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SE22UCAM015

**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

i)  $f(x, y, z) = x^3 y^4 z^3$

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,  $\text{CH}_4$ ,  $\text{NH}_3$ ,  $\text{HCl}$ ,  $\text{H}_2$  and  $\text{N}_2$ ?

### Question 3

Marks 12 + 8 = 20

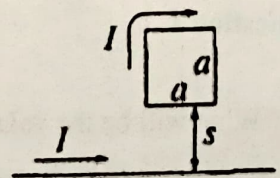
a) A hydrogen atom (Bohr radius is half an angstrom,  $r_B = 0.5 \times 10^{-10}$  m) is situated between two metal plates 1mm apart, which are connected to opposite terminals of a 500 V battery. What fraction of the atomic radius does the separation distance  $d$  amount to, roughly? Estimate the voltage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

b) 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  $V(x)$ ?

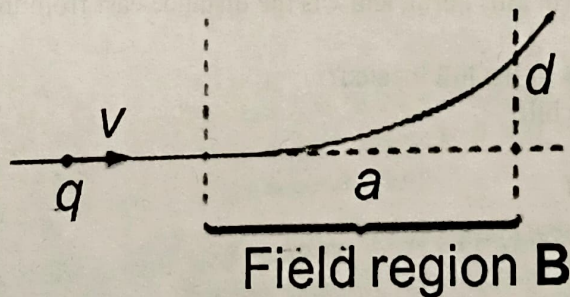
### Question 4

Marks 10 + 10 = 20

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.



### Question 5

Marks 15 + 5 = 20

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

- Calculate the wavelength and frequency of the wave
- 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,  $\nabla t = \frac{\partial t}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial t}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial t}{\partial \varphi} \hat{\varphi}$

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

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