INDIAN INSTITUTE OF SPACE SCIENCE & TECHNOLOGY

B. Tech(I Year) **Physics - II (PH121)** **Final**

4 July 2022 **Duration:2 Hrs** **Full Marks: 40**

Answer all questions(All questions carry equal marks)

1. a. An air spaced transmission line consists of two parallel cylindrical conductors of 2 mm diameter each with their centers 10 mm apart. Calculate maximum potential difference one can apply before the air between them breaks down (at 3 MV/m)

   b. What is the capacitance between them?

2. Use the appropriate expression for the differential surface area $d\mathbf{s}$ to determine the area of each of the following surfaces. Also sketch the outlines of each of the surfaces.

   a) $s = 3,\ 0 \leq \phi \leq \pi/3,\ -2 \leq z \leq 2,$

   b) $2 \leq s \leq 5,\ \pi/2 \leq \phi \leq \pi,\ z = 0,$

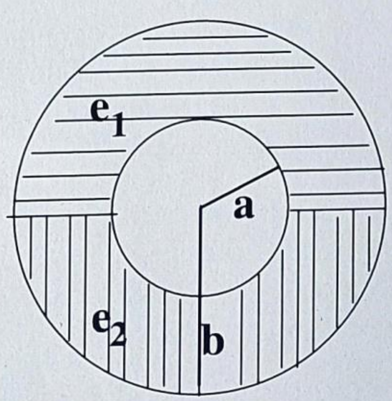
   c) $2 \leq s \leq 5,\ \phi = \pi/4, -2 \leq z \leq 2,$

   d) $r = 2,\ 0 \leq \theta \leq \pi/3,\ 0 \leq \phi \leq \pi,$

   e) $0 \leq r \leq 5,\ \theta = \pi/3,\ 0 \leq \phi \leq 2\pi.$

   a), b) and c) are in cylindrical coordinates, while d) and e) use spherical polar coordinates.

3. A coaxial capacitor consists of two concentric, conducting, cylindrical surfaces, one of radius a and another of radius $b\,(a < b)$. The insulating layer separating the two conducting surfaces is divided equally into two semi-cylindrical sections, one filled with dielectric e_1 and the other filled with dielectric e_2. Find expression for the capacitance. Calculate the value of the capacitance C for $a = 2$ mm, $b = 6$ mm, $e_1 = 2$, $e_2 = 4$, and length $l = 4$ cm.



4. A sphere of radius R has uniform magnetization $\mathbf{M} = M\hat{\mathbf{z}}$. Qualitatively plot field lines for $\mathbf{M}$, $\mathbf{B}$ and $\mathbf{H}$ everywhere. Indicate the conditions satisfied by the three fields, that will help you plot the field lines.

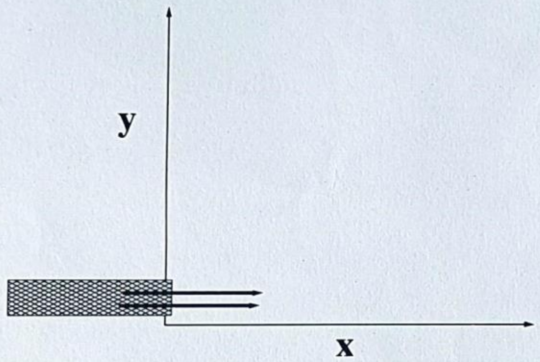
5. a) Identify which of the following can be either electrostatic or magnetostatic fields in free space (possibly with free charges and currents):

   i. $\mathbf{A}_1 = y^2 z\hat{\mathbf{x}} + 2(x+1)yz\hat{\mathbf{y}} - (x+1)z^2\hat{\mathbf{z}}$

   ii. $\mathbf{A}_2 = \frac{(z+1)}{s}\cos\phi\hat{\phi} + \sin\phi\hat{\mathbf{z}}$

   iii. $\mathbf{A}_3 = \frac{1}{r^2}(2\cos\theta\hat{\mathbf{r}} + \sin\theta\hat{\theta})$

   b) The figure below shows a gun injecting particles of positive charge q and mass m each, at the origin in to a square region with uniform magnetic field $-|b|\hat{\mathbf{z}}$. The particles have different velocities. Find the distance from the origin at which they will be ejected out of the quadrant, and the direction, as a function of their mass and charge.



x

6. A infinitely long cylinder, of radius R carries a constant magnetization, parallel to the axis given by $\mathbf{M} = ks\hat{\mathbf{z}}$, where k is a constant and s is the radial distance from the axis. There is no free current anywhere. Find $\mathbf{B}$ and $\mathbf{H}$ everywhere.

7. An infinite solenoid carrying a current I_0 is oriented along the z-axis. The current is switched off and the current takes a finite time to attain zero value and in a continuous manner(say $I(t) = I_0(1-\alpha t)$ for $0 < t \leq 1/\alpha$, and $(I(t) = 0$ for $t > 1/\alpha))$. Obtain the expression for the induced $\mathbf{E}$ field in all space.

8. An infinite parallel plate capacitor separated by a distance d and lying symmetrically parallel to the $x-y$ plane, has surface charge density σ in the upper plate and $-\sigma$ in the lower plate. Obtain the Maxwells stress tensor in all space, and using this, find the force per unit area acting on the upper plate.