



INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session : April 2018

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2104: Electromagnetic Field Theory

Date of Examination : 30 July 2018 (Monday)

Time : 11:00am - 1:00pm 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 :

Mathematical Formulas and Physical Constant

Examiner(s) : Dr. Solahuddin Yusuf Bin Fadhlullah

Moderator : Dr. Ooi Beng Lee

This paper consists of 7 printed pages, including the cover page

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEEI)
EEE2104: ELECTROMAGNETIC FIELD THEORY
FINAL EXAMINATIONS: APRIL 2018 SESSION

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

Question 1

- a) Explain the difference between Electric Field Intensity and Electric Flux Density. (3 marks)
- b) Point charges 1 mC and -2mC are located at (3, 2, -1) and (-1, -1, 4), respectively. Calculate the electric force on a 10 nC charge located at (0, 3, 1) and the electric field intensity at that point. (7 marks)
- c) A point charge, $Q=30$ nC is located at (0,0,0). Find the electric flux density at (1,3,-4) m. (5 marks)
- d) Given the potential $V = (10/r^2) \sin \theta \cos \phi$.
- i. Find the electric flux density \bar{D} at $(2, \frac{\pi}{2}, 0)$. (4 marks)
- ii. Calculate the work done in moving a $10 \mu C$ charge from A (1, 30° , 120°) to B (4, 90° , 60°). (6 marks)

Question 2

- a) Based on the half-sphere with an open surface given in Figure Q2a, determine whether it is a valid Gaussian surface. Justify your answer by giving the definition of Gauss's Law.



Figure Q2a

(2 marks)

- b) An insulating solid sphere of radius a has a uniform volume charge density ρ_v and carries a total positive charge Q . By using Gauss's Law, prove that:

$$\bar{D} = \begin{cases} \frac{r}{3} \rho_v \bar{a}_r & 0 < r \leq a \\ \frac{a^3}{3r^2} \rho_v \bar{a}_r & r \geq a \end{cases}$$

(9 marks)

- c) If $V = x - y + xy + 2z$ V, find \bar{E} at $(1, 2, 3)$.

(5 marks)

- d) Find the potential at point $(0,0,5)$ with respect to point $(0,0,15)$ due to the point charge 500 pC at the origin.

(5 marks)

- e) Region $y < 0$ consists of a perfect conductor while region $y \geq 0$ is a dielectric medium ($\epsilon_{r1}=2$). If there is a surface charge of 2 nC/m^2 on the conductor, determine \bar{E} and \bar{D} at:

- i. A $(3, -2, 2)$
- ii. B $(-4, 1, 5)$

(4 marks)

Question 3

- a) Explain the term capacitance and also write its related formula. (2 marks)
- b) A parallel-plate capacitor with area 0.30 m^2 and separation 5.5 mm contains three dielectrics with interfaces normal to \vec{E} and \vec{D} as follows:
 $\epsilon_{r1} = 3.0$, $d_1 = 1.0 \text{ mm}$, $\epsilon_{r2} = 4.0$, $d_2 = 2.0 \text{ mm}$, $\epsilon_{r3} = 6.0$, $d_3 = 2.5 \text{ mm}$
 Determine the total capacitance. (9 marks)
- c) Two conducting parallel plates are separated by a dielectric material with $\epsilon = 5.6\epsilon_0$ and thickness 0.64 mm . Assume that each plate has an area of 80 cm^2 . If the potential field distribution between the plates is $V=3x+4y-12z+6 \text{ kV}$, determine:
 i. The capacitance of the capacitor (3 marks)
 ii. The potential difference between the plates (8 marks)
- d) Find the capacitance per unit length of a coaxial cable with outer radius of 4 mm and inner radius of 0.5 mm if the dielectric has $\epsilon_r = 5.2$. (3 marks)

Question 4

- a) Define Ampere's Law and explain its importance in understanding electromagnetic field theory.

(3 marks)

- b) Find \vec{H} at (-3,4,5) when there are filamentary currents 10 A along \vec{a}_y and 20 A along $-\vec{a}_z$.

(12 marks)

- c) Given the magnetic vector potential $\vec{A} = -\frac{\rho^2}{4}\vec{a}_z$ Wb/m, calculate the total magnetic flux crossing the surface $\phi = \frac{\pi}{2}$, $1 \leq \rho \leq 2m$, $0 \leq z \leq 5$.

(4 marks)

- d) A current distribution gives rise to the vector magnetic potential:

$$\vec{A} = x^2y\vec{a}_x + y^2x\vec{a}_y - 4xyz\vec{a}_z \text{ Wb/m}$$

Calculate the magnetic flux ϕ through the surface defined by $z=1$, $0 \leq x \leq 1$ and $-1 \leq y \leq 4$.

