2507/305
ELECTROMAGNETIC FIELD
THEORY
June/July 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AVIONICS OPTION)

MODULE III

ELECTROMAGNETIC FIELD THEORY

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non-programmable scientific calculator.
Answer ***FIVE*** *of the* ***EIGHT*** *questions in the answer booklet provided.*
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 6 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

1. (a) Table 1 shows some waves in the electromagnetic spectrum. Complete the table for the wave properties.

Table 1

S/No	Electromagnetic wave	Source	Application	Detector
1	Ultraviolet			
2	X-ray			
3	Gamma Ray			

(9 marks)

(b) Explain the principle of operation of the Geiger Muller counter to detect ionizing radiations.

(6 marks)

(c) (i) Arrange the following types of ionizing radiations in the order of penetration abilities through human tissue.

(I) Alpha;
(II) Beta;
(III) Gamma rays.

(ii) State **two** reasons why paraffin wax/plastic is the most preferred medium for shielding Gama radiations.

(5 marks)

2. (a) Define each of the following terms as applied in electrostetics:

(i) electric flux;
(ii) electric flux density.

(2 marks)

(b) Explain the process of polarization of dipoles in dielectric materials placed in an electrostatic field.

(6 marks)

(c) (i) Show that the electric field (E) on a charge (Q) due to stationery charges q_1, q_2, q_3 ... q_n located at distances r_i is given by:

$$E = \frac{F}{Q} = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n} \frac{Q_i r_i}{r_i^2}$$

(6 marks)

(ii) Figure 1 shows a circular loop of radius r carrying a uniform line charge of density λ per meter length. Obtain an expression for the electric field E at a distance Z_0 above the centre of the loop.

(6 marks)

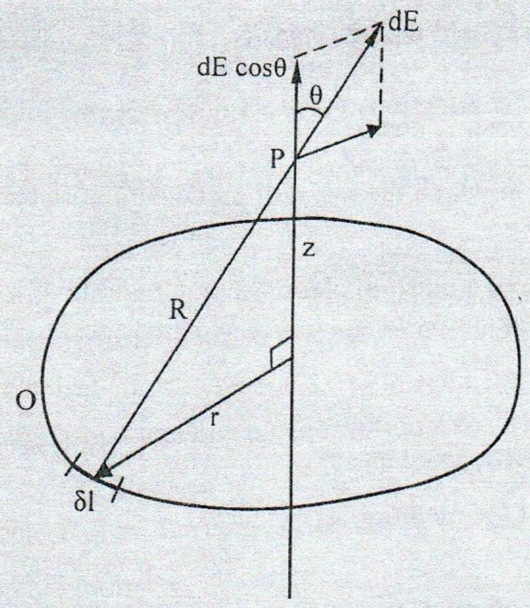

Fig. 1

3. (a) A typical vacuum tube accelerates electrons in a 10^4 Vm^{-1} electric field. Calculate the:

(i) resulting electron velocity $V_{(t)}$ if it starts from rest;

(ii) time taken for the electron to transit the 1 cm tube. (8 marks)

(b) Figure 2 shows a circular coil with N loops, placed in a uniform magnetic field β aligned with the loop axis. Describe the effect of pulling it suddenly at two points along a diameter so that the coil collapses to a linear array of wires in a time, T.

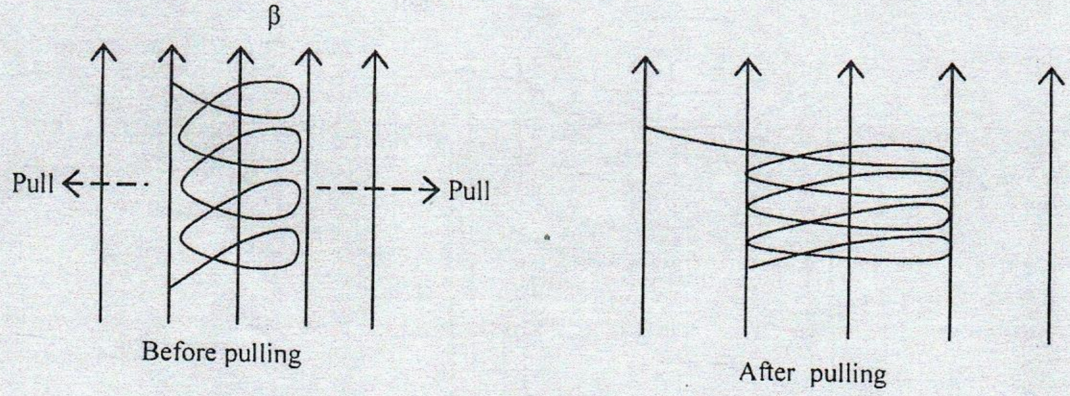

Fig. 2

(6 marks)

