

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 six questions from Part II, choosing two questions
from each of the Sections A, B and 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.

Section 1

Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

[5]

1) Intensity of electric field at a point at a perpendicular distance 'r' from an infinite line charge, having linear charge density 'λ' is given by:

(a) $E = \left(\frac{1}{4\pi \epsilon_0} \right) \frac{\lambda}{r}$

(b) $E = \left(\frac{1}{4\pi \epsilon_0} \right) \frac{2\lambda}{r}$

(c) $E = \left(\frac{1}{4\pi \epsilon_0} \right) \frac{\lambda}{r^2}$

(d) $E = \left(\frac{1}{4\pi \epsilon_0} \right) \frac{2\lambda}{r^2}$

If R_1 and R_2 are filament resistances of a 200 W and a 100 W bulb respectively, designed to operate on the same voltage, then:

- a) $R_1 = R_2$
- b) $R_2 = 2R_1$
- c) $R_2 = 4R_1$
- d) $R_1 = 4R_2$

A metallic wire having length of 2 m and weight of 4×10^{-3} N is found to remain at rest in a uniform and transverse magnetic field of 2×10^{-4} T. Current flowing through the wire is:

- a) 10 A
- b) 5 A
- c) 2 A
- d) 1 A

When a beam of white light is passed through sodium vapours and then through a spectrometer, spectrum so obtained has two dark lines present in the yellow region. This spectrum is called:

- (a) band spectrum
- (b) continuous spectrum
- (c) absorption spectrum of sodium
- (d) emission spectrum of sodium

If l_3 and l_2 represent angular momenta of an orbiting electron in III and II Bohr orbits respectively, then $l_3:l_2$ is:

- (a) 3:2
- (b) 9:4
- (c) 2:3
- (d) 4:9

all questions given below briefly and to the point:

[15]

A parallel plate air capacitor has a capacitance of $5 \mu\text{F}$. It becomes $50 \mu\text{F}$ when a dielectric medium occupies the entire space between its two plates. What is the dielectric constant of the medium?

Find the emf of the battery shown in *Figure 1*:

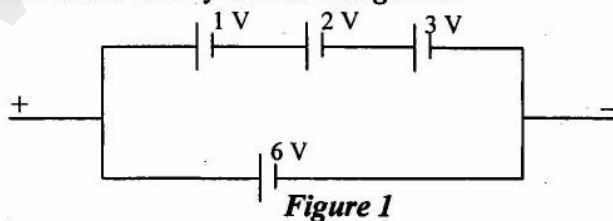


Figure 1

- Two substances A and B have their relative permeabilities slightly greater and slightly less than 1 respectively. What do you conclude about A and B as far as their magnetic materials are concerned?
- When does a moving charged particle **not** experience any force while moving through a uniform magnetic field?
- What is the turns ratio i.e. **transformer ratio**, $n_s:n_p$, in an ideal transformer which increases ac voltage from 220 V to 33000 V?
- What is meant by **coherent sources of light**?
- A ray of light is incident on a transparent medium at **polarizing angle**. What is the angle between the reflected ray and the refracted ray?
- i) Name the physical **principle** on which the working of **optical fibres** is based.
- What is meant by **shortsightedness**?
- How does focal length of a convex lens change with **increase** in **wavelength** of incident light?
- With reference to photo-electric effect, what is meant by **threshold wavelength**?
- Half life of a certain radioactive element is 3.465 days. Find its *disintegration constant*.
- ii) Binding energy per nucleon for helium nucleus (${}^4_2\text{He}$) is 7.0 MeV. Find the value of **mass defect** for helium nucleus.
- Write *one* balanced reaction representing **nuclear fusion**.
- Draw the truth table of a NOR gate.

PART II (50 Marks)

Answer six questions in this part, choosing two questions from each of the Sections A, B and C.

