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.)

All questions are compulsory.

This question paper is divided into 4 Sections, A, B, C and D as follows:

Section A

Question number 1 is of twelve marks. All parts of this question are compulsory.

Section B

Question numbers 2 to 12 carry 2 marks each with two questions having internal choice.

Section C

Question numbers 13 to 19 carry 3 marks each with two questions having internal choice.

Section D

Question numbers 20 to 22 are long-answer type questions and carry 5 marks each. Each question has an internal choice.

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

*Answer **all** questions.*

Question 1

(**A**) Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: **[5×1]**

(i) A point charge '*q*' is kept at each of the vertices of an equilateral triangle having each side 'a'. Total electrostatic potential energy of the system is:

(a) $\left(\frac{1}{4\pi\varepsilon_o}\right)\frac{3q^2}{a^2}$ (b) $\left(\frac{1}{4\pi\varepsilon_o}\right)\frac{3q}{a}$

(c) $\left(\frac{1}{4\pi\varepsilon_o}\right)\frac{3q^2}{a}$ (d) $\left(\frac{1}{4\pi\varepsilon_o}\right)\frac{3q}{a^2}$

(ii) **Curie** temperature is the temperature above which:

(a) a ferromagnetic substance behaves like a paramagnetic substance.

(b) a paramagnetic substance behaves like a diamagnetic substance.

(c) a ferromagnetic substance behaves like a diamagnetic substance.

(d) a paramagnetic substance behaves like a ferromagnetic substance.

(iii) In an **astronomical telescope** of **refracting** type:

(a) Objective should have small focal length.

(b) Objective should have large focal length.

(c) Eyepiece should have large focal length.

(d) Both objective and eyepiece should have large focal length.

(iv) In **photoelectric effect** experiment, the slope of the graph of the **stopping potential** versus **frequency** gives the value of:

(a) $\frac{h}{e}$ (b) h

(c) $\frac{e}{h}$ (d) $\frac{hc}{e}$

(v) In a nuclear reactor, **cadmium** rods are used as:

(a) Control rods

(b) Fuel rods

(c) Coolant

(d) Moderator

(B) Answer the following questions **briefly** and to the point: **[7×1]**

(i) State **Gauss**' theorem.

(ii) A metallic wire having a resistance of 20Ω is bent in order to form a complete circle. Calculate the resistance between *any two* diametrically opposite points on the circle.

(iii) How can a moving coil galvanometer be converted into a **voltmeter**?

(iv) Write **Biot-Savart's law** in vector form.

(v) What is the **phase difference** between *any two* points lying on the **same** wavefront?

(vi) Name the physical **principle** on the basis of which **optical fibres** work.

(vii) What is ***Pair production***?

Section B

*Answer **all** questions.*

Question 2 **[2]**

(a) A uniform copper wire having a cross sectional area of $1mm^2$ carries a current of 5A. Calculate the **drift speed** of free electrons in it.
(Free electron number density of copper = $2\times10^{28}/m^3$.)

OR

(b) An electric bulb is rated as 250V, 750W. Calculate the:

(i) Electric current flowing through it, when it is operated on a 250V supply.

(ii) Resistance of its filament.

Question 3 **[2]**

Write an expression for **force per unit length** between two long current carrying wires, kept parallel to each other, in vacuum and hence define an **ampere,** the SI unit of current.

Question 4 **[2]**

(i) Define *angle of dip*.

(ii) State the relation between **magnetic susceptibility** (χ) and **relative permeability** (μ_r) of a magnetic substance.

Question 5 **[2]**

(a) ***Figure 1*** below shows a metallic rod MN of length l = 80cm, kept in a uniform magnetic field of flux density B = 0·5T, on two parallel metallic rails **P** and **Q**. Calculate the emf that will be induced between its two ends, when it is moved towards right with a constant velocity v of 36 km/hr.