(c) A material whose conductivity (σ), is 5.0 S/m and relative permittivity $\varepsilon_r = 1$, is placed in an electric field whose intensity, $E = 250\sin 10^{10}t\left(\frac{V}{M}\right)$. Determine the:

(i) conduction current density;
(ii) displacement current density;
(iii) frequency, f, at which the two current densities are the same. (6 marks)

4. (a) The electric field (E) of a uniform plane wave in a lossless isotropic medium and uniform dielectric is given as:

$E = (5a_y + j10a_z)e^{j2x}\frac{V}{M}, f = 50MHZ, where\ \mu_r = 1$. Calculate the:

(i) phase velocity, Vp;
(ii) permitivity of the medium, ε_r. (7 marks)

(b) State **four** properties of an electromagnetic wave propagating in a vacuum. (4 marks)

(c) (i) Describe Gauss law of electrostatics. (3 marks)
(ii) Figure 3 shows a cylinder containing a uniform charge whose density is $\ell\frac{C}{m^3}$. Determine electric flux density D at:

(I) $0 < r < 3m$;

(II) $3 \leq r \leq 6m$. (6 marks)

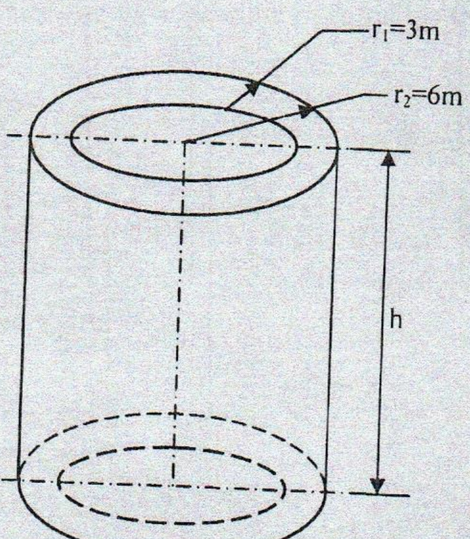

Fig. 3

5. (a) A stripline consists of two-strips of width a = 2 cm, distance between them, d = 2mm, and the thickness of the strips, b = 1 mm. The line carries a time -harmonic current of rms value I = 0.5 A and frequency f = 1 GHZ. The strips are made of copper. Neglecting fringing effect, determine the:

(i) line resistance;
(ii) total inductance per unit length. (9 marks)

(b) A plane wave has components Ex and Ey:

(i) show that the vector E is normal to vector H;
(ii) evaluate the poynting vector for b (i) above. (8 marks)

(c) A solenoid of length L = 0.6 m and circular cross-section of radius 0.025 m has 250 turns. Determine its inductance. (3 marks)

6. (a) Express the four Maxwell's equation in point form. (8 marks)

(b) The electric field density in free space is given by:

$E = 10\sin(wt - 5Z)\underset{\sim}{a}y$. Determine expressions for:

(i) electric flux density $\underset{\sim}{D}$;

(ii) magnetic flux density $\underset{\sim}{B}$;

(iii) magnetic field strength $\underset{\sim}{H}$. (8 marks)

(c) Explain the relations of magnetic fields at the boundary of two media. (4 marks)

7. (a) Explain skin depth as applied in electric conducting materials. (5 marks)

(b) A 2-mil copper foil has conductivity, $\sigma, 5.7 \times 10^7 \frac{s}{m} at\, 100\, MHZ$. Calculate:

(i) its skin depth;
(ii) the shielding effectiveness. (9 marks)

(c) With the aid of sketches, differentiate between near field shielding and plane-wave shielding. (6 marks)

8. (a) Differentiate the following terms as applied in magnetostatics:

(i) magnetic field strength (H);
(ii) magnetic flux density (β). (2 marks)

(b) (i) State the Ampere's current law.

(ii) A current filament of 5.0 A in the $\underset{\sim}{a}_y$ direction is parallel to the y-axis at $x = 2$ m, $Z = -2$ m. Determine the magnetic field intensity, H.

(8 marks)

(c) Figure 4 shows a diagram of a thick slab extending from $Z = -9$ to $Z = 9$ carrying a uniform volume current $J = J_2$. Determine the magnetic field at:

(i) inside the slab;

(ii) outside the slab.

(10 marks)

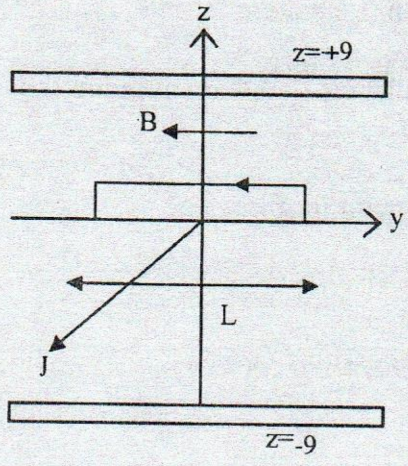

Fig. 4

THIS IS THE LAST PRINTED PAGE.