SECTION A

Answer any two questions.

n 2

An electric dipole of dipole moment \vec{p} is placed in a uniform electric field \vec{E} with its axis inclined to the field. Write an expression for the torque $\vec{\tau}$ experienced by the dipole in **vector form**. Show **diagrammatically** how the dipole should be kept in the electric field so that the **torque** acting on it is:

- (i) maximum
- (ii) zero

[3]

you are provided with $8 \mu\text{F}$ capacitors. Show with the help of a diagram how you will range **minimum** number of them to get a resultant capacitance of $20 \mu\text{F}$. [3]

- i) Define **temperature coefficient** of resistance of the material of a conductor. [3]
- ii) When the cold junction of a thermocouple is maintained at 0°C , the thermo emf 'e', generated by this thermocouple is given by the relation:

$$e = [16.8 \theta + \frac{1}{2}(-0.048) \theta^2] \times 10^{-6},$$

where θ is the temperature of the hot junction in $^\circ\text{C}$. Find the **neutral temperature** of this thermocouple.

3 Draw a **labelled** circuit diagram of a **potentiometer** to compare emfs of two cells. Write the working formula (*Derivation not required*). [3]

How much resistance should be connected to 15Ω resistor shown in the circuit in **figure 2** below so that the points M and N are at the same potential: [3]

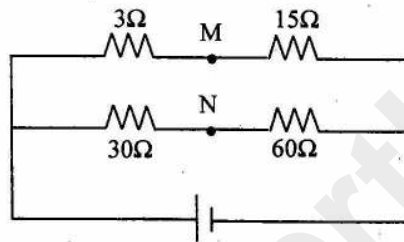


Figure 2

- i) With reference to **free electron theory of conductivity**, explain the terms: [3]
- (1) Drift speed
 - (2) Relaxation time
- ii) What is the **colour code** of a carbon resistor having a resistance of 470Ω and a tolerance of 5%?

4 State **Tangent Law** in magnetism. [2]

i) At a certain temperature, a ferromagnetic material becomes paramagnetic. What is this temperature called?

ii) State **Biot Savart law**. [3]

iii) Find magnetic flux density at a point on the axis of a long solenoid having 5000 turns/m when it is carrying a current of 2 A.

An alternating emf of 110V is applied to a circuit containing a resistance R of 80Ω and an inductor L in series. The current is found to lag behind the supply voltage by an angle $\phi = \tan^{-1}(3/4)$. Find the: [4]

- (i) Inductive reactance
- (ii) Impedance of the circuit
- (iii) Current flowing in the circuit
- (iv) If the inductor has a coefficient of self inductance of 0.1 H, what is the frequency of the applied emf?

SECTION B 7

Answer any two questions

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Name the part of the **electromagnetic spectrum** which is: [2]

- (i) Suitable for radar systems used in aircraft navigation.
- (ii) Produced by bombarding a metal target with high speed electrons.

In **Young's double slit experiment**, using monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in the fringe width is 3×10^{-5} m. If the distance between the two slits is 10^{-3} m, calculate **wavelength** of the light used. [3]

- (i) State **Brewster's law** of polarization of light. [3]
- (ii) How will you identify **with the help of an experiment** whether a given beam of light is of polarized light or of unpolarized light?

6

A narrow beam of monochromatic light, PQ, is incident normally on one face of an equiangular glass prism of refractive index 1.45. When the prism is immersed in a certain liquid, the ray makes grazing emergence along the other face (See **Figure 3**). Find the **refractive index** of the liquid. [2]

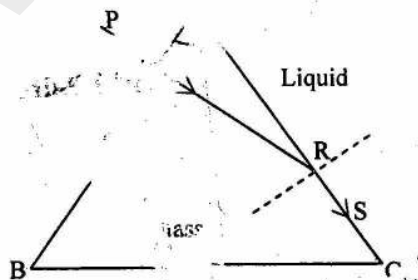


Figure 3

When two thin lenses of focal lengths f_1 and f_2 are kept coaxially and in contact, prove that their **combined focal length** " f " is given by: [3]

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

The **Figure 4** below shows the positions of a point object O, two lenses, a plane mirror and the final image I which coincides with the object. The focal length of the convex lens is 20 cm. Calculate the focal length of the **concave lens**. [3]

