

PHYSICS
PAPER – 1
(THEORY)
(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

A. Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: **[5]**

- (i) A **short** electric dipole (which consists of two point charges, $+q$ and $-q$) is placed at the centre O and inside a **large** cube (ABCDEFGH) of length L , as shown in **Figure 1**. The electric flux, emanating through the cube is:

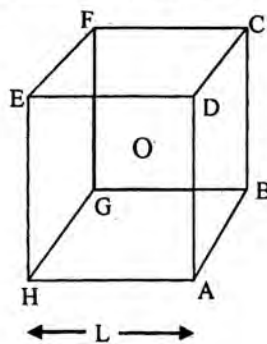


Figure 1

This Paper consists of 8 printed pages.

- (a) $q/4\pi\epsilon_0L$
- (b) zero
- (c) $q/2\pi\epsilon_0L$
- (d) $q/3\pi\epsilon_0L$

(ii) The equivalent resistance between points a and f of the network shown in *Figure 2* is:

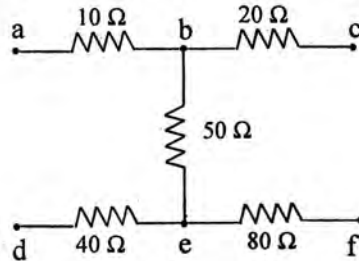


Figure 2

- (a) 24 Ω
 - (b) 110 Ω
 - (c) 140 Ω
 - (d) 200 Ω
- (iii) A moving electron enters a uniform and **perpendicular** magnetic field. Inside the magnetic field, the electron travels along:
- (a) a straight line.
 - (b) a parabola
 - (c) a circle
 - (d) a hyperbola
- (iv) A fish which is at a depth of 12 cm in water ($\mu = \frac{4}{3}$) is viewed by an observer on the bank of a lake. Its **apparent depth** as observed by the observer is:
- (a) 3 cm
 - (b) 9 cm
 - (c) 12 cm
 - (d) 16 cm
- (v) If E_p and E_k represent potential energy and kinetic energy respectively, of an orbital electron, then, according to **Bohr's theory**:
- (a) $E_k = -E_p/2$
 - (b) $E_k = -E_p$
 - (c) $E_k = -2E_p$
 - (d) $E_k = 2E_p$

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

[15]

- (i) What is meant by the term **Quantization of charge**?
- (ii) A resistor **R** is connected to a cell of emf **e** and internal resistance **r**. Potential difference across the resistor **R** is found to be **V**. State the relation between **e**, **V**, **R** and **r**.
- (iii) Three identical cells each of emf 2V and internal resistance 1Ω are connected in series to form a battery. The battery is then connected to a parallel combination of two identical resistors, each of resistance 6Ω . Find the current delivered by the battery.
- (iv) State how **magnetic susceptibility** is **different** for the three types of magnetic materials, i.e. diamagnetic, paramagnetic and ferromagnetic materials.
- (v) An emf of 2V is induced in a coil when current in it is changed from 0A to 10A in 0.40 sec. Find the **coefficient of self-inductance** of the coil.
- (vi) How are electric vector (\vec{E}), magnetic vector (\vec{B}) and velocity vector (\vec{c}) oriented in an electromagnetic wave?
- (vii) State *any two* methods by which ordinary light can be polarised.
- (viii) A monochromatic ray of light falls on a **regular prism**. What is the relation between angle of incidence and angle of emergence in the case of **minimum deviation**?
- (ix) What type of lens is used to correct **long-sightedness**?
- (x) State any one **advantage** of using a reflecting telescope in place of a refracting telescope.
- (xi) State **Moseley's law**.
- (xii) Wavelengths of the first lines of the **Lyman series**, **Paschen series** and **Balmer series**, in hydrogen spectrum are denoted by λ_L , λ_P , and λ_B , respectively. Arrange these wavelengths in **increasing order**.
- (xiii) What is the **significance** of **binding energy per nucleon** of a nucleus of a radioactive element?
- (xiv) Write any one **balanced** equation representing **nuclear fission**.
- (xv) What is the difference between **analogue** signal and **digital** signal?

