

(ii) In a **potentiometer** experiment, a cell of emf 1·25V gives a balance point at 35cm mark of the wire. If this cell is replaced by another cell, the balance point is at 63cm mark. Calculate the **emf** of the second cell.

Question 5 [2]

Magnetic field at the **centre** of a circular coil is B. Calculate the magnetic field at the **same** point when **each** of the current, number of turns of the coil and its radius is doubled.
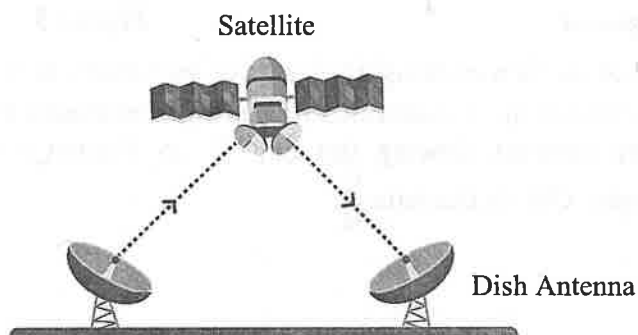
Question 6 [2]

The objective of a telescope consists of two lenses kept in contact. One lens has an optical power of +2·0D whereas the other lens has an optical power of −1·5D. Calculate **focal length** of the objective.

Question 7 [2]

Satellite

Dish Antenna

(i) **Name** the electromagnetic wave travelling from the **satellite** to the **dish antenna** shown in the image above.

(ii) If the wavelength of an electromagnetic wave is 6nm, what is its **frequency**?

Question 8 [2]

With reference to **photoelectric effect,** define the terms:

(i) Threshold frequency.

(ii) Work function.

SECTION C – 27 MARKS

Question 9 [3]

An infinite plane metallic sheet having surface charge density '+σ' is placed in vacuum. P is a point at a small distance 'r' to its right.

(i) Write an expression for **intensity** of electric field at point P.

(ii) Now, an identical charged sheet having surface charge density '−σ' is placed parallel to the first sheet such that the point P is to its **left** at the same distance 'r'. (The point P lies between the two plates.)

(a) What is the **resultant intensity** of electric field at point P?

(b) What is its direction?

Question 10   **[3]**

(i)   Harry sets up a circuit as shown in *Figure* 7 below. He measures potential difference 'V' across the variable resistor **R** with an instrument Y. He also measures current 'I' flowing through **R** with another instrument X.
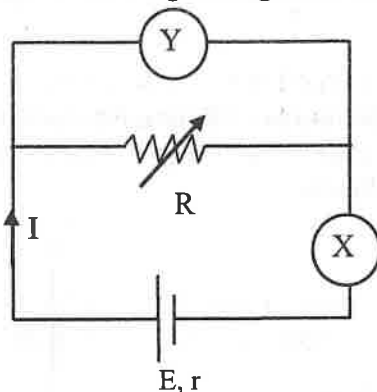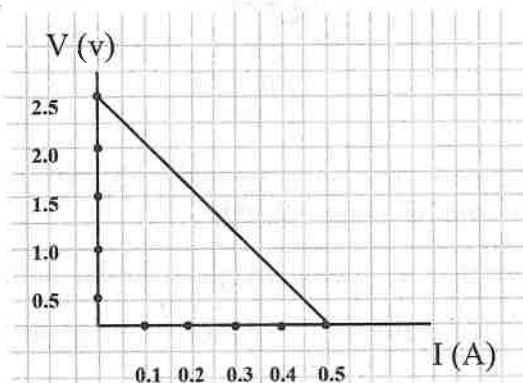

Figure 7

(a)   Identify the instruments X and Y.

(b)   Using the graph of V against I shown below, calculate

(1)   emf (E) of the cell.

(2)   Internal resistance (r) of the cell.

OR

(ii) The graph below shows the variation of current density (J) with electric field (E) applied to two different metallic wires A and B.
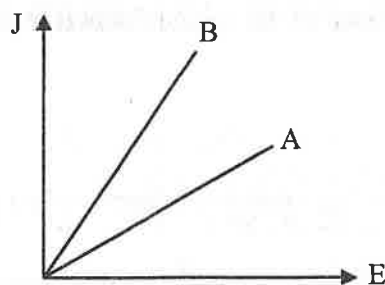
(a)   Which one of the wires, A or B, has higher **resistivity**?

(b)   For a certain value of electric field (E), in which wire 'A' or 'B' is drift velocity greater? Give a reason for your answer.

Question 11   [3]

A galvanometer having a resistance of 20Ω shows a full scale deflection with a current of 1mA. How can it be converted into a **voltmeter** with a range of 0 - 10V?

Question 12   [3]

(i)   Two infinitely long straight wires PQ and RS carrying currents I_1 and I_2 respectively are kept 10cm apart in **vacuum**. Calculate **magnetic field** (B) at the point X shown in *Figure 8* below.
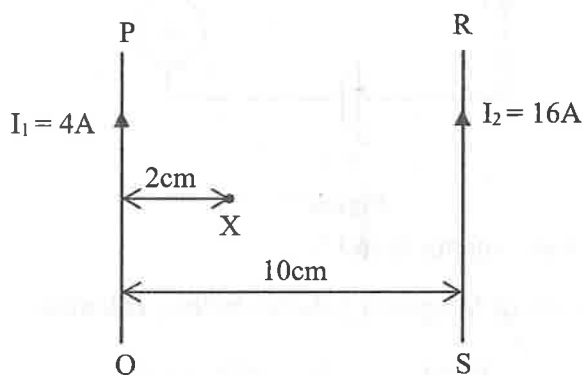

Figure 8

OR

(ii) An electron and a proton are moving along the **+X axis**. If an external magnetic field B = 0·314T is applied along **−Z axis**:

   (a)   What is the **path** followed by the **electron** due to the magnetic field?

