UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: February 2020

Module Number: EE4306 **Module Name: Engineering Electromagnetism**

[3 Hours]

[Answer **all questions**, each question carries ten marks]

(Permittivity of free space $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m and Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ H/m)

Q1 a) An electromagnetic plane wave in free space with power density of 3 W/m^2 impinges normally on a lossless dielectric boundary with a reflection coefficient of 0.375.

i. What is the intrinsic impedance of the dielectric medium?

ii. What is the power density of the wave transmitted into dielectric?

[5 Marks]

b) An electromagnetic plane wave of 50 MHz is propagating in the medium of aluminum $\varepsilon = \varepsilon_0, \mu = \mu_0$ and $\sigma = 3.5\times10^7\ Sm^{-1}$. Calculate the following the parameters for the medium at 50 MHz .

i. The propagation constant γ

ii. The skin depth δ

iii. The wave velocity u [5 Marks]

Q2 a) i) State the Divergence theorem. [2 Marks]

ii) State the Ampere's circuit law. [2 Marks]

b) What do you mean by boundary condition analyze in electrostatic and electromagnetic field? [2 Marks]

c) Asymmetric core of steel shown in Figure Q2 has the permeability of $1000\,\mu_0$ has a uniform cross section of 4 cm^2 except in the central leg with cross section of 6 cm^2 . The other dimensions of the core have been indicated in the figure. The left leg has a coil with 300 turns carrying a 10 A of current and the right

leg has a with coil 200 turns carrying a 5 A of current. Determine the flux density in each leg. [4 Marks]

Q3 In spherical coordinated system (r,θ,ϕ), electrical field component in free space due to a Hertzian dipole placed at the origin along the Z-axis can be expressed with their usual notation as given by the following expressions.

$$E_r = \frac{2I.dl.}{4\pi}\eta_0\beta_0^2\cos\theta\left(\frac{1}{\beta_0^2 r^2}-\frac{j}{\beta_0^3 r^3}\right)e^{-j\beta_0 r}$$

$$E_\theta = \frac{I.dl.}{4\pi}\eta_0\beta_0^2\sin\theta\left(\frac{j}{\beta_0 r}+\frac{1}{\beta_0^2 r^2}-\frac{j}{\beta_0^3 r^3}\right)e^{-j\beta_0 r}$$

$E_\phi = 0$, where η_0, I, dl and β_0 are the intrinsic impedance of free space, the sinusoidal current in the Hertzian dipole, the length of the Hertzian dipole and the phase constant in free space, respectively.

a) Obtain the expressions for the magnetic field components using Maxwell's equations. [2.5 Marks]

b) Obtain the expressions for the electrical and magnetic far-field components of the Hertzian dipole. [2.5 Marks]

c) Obtain the average power flow density vector (Poynting vector) of the propagating far-field components. [2.5 Marks]

d) Hence obtain the total radiated power of the Hertzian dipole. [2.5 Marks]

Q4 a) What is electromagnetic compatibility? [1 Mark]

b) Define electromagnetic interference(EI) [1 Mark]

c) How do you improve immunity of the electronic based system against EI? [2 Marks]

d) How do you assure electromagnetic compatibility of the system? [2 Marks]

e) Discuss the requirements of international standard related to electromagnetic signals or fields control. [4 Marks]

Q5 A filamentary current I_2 of length L is separated by distance b from a parallel and infinite long wire supporting direct current I_1 as shown in Figure Q5.

a) Using Biot-Sarvart law, write down the magnetic flux density at point P due to current element δl carrying the current I_1. [3Marks]

b) Hence, obtain the magnetic flux density at point P due to infinite long wire supporting the direct current I_1. [4 Marks]

c) Find the force on the wire with length L due to the magnetic field generated by the infinitely long wire carrying the direct current I_1. [3 Marks]

