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

FINAL
Examination Paper

(COVER PAGE)

Session : August 2012

Programme : DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING

Course : **EEE2104 : ELECTROMAGNETIC FIELD THEORY**

Date of Examination : 8 December 2012

Time : 11a.m. – 1p.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 8 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME
EEE 2104 : ELECTROMAGNETIC FIELD THEORY
FINAL EXAMINATION : AUGUST 2012 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 square brackets at the right-hand margin.

Question 1

a. Points P and Q are located at (0, 2, 4) and (-3,1,5). Calculate

i. The position vector P (2 marks)
ii. The distance vector from P to Q (2 marks)
iii. The distance between P and Q (2 marks)
iv. A vector parallel to PQ with magnitude of 10 (4 marks)

b. Consider the object shown in Figure Q1(b). By using differential length, area and volume, calculate

i. The distance BC (2 marks)
ii. The surface area AOFD (3 marks)
iii. The volume ABCDFO (4 marks)

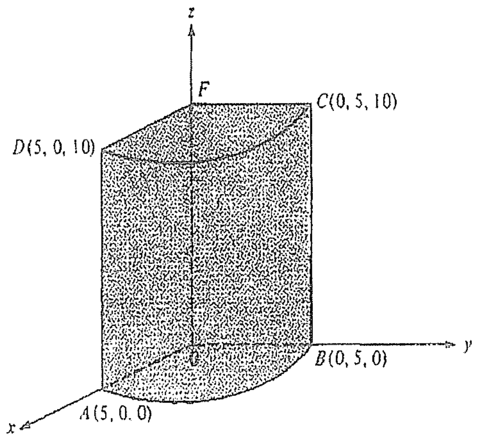

Figure Q1(b)

c. A conducting circular loop of radius 20 cm lies in the $z = 0$ plane in a magnetic field $\mathbf{B} = 10 \cos 377t \ \bar{a}_z$ mWb/m^2. Calculate the induced voltage in the loop. (6 marks)

Question 2

a. Point charge Q1 = 300μC, located at (1,-1,-3)m, experiences a force $\overline{F}_{21} = 8\bar{a}_x - 8\bar{a}_y + 4\bar{a}_z$ due to point charge Q2 at (3, -3, -2)m. Determine Q_2. (13 marks)

b. Calculate the amount of work done in moving a point charge, Q = 10μC from the A(0, 0, 0) to B(2, π/8, π/6) in the electric field $\overline{E} = 2e^{-r/4}\bar{a}_r + \dfrac{10}{r\sin\theta}\bar{a}_\phi$. (12 marks)

Question 3

a. Two infinite plane charges of $10nC/m^2$ and $15nC/m^2$ located at $x = 2$ and $y = -3$. What is the electric field intensity, $\overline{E}$ at (1,1,-1)? If a line charge of 10π nC/m is added into the system at $x = 0$, $z = 2$, calculate the new $\overline{E}$ at (1, 1, -1). (15 marks)

b. Point charges 5nC and -2nC are located at (2,0,4) and (-3,0,5), respectively. Find the electric field $\overline{E}$ at (1, - 3 , 7). (10 marks)

Question 4

a. Determine the capacitance of the capacitor shown in Figure Q4(a). Given $\varepsilon_{r1} = 4$, $\varepsilon_{r2} = 6$, d = 5mm and $S = 30cm^2$. (7 marks)

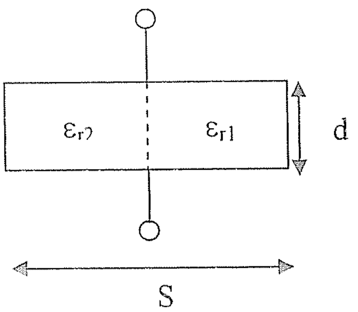

Figure Q4(a)

b. An infinite current filament located at x = 4, y = 5 and a sheet current $\overline{K} = 10\overline{a}_z$ lies in the y = 0 plane. What is the magnitude and direction of the current in the filament if $\overline{H} = 0$ at (2,2,2). (10 marks)

c. By refer to Figure Q4(c), 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. (8 marks)

