

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

(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 20Ω 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 1mm^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** (χ) and **relative permeability** (μ_r) of a magnetic substance.

Question 5

[2]

- (a) **Figure 1** below shows a metallic rod MN of length $l = 80\text{cm}$, 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.

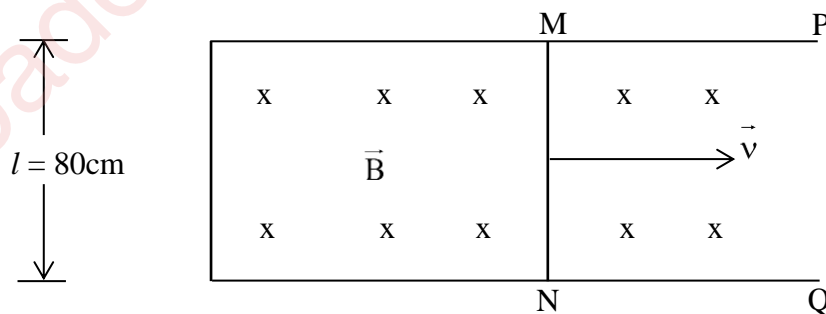


Figure 1

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 (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 (${}^{16}_8\text{O}$) 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 (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:

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

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 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 .

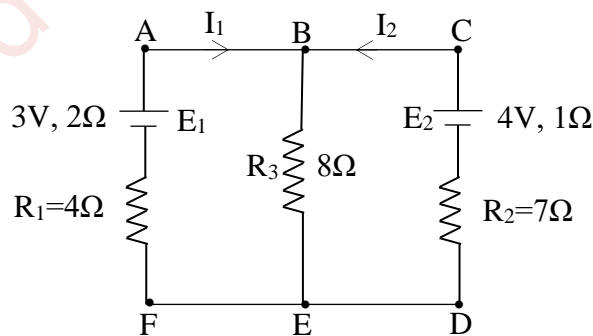


Figure 2

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.

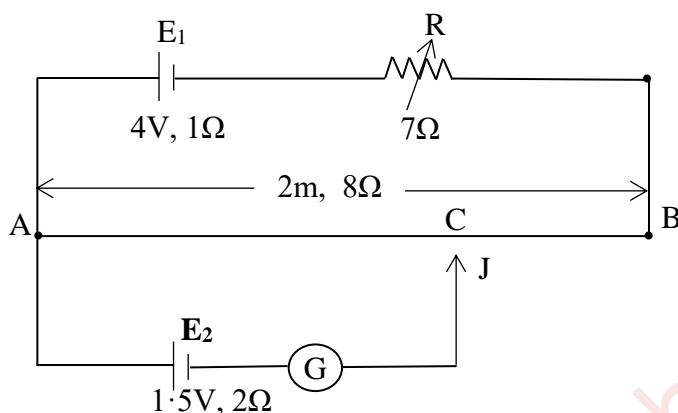


Figure 3

- (i) When the jockey J does not touch the wire AB, calculate:
- 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 10th 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 $5\mu F$ 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 (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
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