**THE INSTITUTION OF ENGINEERS, SRI LANKA**
**IESL ENGINEERING COURSE**
**PART II EXAMINATION – MAY 2012**
**207 – ELECTROMAGNETC FIELDS AND NETWORKS**

**Instructions to the Candidates**
This paper contains **EIGHT (8)** questions on **FIVE (5)** pages
Answer **ANY FIVE (5)** questions with at least **TWO (2)** questions from each section.
Time allowed **THREE (3)** hours.

| | | |
|---|---|---|
| Permittivity of free space, $\varepsilon_0$ | = | $8.85 \times 10^{-12}$ F/m |
| Permeability of free space, $\mu_0$ | = | $4\pi \times 10^{-7}$ H/m |
| Speed of light in a vacuum, c | = | $3 \times 10^{8}$ m/s |

## SECTION A

1. A thin conductor bent into a circle of radius $a$ as shown in Fig 1.1 is charged with a uniform density $\rho_l$.

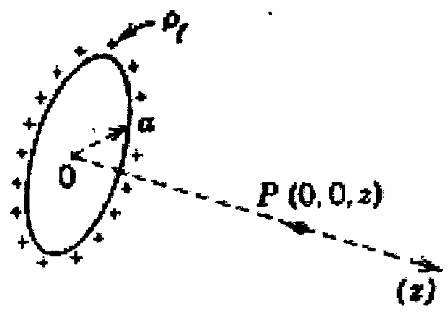


Fig 1.1

(a) Use Gauss' law to show that Electric field intensity $\tilde{E}(0,0,z)$ at any point along the $z$ axis denoted by P (0, 0, z) is

$$\tilde{E}(0,0,z) = \tilde{a}_z \frac{\rho_l a z}{2\epsilon_0 (a^2+z^2)^{3/2}}$$

Here $\tilde{a}_z$ is the unit vector along the z axis which is normal to the plane of the circular conductor.

Sketch roughly $|\tilde{E}|$ versus z to show the variation on either side of the plane of circular conductor.

(12 marks)

(b) Show that the answer to (a) at larger distances from the plane of the circular conductor along the z axis, converges to the electric field intensity created by a point charge, if the answer is expressed in terms of the total charge.

(8 marks)

2. A toroidal iron core of square cross-section, with a 2 mm air gap and wound with 100 turns, has the dimensions shown in Fig 2.1. Assume the iron has the constant $\mu = 1000\mu_0$.

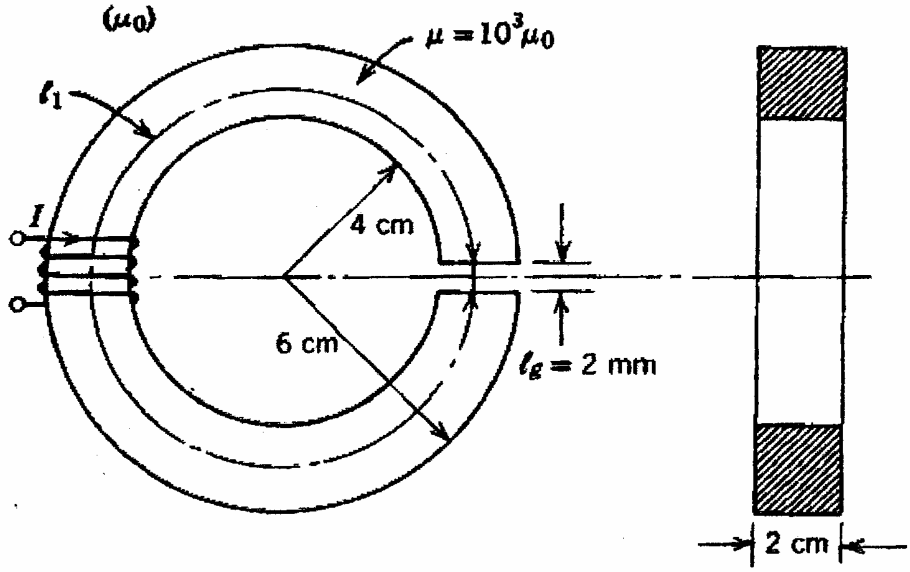


Fig 2.1

Find

(a) the reluctances of the iron path and the air gap, and

(14 marks)

(b) the total flux in the circuit if I = 100 mA.

(6 marks)

3. An X-band rectangular waveguide with a =2.286 cm and b= 1.016 cm has a cutoff frequency of 6.557 GHz for the dominant mode. Find its phase and group velocities at 8.2, 10, and 12.4 GHz.