(6 marks)

Question 5

- a) Explain the classification of magnetic materials according to the magnetic susceptibility. For each type of magnetic materials, state two of its attributes. (9 marks)
- b) A solenoid in Figure Q5b with $N_1 = 2000$, $r_1 = 2$ cm and $L_1 = 100$ cm is concentric within a second coil of $N_2 = 2000$, $r_2 = 4$ cm and $L_2 = 200$ cm. Calculate:
- the Magnetic Flux Density, \vec{B}
 - the mutual inductance between two coils in a free space condition.

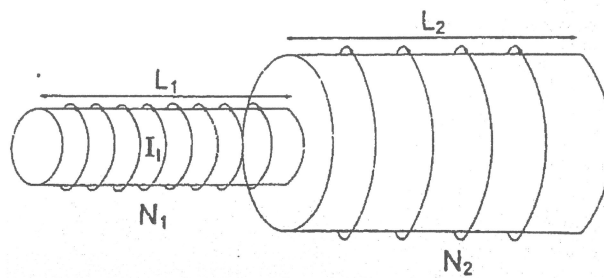


Figure Q5b

(8 marks)

- c) The magnetic circuit in Figure Q5c has a current of 10 A in the coil of 2000 turns. Assume that all the branches have the same cross section of 2 cm² and that the material of the core is iron with $\mu_r = 1500$. Calculate R, F and ϕ for
- the core
 - the air gap

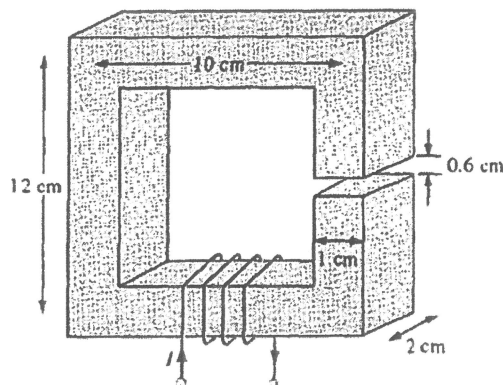


Figure Q5c

(8 marks)

Question 6

- a) Define Lenz's Law and also write down its related equation. (3 marks)
- b) In a Cartesian coordinate system, a conducting bar slides freely over two conducting rails as shown in Figure Q6b. Using Faraday's Law, solve the generated electromagnetic force (emf) if:
- the bar is stationary at $x = 4 \text{ cm}$ and $\vec{B} = 4\cos 10^6 t \vec{u}_z \text{ mWb/m}^2$ (5 marks)
 - the bar is sliding at a velocity of $\vec{v} = 10\vec{u}_x \text{ m/s}$ and $\vec{B} = 4\vec{u}_z \text{ mWb/m}^2$ (5 marks)

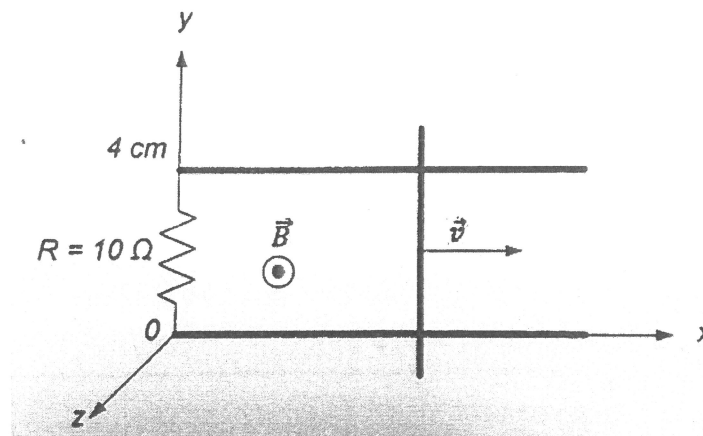


Figure Q6b

- c) A parallel plate capacitor with an area of 5 cm^2 and plate separation of 3 mm has a voltage of $50 \sin 10^3 t \text{ V}$ applied to its plate. Calculate the displacement current assuming $\epsilon = 2\epsilon_0$. (6 marks)
- d) The magnetic field intensity of uniform plane wave in free space is 35 A/m along \vec{u}_y direction and the wave is propagating at frequency of $4 \times 10^9 \text{ rad/sec}$. Compute:
- the wavelength (λ)
 - the frequency (f)
 - the period (T)

(6 marks)

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