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) Derive an expression for intensity of electric field at a point in **broadside position** or on an **equatorial line** of an electric dipole. [4]
- (b) Two point charges of 10C each are kept at a distance of 3m in vacuum. Calculate their electrostatic potential energy. [1]

Question 3

- (a) Four capacitors, C_1 , C_2 , C_3 and C_4 are connected as shown in **Figure 3** below. Calculate **equivalent** capacitance of the circuit between points X and Y. [3]

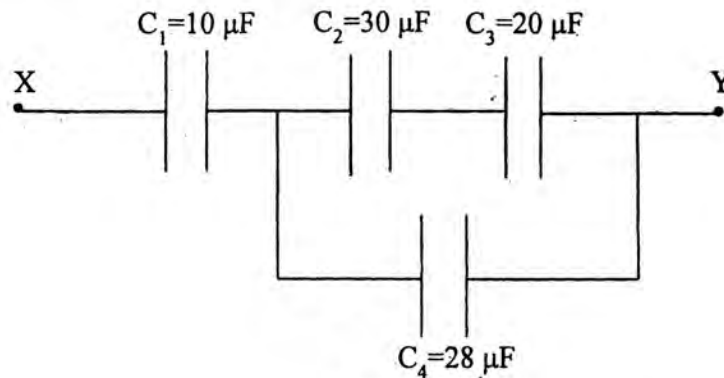


Figure 3

- (b) Draw labelled graphs to show how **electrical resistance** varies with **temperature** for: [2]
 - (i) a metallic wire.
 - (ii) a piece of carbon.

Question 4

- (a) Two resistors $R_1 = 400 \Omega$ and $R_2 = 20 \Omega$ are connected in **parallel** to a battery. If heating power developed in R_1 is 25 W, find the heating power developed in R_2 . [2]
- (b) With the help of a labelled diagram, show that the **balancing condition** of a **Wheatstone bridge** is: [3]

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \text{where the terms have their usual meaning.}$$

Question 5

- (a) A 10m long uniform metallic wire having a resistance of 20Ω is used as a potentiometer wire. This wire is connected in series with another resistance of 480Ω and a battery of emf 5V having negligible internal resistance. If an unknown emf e is balanced across 6m of the potentiometer wire, calculate: [3]
- (i) the potential gradient across the potentiometer wire.
 - (ii) the value of the unknown emf e .
- (b) (i) Explain the term *hysteresis*. [2]
- (ii) Name **three elements** of the earth's magnetic field which help in defining **earth's magnetic field** completely.

Question 6

- (a) Obtain an expression for **magnetic flux density** B at the centre of a circular coil of radius R , having N turns and carrying a current I . [3]
- (b) A coil of self inductance 2.5H and resistance 20Ω is connected to a battery of emf 120V having internal resistance of 5Ω . Find: [2]
- (i) The **time constant** of the circuit.
 - (ii) The current in the circuit in **steady state**.

Question 7

- (a) **Figure 4** below shows a capacitor C , an inductor L and a resistor R , connected in series to an a.c. supply of **220 V**. [4]

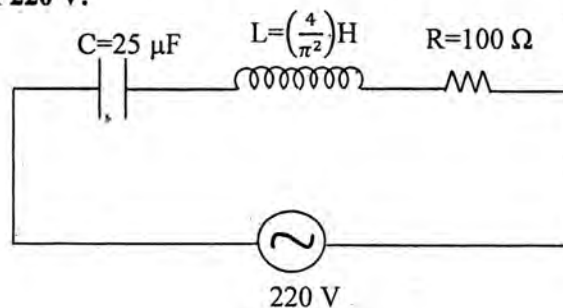


Figure 4

- Calculate:
- (i) The **resonant frequency** of the given CLR circuit.
 - (ii) Current flowing through the circuit.
 - (iii) Average power consumed by the circuit.
- (b) In a series LCR circuit, what is the **phase difference** between V_L and V_C where V_L is the potential difference across the inductor and V_C is the potential difference across the capacitor? [1]

SECTION B

Answer any **three** questions.