   (b)   Calculate the **frequency** of revolution of the **proton**.

Question 13   [3]

A convex lens having small focal length is to be used as a **magnifying glass** (simple microscope) to obtain an image of a small diamond. If the image lies at least distance of distinct vision (D):

(i)   Where will you keep the diamond to obtain its image at D?

(ii) State *any two* characteristics of the image formed by the magnifying glass.

Question 14   [3]

A parallel beam of light is travelling **obliquely** from an optically rarer medium to an optically denser medium.

(i)   Draw a labelled diagram showing incident and refracted wavefronts. Mark angle of incidence as '*i*' and angle of refraction as '*r*'.

(ii) Use **Huygen's wave theory** to prove **Snell's law**.

Question 15   [3]

For any prism, show that refractive index 'n' of its material is given by:

$$n = \frac{\sin\left(\frac{A + \delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where the terms have their usual meaning.

Question 16   [3]

Two identical rectangular slits 5mm apart are illuminated with a monochromatic light of wavelength 600nm. The screen is kept 1·2m away from the slits.

(i) Calculate the **distance** between the 5th bright fringe (band) on **one side** and the 3rd bright fringe on the **other side** of the central bright band.

(ii) What will be the **change** in the interference pattern if the given light is replaced with monochromatic light of wavelength 500nm?

Question 17   [3]

(i) Plot a **labelled** graph of **stopping potential** (V_s) versus **frequency** (f) of incident UV radiation.

(ii) State how the value of **Planck's constant** can be determined from this graph.

SECTION D – 15 MARKS

Question 18   [5]

(i) (a) *Figure 9* shows a metallic rod MN of length $l = 3m$ moving in an external uniform magnetic field, $\mathbf{B} = \left(\frac{1}{\pi}\right)$ T which is directed into the plane of this paper.
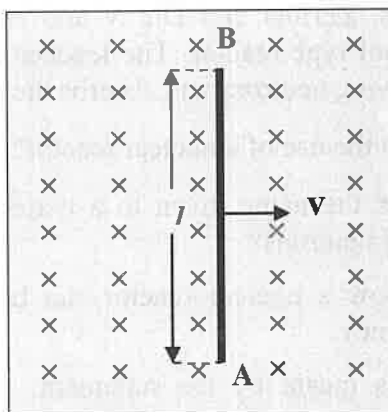

Figure 9

If the position of the rod changes with time as $x = \pi t$, where x is in meter and t is in second, then:

(1) Calculate the **motional emf** developed in the rod.

(2) **Name** the law used to find the direction of induced current.

(b) When current flowing through a solenoid decreases from 15A to 0 in 0·2s, an emf of 30V is induced in it. Calculate the **coefficient of self-inductance** of the solenoid.

OR

(ii) An alternating emf $E = 5 \cdot 0 \, \text{Sin}(314t)V$ is applied to a circuit containing a resistor connected in series with an unknown component X.

The current in the circuit is found to be $I = 3 \cdot 0 \, \text{Sin}(314t - \frac{\pi}{3})$ A.

(a) Identify the component X.

(b) Calculate rms value (I_{rms}) of the current flowing through the circuit.

(c) Find the frequency of the source.

(d) Calculate power factor.

(e) Find the impedance (Z) of the circuit.

Question 19   [5]

(i) (a) Show that radius (r_n) of the nth **Bohr orbit** varies directly with square of the **principal quantum number (n)** of the orbit.

(b) (1) Where does **nuclear fusion** reaction take place continuously in the Universe?

(2) What is meant by "Mass defect" of a nucleus?

OR

(ii) (a) A group of students went on an educational tour of **Bhabha Atomic Research Centre**, Mumbai. They visited various nuclear reactors like Apsara, Cirus, Zerlina and Dhruv and observed that Apsara was a swimming pool type reactor. The teacher explained how water slows down fast moving neutrons and absorbs the heat produced in the reactor.

(1) What is the use of a nuclear reactor?

(2) What is the name given to a material which slows down fast moving neutrons?

(3) State how a nuclear reactor can be shut down in case of an emergency.

(b) (1) What is meant by the statement: 'Angular momentum of an orbiting electron is **quantised**'?

(2) What is the **physical significance** of the fact that total energy of an orbiting electron is negative?

When a television set (scientifically known as a television receiver) is opened, many components like semiconductor diodes, transistors, capacitors, resistors etc. can be observed on its motherboard. There are different types of diodes like photo diode, Zener diode, LED etc. found in the T.V. set. With the help of these components, a television receives audio as well as video signals.

(i) A semiconductor diode has two types of semiconducting materials: 'P' type and 'N' type. What is the difference between them?

(ii) Draw a **labelled** diagram of a **full wave rectifier**. Show graphically how its output voltage varies with time.

(iii) What type of diode can be used as a **voltage regulator**?

USEFUL CONSTANTS AND RELATIONS

1.	Speed of light in vacuum	c	=	$3 \times 10^8 \, ms^{-1}$
2.	Charge of a proton	e	=	$1 \cdot 6 \times 10^{-19} \, C$
3.	Mass of a proton	m_p	=	$1 \cdot 67 \times 10^{-27} \, kg$
4.	Permeability of vacuum	μ_0	=	$4\pi \times 10^{-7} \, Hm^{-1}$
5.	1 nm		=	$10^{-9} m$
6.	π		=	$3 \cdot 14$