



UTKARSH
MANHAN
SE22UCA MOIS

Mahindra University Hyderabad
École Centrale School of Engineering
End Semester

**Program: B. Tech. Branch: AI, CSE, ECM, ECE, CM, CE, ME, MT, NT Year: II Semester: I
Subject: Physics II (PH2102)**

Date: 19.12.2023

Time Duration: 3 Hours

Start Time: 10:00 AM

Max. Marks: 100

Instructions:

- 1) All questions are mandatory
- 2)

Question 1

Marks 5 + 10 + 5 = 20

a) What will be the value of the integral $\int_{-1}^1 e^{x+3} \delta(x-2) dx$

b) What is the physical meaning of gradient of a vector. The height of a certain hill (in meter) is given by the equation

$$h(x, y) = 5(12 + 28y + 2xy - 3x^2 - 4y^2 - 18x)$$

where y is the distance (in km) north, and x is the distance east from the origin point.

- i) Where is the top of the hill located?
- ii) How high is the hill?

c) Find the gradient of

$$\text{i) } f(x, y, z) = x^3 y^4 z^3$$

$$\text{ii) } f(x, y, z) = \exp(x) \sin(y) \ln(z)$$

Question 2

Marks 6 + 9 + 5 = 20

a) Twelve equal charges, $+q$, are situated at the corners of regular 12-sided polygon (for instance, one on each numeral of a clock face). What will be the net force on a test charge $+Q$ situated at the center?

b) If one $+q$ among the 12 $+q$ charges is removed. What is the force on Q ?
c) Identify the polar and non-polar molecules from the following list, CH_4 , NH_3 , HCl , H_2 and N_2 ?

Marks 12 + 8 = 20

Question 3

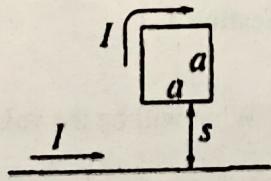
- a) A hydrogen atom (Bohr radius is half an angstrom, $r_B = 0.5 \times 10^{-10} \text{ m}$) is situated between two metal plates 1mm apart, which are connected to opposite terminals of a 500 V battery. What fraction of the atomic radius does the separation distance d amount to, roughly? Estimate the voltage you would need with this apparatus to ionize the atom. Consider $\alpha/4\pi\epsilon_0 = 0.667 \times 10^{-30}$

~~4~~ In a one-dimensional device the charge density is $\rho = \rho_0(x/x_0)$. If $E = 0$ at $x = 0$ and $V = 0$ at $x = x_1$, find $V(x)$?

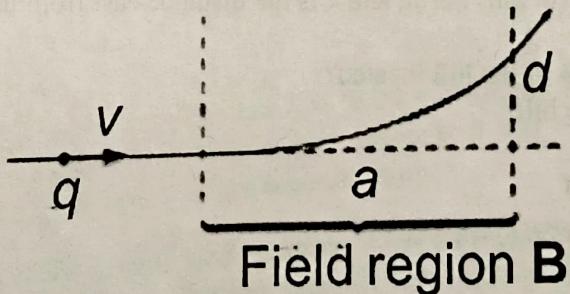
Marks 10 + 10 = 20

Question 4

- a) Find the force on a square loop placed as shown in the below figure near an infinite straight wire. Both the loop and the wire carry a steady current I .



- b) A particle of charge q enters a region of uniform magnetic field B (pointing into the page). The field deflects the particle a distance d above the original line of flight, as shown in the figure below. Is the charge positive or negative? In terms of a , d , B and q , find the momentum of the particle.



Marks 15 + 5 = 20

Question 5

- a) An x-polarized electromagnetic wave propagating in vacuum is described by the following equation

$$\vec{E} = \hat{x}E_0 \exp[i(\omega t - 300y + 400z)]$$

Where all units are in SI units

- i) Calculate the wavelength and frequency of the wave
- ii) Calculate the angle that the k vector makes with the y-axis

iii) Show that the wave is transverse

b) Consider an infinitely long wire (along the z-axis) carrying the current I along its length. Find the magnetic field at an arbitrary point P at a distance s from the wire.

Useful relations and constants:

i) $q_{e,P} = 1.6 \times 10^{-19} \text{ C}$, $m_P = 1.7 \times 10^{-27} \text{ kg}$ and $m_e = 9.1 \times 10^{-31} \text{ kg}$]

ii) Gradient in Spherical polar coordinates, $\nabla t = \frac{\partial t}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial t}{\partial \theta} \hat{\theta} \frac{1}{r \sin \theta} \frac{\partial t}{\partial \phi} \hat{\phi}$

iii) Laplacian in cylindrical polar coordinates, $\nabla^2 t = \frac{1}{s} \frac{\partial t}{\partial s} \left(s \frac{\partial t}{\partial s} \right) + \frac{1}{s^2} \frac{\partial^2 t}{\partial \theta^2} + \frac{\partial^2 t}{\partial z^2}$

iv) Laplacian in cartesian coordinate system, $\nabla^2 t = \frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2}$