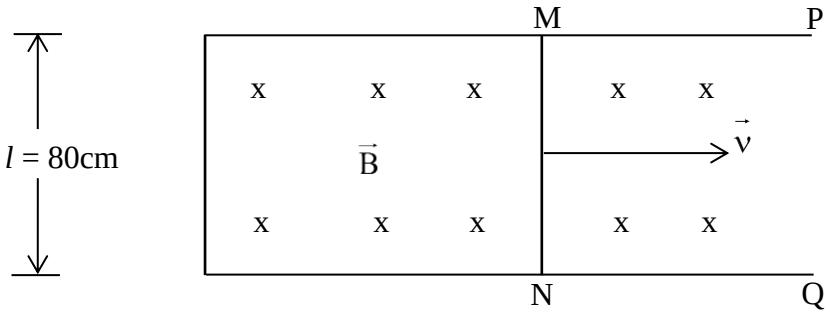

Figure 1

OR

(b) When current flowing through one coil changes from 0 Amp to 15 Amp in 0·2 s, an emf of 750V is induced in an adjacent coil. Calculate the coefficient of mutual inductance of the two coils.

Question 6 **[2]**

(i) State *any one* use of **infrared** radiations.

(ii) State *any one* source of **ultraviolet** radiations.

Question 7 **[2]**

Where will you keep an object in front of a:

(i) Convex lens in order to get a **virtual** and **magnified** image?

(ii) Concave mirror to get a **real** and **diminished** image?

Question 8 **[2]**

Draw a **labelled** graph of angle of deviation (δ) versus angle of incidence (i) for a prism.

Question 9 **[2]**

(i) State **de Broglie** hypothesis.

(ii) What conclusion can be drawn from **Davisson** and **Germer's** experiment?

Question 10 **[2]**

Calculate binding energy of oxygen nucleus $\left({}^{16}_{8}\mathrm{O}\right)$ from the data given below:

Mass of a proton	=	1·007825u
Mass of a neutron	=	1·008665u
Mass of $\left({}^{16}_{8}\mathrm{O}\right)$	=	15·994915u

Question 11 **[2]**

For a **radioactive substance**, write the relation between:

(i) Half life (T) and disintegration constant (λ).

(ii) Mean life (τ) and disintegration constant (λ).

Question 12 **[2]**

With reference to **communication systems**, what is meant by:

(i) modulation?

(ii) demodulation?

Section C

*Answer **all** questions.*

Question 13 **[3]**

Show that intensity of electric field **E** at a point in **broadside on** position is given by:

$$E = \left(\frac{1}{4\pi \in_o} \right) \frac{p}{\left(r^2 + l^2 \right)^{3/2}},$$

where the terms have their usual meaning.

Question 14 **[3]**

A **parallel plate capacitor** is charged by a battery, which is then disconnected. A dielectric slab having **dielectric constant** (relative permittivity) K, is now introduced between its two plates in order to occupy the space completely.

State, in terms of K, its effect on the following:

(i) The capacitance of the capacitor.

(ii) The potential difference between its plates.

(iii) The energy stored in the capacitor.

Question 15 **[3]**

(a) E_1 and E_2 are two batteries having emfs of 3V and 4V and internal resistances of 2Ω and 1Ω respectively. They are connected as shown in ***Figure 2*** below. Using **Kirchhoff's Laws** of electrical circuits, calculate the currents I_1 and I_2.

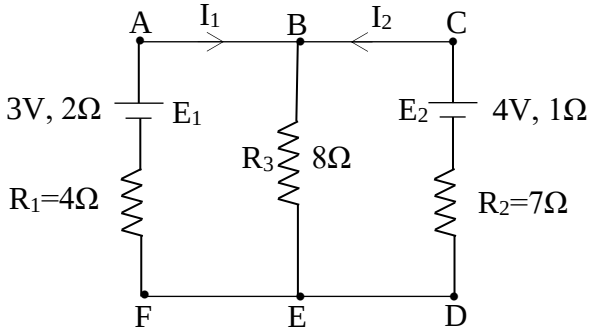

Figure 2

OR

(b) A **potentiometer** circuit is shown in ***Figure 3*** below. AB is a uniform metallic wire having length of 2m and resistance of 8Ω. The batteries E_1 and E_2 have emfs of 4V and 1·5V and their internal resistances are 1Ω and 2Ω respectively.

