INTI
INTERNATIONAL COLLEGE PENANG (507232-U)
LAUREATE INTERNATIONAL UNIVERSITIES

FINAL
Examination Paper

(COVER PAGE)

Session	:	April 2013
Programme	:	DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING
Course	:	**EEE2104 : ELECTROMAGNETIC FIELD THEORY**
Date of Examination	:	2 August 2013
Time	:	8a.m. – 10a.m. Reading Time : Nil
Duration	:	2 Hours

Special Instructions :

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted :

Non Programmable Scientific Calculator

Materials provided :

Appendix

Examiner(s) : **Liong Han Wen**

Moderator : **Chai Yoon Yik**

This paper consists of 9 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME
EEE 2104: ELECTROMAGNETIC FIELD THEORY
FINAL EXAMINATION: APRIL 2013 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks. The marks allocated to each sub-question are shown in the brackets at the right-hand margin.

Question 1

a. Two point charges $Q_1 = 8\mu C$ and $Q_2 = -5\mu C$ are located at P1(2,5,8) and P2(6,15,8) respectively. What is the electric force acting on Q_2 and electric field intensity at P2? (11 marks)

b. If the third point charge is put into the system, find the location of the point charge such that the zero force acting on Q2. (11 marks)

c. Define Coulomb's Law. (3 marks)

Question 2

a. An electric field $\overline{E} = \overline{a}_x + z^2\overline{a}_y + 2yz\overline{a}_z$ V/m in medium 1 passes through a boundary into medium 2 as shown in Figure Q2(a). Determine the electric field intensity in medium 2. (9 marks)

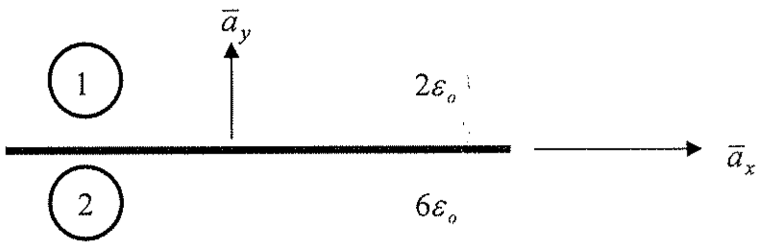

Figure Q2(a)

b. Find the work done in carrying a 5C charge from point A(1,2,-4) to B(3,-5,6) in an electric field $\overline{E} = \overline{a}_x + z^2\overline{a}_y + 2yz\overline{a}_z$ V/m. (11 marks)

c. Determine whether $\overline{E} = yz\overline{a}_x + xz\overline{a}_y + xyz\overline{a}_z$ is conservative or not. (5 marks)

Question 3

a. Given vectors $\overline{X} = \overline{a}_x + 3\overline{a}_z$ and $\overline{Y} = 5\overline{a}_x + 2\overline{a}_y - 6\overline{a}_z$. Find:

i. $|\overline{X} + \overline{Y}|$ (3 marks)

ii. $5\overline{X} - \overline{Y}$ (3 marks)

iii. The component of $\overline{X}$ along $\overline{a}_y$ (3 marks)

iv. A unit vector parallel to $3\overline{X} + \overline{Y}$ (3 marks)

b. A parallel-plate conductor separated by 3mm of air has plate area of 200cm^2. The charge density of each plate is $1\mu C/m^2$. Calculate:

i. The capacitance of the capacitor. (3 marks)

ii. Voltage between the plates. (4 marks)

iii. The attraction force between the plates. (3 marks)

c. Define Gauss's Law. (3 marks)

Question 4

a. Planes z = 0 and z = 4 carry current $\overline{K}_1 = -10\overline{a}_x$ A/m and $\overline{K}_2 = 10\overline{a}_x$ A/m respectively. Determine $\overline{H}$ at

i. (1,1,1) (5 marks)

ii. (0,-3-10) (5 marks)

b. Given that $\overline{B} = 6x\,\overline{a}_x - 9y\,\overline{a}_y + 3z\,\overline{a}_z$ Wb/m^2, find the total force experienced by the rectangular loop (on z = 0 plane) shown in Figure Q4(b). (15 marks)

