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.)

Answer all questions in Part I and ten questions from Part II, choosing four questions from Section A, three questions from Section B and three questions from Section C.

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

The intended marks for questions or parts of questions are given in brackets []. (Material to be supplied: Log tables including Trigonometric functions)

A list of useful physical constants is given at the end of this paper.

PART I (20 Marks)

Answer all questions.

Question 1

Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

[5]

(i) In Figure 1 below, a charge Q is fixed. Another charge q is moved along a circular arc MN of radius r around it, from the point M to the point N such that the length of the arc MN = l. The work done in this process is:

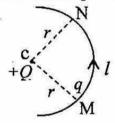


Figure 1

- (a) zero
- (b) $\frac{1}{4\pi\epsilon_0} \cdot \frac{Qq}{r^2} l$
- (c) $\frac{Qq}{2\epsilon_0 r^2} l$
- (d) $\frac{Qq}{2\pi\epsilon_0 r^2}$

This Paper consists of 8 printed pages.

(ii) A carbon resistor has coloured bands as shown in *Figure 2* below. The resistance of the resistor is:

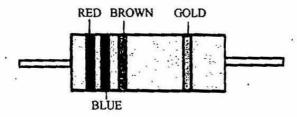
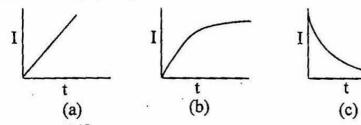


Figure 2.

- (a) $26\Omega \pm 10\%$
- (b) $26\Omega \pm 5\%$
- (c) $260\Omega \pm 5\%$
- (d) $260\Omega \pm 10\%$
- (iii) A solenoid L and a resistor R are connected in series to a battery, through a switch. When the switch is put on, current I flowing through it varies with time t as shown in which of the graphs given below:



- (iv) Two thin lenses having optical powers of -10D and + 6D are placed in contact with each other. The focal length of the combination is:
 - (a) +0.25 cm
 - (b) 0.25 cm
 - (c) +0.25 m
 - (d) 0.25 m
- (v) Total energy of an electron in the ground state of hydrogen atom is -13.6 eV. Its total energy, when hydrogen atom is in the first excited state, is:
 - (a) + 13.6 eV
 - (b) + 3.4 eV
 - (c) 3.4 eV
 - (d) -54.4 eV

(d)

B. Answer all questions given below briefly and to the point:

- (i) A charged oil drop weighing 1.6×10^{-15} N is found to remain suspended in a uniform electric field of intensity 2×10^3 NC⁻¹. Find the **charge** on the drop.
- (ii) For a metallic conductor, what is the relation between current density (J), conductivity (σ) and electric field intensity E?
- (iii) In Figure 3 given below, find the value of resistance x for which points A and B are at the same potential:

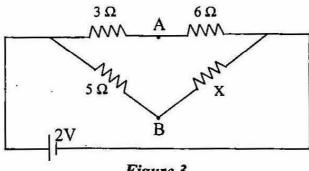


Figure 3

- (iv) Write the expression for the Lorentz force F in vector form.
- (v) A coil has a self-inductance of 0.05 Henry. Find magnitude of the emf induced in it when the current flowing through it is changing at the rate 100 As⁻¹.
- (vi) To which regions of the electromagnetic spectrum do the following wavelengths belong:
 - (a) 250 nm
 - (b) 1500 nm
- (vii) What is the difference between polarised light and unpolarised light?
- (viii) Name the principle on the basis of which optical fibres work.
- (ix) Calculate dispersive power of a transparent material given:

$$n_v = 1.56$$
, $n_r = 1.54$, $n_y = 1.55$.

- (x) What is meant by short-sightedness?
- (xi) Two metals A and B have work functions 4eV and 6eV respectively. Which metal has lower threshold wavelength for photoelectric effect?
- (xii) Calculate angular momentum of an electron in the third Bohr orbit of hydrogen atom.
- (xiii) In a nuclear reactor, what is the function of a moderator?
- (xiv) In our Nature, where is the nuclear fusion reaction taking place continuously?
- (xv) What is the use of a Zener diode?

PART II (50 Marks)

Answer ten questions in this part, choosing four questions from Section A, three questions from Section B and three questions from Section C.

SECTION A

Answer any four questions.

Question 2

(a) Two point charges $Q_1 = 400\mu\text{C}$ and $Q_2 = 100\mu\text{C}$ are kept fixed, 60 cm apart in vacuum. [3] Find intensity of the electric field at midpoint of the line joining Q_1 and Q_2 .

(b) (i) State Gauss' Law.

[2]

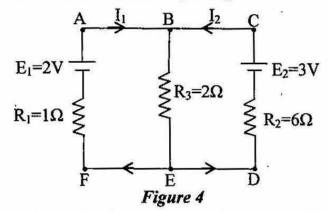
(ii) In an electric dipole, at which point is the electric potential zero?

Question 3

- (a) Obtain an expression for equivalent capacitance when three capacitors C₁, C₂ and C₃ [3] are connected in series.
- (b) A metallic wire has a resistance of 3.0Ω at 0° C and 4.8Ω at 150° C. Find the [2] temperature coefficient of resistance of its material.

Question 4

(a) In the circuit shown in *Figure 4* below, E₁ and E₂ are two cells having emfs 2V and 3V respectively, and negligible internal resistances. Applying **Kirchoff's laws** of electrical networks, find the values of currents I₁ and I₂



(b) State how a moving coil galvanometer can be converted into an ammeter.

