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

EEE 3352: Electromechanics & Electrical Machines

ASSIGNMENT 1: ELECTROMAGNETIC FIELDS
(*Class Quiz - xx/07/2021)*
Time 80 minutes

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1. *Two circular metal plates of diameter 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 600 V dc between them.* What is the capacitance created by the plates in uF? [1 decimal place] [5]

$$C = \frac{\varepsilon A}{l} = \frac{\varepsilon_r \varepsilon_0 A}{l} = 6.95 \times 10^{-7} \text{ F}$$

Ans: 69.5 µF

2. *Two circular metal plates of diameter 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 600 V dc between them.* 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]

$$E = \frac{V}{l} = 2.50 \times 10^{5} \text{ V/m}$$

Ans: 250 V/mm

3. *Two circular metal plates of diameter 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 600 V dc between them.* 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]

$$E = \frac{V}{l} = 2.50 \times 10^{5} \text{ V/m}$$

Ans: 250 V/mm

4. *Two circular metal plates of diameter 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 600 V dc between them.* 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]

$$W_{density} = \frac{1}{2} DE = \frac{1}{2} \varepsilon E^2 = 0.28 \text{ J/m}^3$$

Ans: 0.28 J/m^3

5. *Two circular metal plates of diameter 20 cm are placed equidistant in air at 4 mm from each other and are subjected to 600 V dc between them.* What is the force, in mN, on the postive plate? [1 decimal place] [5]

$$Force = \frac{1}{2} DEA = \frac{1}{2} \varepsilon E^2 \text{A} = 8.7 \times 10^{-3} \text{ N}$$

Ans: 8.7 mN

6. *A 100-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 3 cm, respectively.* If the electric field strength capability of the of the insulation is 2 kV/mm, what is the maximum dc voltage, in kV, that can be applied to the cable? [1 decimal place] [7.5]

$$E_{\max} = \frac{V}{r_1 \ln \frac{r_2}{r_1}} \quad \rightarrow \quad V = r_1 \ln \frac{r_2}{r_1} E_{\max} = 1099 \text{ V}$$

Ans: 1.1 V

7. *A 100-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 3 cm, respectively.* If the relative permittivity of the insulation of the cable is 4.5, what is the capaciatance, in nF, of the cable? [1 decimal place] [5]

$$C = \frac{2\pi l \varepsilon_r \varepsilon_0}{\ln \frac{r_2}{r_1}} = 2.28 \times 10^{-8} \text{ F}$$

Ans: 22.8 nF

8. *A 100-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 3 cm, respectively.* If the relative permittivity of the insulation of the cable is 4.5 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]

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

$$E(r_m) = \frac{V}{\ln \frac{r_2}{r_1}} \frac{1}{r_m} = 246630 \text{ V/m}$$

Ans: 247 V/mm

9. *A 100-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 3 cm, respectively.* What is the resistance of the insulation, in GΩ, if the conductivity of the insulation is 10^{-14} S/m? [A whole number, 0 decimal places] [10]

$$R_{Cu} = \frac{l}{\sigma A} = \frac{l}{\sigma(\pi r_1^2)} = 0.0216 \ \Omega$$

Ans: 21.6 mΩ

10. *A 100-m concentric cable has a central copper conductor and a metallic metal covering embracing diameters of 1 cm and 3 cm, respectively.* If the conductivity of copper is 59 MS/m, what is resistance of the cable, in mΩ, over its run? [1 decimal place] [10]

$$R_{ins} = \frac{1}{G_{ins}} = \frac{\ln \frac{r_2}{r_1}}{2\pi l \sigma} = 175 \times 10^9 \ \Omega$$

Ans: 175 Ω

11. *A toroid made of steel of relative permeability of 1800 is wound with a coil of 100-turns, carrying a current of 1 A dc.* If the toroid has inner and outer diameters of 10 cm and 14 cm, respectively, and has circular cross-section area, what is the cross-sectional area, in cm^2, of the presented magnetic circuit? [1 decimal place] [5]

$$r = \frac{D}{2} = \frac{1}{2}\left(\frac{D_2}{2} - \frac{D_1}{2}\right)$$

$$A = \pi r^2 = 12.6 \text{ cm}^2$$

Ans: 12.6 cm^2

12. *A toroid made of steel of relative permeability of 1800 is wound with a coil of 100-turns, carrying a current of 1 A dc.* What is the value of the mmf, in A, produced by the current-excited coil? [A whole number, 0 decimal places] [5]

$$F = NI = 100 \text{ A}$$

Ans: 100 A

13. *A toroid made of steel of relative permeability of 1800 is wound with a coil of 100-turns, carrying a current of 1 A dc.* 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]

$$H = \frac{F}{l} = \frac{NI}{l_{mean}} = 265 \text{ A}$$

Ans: 265 A

14. *A toroid made of steel of relative permeability of 1800 is wound with a coil of 100-turns, carrying a current of 1 A dc.* What is the magnetic flux desnsity, in T, in the middle of the cross-section of the toroid? [1 decimal place] [7.5]

$$B = \mu H = \mu_r \mu_0 H = 0.6 \text{ T}$$

Ans: 0.6 T

15. *A toroid made of steel of relative permeability of 1800 is wound with a coil of 100-turns, carrying a current of 1 A dc.* If the crossectional area of the magnetic circuit is 10 cm^2, what is the total stored energy, in mJ, in the toroid? [1 decimal place] [7.5]

$$W = \frac{1}{2} BH \times vol = \frac{1}{\mu_r \mu_0} B^2 Al = 0.0377 \text{ J}$$

Ans: 37.7 mJ

A Zulu
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