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.)*

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*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) The electrostatic potential energy of two point charges, 1 μC each, placed 1 meter apart in air is:

(a) 9×10^{3}J

(b) 9×10^{9}J

(c) 9×10^{-3}J

(d) 9×10^{-3}eV

(ii) A wire of resistance 'R' is cut into 'n' equal parts. These parts are then connected in parallel with each other. The equivalent resistance of the combination is:

(a) nR

(b) R/n

(c) n/R^2

(d) R/n^2

This Paper consists of 8 printed pages.

(iii) Magnetic susceptibility of platinum is 0·0001. Its relative permeability is:

(a) 1·0000

(b) 0·9999

(c) 1·0001

(d) 0

(iv) When a light wave travels from air to glass:

(a) its wavelength decreases.

(b) its wavelength increases.

(c) there is no change in wavelength.

(d) its frequency decreases.

(v) A radioactive substance decays to $1/16^{th}$ of its initial mass in 40 days. The half life of the substance, in days, is:

(a) 20

(b) 10

(c) 5

(d) 2·5

B. Answer **all** questions given below **briefly** and to the point: **[15]**

(i) **Maximum** torque acting on an electric dipole of moment 3×10^{-29} Cm in a uniform electric field E is 6×10^{-25} Nm. Find E.

(ii) What is meant by **drift speed** of free electrons?

(iii) On which conservation principle is **Kirchoff's Second Law** of electrical networks based?

(iv) Calculate magnetic flux density of the magnetic field at the centre of a circular coil of 50 turns, having radius of 0·5m and carrying a current of 5 A.

(v) An a.c. generator generates an emf 'ε' where $\varepsilon = 314\ Sin(50\pi t)$ *volt.* Calculate the **frequency** of the emf ε.

(vi) With what type of source of light are **cylindrical** wave fronts associated?

(vii) How is fringe width of an interference pattern in **Young's double slit experiment** affected if the two slits are brought closer to each other?

(viii) In a **regular** prism, what is the relation between angle of incidence and angle of emergence when it is in the **minimum deviation** position?

(ix) A converging lens of focal length 40 cm is kept in contact with a diverging lens of focal length 30 cm. Find the focal length of the combination.

(x) How can the **spherical aberration** produced by a lens be minimised?

(xi) Calculate the **momentum** of a **photon** of energy 6×10^{-19}J.

(xii) According to **Bohr**, 'Angular momentum of an orbiting electron is quantised'. What is meant by this statement?

(xiii) Why nuclear fusion reaction is also called **thermo-nuclear** reaction?

(xiv) What is the **minimum** energy which a gamma ray photon must possess in order to produce **electron-positron** pair?

(xv) Show the variation of voltage with time, for a **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) Show that **electric potential** at a point P, at a distance 'r' from a fixed point charge Q, is given by: **[4]**

$$V = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{Q}{r}.$$

(b) Intensity of electric field at a perpendicular distance of 0·5 m from an infinitely long line charge having linear charge density (λ) is $3\cdot6\times10^3$ Vm^{-1}. Find the value of λ. **[1]**

Question 3

(a) Three capacitors $C_1 = 3\mu F$, $C_2 = 6\mu F$ and $C_3 = 10\mu F$ are connected to a 50 V battery as shown in the ***Figure 1*** below: **[3]**

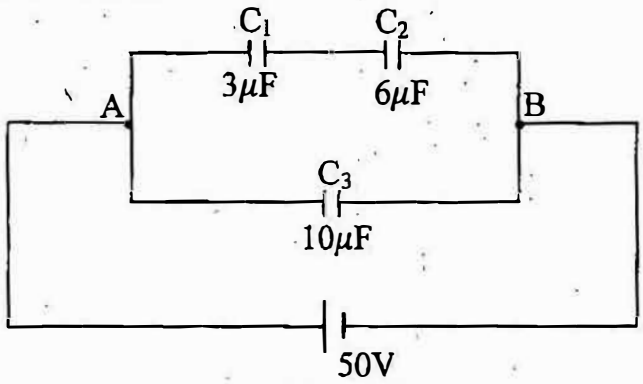

Figure 1

Calculate:

(i) The equivalent capacitance of the circuit between points A and B.

(ii) The charge on C_1.

