UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2016 SEMESTER

COURSE : **ECB2173/EDB2013 – ELECTROMAGNETIC THEORY**

DATE : **29TH APRIL 2016 (FRIDAY)**

TIME : **9.00 AM – 12.00 NOON (3 hours)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions from the Question Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumption.
5. Do not open this Question Booklet until instructed.

Note :
i. There are **FIVE (5)** pages in this Question Booklet including the cover page.
ii. Smith chart will be provided.

1. a. An infinitely long line of charge with uniform charge density, ρ_l, is placed along the y-axis as shown in **FIGURE Q1**.

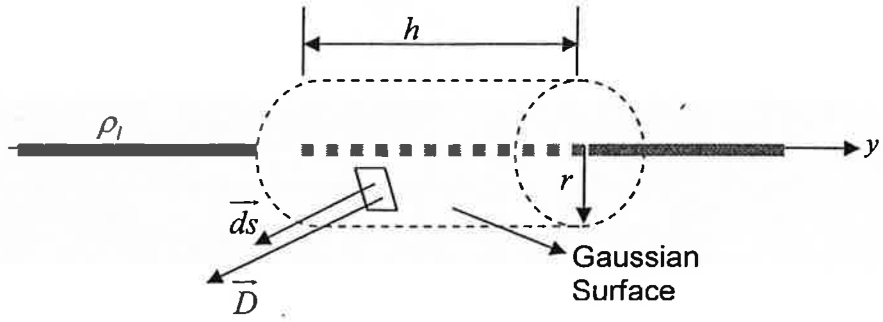

FIGURE Q1

i. Using the Gauss's law in differential form, derive its integral form.

[4 marks]

ii. Based on the integral form of Gauss's law, derive an expression for the electric field, $\vec{E}$, in free space due to the line charge given in **FIGURE Q1**.

[15 marks]

b. Define the following:

i. Lorentz Force

[3 marks]

ii. Force on a Current-Carrying Conductor

[3 marks]

2. a. **FIGURE Q2** shows a plane wave propagation of **E**-field and **H**-field in both time and space. The direction of propagation is toward **+z**.

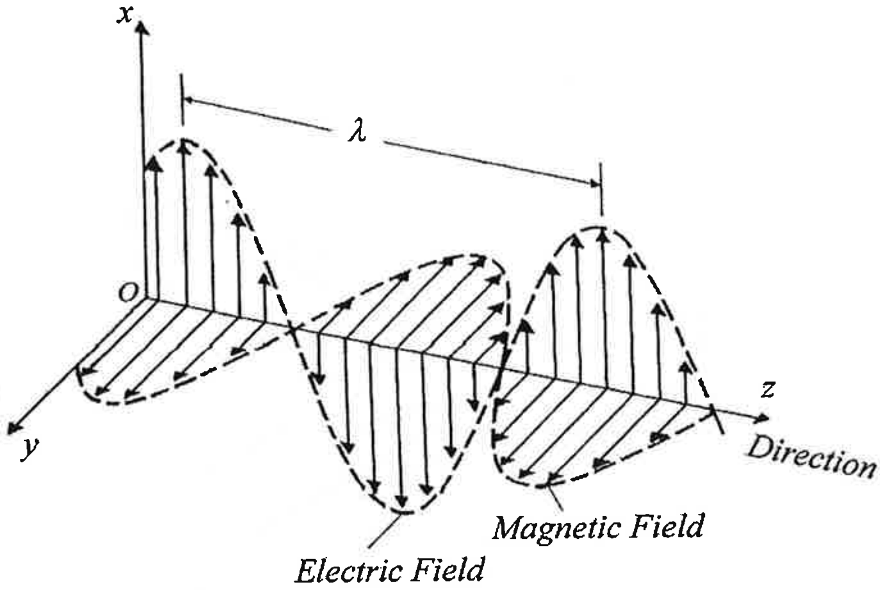

FIGURE Q2

i. State the **FOUR (4)** Maxwell equations.

[4 marks]

ii. Based on Maxwell equations and **FIGURE Q2**, derive the wave equations for both **E** and **H**-field and show that the vector fields are transverse.

