

# 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 [5×1] below:

(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)  $\left(\frac{1}{4\pi\epsilon_0}\right)\frac{3q^2}{a^2}$       (b)  $\left(\frac{1}{4\pi\epsilon_0}\right)\frac{3q}{a}$

(c)  $\left(\frac{1}{4\pi\epsilon_0}\right)\frac{3q^2}{a}$       (d)  $\left(\frac{1}{4\pi\epsilon_0}\right)\frac{3q}{a^2}$

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**Turn over**

- (ii) **Curie** temperature is the temperature above which:
- a ferromagnetic substance behaves like a paramagnetic substance.
  - a paramagnetic substance behaves like a diamagnetic substance.
  - a ferromagnetic substance behaves like a diamagnetic substance.
  - a paramagnetic substance behaves like a ferromagnetic substance.
- (iii) In an **astronomical telescope** of **refracting** type:
- Objective should have small focal length.
  - Objective should have large focal length.
  - Eyepiece should have large focal length.
  - 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:
- $\frac{h}{e}$
  - $h$
  - $\frac{e}{h}$
  - $\frac{hc}{e}$
- (v) In a nuclear reactor, **cadmium** rods are used as:
- Control rods
  - Fuel rods
  - Coolant
  - Moderator

(B) Answer the following questions **briefly** and to the point:

[7×1]

- State **Gauss'** theorem.
- A metallic wire having a resistance of  $20\Omega$  is bent in order to form a complete circle. Calculate the resistance between *any two* diametrically opposite points on the circle.
- How can a moving coil galvanometer be converted into a **voltmeter**?
- Write **Biot-Savart's law** in vector form.
- What is the **phase difference** between *any two* points lying on the **same** wavefront?
- Name the physical **principle** on the basis of which **optical fibres** work.
- What is **Pair production**?

## Section B

Answer *all* questions.

### Question 2

[2]

- (a) A uniform copper wire having a cross sectional area of  $1\text{mm}^2$  carries a current of 5A. Calculate the **drift speed** of free electrons in it.  
(Free electron number density of copper =  $2 \times 10^{28}/\text{m}^3$ .)

OR

- (b) An electric bulb is rated as 250V, 750W. Calculate the:
- Electric current flowing through it, when it is operated on a 250V supply.
  - 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

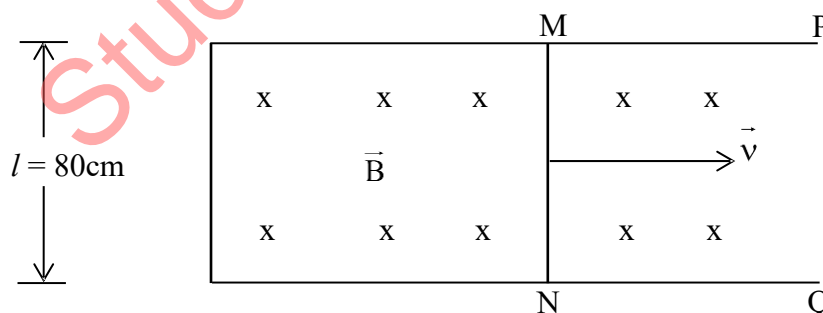
[2]

- Define *angle of dip*.
- State the relation between **magnetic susceptibility** ( $\chi$ ) and **relative permeability** ( $\mu$ ) of a magnetic substance.

### Question 5

[2]

- (a) **Figure 1** below shows a metallic rod MN of length  $l = 80\text{cm}$ , kept in a uniform magnetic field of flux density  $B = 0.5\text{T}$ , 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 ( $\delta$ ) 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 ( ${}^{16}_8\text{O}$ ) from the data given below:

Mass of a proton	=	1.007825u
Mass of a neutron	=	1.008665u
Mass of ( ${}^{16}_8\text{O}$ )	=	15.994915u

**Question 11** [2]

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

- (i) Half life (T) and disintegration constant ( $\lambda$ ).  
(ii) Mean life ( $\tau$ ) and disintegration constant ( $\lambda$ ).

**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:

$$E = \left( \frac{1}{4 \pi \epsilon_0} \right) \frac{P}{(r^2 + l^2)^{3/2}},$$

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:

- The capacitance of the capacitor.
- The potential difference between its plates.
- 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  $2\Omega$  and  $1\Omega$  respectively. They are connected as shown in **Figure 2** below. Using **Kirchhoff's Laws** of electrical circuits, calculate the currents  $I_1$  and  $I_2$ .

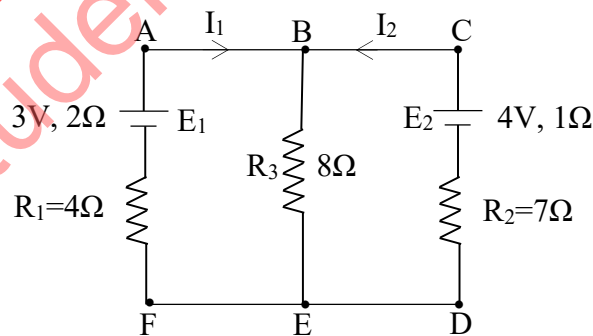
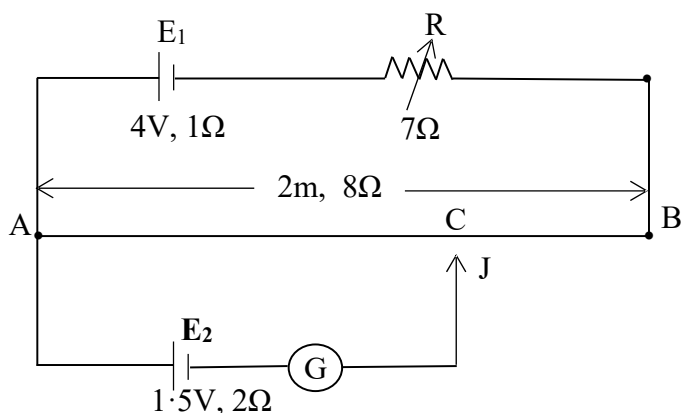


Figure 2

OR

- (b) A **potentiometer** circuit is shown in **Figure 3** below. AB is a uniform metallic wire having length of 2m and resistance of  $8\Omega$ . The batteries  $E_1$  and  $E_2$  have emfs of 4V and 1.5V and their internal resistances are  $1\Omega$  and  $2\Omega$  respectively.



**Figure 3**

- (i) When the jockey  $J$  does not touch the wire  $AB$ , calculate:
- the current flowing through the potentiometer wire  $AB$ .
  - 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:
- Fringe width i.e. fringe separation of the interference pattern.
  - Distance of 10<sup>th</sup> 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  $\alpha$  and  $\beta$  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  $400\Omega$  resistor, a  $3H$  inductor and a  $5\mu F$  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** ( $f_0$ ) 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 ( $\theta$ ) 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
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