FIJI NATIONAL UNIVERSITY
College of Engineering, Science & Technology

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

BACHELOR OF ENGINEERING

EEE701 – FIELDS AND WAVES
(SPECIAL EXAMINATION)

SEMESTER 2, 2016

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. Answer ALL questions in Section A and in Section B
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. Data sheet having useful formulae are given in the last page

Total number of pages 6

Section A

Answer ALL questions.

A1. P (1,-3, 4) and Q (-2, 4, 0) are two points in a Cartesian coordinate system. Draw a neat diagram. Find the distance PQ and the unit vector ($\overrightarrow{PQ}$) from P to Q

(4 marks)

A2. An electric field $\mathbf{E}_1$ in Cartesian coordinates $3\,\mathbf{i} - 4\,\mathbf{j} + 12\,\mathbf{k}$ and another electric field $\mathbf{E}_2$ in cylindrical coordinates $3\,\boldsymbol{\rho} + 12\boldsymbol{\phi}$ are acting at (2, 3, 5).. Find the angle between the vectors.

(6 marks)

A3. A spherical shell of radius 0.15 m has a uniform charge density of 31 nC m^{-2}. Calculate the electric field intensity **E** at *a*) 0.10 m from the centre of the shell and *b*) 0.20 m from the centre of the shell.

(3 marks)

A4. The distance between two current carrying long parallel conductors is 0.24 m. The current in one conductor is double the current in the other. Draw a labeled diagram illustrating the set up. From the conductor carrying the larger current, find the point where the total magnetic induction **B** is zero.)

(3 marks)

A5. *a*) Name the two different types of transmission lines.

b) Draw the cross sectional view of the two transmission lines and draw the electric (E) and magnetic (**H**) field lines, with appropriate arrow directions on ALL the field lines. Write clearly the direction of propagation of the energy with respect to the plane of the paper.

(4 marks)

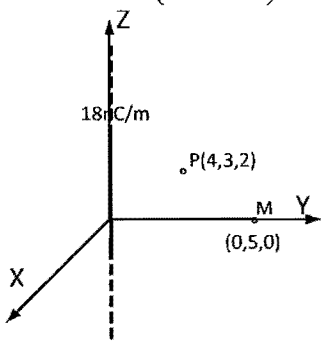
Section B

Answer ALL questions.

B1. *i)* State the Gauss law in electrostatics. If a mathematical expression is used ALL symbols MUST be explained. (4 marks)

ii) Using the Gauss' law or otherwise, derive an expression for the electric field due to a linear charge distribution. (4 marks)

iii) A **long** line charge of uniform charge density 18 nC m^{-1} is kept along the z – axis in a coordinate system as shown in the figure. Find the electric field at P(4,3,2). (4 marks)



iv) A point charge of 20 nC is now kept at M (0,5,0). Find the total electric field at P. (8 marks)

B2. *i)* *a)* A metallic spherical shell of radius *a* has a **total charge** of Q coulombs. Write down the expression for the electric field intensity **E** outside of the shell. Hence **Derive** an expression for the electric potential V at any point outside of the shell. (4 marks)

b) If *a* = 50 cm and **total charge** Q = 30 nC. Starting from first principles, calculate the total electrical energy stored in the shell. (5 marks)

ii) *a)* State the Biot-Sarvat's law in magneto statics. If a mathematical expression is used ALL symbols MUST be explained. (4 marks)

b) A coil of *n* turns and radius *a* carrying a current *I* is kept in the xy plane of a coordinate system with its centre at the origin. Derive an expression for the magnetic induction field **B** at any pint along the z axis (4 marks)

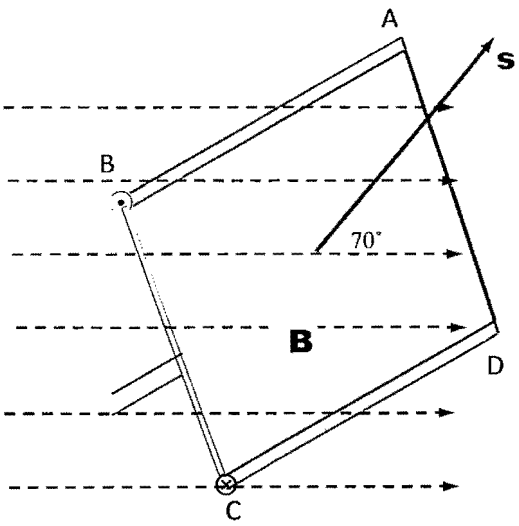
c) If the *n* = 200 turns, *a* = 2 m and *I* = 3 A, determine the magnitude and direction of the **B** field at the following points: (*a*) (0, 0, 5); (*b*) (0, 0, 0) [origin]; (*c*) (0, 0 – 5). (3 marks)

B3. *i)* State the Amperes force law on a current carrying element in magneto statics. If a mathematical expression is used ALL symbols MUST be explained.