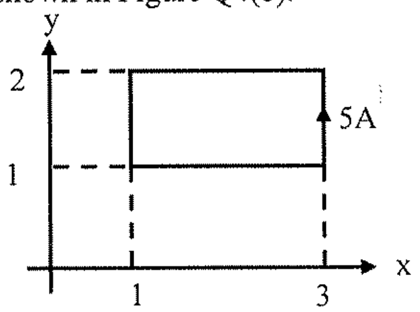

Figure Q4(b)

Question 5

a. Refer to Figure Q5(a), find the total flux crossing the portion of the plane at $\phi = \pi/4$ defined by $0.01 \le \rho \le 0.05$m and $0 \le z \le 2$m due to current filament of 2.5A along the z-axis in the $\overline{a}_z$ direction. Assume the medium is free space. (10 marks)

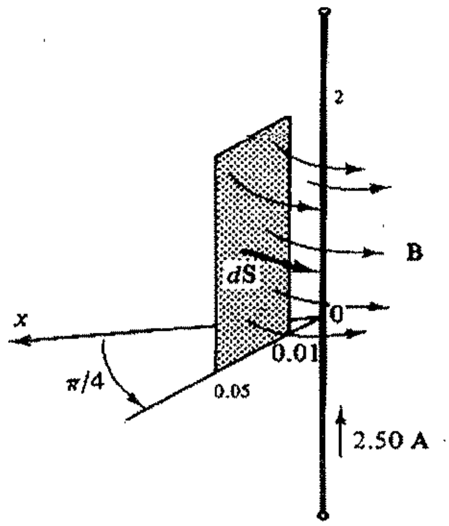

Figure Q5(a)

b. The loop shown in Figure Q5(b) is inside a uniform magnetic field $\overline{B} = 50\ \overline{a}_x$ Wb/m^2. If DC side of the loop start to cuts the flux lines at the frequency of 50Hz and the loop lies in the xz-plane at time t = 0, find the induced emf at t = 1milisecond for DC side. (15 marks)

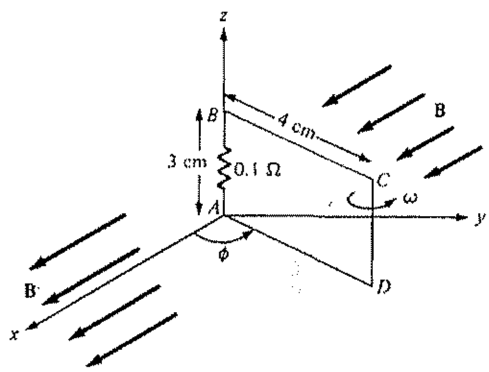

Figure Q5(b)

Question 6

a. In the magnetic circuit as shown in Figure Q6(a) below, calculate the current in the coil that will produce a magnetic flux density of 1.5Wb/m^2 in the air gap assuming that $\mu = 50\mu_o$ and that all branches have the same cross-sectional area of 10 cm^2. (16 marks)

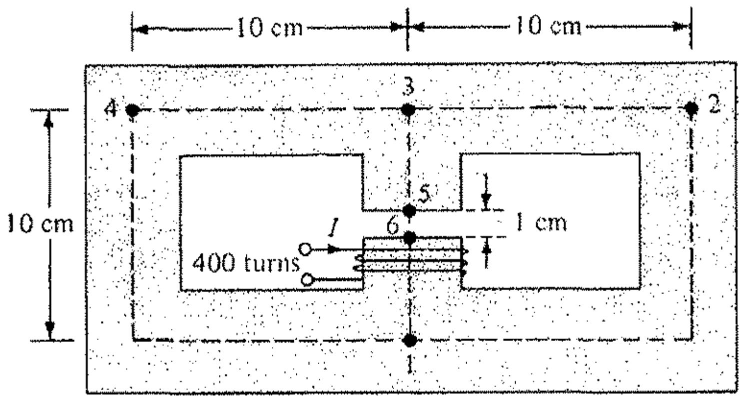

Figure Q6(a)

b. A sinusoidal electromagnetic wave of frequency 40.0 MHz travels in free space in the x direction.

   i. Determine the wavelength and period of the wave. (3marks)

   ii. At some point and at some instant, the electric field has its maximum value of 750 V/m and is along the y axis. Calculate the magnitude and direction of the magnetic field at this position and time. (3 marks)

c. Define Lenz's Law. (3 marks)

--THE END --

(EEE 2104/(F)/April 2013/Liong Han Wen /5-5-2013)