(b) Two resistors $R_1 = 60\ \Omega$ and $R_2 = 90\ \Omega$ are connected in **parallel**. If electric power consumed by the resistor R_1 is 15 W, calculate the power consumed by the resistor R_2. [2]

Question 4

(a) ***Figure 2*** below shows two resistors R_1 and R_2 connected to a battery having an emf of 40V and negligible internal resistance. A voltmeter having a resistance of 300Ω is used to measure potential difference across R_1. Find the reading of the voltmeter. [3]

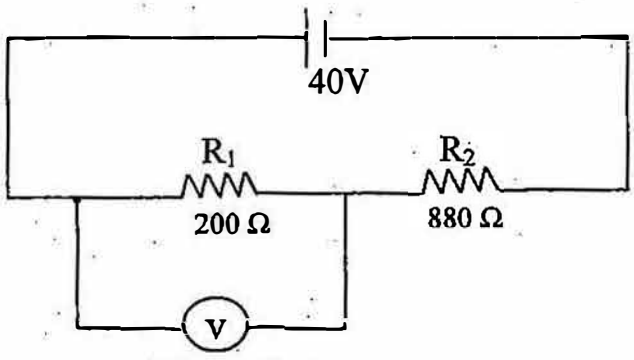

Figure 2

(b) A moving coil galvanometer has a coil of resistance 59Ω. It shows a full scale deflection for a current of 50 mA. How will you convert it to an **ammeter** having a range of 0 to 3A? [2]

Question 5

(a) In a meter bridge circuit, resistance in the left hand gap is 2 Ω and an unknown resistance X is in the right hand gap as shown in ***Figure 3*** below. The null point is found to be 40 cm from the left end of the wire. What resistance should be connected to X so that the new null point is 50 cm from the left end of the wire?

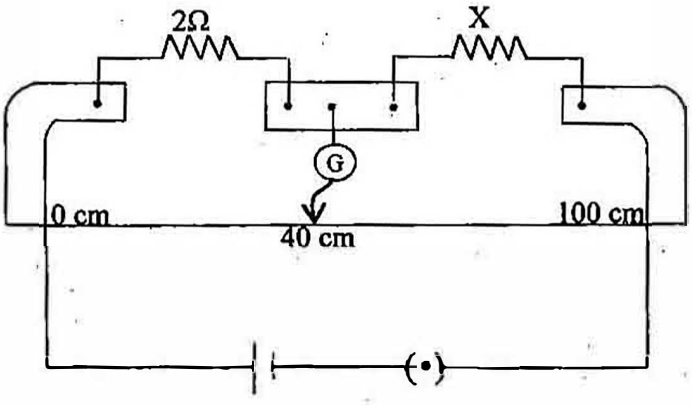

Figure 3

(b) The horizontal component of earth's magnetic field at a place is $\frac{1}{\sqrt{3}}$ times the vertical component. Determine the **angle of dip** at that place. [2]

Question 6

(a) Using **Ampere's circuital law,** obtain an expression for the magnetic flux density 'B' at a point 'X' at a perpendicular distance 'r' from a **long** current carrying conductor. (*Statement of the law is not required*). [3]

(b) PQ is a long straight conductor carrying a current of 3A as shown in ***Figure 4*** below. An electron moves with a velocity of 2×10^{7} ms^{-1} parallel to it. Find the force acting on the electron. [2]

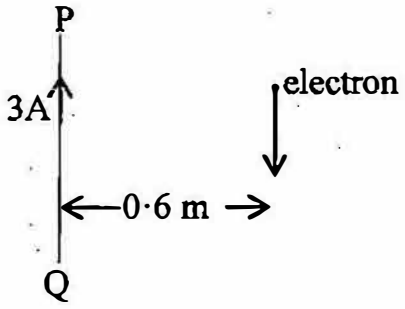

Figure 4

Question 7

(a) (i) AB and CD are two parallel conductors kept 1 m apart and connected by a resistance R of 6 Ω, as shown in ***Figure 5*** below. They are placed in a magnetic field B = 3×10^{-2} T which is perpendicular to the plane of the conductors and directed into the paper. A wire MN is placed over AB and CD and then made to slide with a velocity 2 ms^{-1}. (Neglect the resistance of AB, CD, and MN.) [3]

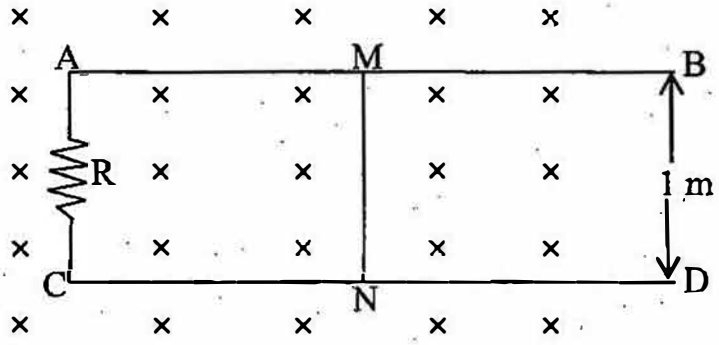

Figure 5

Calculate the induced current flowing through the resistor R.