[15 marks]

b. A 10-MHz uniform plane wave is travelling in a nonmagnetic medium with $\mu=\mu_o$ and $\varepsilon_r=9$ where $\mu_0 = 4\pi \times 10^{-7}\ H/m$, $\varepsilon_0 = 8.854 \times 10^{-12}\ F/m$.

i. Determine the phase velocity *v*.

[3 marks]

ii. Determine the wavenumber *k*.

[3 marks]

3. Two half-wave dipole antennas, each with impedance of $Z_L = 75\,\Omega$, are connected in parallel through a pair of transmission lines, and the combination is connected to a feed transmission line, as shown in **FIGURE Q3**. All lines are lossless with characteristic impedance of $Z_0 = 50\,\Omega$.

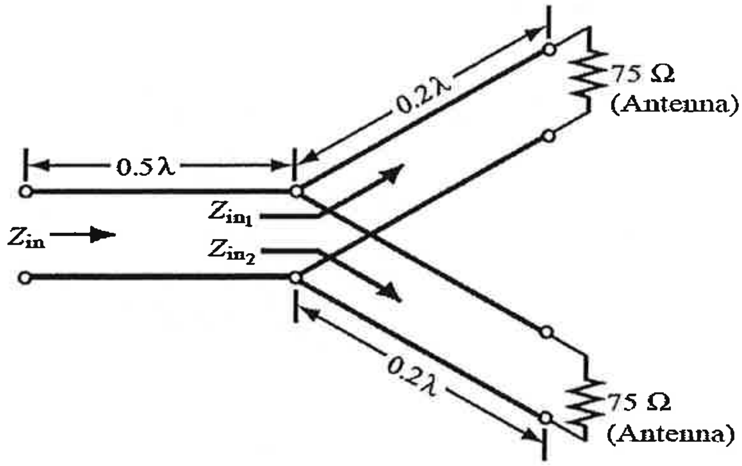

FIGURE Q3

a. Calculate Z_{in1} and Z_{in2}, the input impedance of the antenna-terminated line, at the parallel juncture as indicated in **FIGURE Q3**.

[3 marks]

b. Determine Z'_L, the effective load impedance of the feedline by combining Z_{in1} and Z_{in2} in parallel.

[3 marks]

c. Calculate input impedance Z_{in}, of the feedline.

[4 marks]

d. Assuming that all the transmission lines in **FIGURE Q3** have characteristic impedance of $Z_0 = 75\,\Omega$, determine the new value of input impedance Z'_{in} and construct a matching network to match to a Z'_{in} $50\,\Omega$ system.

[15 marks]

4. Consider the network shown in **FIGURE Q4**. All transmission lines in this network are lossless with $Z_0 = 50\ \Omega$.

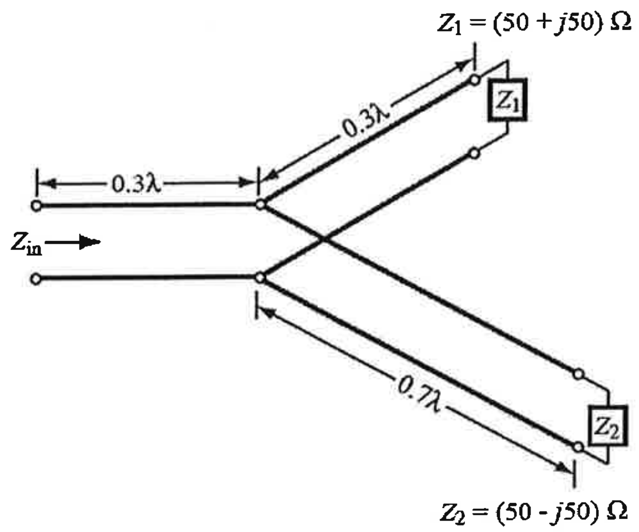

FIGURE Q4

a. Using the Smith Chart, determine the reflection coefficient at the load impedance, Z_1.

[3 marks]

b. Using the Smith Chart, determine the reflection coefficient at the load impedance, Z_2.

[3 marks]

c. With the help of the Smith Chart, determine the input impedance Z_{in}, of the feed line.

[4 marks]

d. All the transmission lines shown in **FIGURE Q4** are replaced with half-wavelength transmission lines. Using the Smith Chart, determine the new input impedance Z'_{in}.

[15 marks]

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