Faculty of Electronic Engineering
Dept. Electrical Comm. Engineering
1st term
(2nd year)

Subject: Fields and Waves
Final Exam (70 Mark)
Allowed Time: 3 Hour [both parts]
Date: 13/1/2020 (10 AM-1 PM)

Answer as much as you can

[1] Question One [15 Marks]:

A) State and explain Coulomb's law for the vector force between two point charges in free space.

B) Given the flux density $\bar{D} = \frac{16}{r} cos(2\theta)\, \hat{a}_\theta$ C/m^2, use two different methods to find the total charge within the region 1<r<2 m, 1<θ<2 rad, 1<φ<2 rad.

C) if $\bar{A} = \hat{a}_x + 2\,\hat{a}_y - 3\,\hat{a}_z$ and $\bar{B} = 2\hat{a}_x - \hat{a}_y + \hat{a}_z$ determine:

(a) The magnitude of projection of $\bar{B}$ on $\bar{A}$

(b) The smallest angle between $\bar{A}$ *and* $\bar{B}$

(c) The vector projection of $\bar{A}$ on $\bar{B}$

(d) The unit vector perpendicular to the plane contain $\bar{A}$ *and* $\bar{B}$

[2] Question Two [15 Marks]:

A) Using Gauss law, Find E at any point due to long infinite charge wire

B) An electric field in free space is given by $\bar{E} = x\,\hat{a}_x + y\,\hat{a}_y + z\,\hat{a}_z$ V/m. Find the work done in moving a 1-μC charge through this field

(a) From (1, 1, 1) to (0, 0, 0);

(b) From (ρ=2, φ=0) to (ρ=2, φ=90◦);

(c) From (r=10, θ=θ_0) to (r=10, θ=θ_0 + 180◦).

C) Let S = 100 mm^2, d=3 mm, and r=12 for a parallel-plate capacitor,

(a) Calculate the capacitance.

(b) After connecting a 6-V battery across the capacitor, calculate E, D, Q, and the total stored electrostatic energy.

[3] Question Three [10 Marks]:

A) In a certain medium, the electric potential is given by

$$V(x) = \frac{\rho_o}{a\varepsilon_o}\,(1 - e^{-ax})$$

where ρ_0 and a are constants.

(a) Find the electric field intensity, E.

(b) Find the potential difference between the points x = d and x = 0.

(c) If the medium permittivity is given by $\varepsilon(x) = \varepsilon_0 e^{ax}$, find the electric flux density, D, and the volume charge density, ρ_v, in the region.

(d) Find the stored energy in the region (0 < x < d), (0 < y < 1), (0 < z < 1).

B) Solve Laplace's equation for the potential field in the homogeneous region between two concentric conducting spheres with radii a and b, $b > a$, if V= 0 at $r=b$, and $V=V_0$ at $r=a$. Find the capacitance between them. (Assume that V is a function only of x)

C) Given the current density $J = -10^4\left[sin(2x)\, e^{-2y}\, \hat{a}_x + cos(2x)\, e^{-2y}\, \hat{a}_y\right]$ kA/m^2

(a) Find the total current crossing the plane y=1 in the $\hat{a}_y$ direction in the region 0<x<1, 0<z<2.

(b) Find the total current leaving the region 0< x, y < 1, 2 < z < 3 using two methods.

Best Wishes
Dr. Hend A. Malhat