THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
Department of Electrical & Electronic Engineering

EEE 3352: Electromechanics & Electrical Machines

ASSIGNMENT 3: ELECTROMAGNETIC FIELDS
(*Class Quiz - 31/08/2022)*
Time 60 minutes

Q 1-5.
Two square metal plates of side 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 500 V dc between them.

1.What is the capacitance created by the plates in uF? [1 decimal place] [5]

$$C = \frac{\varepsilon A}{l} = \frac{\varepsilon_r \varepsilon_0 A}{l} = 8.85 \times 10^{-7} \text{ F}$$

Ans: 88.5 µF

2. What is the electric field strength, in V/mm, at the centre of the plates and mid-way between the plates? [A whole number, 0 decimal places] [5]

$$E = \frac{V}{l} = 1.25 \times 10^{5} \text{ V/m}$$

Ans: 125 V/mm

3. What is the electric field strength, in V/mm, at the centre of the plates and three-quarter distance from the postive plate? [A whole number, 0 decimal places] [5]

$$E = \frac{V}{l} = 1.25 \times 10^{5} \text{ V/m}$$

Ans: 125 V/mm

4. What is the energy density, in J/m^3, at the centre of the plates and three-quarter distance from the postive plate? [2 decimal place] [5]

$$W = \varepsilon_r \varepsilon_0 E^2 = 0.07 \text{ J/m}^3$$

Ans: 0.07 J/m^3

$$W = \varepsilon_r \varepsilon_0 E^2 = 0.07 \text{ J/m}^3$$

5. What is the force, in mN, on the postive plate? [1 decimal place] [5]

$$F = \varepsilon_r \varepsilon_0 E^2 A = 2.2 \times 10^{-3} \text{ Nm}$$

Ans: 2.2 mNm

Q6-10
An 80-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 2.5 cm, respectively.

6. If electric field strength capability of the of the insulation is 6 kV/mm, what is the maximum dc voltage, in kV, that can be applied to the cable before beakdown? [1 decimal place] [7.5]

$$E_{\max} = \frac{V}{r_1 \ln \frac{r_2}{r_1}} \quad \rightarrow \quad V = r_1 \ln \frac{r_2}{r_1} E_{\max} = 2749 \text{ V}$$

Ans: 2.7 kV

7. If the relative permittivity of the insulation of the cable is 5, what is the capaciatance, in nF, of the cable? [1 decimal place] [5]

$$C = \frac{2\pi l \varepsilon_r \varepsilon_0}{\ln \frac{r_2}{r_1}} = 2.43\times10^{-8} \text{ F}$$

Ans: 24.3 nF

8. If the relative permittivity of the insulation of the cable is 5 and 1 kV is applied, what is the electric field strength, in V/mm, at a point mid-way between the radius of copper conductor and the metallic sheath? [A whole number, 0 decimal places] [10]

$$r_m = r_1 + \frac{r_2 - r_1}{2} = \frac{r_1 + r_2}{2}$$

$$E(r_m) = \frac{V}{\ln \frac{r_2}{r_1}} \frac{1}{r_m} = 320420 \text{ V/m}$$

Ans: 320 V/mm

9. What is the resistance of the insulation, in GΩ, if the conductivity of the insulation is 10^{-15} S/m? [A whole number, 0 decimal places] [10]

$$R_{ins} = \frac{\ln \frac{r_2}{r_1}}{2\pi l \sigma} = 1.82\times10^{12} \ \Omega$$

Ans: 1823 GΩ

10. If the conductivity of copper is 62 MS/m, what is resistance of the cable, in mΩ, over its run? [1 decimal place] [10]

$$R_{Cu} = \frac{l}{\sigma A} = \frac{l}{\sigma(\pi r_1^2)} = 0.0164 \ \Omega$$

Ans: 16.4 mΩ

Q11-15. A toroid made of steel of relative permeability of 2000 is wound with a coil of 120-turns, carrying a current of 1.5 A dc. The toroid has inner and outer diameters of 10 cm and 14 cm, respectively, and has square cross-section area.

11. What is the cross-sectional area, in cm^2, of the presented magnetic circuit? [1 decimal place] [5]

$$l = w = \frac{D_2}{2} - \frac{D_1}{2} = 2 \text{ cm}$$

$$A = l^2 = 4 \text{ cm}^2$$

Ans: 4 cm^2

12.What is the value of the mmf, in A, produced by the current-excited coil? [A whole number, 0 decimal places] [5]

$$F = NI = 180 \text{ A}$$

Ans: 180 A

13. What is the magnetic field intensity, in A/m, in the middle of the cross-section of the toroid? [A whole number, 0 decimal places] [7.5]

$$H = \frac{F}{l} = \frac{NI}{l_{mean}} = 477 \text{ A}$$

Ans: 477 A

14. What is the magnetic flux density, in T, in the middle of the cross-section of the toroid? [1 decimal place] [7.5]

$$B = \mu H = \mu_r \mu_0 H = 1.2 \text{ T}$$

Ans: 1.2 T

15. What is the total stored energy, in mJ, in the toroid core? [A whole number, 0 decimal places] [7.5]

$$W = \frac{1}{2} BH \times vol = \frac{1}{\mu_r \mu_0} B^2 A l_m = 0.043 \text{ J}$$

Ans: 43 mJ

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