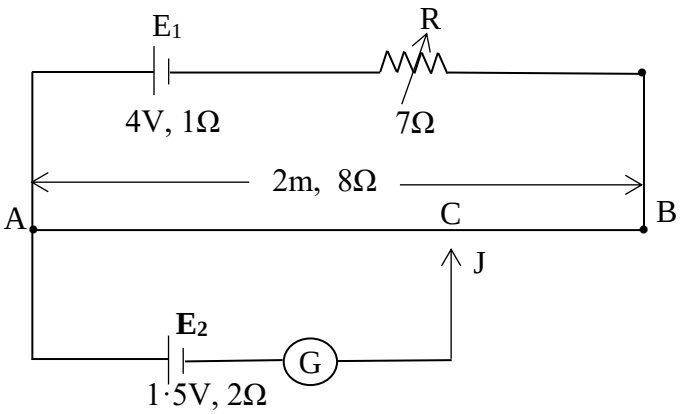

Figure 3

(i) When the jockey J does not touch the wire AB, calculate:

(a) the current flowing through the potentiometer wire AB.

(b) the potential gradient across the wire AB.

(ii) Now the jockey J is made to touch the wire AB at a point C such that the galvanometer (G) shows no deflection. Calculate the length AC.

Question 16 **[3]**

For two **thin lenses** kept in **contact** with each other, show that:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

where the terms have their usual meaning.

Question 17 **[3]**

(a) A **compound microscope** consists of two convex lenses having focal length of 1·5cm and 5cm. When an object is kept at a distance of 1·6cm from the objective, the final image is virtual and lies at a distance of 25cm from the eyepiece. Calculate **magnifying power** of the compound microscope in this set-up.

OR

(b) In **Young's double slit experiment**, the screen is kept at a distance of 1·2m from the plane of the slits. The two slits are separated by 5mm and illuminated with monochromatic light having wavelength 600nm. Calculate:

(i) Fringe width i.e. fringe separation of the interference pattern.

(ii) Distance of 10^{th} bright fringe from the centre of the pattern.

Question 18 **[3]**

Draw the **energy level diagram** of hydrogen atom and show the transitions responsible for:

(i) absorption lines of **Lyman** series.

(ii) emission lines of **Balmer** series.

Question 19 **[3]**

(i) State *any one* difference between energy band diagram of conductors and that of insulators.

(ii) Give a relation between α and β for a transistor.
(Derivation is **not** required.)

(iii) What is the **advantage** of an LED bulb over the filament electric bulb?

Section D

*Answer **all** questions.*

Question 20 **[5]**

(a) (i) A 400Ω resistor, a 3H inductor and a 5μF capacitor are connected in series to a 220V, 50Hz ac source. Calculate the:

(1) Impedance of the circuit.

(2) Current flowing through the circuit.

(ii) Draw a **labelled** graph showing the variation of **impedance** (Z) of a series LCR circuit versus **frequency** *(f)* of the ac supply.

OR

(b) (i) When an alternating emf $e = 310 \sin(100\pi t)$V is applied to a series LCR circuit, current flowing through it is $i = 5 \sin(100\pi t + \pi/3)$A.

(1) What is the **phase difference** between the current and the emf?

(2) Calculate the **average power** consumed by the circuit.

(ii) Obtain an expression for the **resonant** frequency (f_o) of a series LCR circuit.

Question 21 **[5]**

(a) (i) **Derive** an expression for refraction at a single (convex) spherical surface, i.e. a relation between u, v, R, n_1 (rarer medium) and n_2 (denser medium), where the terms have their usual meaning.

(ii) Name the **phenomenon** due to which the sun appears reddish at sunset.

OR

(b) (i) Draw a **labelled** graph of intensity of diffracted light (I) versus angle (θ) in the **Fraunhofer** diffraction experiment for a single slit diffraction.

(ii) State the law of **Malus**.

(iii) How will you distinguish **experimentally** between ordinary light and plane polarized light?

Question 22 **[5]**

(a) (i) In a semiconductor diode, what is meant by **potential barrier**?

(ii) Draw a **labelled** circuit diagram of a **Zener** diode as a **voltage regulator**.

(iii) Show with the help of a diagram, how you will obtain an **AND** gate using only **NAND** gates. (Truth table is **not** required.)

OR

(b) (i) Draw a **labelled** circuit diagram of a transistor acting as a **common emitter amplifier**. What is meant by *phase reversal*?

(ii) Draw the symbol of a **NAND** gate and write its truth table.

Useful Constant and Relation:

1u	=	931MeV