B.E. (Electrical) Part II 4th Semester Final Examination, 2012

Field and Circuit Theory (EE-403)

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

Answer any SIX questions taking THREE from each half
Two marks are reserved for neatness in each half
Everywhere bold symbols represent vectors
Figures in the margin indicate marks

First Half

1. (a) Starting from the expressions of energy stored in an electric field and magnetic field in static cases, derive the necessary relations to state and explain Poynting's theorem. Show that in effect it is a restatement of the law of conservation of energy. Clarify the implications of the different terms.
(b) Show that for an electrostatic field, $\nabla \times \mathbf{E} = 0$.
(c) Show that a time varying magnetic field '**B**' gives rise to an electric field.
[6 + 3+ 2]

2. (a) Derive expressions for energy stored in an electrostatic field.
(b) Show that potential difference V_{AB} between two points A and B in space is independent of the choice of the reference point.
(c) Find the energies associated with a uniformly charged spherical shell and that of a uniformly charged solid sphere for the same radius 'R' and same net charge 'Q'. If the solid sphere is metallic, determine, through appropriate logic, whether it can maintain its uniform volume charge distribution in the steady state.
[5 + 1 + 5]

3. (a) A uniform C-shaped permanent magnet (PM) has a mean length of 8cm with an air-gap 5mm long. The material of the PM has a B-H characteristic given by the table below:

B(T)	0	0.4	0.7	0.82	0.9	0.94
H(kA/m)	-100	-80	-60	-40	-20	0

Determine the flux density in the air-gap. Neglect leakage and fringing.
(b) Cobalt steel has the following B-H characteristic (w.r.t 2nd quadrant):
B at max energy density point = 0.6 T
H at max. energy density point = 13 kA/m (2nd quad)
Determine the minimum volume of a cobalt steel based PM required to maintain a flux density of 0.45 T in an air gap of length 2 mm and area 6 sq. cm. Neglect leakage and fringing.

(c) Compare the energy density of a steady electrostatic field (**E**) associated with normal atmospheric air just below its breakdown strength with regard to the energy density of the magnetic field (**B**) associated with a typical electrical steel sample just below its saturation. Take standard magnitudes for E and B above.

[5 + 4 +2]

4. (a) Prove that

$$\nabla \cdot \mathbf{B} = 0.$$

(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 out of the surface.

(c) Show that 4(a) above mathematically implies that magnetic fields must have vector potential A as its basis. How is A related to the concept of flux ϕ?

[5 + 4 +2]

5. (a) Analytically derive the force on an *n*-turn shorted coil, carrying a dc of *I* amperes, mounted on an equilateral triangular frame of sides *a* and placed above a very long straight wire carrying the same current. The 'base' of the triangular frame is parallel to the wire and nearest to it and their current directions are also parallel. The separation between the frame base and the wire is also *a*. Evaluate the force when a= 0.25 m, n=10, I = 50A.

(b) Show that a toroidal-coil with closely packed turns and carrying a steady dc has only a circumferential magnetic field component and that too is restricted in the tunnel within the coil. **[6 + 5]**

[**N.B.** : All capital bold letters represent vectors(or vector operators) and lowercase bold letters represent unit vectors. Symbols have their usual significance. Take $\varepsilon_O = 8.854 \times 10^{-12}$ F/m and $\mu_O = 4\pi \times 10^{-7}$ H/m, wherever needed.]

SECOND HALF

6. (a)For the linear oriented graph shown in figure. 6a obtain the fundamental tie sets and fundamental tie set matrix and basic cut sets and basic cut set matrix. **[5]**

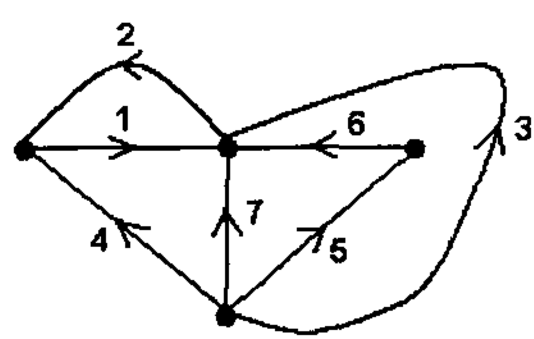

Fig. 6a

(b) Find the dual network for the network shown in Fig. 6b. [6]

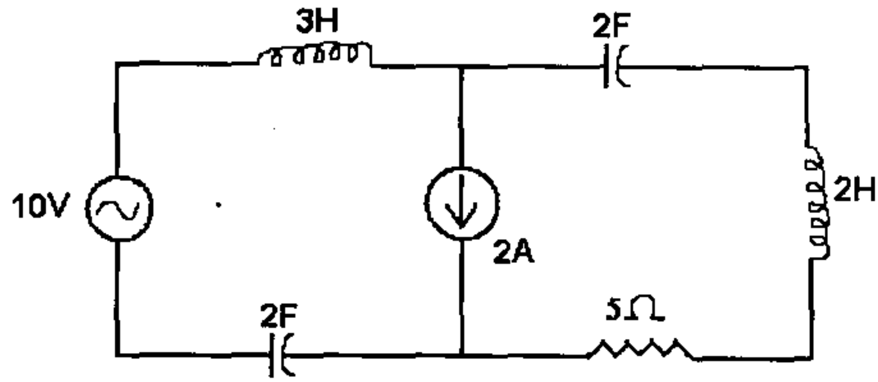

Fig. 6b

7. (a) Define a Hurwitz polynomial. State and explain its properties. [5]
   (b) Check whether the following polynomial is Hurwitz or not.
   $$Q(s) = s^5 + 3s^4 + 3s^3 + 4s^2 + s + 1$$ [6]

8. (a) Check whether the following function is a positive real function: [5]

$$F(s) = \frac{s^2 + 6s + 5}{s^2 + 9s + 14}$$

   (b) The characteristic equation of a system is given by $s^5 - s^4 - 2s^3 + 2s^2 - 8s + 8 = 0$. Comment on the stability of the system using Routh Hurwitz criteria and hence find the number of roots with positive real part, zero real part and negative real part. [6]

9. (a) Synthesize the given admittance function in second Foster form in RC format. [5]

$$Y(s) = \frac{(s+1)(s+6)}{(s+2)}$$

   (b) Realize the following impedance function in Cauer-II form of RC network. [6]

$$Z_{RC}(s) = \frac{2(s+2)(s+4)}{(s+1)(s+3)}$$

10. (a) Develop an m-derived π-section filter from its equivalent prototype. [5]

   (b) In a filter section it is required to have a cut-off frequency of 1.2 MHz and a frequency of infinite attenuation 1.3 MHz. If the nominal impedance of the line into which the filter is to be inserted is 600 ohm, determine suitable component values if the filter section is an m-derived π type. [6]