FIJI NATIONAL UNIVERSITY
College of Engineering, Science & Technology

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

BACHELOR OF ENGINEERING (HONOURS)

EEB605 – Engineering Electromagnetics

Final Examination
Semester I, 2019

DAY/DATE: As timetabled DURATION : Three hours
ROOM: As timetabled

INSTRUCTION TO STUDENTS

1. You are allowed 10 minutes extra reading time during which you are **NOT** to write.
2. This Question paper has single section. Answer **ALL** questions
3. **Begin the answer to each Question** on a fresh page and use both sides of the sheet.
4. Write clearly the number of the question attempted on the top of each sheet
5. Write your candidate number at the top of each sheet & attach them.
6. Insert all written foolscaps, graph paper etc. in their correct sequence and secure with a string.
7. All sheets of paper on which rough/draft work has been done, cross it through and attach all of them to your answer scripts.
8. Where ever possible, draw clear neat diagrams
9. Some useful mathematical relations are given in page 5

Number of pages including instruction page = 5

Useful constants: $\varepsilon_0 = 8.854 \times 10^{--12}$ Fm^{-1}; $\left|\frac{1}{4\pi\varepsilon_0}\right| = 9 \times 10^9$; $\mu_{0_0} = 4\pi \times 10^{-7}$ Hm^{-1}

Answer **ALL** questions

Question 1 **[Total 10 marks]**

a) Given points P (l, - 3, 5), *Q (2,* 4, 6), and *R (0,* 3, 8), find:

(I) The position vectors of *P* and *R.* *(1marks)*

(II) The vector $\overrightarrow{\mathbf{QR}}$. *(2marks)*

(III) The distance between *Q* and *R.* *(2marks)*

b) Three field quantities are given by

P = 2**i** – **k; Q** = 2**i** – **j** + 2**k**; and **R** = 2**i** – 3**j** + **k.** Determine:

(I) **(P + Q)** ∧ **(P - Q).** *(1marks)*

(II) **Q · (R ∧ P).** *(2marks)*

(III) The angle between **Q** and **R.** *(2marks)*

Question 2 **[Total 15 marks]**

a) Two vector fields $\mathbf{E}_1$, and $\mathbf{E}_2$ are present in a region. In spherical coordinates

$\mathbf{E_1} = \frac{5}{r^2}\,\mathbf{r}$, and in cylindrical coordinates $\mathbf{E_2} = \frac{12}{\rho}\,\boldsymbol{\rho}$.

Find the resultant field **E** at (3, - 4, 2). *(5 marks)*

b) Vectors $\boldsymbol{A} = 3\hat{\boldsymbol{x}}+4\hat{\boldsymbol{y}}-5\hat{\boldsymbol{z}}$ and $\boldsymbol{B} = -6\hat{\boldsymbol{x}} + 2\hat{\boldsymbol{y}} + 4\hat{\boldsymbol{z}}$ extend out from the origin. Find

(I) The angle between A and B. **(2marks)**

(II) The distance between the tips of the vectors. **(2marks)**

(III) The unit vectors normal to the plane containing A and B. **(2marks)**

(IV) The area of the parallelogram of which A and B are adjacent sides. **(2marks)**

(V) The unit vector parallel to the bisector of the angle between the two vectors. **(2marks)**

Note: The radial distance r in cylindrical coordinates **(r,φ,z)** can be distinguished from the radial distance r in spherical coordinates **(r,θ,φ)** by the context (that is the associated coordinates : (**φ,z or θ,φ).**

Question 3 **[Total 15 marks]**

a) The electric potential in a given region in free space is $\mathbf{V} = \mathbf{xy^2z}$

$$E = -\Delta V$$

I) Obtain an expression for the electric field **E**. *(3marks)*

II) Calculate the **magnitude** of the electric field at (3,1,1). *(3marks)*

III) For a vector field A, show explicitly that **V • V x A = 0**; that is, the divergence of the curl of any vector field is zero. *(5marks)*

b) Determine the divergence of the given vector field.

$$\mathbf{P} = \mathbf{x^2yz\,a_x} + \mathbf{xz\,a_z}$$ *(4marks)*

Question 4 **[Total 10 marks]**

a) Two point charges -4μC and 5μC are located at (2, -1,3) and (0,4, -2), respectively. Find the potential at (1, 0,1) assuming zero potential at infinity. *(5 marks)*

b) State the Faradays Law of induction in magnetism. *(2 marks)*

c) Name **TWO** distinctly different practical applications of Faradays Law. Briefly explain how the law leads to the said applications. *(3marks)*