(ii) In an **ideal** transformer, an output of 66 kV is required when an input voltage of 220 V is available. If the **primary** has 300 turns, how many turns should the **secondary** have?

(b) In a series LCR circuit, obtain an expression for the **resonant frequency**. [2]

SECTION B

*Answer any **three** questions.*

Question 8

(a) (i) State any one property which is **common** to all **electromagnetic** waves. [3]

(ii) Arrange the following electromagnetic waves in increasing order of their frequencies (i.e. begin with the lowest frequency):

Visible light, γ rays, X rays, micro waves, radio waves, infrared radiations and ultraviolet radiations.

(b) (i) What is meant by **diffraction** of light? [2]

(ii) In **Fraunhofer diffraction**, what kind of source of light is used and where is it situated?

Question 9

(a) In **Young's double slit experiment** using monochromatic light of wavelength 600 nm, 5^{th} bright fringe is at a distance of 0·48 mm from the centre of the pattern. If the screen is at a distance of 80 cm from the plane of the two slits, calculate: [3]

(i) Distance between the two slits.

(ii) Fringe width, i.e. fringe separation.

(b) (i) State **Brewster's** law. [2]

(ii) Find **Brewster's** angle for a transparent liquid having refractive index 1·5.

Question 10

(a) Find critical angle for glass and water pair, given refractive index of glass is 1·62 and that of water is 1·33. [2]

(b) Starting with an expression for refraction at a single spherical surface, obtain **Lens Maker's Formula**. [3]

Question 11

(a) A compound microscope consists of two convex lenses of focal length 2 cm and 5 cm. When an object is kept at a distance of 2·1 cm from the objective, a virtual and magnified image is formed 25 cm from the eye piece. Calculate the **magnifying power** of the microscope. [3]

(b) (i) What is meant by **resolving power** of a telescope? [2]

(ii) State any one method of increasing the **resolving power** of an astronomical telescope.

SECTION C

*Answer any **three** questions.*

Question 12

(a) (i) Plot a **labelled** graph of $|V_s|$ where V_s *is* **stopping potential** versus frequency f of the incident radiation. **[3]**

(ii) State how will you use this graph to determine the value of **Planck's** constant.

(b) (i) Find the **de Broglie** wavelength of electrons moving with a speed of $7\times10^6\ ms^{-1}$. **[2]**

(ii) Describe in brief what is observed when moving electrons are allowed to fall on a thin graphite film and the emergent beam falls on a fluorescent screen.

Question 13

(a) Draw energy level diagram for hydrogen atom, showing first four energy levels corresponding to n=1, 2, 3 and 4. Show transitions responsible for: **[3]**

(i) Absorption spectrum of **Lyman** series.

(ii) Emission spectrum of **Balmer** series.

(b) (i) Find maximum frequency of X-rays produced by an X-ray tube operating at a tube potential of 66 kV. **[2]**

(ii) State any one difference between **characteristic** X-rays and **continuous** X-rays.

Question 14

(a) Obtain a relation between **half life** of a radioactive substance and **decay constant** (λ). **[2]**

(b) Calculate **mass defect** and **binding energy per nucleon** of $^{20}_{10}Ne$, given **[3]**

Mass of $^{20}_{10}Ne = 19\cdot992397\ u$

Mass of $^{1}_{1}H = 1\cdot007825\ u$

Mass of $^{1}_{0}n = 1\cdot008665\ u$

Question 15

(a) With reference to a semi-conductor diode, what is meant by: **[3]**

(i) Forward bias

(ii) Reverse bias

(iii) Depletion region

(b) Draw a diagram to show how **NAND** gates can be combined to obtain an **OR** gate. (Truth table is not required). **[2]**

Useful Constants and Relations:

1.	Charge of a proton	(e)	$= 1{\cdot}6 \times 10^{-19}$C
2.	Planck's constant	(h)	$= 6{\cdot}6 \times 10^{-34}$ Js
3.	Mass of an electron	(m)	$= 9{\cdot}1 \times 10^{-31}$ kg
4.	Permittivity of vacuum	(ϵ_0)	$= 8{\cdot}85 \times 10^{-12}$Fm^{-1}
5.		$\left(\frac{1}{4\pi\epsilon_0}\right)$	$= 9 \times 10^{9}$ mF^{-1}
6.	Permeability of vacuum	(μ_0)	$= 4\pi \times 10^{-7}$Hm^{-1}
7.		$\left(\frac{\mu_0}{4\pi}\right)$	$= 1 \times 10^{-7}$ Hm^{-1}
8.	Speed of light in vacuum	(c)	$= 3 \times 10^{8}$ ms^{-1}
9.	Unified atomic mass unit	(u)	= 931 MeV
10.	Electron volt	(1eV)	$= 1{\cdot}6 \times 10^{-19}$J