Appendix A : Trigonometry Identities

Sum or difference of two angles:

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$$
$$\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$$
$$\tan(a \pm b) = \frac{\tan a \pm \tan b}{1 \mp \tan a \tan b}$$

Double angle formulas:

$$\tan 2\theta = \frac{2\tan\theta}{1-\tan^2\theta}$$

$$\sin 2\theta = 2\sin\theta\cos\theta \qquad \cos 2\theta = 2\cos^2\theta - 1$$
$$\cos 2\theta = 1 - 2\sin^2\theta \qquad \cos 2\theta = \cos^2\theta - \sin^2\theta$$

Pythagorean Identities:

$$\sin^2\theta + \cos^2\theta = 1$$
$$\tan^2\theta + 1 = \sec^2\theta \qquad \cot^2\theta + 1 = \csc^2\theta$$

Half angle formulas:

$$\sin^2\theta = \frac{1}{2}(1-\cos 2\theta) \qquad \cos^2\theta = \frac{1}{2}(1+\cos 2\theta)$$
$$\sin\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{2}} \qquad \cos\frac{\theta}{2} = \pm\sqrt{\frac{1+\cos\theta}{2}}$$
$$\tan\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{1+\cos\theta}} = \frac{\sin\theta}{1+\cos\theta} = \frac{1-\cos\theta}{\sin\theta}$$

Appendix B : Differential Length, Area and Volume

Cartesian System :

Differential displacement, $d\bar{l} = dx\bar{a}_x + dy\bar{a}_y + dz\bar{a}_z$

Differential normal area,
$$d\bar{s}_x = dydz\bar{a}_x$$
$$d\bar{s}_y = dxdz\bar{a}_y$$
$$d\bar{s}_z = dxdy\bar{a}_z$$

Differential volume, $dv = dxdydz$

Cylindrical System :
Differential displacement, $d\bar{l} = d\rho \bar{a}_\rho + \rho d\phi \bar{a}_\phi + dz \bar{a}_z$

Differential normal area,
$$d\bar{s}_\rho = \rho d\phi dz\, \bar{a}_\rho$$
$$d\bar{s}_\phi = d\rho\rho\, dz \bar{a}_\varphi$$
$$d\bar{s}_z = \rho d\phi d\rho \bar{a}_z$$

Differential volume, $dv = \rho d\rho d\varphi dz$

Spherical System :
Differential displacement, $d\bar{l} = dr\bar{a}_r + rd\theta\bar{a}_\theta + r\sin\theta\, d\varphi\, \bar{a}_\varphi$

Differential normal area,
$$d\bar{s}_r = r^2 \sin\theta\, d\theta\, d\phi\, \bar{a}_r$$
$$d\bar{s}_\theta = r\sin\theta\, dr\, d\phi\, \bar{a}_\theta$$
$$d\bar{s}_\phi = rdrd\theta\bar{a}_\phi$$

Differential volume, $dv = r^2 \sin\theta\, dr\, d\theta\, d\phi$

Appendix C : Gradient of scalar

Cartesian System : $\nabla V = \frac{\partial V}{\partial x}\bar{a}_x + \frac{\partial V}{\partial y}\bar{a}_y + \frac{\partial V}{\partial z}\bar{a}_z$

Cylindrical System : $\nabla V = \frac{\partial V}{\partial \rho}\bar{a}_\rho + \frac{1}{\rho}\frac{\partial V}{\partial \varphi}\bar{a}_\phi + \frac{\partial V}{\partial z}\bar{a}_z$

Spherical System : $\nabla V = \frac{\partial V}{\partial r}\bar{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\bar{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\bar{a}_\phi$

Appendix D : Curl of a Vector

Cartesian System : $\nabla \times \bar{A} = \begin{vmatrix} \bar{a}_x & \bar{a}_y & \bar{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ A_x & A_y & A_z \end{vmatrix}$

Cylindrical System : $\nabla \times \overline{A} = \frac{1}{\rho}\begin{vmatrix} \overline{a}_\rho & \rho\overline{a}_\phi & \overline{a}_z \\ \frac{\partial}{\partial\rho} & \frac{\partial}{\partial\varphi} & \frac{\partial}{\partial z} \\ A_\rho & \rho A_\phi & A_z \end{vmatrix}$