Question 5 **[Total 15 marks]**

a) Write down the FOUR Maxwell's equations in electromagnetism *(4marks)*

b) Using the distributed parameters R, C, L and G of a transmission line, draw a small section of the transmission line of length δx. *(6 marks)*

c) Given the potential field, $V = 2x^2y - 5z$, and a point $P(-4,3,6)$, find V, **E**, direction of **E**, **D**, and ρ_v. *(5marks)*

Question 6 **[Total 15 marks]**

a) A parallel plate capacitor of plate area $0.2m^2$ and plate spacing 1cm is charged to 1000V and is then disconnected from the battery.

i) How much work is required if the plates are pulled apart to double the plate spacing. ***(5 marks)***

ii) What will be the final voltage on the capacitor? ***(3 marks)***

b) An air spaced coaxial cable has an inner conductor 0.5 cm in diameter and an outer conductor 1.5cm in diameter. When the inner conductor is at a potential of +8000V with respect to the grounded outer conductor;

i) What is the charge per meter on the inner conductor? ***(4 marks)***

ii) What is the electric filed intensity at r = 1 cm? ***(3 marks)***

Question 7 **[Total 20 marks]**

a) A charge q= 2μC is placed at a = 10cm from an infinite grounded conducting plane sheet Calculate:

i) The total charge induced on the sheet. ***(2 marks)***

ii) The force on the q. ***(4 marks)***

iii) The total work required to remove the charge slowly to an infinite distance from the plane. ***(4marks)***

b) The general expression for the voltage V and current I wave along a transmission line are:

$$\boldsymbol{V = \left(A\, e^{-Px} + B\, e^{Px}\right) e^{j\omega t}} \quad \textbf{and} \quad \boldsymbol{I = \frac{1}{Z_0}\left(A\, e^{-Px} - B\, e^{Px}\right) e^{j\omega t}}$$

where $\mathbf{Z_0}$ is the characteristic impedance, the terms $\boldsymbol{A\, e^{-Px}}$ and $\boldsymbol{B\, e^{Px}}$ correspond to the components of the incident and the reflected wave as shown in Figure 1. P is the propagation constant and Z_o is the characteristic impedance of the transmission line. The load $\boldsymbol{Z}$ is connected at the origin of the coordinate system (x = 0). Drive the expression for characteristic impedance that is $\mathbf{Z_0}$.

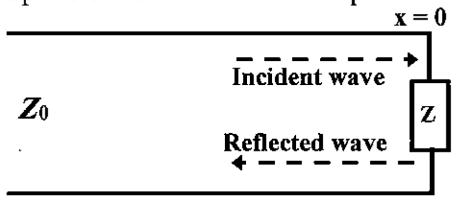

Figure 1: Transmission line impedance

(10marks)

THE END

Mathematical data for reference.

Relationship between different sets of coordinates:

	Cartesian x, y, z	Cylindrical ρ, ϕ, z	Spherical r, θ, ϕ
Cartesian x, y, z		$x = \rho \cos \phi$ $y = \rho \sin \phi$ $z = z$	$x = r \sin \theta \cos \phi$ $y = r \sin \theta \sin \phi$ $z = r \cos \theta$
Cylindrical ρ, ϕ, z	$\rho = \sqrt{x^2 + y^2}$ $\phi = \tan^{-1} \frac{y}{x}$ $z = z$	$\rho = r \sin \theta$ $\phi = \phi$ $z = r \cos \theta$	
Spherical r, θ, ϕ	$r = \sqrt{x^2 + y^2 + z^2}$ $\theta = \tan^{-1} \frac{\sqrt{x^2 + y^2}}{z}$ $\phi = \tan^{-1} \frac{y}{x}$	$r = \sqrt{\rho^2 + z^2}$ $\theta = \tan^{-1} \frac{\rho}{z}$ $\phi = \phi$	

To convert between different coordinates systems:

$$\begin{bmatrix} \mathbf{A}_x \\ \mathbf{A}_y \\ \mathbf{A}_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{A}_\rho \\ \mathbf{A}_\phi \\ \mathbf{A}_z \end{bmatrix}$$

$$\begin{bmatrix} \mathbf{A}_x \\ \mathbf{A}_y \\ \mathbf{A}_z \end{bmatrix} = \begin{bmatrix} \sin\theta\cos\phi & \cos\theta\cos\phi & -\sin\phi \\ \sin\theta\sin\phi & \cos\theta\sin\phi & \cos\phi \\ \cos\theta & -\sin\theta & 0 \end{bmatrix} \begin{bmatrix} \mathbf{A}_r \\ \mathbf{A}_\theta \\ \mathbf{A}_\phi \end{bmatrix}$$