(20 marks)

4. Assume a two-region system as shown in Fig 4.1. A plane wave arrives at normal incidence in air with the amplitude $100e^{j0^o}$ V/m and a frequency of 100 MHz. The slab is Teflon with $\varepsilon_r = 2.1$

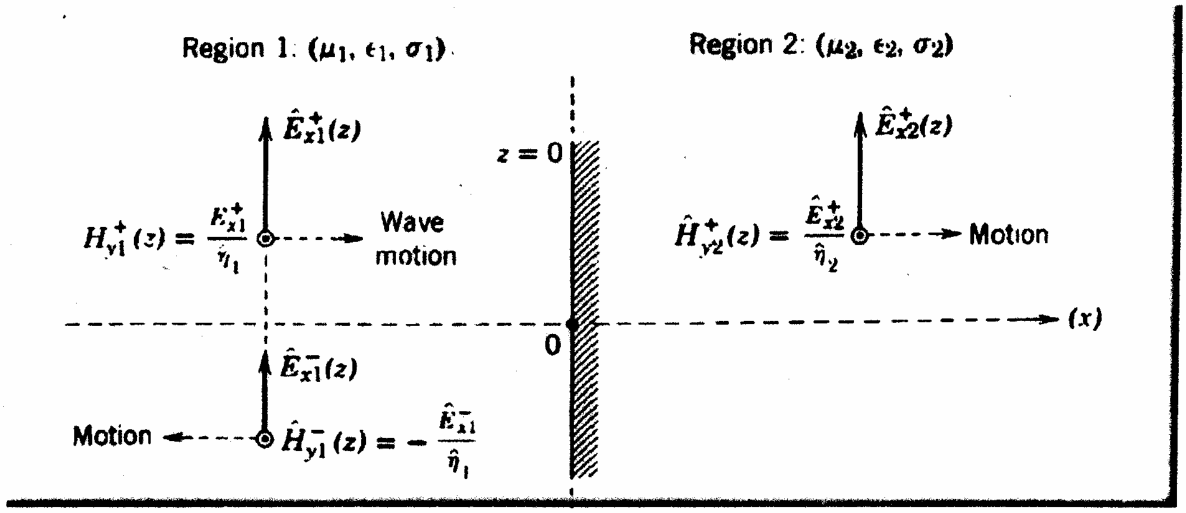

Fig 4.1

(a) What are the intrinsic wave impedance and propagation constant of each region? (10 marks)

(b) Find the complex amplitudes of the reflected and transmitted waves. (10 marks)

## SECTION B

5. (a) Find the first Foster form of network for the driving-point impedance function

$$Z_D(s) = \frac{(s+1)(s+3)}{s(s+2)}$$

(12 *marks*)

(b) Find the partial fraction form of network whose driving-point impedance function $Z_D(s)$ has zeros at s = -2 and -6 and poles at s = 0, -4 and -8. Assume that $Z_D(s) = 1\Omega$ at s = -3.

(8 marks)

6. (a) The circuit of Fig 6.1 was initially in the steady state with the switch S in position a. At t=0, the switch goes from a to b. Find an expression for the voltage $v_0(t)$ for t>0.

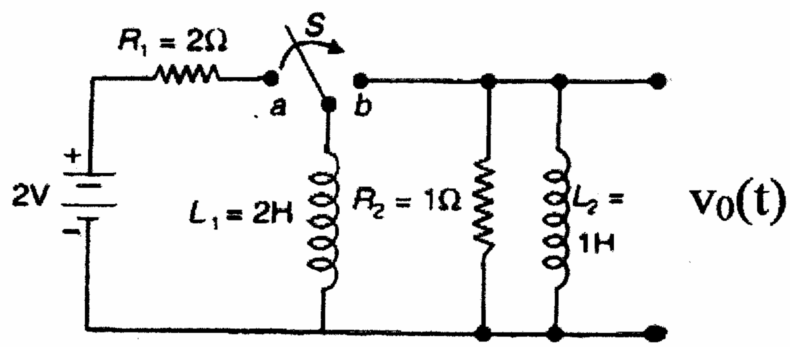


Fig 6.1

(12 marks)

(b) Determine the Fourier transform of the triangular pulse v(t) shown in Fig 6.2

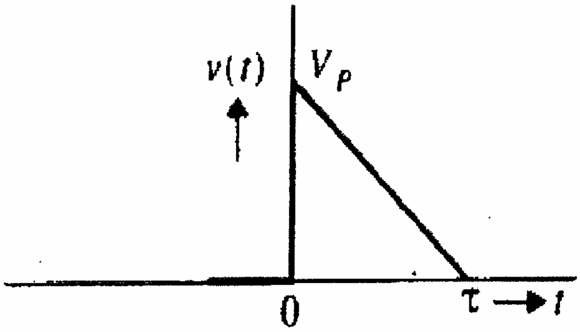


Fig 6.2

(8 marks)

7. Design a third order Butterworth low-pass filter having a cut-off frequency of 1 kHz.
(20 marks)

8. Solve in time domain the state equation,

$$\begin{bmatrix} \dot{v}_C \\ \dot{i}_L \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ -3 & -1 \end{bmatrix} \begin{bmatrix} v_C \\ i_L \end{bmatrix}$$

given $v_C(0_-)$, $i_L(0_-)$

(20 marks)