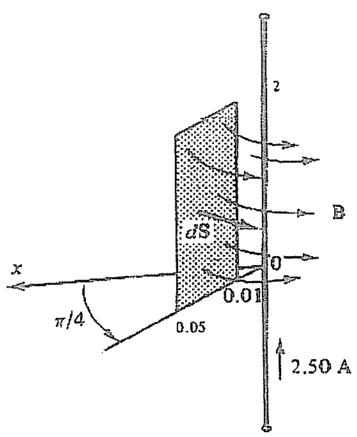

Figure Q4(c)

Question 5

a. By using Ampere's Law, prove that the magnetic field intensity (H) of an infinite current line (with current I) is equal to

$H = \frac{I}{2\pi \rho}$;where ρ is the shortest distance from point of measurement to the current line.
(7 marks)

b. A rectangular loop of wire in free space with four corner points at A(1, 0, 1), B(3, 0, 1), C(3, 0, 4) and D(1, 0, 4). The wire carries a current of 6 A, flowing in the $\overline{a}_z$ direction from B to C. A filamentary current of 15 A flows along the entire z axis in the $\overline{a}_z$ direction. Find the total force acting on the loop.
(15 marks)

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

Question 6

a. State 4(FOUR) Maxwell's equations(either differential or integral form) for static EM field and explain each of them.
(16 marks)

b. Find the displacement current due to an electric field, $E = 7\sin\left(8 \times 10^8 t\right)$ μV/m in a material with relative permittivity of 4.
(4 marks)

c. Find the magnitude of force at a particle of mass 1.70×10^{-27} kg and charge 1.60×10^{-19} C when it enters a magnetic field with magnetic flux density, B = 5mT with an constant initial speed of 83.5km/s. The particle is moving perpendicular with the direction of B. Calculate the radius of the circular path.
(5 marks)

--THE END --

(EEE 2104/(F)/August 2012/Liong Han Wen /3-9-2012)

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,
$$d\bar{s}_\rho = \rho d\phi dz\bar{a}_\rho$$
$$d\bar{s}_\phi = d\rho dz\bar{a}_\phi$$
$$d\bar{s}_z = \rho d\phi d\rho\bar{a}_z$$

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

Spherical System :

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

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

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

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

Appendix D : Curl of a Vector

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

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

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

Appendix E :Divergence of a vector

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

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

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

Appendix F : Relationship between Cartesian and Cylindrical System

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

or

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

$a_x = \cos\phi\, a_\rho - \sin\phi\, a_\phi$

$a_y = \sin\phi\, a_\rho + \cos\phi\, a_\phi$

$a_z = a_z$

$a_\rho = \cos\phi\, a_x + \sin\phi\, a_y$

$a_\phi = -\sin\phi\, a_x + \cos\phi\, a_y$

$a_z = a_z$

Appendix G : Vector relationship between Cartesian and Spherical System

$\mathbf{a}_x = \sin\theta\cos\phi\mathbf{a}_r + \cos\theta\cos\phi\mathbf{a}_\theta - \sin\phi\mathbf{a}_\phi$

$\mathbf{a}_y = \sin\theta\sin\phi\mathbf{a}_r + \cos\theta\cos\phi\mathbf{a}_\theta + \cos\phi\mathbf{a}_\phi$

$\mathbf{a}_z = \cos\theta\mathbf{a}_r - \sin\theta\mathbf{a}_\theta$

$\mathbf{a}_r = \sin\theta\cos\phi\mathbf{a}_x + \sin\theta\sin\phi\mathbf{a}_y + \cos\theta\mathbf{a}_z$

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

$\mathbf{a}_\phi = -\sin\phi\mathbf{a}_x + \cos\phi\mathbf{a}_y$

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

or

$$x = r\sin\theta\cos\phi\ , \quad y = r\sin\theta\sin\phi\ , \quad z = r\cos\theta$$

Appendix H : Physical Constant

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

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