Ex/BESUS/ EE-403/10

B.E. (EE) Part-II 4th Semester Examination, 2010

Field 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.
Graph papers should be supplied.

FIRST HALF

1. a) Derive relations for continuity conditions (or otherwise) of the vector E across any boundary.

b) Evaluate from basic principles the force on the thin triangular frame structure ABC shown in Fig.-1(b), if a shorted coil of 50 mutually insulated turns is wound in a concentrated fashion on it. The coil carries a current of I_1 = 1A through each turn. The value of current through the infinitely long straight conductor is I_2 = ?A. Take ***s*** = 10cm and ***a*** **= 5** cm. Derive the necessary expression.

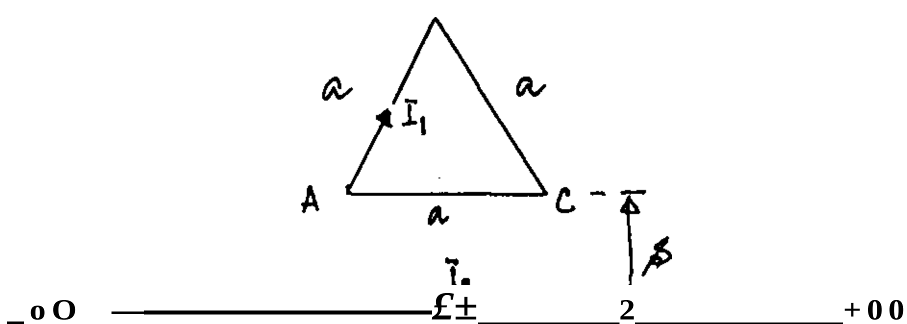

Fig.-1(b)

c) The current rating of a switch-fuse units may be justified considering Joule heating of the fuse. Why does the unit have a voltage rating? |3+6+2|

2. a) Prove that

$$\nabla \cdot E = \rho / \epsilon_0$$

for an electrostatic field.

b) Prove that

$$E = -\nabla V.$$

c) A long co-axial cable carries a uniform volume charge density ρ on the inner cylinder (radius ***a),*** and a uniform surface charge density on the outer cylindrical shell (radius ***b).*** This surface charge is negative and of just the right magnitude so that the cable as a whole is electrically neutral. Find the expression and magnitude of the electric field E in each of the three (i) inside the inner solid cylinder ($r < a$), (ii) between the cylinders $\{b > r > a)$ and (iii) outside the cable $(b > r)$. Plot the magnitude of E as a function of ***r.*** Take a = 1.25 cm. b = 2.75 cm and p $= 2.7 x 10^4$ couloms/cc. Show that there is a discontinuity in E at the surface of the outer cable and justify the same from boundary condition considerations. |2+2+7|

3. a) Prove that

$$V X B = u_Q J$$

for steady d.c. What is the name of this law? Derive the integral form of the same. Show how the above relation may be modified to include the general case of any current steady or non-steady. What is the implication of the extra term introduced?

b) A toroidal air-cored coil has a square toroid cross section of 'S' and a mean radius of 'R\ The coil has N very closely wound turns. It carries a direct current of I. First prove that the flux density vector will only have a circumferential component within the coil tunnel and nothing outside and find its expression both in the tunnel and outside. Evaluate B vector if S = 1 sq. cm., R = 10cm, N = 100 and I = 15 A. |7+4|

4. a) Derive expression for energy stored in a magnetostatic field.

b) Starting from the expressions of energy stored in an electrostatic and field derive expressions for power associated with a general electrodynamic field case of charges moving and currents flowing. Thereafter state Poynting's theorem and highlight the importance of Poynting's vector. Point out that this theorem is in effect a restatement of the conservation of energy principle.

I5+6J

5. a) A permanent magnet is 4 cm long and is made from a material having the following demagnetization curve (table):

B(T)	0.00	0.40	0.70	0.82	0.90	0.94
H (kA/m)	-100	-80	-60	-40	-20	0

Graphically determine the flux density in air gap 2.5 mm long. Neglect leakage and fringing.

b) Determine the minimum volume of a cobalt steel permanent magnet required to maintain a flux density of 0.47 T across an air gap of 2.5 mm in length and having a cross section of 6 sq. cm. Neglect leakage and fringing. Cobalt steel has the following magnetic properties :

Value of B at $(BH)_{max}$ point = 0.6T

Value of H at $(BH)_{max}$ point = 13 kA/m.

Derive any formula used.

c) Explain the basic principle of a superconducting magnetic energy storage system. Draw a block diagram of such a scheme. Mention the criticalities of implementing such a superconducting magnet system. |4+3+4|

N.B. : (i) All symbols have their usual significance.

(ii) Take to $\epsilon_0 = 8.854 \times 10^{-12}$ F/m

$\mu_0 = 4\pi \times 10^{-7}$ H/m wherever necessary.

SECOND HALF

6 a) In the light of graph theory, derive the interrelationship among the following matrices :

(i) Fundamental cut set matrix and branch current matrix

(ii) Reduced Incidence matrix and branch current matrix

(iii) Branch current matrix and loop current matrix

(iv) Fundamental tie-set matrix and branch voltage matrix

Select any linear oriented graph for derivation.

b) The linear oriented graph is shown in Fig.-6(b):

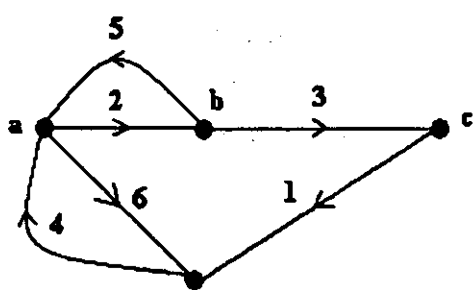

Fig.-6(b)

(i) Find the reduced incidence matrix

(ii) Find the basic cut-set matrix

Select a tree of twigs { 1, 2, 3 } (5+6]

(EE-403)

7 a) Define a Hurwitz polynomial. State and explain its properties,

b) Check whether the following polynomial is Hurwitz or not.

$$Q(s) = s^5 + 3s^3 + 2s$$ [5+6[

8 a) State Routh-Hurwitz criteria for stability of a system. Explain the effect of poles on s-plane on stability of a system at the following locations:

(i) Simple pole on positive real axis

(ii) Complex pole in the left half of s-plane

Draw the response in the time domain.

b) Determine the number of roots with positive real parts, zero real parts and negative real part for the system having the following characteristic equation using Routh-Hurwitz criteria. Hence comment on the stability of the system.

$$s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$$ [5+6]

a) Check whether the following function is a positive real function :

„, ^ $s^2 + s + 1$

F(s) = 1*7777

b) Determine the Foster first form in R-C format for the following driving point impedance function.

$$Z(s) = \frac{3(s+2)(s+4)}{s(s+3)}$$

15+6 [

0 a) What are the different types of classical filters? Derive the expression of characteristic impedance and cut-off frequency for a symmetrical high pass % network filter.

b) Design an m-derived T-network high pass filter with a design impedance R_0 = 900 O, cut off frequency f_c=2 kHz and frequency at infinite attenuation fco=1.8kHz. [5+6[