Question 8

- (a) On the basis of **Huygen's Wave theory of light**, show that angle of reflection is equal to angle of incidence. You must draw a labelled diagram for this derivation. [4]
- (b) State any one difference between **interference of light** and **diffraction of light**. [1]

Question 9

- (a) Laser light of wavelength 630 nm is incident on a pair of slits which are separated by 1.8mm. If the screen is kept 80 cm away from the two slits, calculate: [3]
- (i) fringe separation i.e. fringe width.
- (ii) distance of 10th bright fringe from the centre of the interference pattern.
- (b) Show graphically the intensity distribution in **Fraunhofer's single slit diffraction experiment**. Label the axes. [2]

Question 10

- (a) A point object **O** is placed at a distance of 15cm from a convex lens **L** of focal length 10cm as shown in **Figure 5** below. On the other side of the lens, a convex mirror **M** is placed such that its distance from the lens is equal to the focal length of the lens. The final image formed by this combination is observed to **coincide** with the object **O**. Find the **focal length** of the **convex mirror**. [3]

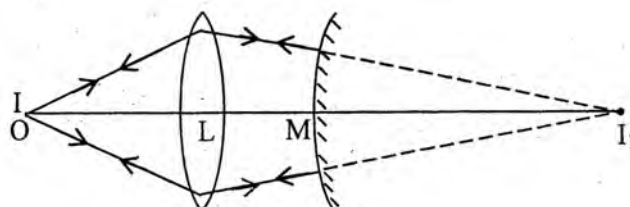


Figure 5

- (b) What is **chromatic aberration**? How can it be minimised or eliminated? [2]

Question 11

- (a) Draw a labelled ray diagram of an image formed by a **compound microscope**, when the final image lies at the **least distance of distinct vision (D)**. [3]
- (b) With regard to an **astronomical telescope of refracting type**, state how you will increase its: [2]
- (i) magnifying power
- (ii) resolving power

SECTION C

Answer any *three* questions.

Question 12

- (a) In an experiment of photoelectric effect, the graph of maximum kinetic energy E_K of the emitted photoelectrons versus the frequency ν of the incident light is a straight line AB as shown in *Figure 6* below: [3]

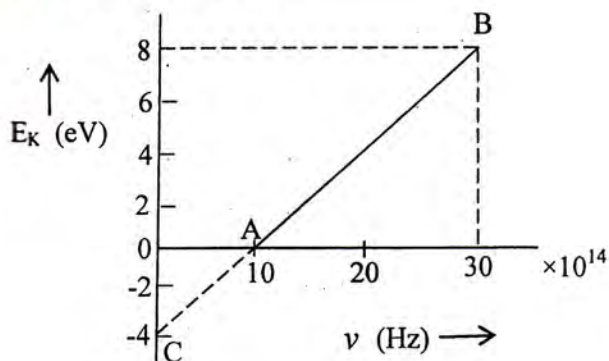


Figure 6

Find:

- Threshold frequency of the metal.
 - Work function of the metal.
 - Stopping potential for the photoelectrons emitted by the light of frequency $\nu = 30 \times 10^{14}$ Hz.
- (b) (i) State how **de-Broglie wavelength** (λ) of moving particles varies with their linear momentum (p). [2]
- (ii) State any one phenomenon in which moving particles exhibit wave nature.

Question 13

- (a) On the basis of **Bohr's** theory, derive an expression for the **radius** of the n^{th} orbit of an electron of hydrogen atom. [3]
- (b) Using the constants given on page 8 of this Paper, find the **minimum wavelength** of the emitted X rays, when an **X ray tube** is operated at 50 kV. [2]

Question 14

- (a) (i) Define **half-life** of a radioactive substance. [3]
- (ii) Using the equation $N = N_0 e^{-\lambda t}$, obtain the relation between **half-life (T)** and **decay constant (λ)** of a radioactive substance.
- (b) With the help of a suitable **example** and an **equation**, explain the term **pair production**. [2]

Question 15

- (a) Draw a labelled diagram of a **full wave rectifier**. Show how output voltage varies with time, if input voltage is a **sinusoidal** voltage. [3]
- (b) What is a NAND gate? Write its truth table. [2]

Useful Constants and Relations:

1.	Speed of Light in vacuum	(c)	$= 3.0 \times 10^8 \text{ ms}^{-1}$
2.	Charge of a proton	(e)	$= 1.6 \times 10^{-19} \text{ C}$
3.	Planck's constant	(h)	$= 6.6 \times 10^{-34} \text{ Js}$
4.	Constant for Coulomb's law	$\left(\frac{1}{4\pi\epsilon_0} \right)$	$= 9 \times 10^9 \text{ mF}^{-1}$
5.	Electron Volt	(1eV)	$= 1.6 \times 10^{-19} \text{ J}$