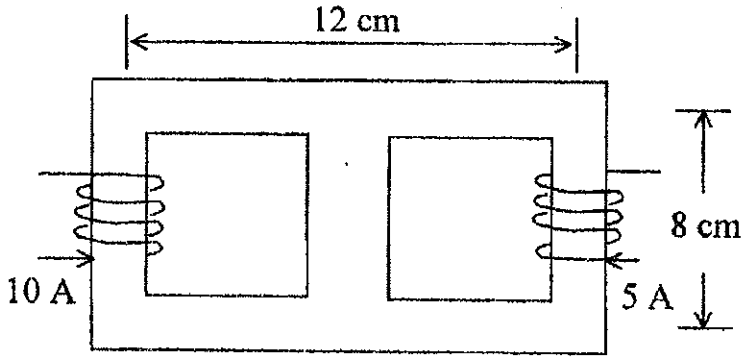

Figure Q2

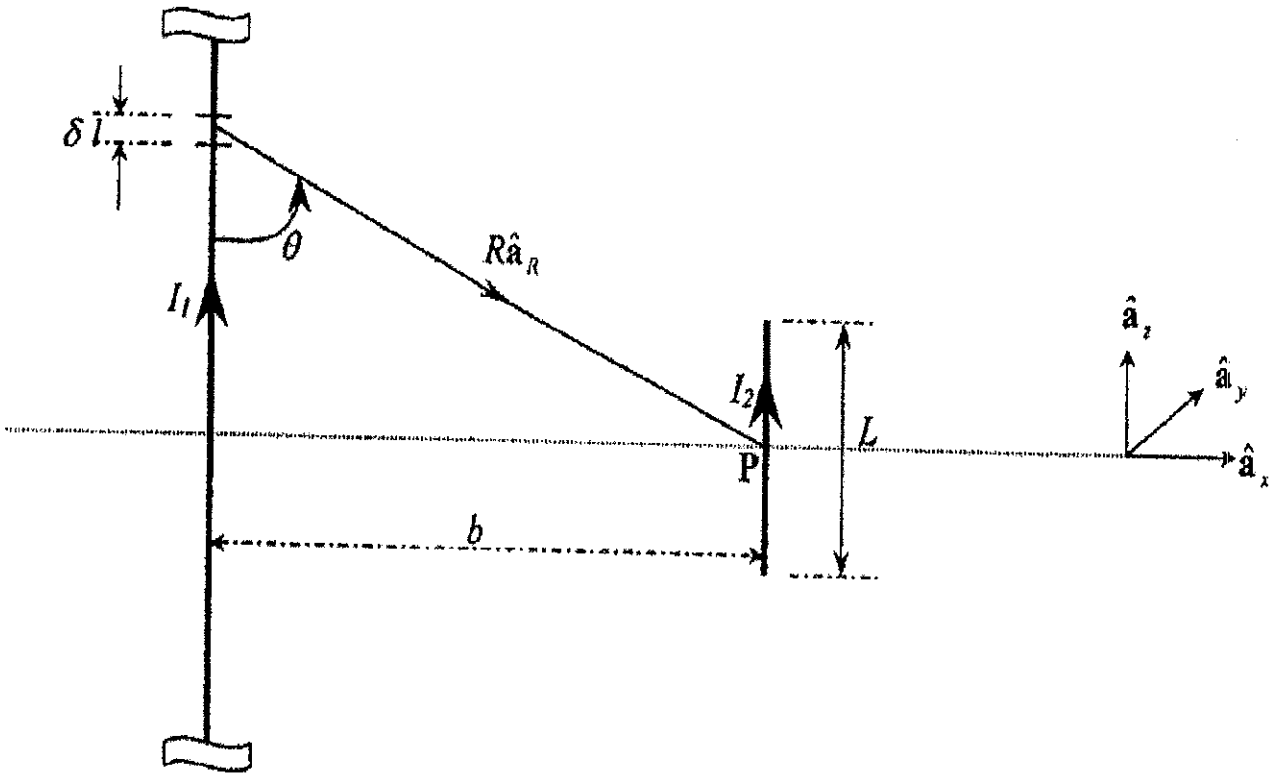

Figure Q5