King Saud University
College of Engineering
Electrical Engineering Department

EE203: ELECTROMAGNETICS (1)

First Midterm Exam

Instructors: A. Sheta & I. Elshafiey
Date: 16/3/1428
Time: 4-5:30 pm

Question	Mark
1	
2	
3	
4	
5	
Total Mark	

اسم الطالب:	
الرقم الجامعى:	
الشعبة :	
مسلسل :	

Answer All Five Problems **(Explaining clearly your answer.) (60 points)**

$\varepsilon_o = \frac{10^{-9}}{36\pi} \quad F/m$ $\qquad \nabla \cdot \underline{A} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z}$

$\nabla \cdot \underline{A} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta) + \frac{1}{r\sin\theta}\frac{\partial A_\varphi}{\partial \varphi}$

Problem I (10 points)

a. State Gauss's law.

b. State Coulomb's Law.

c. State Maxwell's equations for electrostatic field.

d. Put the following equations related to electrostatic field in correct form:

i. $\nabla \boldsymbol{D} = \rho_v$

ii. $\boldsymbol{E} = -\nabla V$

iii. $\oint_L \boldsymbol{E} \cdot d\boldsymbol{L} = \boldsymbol{Q}_{enc}$

iv. $\oint \boldsymbol{D} \cdot d\boldsymbol{S} = \rho_v$

Problem II (15 points)

a. Prove that the electric field due to an infinite line along z-axis carrying uniform charge distribution ρ_L is given as

$$\boldsymbol{E} = \frac{\rho_L}{2\pi\varepsilon_0\rho}\boldsymbol{a}_\rho$$

b. A charge distribution consists of a point charge Q= 10 mC at the origin, and an infinite line with uniform charge density of ρ_L= 10 nC/m located along the line defined by y=1 and z=1. Calculate the following:
   i. magnitude and direction of the force by which the line affects the charge Q.
   ii. the work done in moving 1C from point A (2,2,2) to point C (3,3,3).

Problem III (10 points)

Two charged infinite parallel planes are located at z= -1 and z = 1. The plane at z = 1 has surface charge density of 10 nC/m^2 and the other plane has charge density of -10 nC/m^2. Find the following:

a. **E** at the origin.
b. **E** at the point A (3,4,3.5).
c. **E** at the point B (-3,-4,-2.5).
d. The force per unit area exerted on the z=-1 plane due to the other plane.

Problem IV (15 points)

A sphere of radius $a = 1$ m is charged with uniform volume charge density of $\rho_v = 1$ nC/m^3. Find the following:

a. **D** at the point P_1 (0.5, 30°, 90°).
b. **D** at the point P_2 (1, 2, 2).
c. Energy associated with the electrostatic field, stored in the space outside of the sphere.

Problem V (10 points)

a. Prove that the electric field intensity due to a dipole of moment $p\mathbf{a}_z$ located at the origin is given as

$$\boldsymbol{E} = \frac{p}{4\pi\varepsilon_0 r^3}(2\cos\theta\boldsymbol{a}_r + \sin\theta\boldsymbol{a}_\theta)$$

b. A dipole with moment $\boldsymbol{p}$= 10 $\mathbf{a}_z$ nC.m is located at the origin in free space. Find V and **E** at the point A(r=10,θ=30°,φ=0).