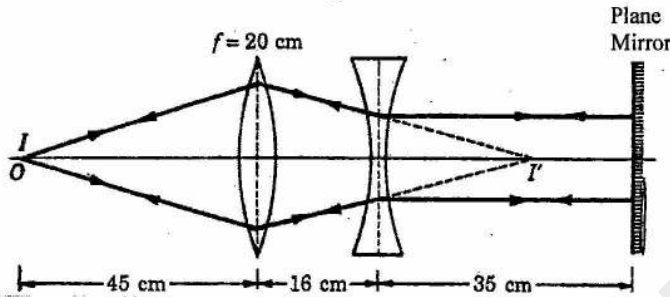


Figure 4

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(i) What is meant by **dispersive power** of a transparent material? [4]

(ii) Show that, two thin lenses kept in contact, form an **achromatic doublet** if they satisfy the condition:

$$\frac{\omega}{f} + \frac{\omega'}{f'} = 0$$

where the terms have their usual meaning.

(i) Define **magnifying power** of a **microscope** in terms of **visual angles**. [2]

(ii) What is the advantage of a **compound microscope** over a simple microscope?

An astronomical telescope uses two lenses of powers 10 dioptre and 1 dioptre. If the final image of a distant object is formed at infinity, calculate the length of the telescope. [2]

SECTION C

Answer any two questions.

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Answer the following questions with reference to **Millikan's oil drop experiment**: [3]

(i) What is an atomiser?

(ii) What is the use of an X-ray tube?

(iii) What is the unique property shown by the charge of an oil drop?

- l) Write Einstein's photo electric equation. [3]
- i) If the frequency of the incident radiation is increased from 4×10^{15} Hz to 8×10^{15} Hz, by how much will the stopping potential for a given photosensitive surface go up?
- j) What are matter waves? [2]
- i) Show with the help of a labelled graph how their wavelength (λ) varies with their linear momentum (p).

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he energy levels of an atom of a certain element are shown in the given **Figure 5**. [3]
Which one of the transitions A, B, C, D or E will result in the emission of photons of electromagnetic radiation of wavelength 618.75 nm? Support your answer with mathematical calculations.

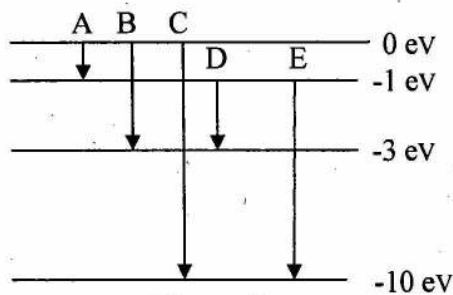


Figure 5

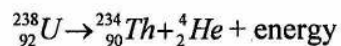
voltage applied between cathode and anode of an X-ray tube is 18 kV. Calculate the minimum wavelength of the X-rays produced. [2]

In a nuclear reactor, what is the function of: [3]

- i) The moderator
ii) The control rods
iii) The coolant

o

i) The atomic mass of Uranium ${}_{92}^{238}\text{U}$ is 238.0508 u, while that of Thorium ${}_{90}^{234}\text{Th}$ is 234.0436 u, and that of Helium ${}_{2}^{4}\text{He}$ is 4.0026 u. Alpha decay converts ${}_{92}^{238}\text{U}$ into ${}_{90}^{234}\text{Th}$ as shown below: [3]



Determine the energy released in this reaction.

ii) What is a neutrino?

- 1) In semi conductor physics, what is meant by: [3]
- (i) a rectifier
 - (ii) an amplifier
 - (iii) an oscillator
- 2) With the help of a diagram, show how you can use several NAND gates to obtain an OR gate. [2]

Constants and Relations:

Speed of Light in vacuum	(c)	= 3.0×10^8 m/s
Charge of a proton	(e)	= 1.6×10^{-19} C
Planck's constant	(h)	= 6.6×10^{-34} Js
Permeability of vacuum	(μ_0)	= $4\pi \times 10^{-7}$ Hm ⁻¹
Electron Volt	(1eV)	= 1.6×10^{-19} J
Unified Atomic Mass Unit	(1u)	= 931 MeV
	(π)	= 3.14
	(ln2)	= 0.693