[1]

Question 5

- Draw a labelled circuit diagram of a potentiometer to measure internal resistance of a (a) [3] cell. Write the working formula. (Derivation not required).

(b) Define Curie temperature. (i)

- [2]
- (ii) If magnetic susceptibility of a certain magnetic material is 0.0001, find its relative permeability.

Question 6

Two infinitely long current carrying conductors X and Y are kept parallel to each (a) (i) [3] other, 24 cm apart in vacuum. They carry currents of 5A and 7A respectively, in the same direction, as shown in Figure 5 below. Find the position of a neutral point, i.e. a point where resultant magnetic flux density is zero. (Ignore earth's magnetic field).

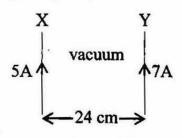


Figure 5

- (ii) If current through the conductor Y is reversed in direction, will neutral point lie between X and Y, to the left of X or to the right of Y?
- (b) (i) Define Ampere in terms of force between two current carrying conductors.
 - [2]

(ii) What is an **ideal** transformer?

Question 7

A coil having self-inductance of 0.7H and resistance of 165Ω is connected to an (a) [3] a.c. source of 275V, 50Hz. If $\pi = \frac{22}{7}$,

Calculate:

- Reactance of the coil (i)
- (ii) Impedance of the coil
- (iii) Current flowing through the coil
- Draw a labelled graph showing variation of impedance of a series LCR circuit with (b) [2] frequency of the a.c. supply.

SECTION B

Answer any three questions.

Question 8

(a) Derive Snell's law of refraction using Huygen's wave theory.

[3]

Monochromatic light of wavelength 650nm falls normally on a slit of width 1.3×10^{-4} cm and the resulting Fraunhofer diffraction is obtained on a screen. Find the angular width of the central maxima.

[2]

Question 9

(a) In Young's double slit experiment, show that:

[4]

[1]

$$\beta = \frac{\lambda D}{d},$$

where the terms have their usual meaning.

(b) A ray of ordinary light is travelling in air. It is incident on air glass pair at a polarising angle of 56°. Find the angle of refraction in glass.

Question 10

Find the angle of incidence at which a ray of monochromatic light should be incident on the first surface AB of a regular glass prism ABC so that the emergent ray grazes the adjacent surface AC. (Refractive Index of glass = 1.56).

[3]

State how focal length of a glass lens (Refractive Index 1.5) changes when it is completely immersed in:

[2]

- (i) Water (Refractive Index 1.33)
- (ii) A liquid (Refractive Index 1.65)

Question 11

A convex lens of a focal length 5 cm is used as a simple microscope. Where should an (a) object be placed so that the image formed by it lies at the least distance of distinct vision (D=25cm)?

[2]

(b) Draw a labelled ray diagram showing the formation of an image by a [3] refracting telescope when the final image lies at infinity.

SECTION C

Answer any three questions.

Question 12

- (a) Monochromatic light of wavelength 198 nm is incident on the surface of a metallic cathode whose work function is 2.5 eV. How much potential difference must be applied between the cathode and the anode of a photocell to just stop the photo current from flowing?
 - rai

(b) (i) What is de Broglie hypothesis?

- [2]
- (ii) What conclusion can be drawn from Davisson and Germer's experiment?

Question 13

- (a) (i) How are various lines of Lyman series formed? Explain on the basis of [3] Bohr's theory.
 - (ii) Calculate the **shortest** wavelength of electromagnetic radiation present in **Balmer** series of hydrogen spectrum.
 - (b) State the effect of the following changes on the X-rays emitted by Coolidge X-ray tube: [2]
 - (i) High voltage between cathode and anode is increased.
 - (ii) Filament temperature is increased.

Question 14

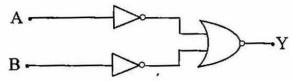
(a) Half life of a certain radioactive material is 8 hours.

[3]

- (i) Find disintegration constant of this material.
- (ii) If one starts with 600g of this substance, how much of it will disintegrate in one day?
- (b) Sketch a graph showing the variation of binding energy per nucleon of a nucleus with its [2] mass number.

Question 15

- (a) Draw a circuit diagram for the common emitter transistor amplifier. What is meant by phase reversal?
- (b) Write the truth table of the following circuit. Name the gate represented by this circuit. [2]



Useful Constants and Relations:

1.	Charge of a proton	(e)	$= 1.6 \times 10^{-19}$ C
2.	Planck's constant	(h)	$= 6.6 \times 10^{-34} \text{ Js}$
3.	Mass of an electron	(m)	$= 9.1 \times 10^{-31} \text{ kg}$
4.	Permittivity of vacuum	(ϵ_0)	$= 8.85 \times 10^{-12} \text{Fm}^{-1}$
5.		$\left(\frac{1}{4\pi\epsilon_0}\right)$	$= 9 \times 10^9 \mathrm{mF}^{-1}$
6.	Permeability of vacuum	(μ_0)	$=4\pi\times10^{-7}\text{Hm}^{-1}$
7.		$\left(\frac{\mu_0}{4\pi}\right)$	= 10 ⁻⁷ Hm ⁻¹
8.	Rydberg's constant	(R)	$= 1.097 \times 10^7 \text{ m}^{-1}$
9.	Speed of light in vacuum	(c)	$= 3 \times 10^8 \text{ ms}^{-1}$