2507/305
ELECTROMAGNETIC FIELD THEORY
Oct./Nov. 2022
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.
*This paper consists of **EIGHT** questions.*
*Answer any **FIVE** of the **EIGHT** questions in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

Take: Permittivity of free space, $\varepsilon_0 = 8.854 \times 10^{-12}\ F/M$
Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} H/M$

This paper consists 5 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) (i) Explain the term electromagnetic radiation.

(ii) Outline three sources of radiations in (a) (i). (5 marks)

(b) State **six** types of electromagnetic waves. (6 marks)

(c) Explain each of the following characteristics of electromgnetic waves:

(i) wavelength;

(ii) amplitude;

(iii) frequency.

(6 marks)

(d) List **three** types of detectors used to detect electromagnetic waves. (3 marks)

2. (a) Explain electric flux density in electrostatics. (2 marks)

(b) A positive charge of $2\mu C$ is placed at (0, 2)m and another of $-7\mu C$ at (0, −2)m.

(i) Sketch the arrangement of the charges;

(ii) Determine at a point (0, −1)m the value of $\overline{E}$.

(10 marks)

(c) Explain each of the following terms as used in magnetostatics:

(i) magnetic field strength;

(ii) magnetic flux.

(4 marks)

(d) Two long parallel wires each carrying a current of 2A are separated by a distance of 1.5 m. Determine the force between them. (4 marks)

3. (a) State Maxwells equation in differential form citing the laws represented in each case. (8 marks)

(b) Explain the following with relation to electromagnetic waves:

(i) Propagation constant:

(ii) attenuation constant.

(4 marks)

(c) In a lossless transmission line the velocity of propagation is $3\times 10^{8} m/s$ and the capacitance is $40\ pF/m$. Determine the:

(i) phase constant at a frequency of 120×10^{6} Hz;

(ii) Characteristic impedance of the line.

(8 marks)

4. (a) (i) Explain 'electromagnetic shielding'.

(ii) State **three** materials used to achieve electric shielding.

(5 marks)

(b) (i) Explain skin effect in relation to electromagnetic waves.

(ii) Outline **four** factors that affect skin effect.

(10 marks)

(c) A lossless transmission line has a characteristic impedance of $75\ \Omega$ and a phase constant of 4 rad/sec at a frequency of 150 MHz. Determine the capacitance of the line per metre. (5 marks)

5. (a) Describe the energy conservation theorem. (2 marks)

(b) (i) Explain magnetostatic field energy density.

(ii) State 'Poynting Vector'.

(4 marks)

(c) (i) State **three** configurations of current distribution in magnetostatic fields.

(ii) Determine the ration of free space wavelength to wavelength in a conductor with $\tau = 10^{6} mho/m$ and $\mu r = 6$ at a frequency of 12×10^{3} Hz.

(10 marks)

(d) A transmission line has the voltage minima 0.2 m from the load and the distance between two consecutive minima is 24 cm. Determine the unknown frequency.

(4 marks)

6. (a) Table 1 shows magnetic quantities and their SI units. Complete the table. (6 marks)

Table 1

Magnetic quantity	SI units
Magnetic field density	
Magnetic moment	
Permeability	
Magnetisation	
Energy product	
Susceptibility	

(b) With the aid of diagrams explain the steps involved in plotting B-H curve using the 'step by step' method. (11 marks)

(c) (i) State Gauss' law for magnetic field.

(ii) Write the expression of the law in (c) (i) in integral form. (3 marks)

7. (a) (i) State 'amperes circuital law' in integral form.

82

(ii) List **four** applications of amperes circuital law. (6 marks)

(b) Derive the expression for energy stored in a magnetic field. (6 marks)

(c) (i) Explain divergence with reference to electromagnetics.

(ii) Determine the divergence of the following vector field at the given point.

$\overline{A} = yz\tilde{a}x + 4xy\tilde{a}y + y\tilde{a}z$ at (1,-2,3) (8 marks)

8. (a) (i) Explain 'Biot-Savart law'.

(ii) Write the equation of the law in (a) (i) and define its elements. (5 marks)

(b) With the aid of a diagram explain dot product. (5 marks)

(c) State the **three** co-ordinate systems used in electromagnetics. (3 marks)

(d) Figure 1 shows four identical charges of $Q = 1nC$ each situated at corners of 1 m side. Determine the total energy stored by the charges. (7 marks)

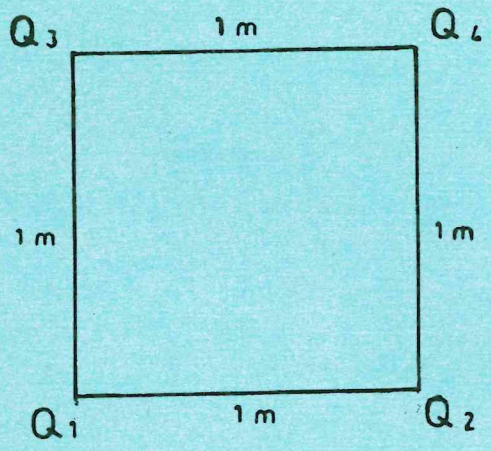

Fig. 1

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