Spherical System : $\nabla \times \overline{A} = \frac{1}{r^2 \sin\theta}\begin{vmatrix} \overline{a}_r & r\overline{a}_\theta & r\sin\theta\overline{a}_\phi \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial\theta} & \frac{\partial}{\partial\varphi} \\ A_r & rA_\theta & r\sin\theta A_\phi \end{vmatrix}$

Appendix E :Divergence of a vector

Cartesian System : $\nabla \cdot \overline{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$

Cylindrical System : $\nabla \cdot \overline{A} = \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho A_\rho\right) + \frac{1}{\rho}\frac{\partial}{\partial\varphi}\left(A_\varphi\right) + \frac{\partial}{\partial z}\left(A_z\right)$

Spherical System : $\nabla \cdot \overline{A} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 A_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}\left(A_\theta \sin\theta\right) + \frac{1}{r\sin\theta \cdot}\frac{\partial}{\partial\phi}\left(A_\phi\right)$

Appendix F : Relationship between Cartesian and Cylindrical System

$\rho = \sqrt{x^2 + y^2}$, $\tan\phi = \frac{y}{x}$, $z = z$

or

$x = \rho\cos\phi$, $y = \rho\sin\phi$, $z = z$

$\overline{a}_x = \cos\phi\,\overline{a}_\rho - \sin\phi\overline{a}_\phi$ $\qquad$ $\overline{a}_\rho = \cos\phi\,\overline{a}_x + \sin\phi\,\overline{a}_y$

$\overline{a}_y = \sin\phi\,\overline{a}_\rho + \cos\phi\overline{a}_\phi$ $\qquad$ $\overline{a}_\phi = -\sin\phi\,\overline{a}_x + \cos\phi\,\overline{a}_y$

$\overline{a}_z = \overline{a}_z$ $\qquad$ $\overline{a}_z = \overline{a}_z$

Appendix G : Vector relationship between Cartesian and Spherical System

$\mathrm{r} = \sqrt{\mathrm{x}^2 + \mathrm{y}^2 + \mathrm{z}^2}$, $\tan\theta = \frac{\sqrt{\mathrm{x}^2 + \mathrm{y}^2}}{\mathrm{z}}$, $\tan\phi = \frac{\mathrm{y}}{\mathrm{x}}$

or

$\mathrm{x} = \mathrm{r}\sin\theta\cos\phi$, $\mathrm{y} = \mathrm{r}\sin\theta\sin\phi$, $\mathrm{z} = \mathrm{r}\cos\theta$

$$\bar{a}_x = \sin\theta\cos\phi\,\bar{a}_r + \cos\theta\cos\phi\,\bar{a}_\theta - \sin\phi\,\bar{a}_\phi$$
$$\bar{a}_y = \sin\theta\sin\phi\,\bar{a}_r + \cos\theta\cos\phi\,\bar{a}_\theta + \cos\phi\,\bar{a}_\phi$$
$$\bar{a}_z = \cos\theta\,\bar{a}_r - \sin\theta\,\bar{a}_\theta$$

$$\bar{a}_r = \sin\theta\cos\phi\,\bar{a}_x + \sin\theta\sin\phi\,\bar{a}_y + \cos\theta\,\bar{a}_z$$
$$\bar{a}_\theta = \cos\theta\cos\phi\,\bar{a}_x + \cos\theta\sin\phi\,\bar{a}_y - \sin\theta\,\bar{a}_z$$
$$\bar{a}_\phi = -\sin\phi\,\bar{a}_x + \cos\phi\,\bar{a}_y$$

Appendix H : Physical Constant

Permittivity of free space, $\varepsilon_o = 8.854 \times 10^{-12}$ F/m $\cong \frac{10^{-9}}{36\pi}$ F/m

Permeability of free space, $\mu_o = 12.6 \times 10^{-7}$ H/m $\cong 4\pi \times 10^{-7}$ H/m

Appendix I : Derivatives of Trigonometric Functions

$$\frac{d}{dx}\sin(x) = \cos(x) \qquad \frac{d}{dx}\cos(x) = -\sin(x)$$

$$\frac{d}{dx}\tan(x) = \sec(x)^2 \qquad \frac{d}{dx}\cot(x) = -\csc(x)^2$$

$$\frac{d}{dx}\sec(x) = \sec(x)\tan(x) \qquad \frac{d}{dx}\csc(x) = -\csc(x)\cot(x)$$