B.E. (EE) Part-II 4th Semester Examination, 2007

Field and Circuit Theory

(EE-403)

Time : 3 hours **Full Marks : 70**

Use separate answerscript for each half.

Answer SIX questions, taking THREE from each half.

Two marks are reserved for neatness in each half.

FIRST HALF

(In this part all symbols have their usual significance. Letters marked in bold represent vectors.)

1. (a) Show that: (i) Electric field due to a static charge is irrotational field. (ii) $\nabla \cdot \mathbf{D} = \rho_v$, where **D** is the electric flux density vector and ρ_v is the volume charge density.

(b)Show that the energy stored by a system of *n* point charges is given by

$$W = 0.5 \Sigma Q_r \varphi_r ,$$

where φ_r is the potential at the position of the r^{th} charge, due to all other charges except that one. Also show that the energy stored per unit volume in an electric field is (½) **E . D**. [(2+4)+5]

2. (a)What is Poynting vector? Explain its physical significance with the help of Poynting's Theorem.

(b) Given $E = E_m \sin(\omega t - \beta z)\, a_x$ in free space, find the magnetic field intensity **H** and the characteristic impedance Z for free space. [5+(3+3)]

3. Show that for steady currents

$$\nabla \times \mathbf{B} = \mu_o \mathbf{J} .$$

Justify all assumptions made.

Thereafter make appropriate derivations to introduce Maxwell's correction. Clarify why this correction is essential.

(b) Evaluate the force on the square member shown in Fig. 3. Take I = 10 A, a = 20 mm. [7+4]

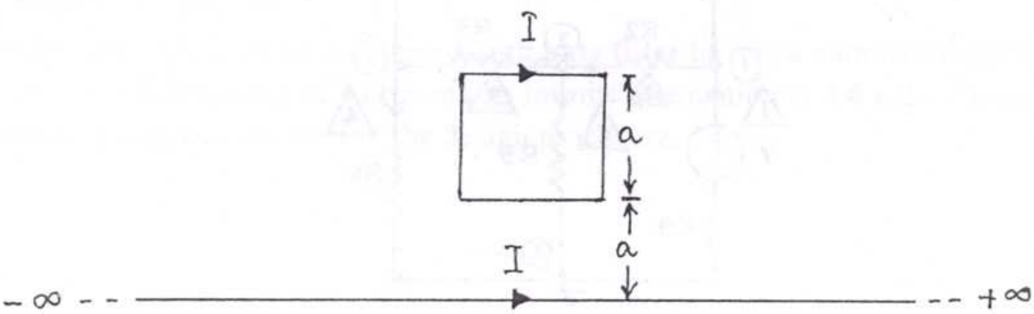

Fig.-3

4. (a) Prove that any vector in a 3-D space is completely defined by specifying its divergence, its curl and its normal component over the boundary.

(b) Show that the magnetostatic boundary condition across a surface carrying a current of **K** A/m is given by

$\mathbf{B}_{above} - \mathbf{B}_{below} = \mu_0 (\mathbf{K} \times \mathbf{n})$, where **n** is the normal unit vector out of the surface.

(c) Show that electromotive force is not a force but work done by the source to move unit charge around a closed electric circuit. [4+5+2]

5. (a) A permanent magnet is 120 mm long and 2 sq. cm in cross section and is bent in the shape of the English letter "D". An air gap of 5 mm exists in the vertical arm of this "D". Calculate graphically the flux density in the air gap. The demagnetisation curve for the material of the permanent magnet is as follows:

B (T) :	0	0.25	0.5	0.75	1.0	1.1	1.25
H(kA/m):	-45	-43	-41	-38	-34.5	-28	0

Neglect leakage and fringing.

(b) The above magnet material is to be used maintain a flux density of 0.7 T across an air gap 2mm long and 15 mm x 25 mm in cross section. Calculate the minimum volume of the material required.

(c) Prove that

$\nabla \cdot (\mathbf{r}/r^2) = 4\pi\delta^3(\mathbf{r})$, where symbols have their usual significance. [4+4+3]

N.B. All capital bold letters represent vectors(or vector operators) and lowercase bold letters represent unit vectors. Other symbols have their usual significance unless otherwise mentioned. You can take the following values of the commonly used physical constants.

$$\mu_o = 4\pi \times 10^{-7}\ \text{H/m}$$
$$\varepsilon_o = 8.854 \times 10^{-12}\ \text{F/m}$$

SECOND HALF

6. a) Draw the oriented graph of the resistive network shown in Fig.6(a). Hence obtain the following :
   i) Reduced incidence matrix
   ii) Number of possible trees of the graph
   iii) Fundamental tie-set matrix for the tree {1, 2, 4}
   iv) Fundamental cut-set matrix for the tree {1, 2, 4}

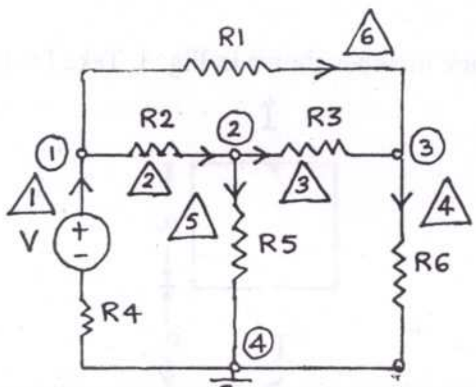

Fig.6(a)

b) What do you understand by dual circuit? Draw the dual of the R-L-C network shown in Fig.-6(b). [7+4]

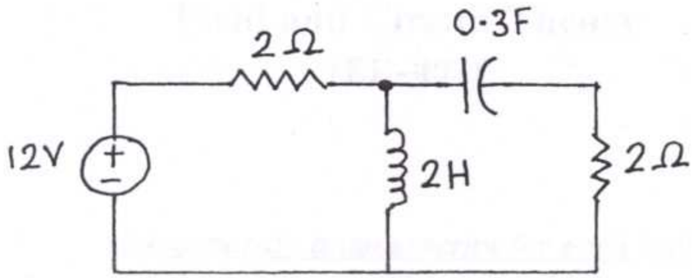

Fig.-6(b)

7. a) State the necessary conditions of stability of a network function.

   b) State the properties of a Hurwitz polynomial. Hence check whether the polynomial $P(s) = s^4 + 11s^3 + 41s^2 + 61s + 30$ is Hurwitz. [5+6]

8. a) Comment and explain the stability of a system with reference to the position of poles in the s-plane.

   b) By means of Routh criteria, determine the stability of the system represented by the following characteristic equation. Wherever necessary find the number of roots in the right half of s-plane and on the imaginary axis.

   $$s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$$ [5+6]

9. a) State the conditions of a network function to be a positive real function. The driving point impedance function is given by

   $$Z(s) = \frac{s^3 + 5s^2 + 9s + 3}{s^3 + 4s^2 + 7s + 9}$$

   Check whether the function is a positive real function.

   b) Realize the following function in First and Second Foster form in R-C format.

   $$Z(s) = \frac{(s+2)(s+5)}{(s+1)(s+4)}$$ [5+6]

10. a) What do you mean by constant –K prototype filter. Why is it so named? Derive the expression of the characteristic impedance and the cut-off frequency of a T-section **low pass filter**.

    b) Design a π-section of an **m-derived high pass filter** having a nominal impedance of **600** ohm, cut off frequency of 4 kHz and an infinite attenuation at **3.6** kHz. Clearly state the necessary expressions used in the design procedure. [5+6]

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