Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

Dept. of Electrical Engineering
Second Exam, Second Semester: 2018/2019

Course Title: Electromagnetics I	**Date: 1/5/2019**
Course No: (610213)	**Time Allowed: 50 Minutes**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 3**

Question 1: ***(30Mark)***

Objectives: This question is related to electric potential and work

In an electric field

$$\vec{E} = 20r\sin\theta\hat{r} + 10r\cos\theta\hat{\theta} \text{ V/m}$$

1) Calculate the energy expended in transferring a 10 nC charge from point $A(r,\phi,\theta) = (5,30°,0°)$ to point $B(r,\phi,\theta) = (10,30°,60°)$
2) Calculate the potential difference between A and B V_{AB}

1) $W_{AB} = -Q\int_A^B \vec{E}\cdot\vec{dl}$

$= -Q\int_{r=5}^{10} 20r\sin\theta dr\Big|_{\theta=0°} - Q\int_{\theta=0}^{60} 10r\cos\theta r d\theta\Big|_{r=10}$

$= 0 - Q10r^2\Big|_{r=10}\sin\theta\Big|_0^{60}$

$= -Q\times 1000\times\sin 60 = -Q\times 866 = -8660$ nJ

2) $V_{AB} = \dfrac{W_{BA}}{Q} = 866$ V

Question 2: ***(50Mark)***

Objectives: This question is related to parallel plate capacitor

The conducting plates of parallel plate capacitor placed at $z = -2$ m and $z = 2$ m are maintained at potentials of 0 and 200 V, respectively. If the surface area of each plate is 1000 m^2 and that the plates are separated by air. Calculate:

1) The potential between the plates by solving the Laplace equation
2) The electric field between the plates through $\vec{E} = -\nabla V$
3) The electric flux density between the plates
4) The surface charge densities at the plates ρ_s
5) The capacitance using $C = Q/V$
6) Total energy stored in the capacitor using $\frac{1}{2}\iiint \varepsilon E^2 dv$
7) Total energy stored in the capacitor using $\frac{1}{2}CV^2$

1) $\frac{d^2V}{dz^2} = 0$

$\frac{dV}{dz} = A$

$V = Az + B$

$\left.\begin{array}{l} V(-2) = 0 = -2A + B \\ V(2) = 200 = 2A + B \end{array}\right\} \Rightarrow \begin{array}{l} 200 = 2B \Rightarrow B = 100 \\ \therefore A = 50 \end{array}$

$\therefore \boxed{V = 50z + 100}\ V$

2) $\vec{E} = -\nabla V = -\frac{\partial V}{\partial z}\hat{z} = -50\hat{z}\ V/m$

3) $\vec{D} = \varepsilon_0 \vec{E} = 8.85 \times 10^{-12} \times -50\,\hat{z} = -4.425 \times 10^{-10}\,\hat{z}\ C/m^2$

4) $\rho_s = |D_z| = 4.425 \times 10^{-10}\ C/m^2$ on the upper plate

5) $C = \frac{Q}{V} = \frac{\rho_s A}{V} = \frac{4.425 \times 10^{-10} \times 1000}{200} = 2.2125\ nF$

6) $W = \frac{1}{2}\iiint \varepsilon E^2 dv = \frac{1}{2}\varepsilon_0 E^2 \times \text{Volume}$

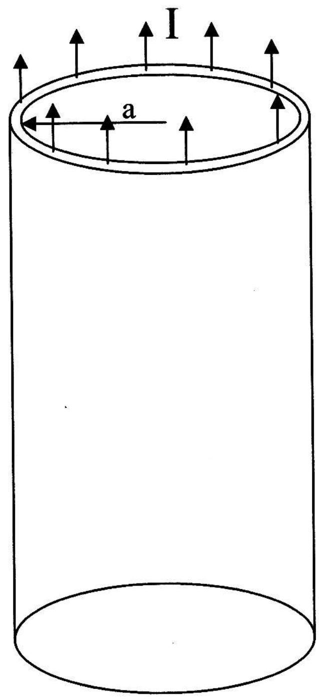
$= \frac{1}{2} \times 8.85 \times 10^{-12} \times 50^2 \times 1000 \times 4 = 44.25\ \mu J$

7) $W = \frac{1}{2}CV^2 = \frac{1}{2} \times 2.2125 \times 10^{-9} \times 200^2 = 44.25\ \mu J$

Question 3: ***(20Mark)***

Objectives: This question is related to Ampere's law

A thin cylindrical conducting shell of radius a, infinite in length along the z axis, carries a current I. Find $\vec{H}$ in all regions.



H has only one component in the ϕ direction

Also H_ϕ is a function of r only.

Proper Ampere's path are concentric circles.

The space is divided into two regions: region 1 inside the cylinder
region 2 outside the cylinder

region 1 $r < a$

$$\oint \vec{H} \cdot \vec{dL} = I_{enc} = 0$$

$$\therefore H = 0$$

region 2 $r > a$

$$\oint \vec{H} \cdot \vec{dL} = I_{enc} = I$$

$$H_\phi \, 2\pi r = I \implies H_\phi = \frac{I}{2\pi r} \text{ A/m}$$