(3 marks)

ii) *a)* A rectangular coil ABCD is kept in a uniform magnetic induction **B** of 1.2 Tesla. The coil has 200 turns of wire. AB = 0.5m; BC = 0.2m. A current of 15 A flows in the direction A→ B in the coil. The direction of the area vector **s** is as shown and makes an angle of 70° with **B**. Calculate the torque acting on the coil.

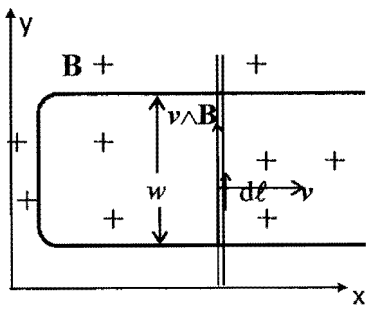
(5 marks)



b) State a practical device that is based on the Amperes force law and stating the reason, explain what modification must be included in the practical device.

(4 marks)

iii) *a)* Consider the expanding loop shown in the diagram in which the sliding metallic rod moves with a velocity v and all the symbols have their usual meanings. Deduce that the rate of change of magnetic flux is equal to the induced e.m.f.



(5 marks)

b) State the Lenzs' law in electromagnetic induction

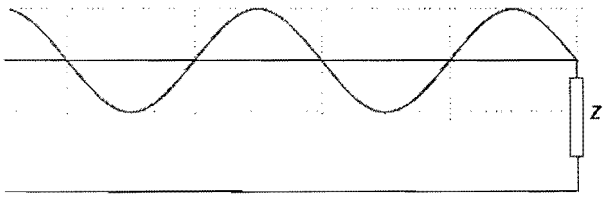
(3 marks)

B4. *i*) For a transmission line having negligible resistance and conductance, the inductance and capacitance per unit lengths are 330 nH/m and 75 pF/m respectively.

a) Calculate the "characteristic impedance (Z_0)" of the line.

(2 marks)

b) The transmission line is connected to a load Z. The amplitude of the voltage waves incident on the load and reflected from the load are A and B satisfy the equation $\frac{Z}{Z_0} = \frac{A+B}{A-B}$. The incident wave is 50 sin 300 t. The incident wave is shown the figure.



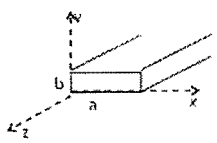
Calculate the amplitude and phase angle of the reflected wave for loads *1*). $Z = 40\Omega$; and *2*). $Z = 80\Omega$.

(5 marks)

c) Draw the incident and the reflected wave on the same diagram for each case in *b*).

(2 marks)

ii) The propagation coefficient P for EM waves inside an air filled wave guide, is given by: $P^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \varepsilon_0\mu_0\omega^2$, where ω is the angular frequency of the wave. If a = 2.8 cm and b = 1.6 cm, calculate the minimum frequency of the wave that can propagate through the waveguide



(4 marks)

iii) *a*) What is the significance of "*numerical aperture*" in optical communication? The refractive indices of the "*fiber*" and the "*cladding*" are 1.5 and 1.35 respectively. Calculate the numerical aperture of the fiber.

(3 marks)

b) Giving labeled diagrams of the cross sectional profile of the refractive indices, give the different types of "*optical fibers*" used in communication and state their applications with respect to the *numerical aperture.*

(4 marks)

THE END

DATA SHEET

1. **Some useful constants:**

$$\varepsilon_0 = 8.854 \times 10^{-9}\ \text{F/m}; \quad 1/(4\pi\varepsilon_0) = 9 \times 10^9$$
$$\mu_0 = 4\pi \times 10^{-7}\ \text{H/m}$$

2. **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	$r = \sqrt{x^2 + y^2 + z^2}$ $\theta = \tan^{-1}\frac{\sqrt{x^2 + y^2}}{z}$ $\phi = \tan^{-1}\frac{y}{x}$	$r = \sqrt{\rho^2 + z^2}$ $\theta = \tan^{-1}\frac{\rho}{z}$ $\phi = \phi$	

3. **Vector transformations**

$$\begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix}$$

$$\begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} = \begin{bmatrix} \sin\theta\cos\phi & \cos\theta\cos\phi & -\sin\phi \\ \sin\theta\sin\phi & \cos\theta\sin\phi & \cos\phi \\ \cos\theta & -\sin\theta & 0 \end{bmatrix} \begin{bmatrix} A_r \\ A_\theta \\ A_\phi \end{bmatrix}$$