2507/305
ELECTROMAGNETIC FIELD THEORY
June/July 2019
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 **FIVE** questions in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
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 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.

Turn over

1. (a) List **three** sources of electromagnetic waves. (3 marks)

(b) Table 1 shows an electromagnetic spectrum. Complete the table. (9 marks)

Table 1

S/No	Type of work	Source	Detector	Wavelength (λ)
1.	Radio wave			
2.	Infra red waves			
3.	Gamma rays			

(c) (i) Define each of the following with respect to electromagnetic waves:

(i) frequency;
(ii) wave speed;
(iii) period.

(3 marks)

(ii) Draw a linearly polarized electromagnetic wave propagating from left to right on the X-axis plane. (5 marks)

2. (a) State Coulomb's law. (2 marks)

(b) The force on a 50 μC point charge at (0, 0, 5) m due to a charge of 500 $\pi\mu$C is uniformly distributed over the circular disc $r \leq 5$ m, $Z = 0$ m.

(i) sketch the disk on the x, y, z planes;

(ii) determine the charge density exerted on the point charge. (5 marks)

(c) (i) State Gauss Law.

(ii) With the aid of a diagram, derive the relationship between flux density and electric field intensity. (10 marks)

(d) Highlight **three** conditions, of a special Gaussian surface. (3 marks)

3. (a) Describe 'potential between two points' with respect to electrostatic fields. (2 marks)

(b) (i) State Biot-Savart law in integral form.

(ii) With the aid of a diagram, describe Biot-Savart law.

(8 marks)

(c) (i) List the properties of the curl operator.

(ii) State the Maxwell's equations, in intergral form.

(10 marks)

4. (a) Define each of the following with respect to electromagnetic waves.

(i) polarisation;
(ii) standing waves;
(iii) poynting vector.

(3 marks)

(b) State the equation of intrinsic impedances of each of the following media:

(i) partially conducting medium;
(ii) conducting medium;
(iii) free space.

(6 marks)

(c) A material has $\mu r = 1$, Er = 8 and $\sigma = 0.25$ p S/m.

The wave frequency is 1.6 mHz:

(i) determine the propagation constant;
(ii) state, with a reason, the nature of the material used.

(11 marks)

5. (a) List **four** properties of an electromagnetic wave. (4 marks)

(b) (i) Describe skin depth as used in electromagnetic waves.

(ii) Figure 1 shows a field $E = 1.0^{-az} e^{j(wt-\beta Z)} ax$ (V/m) with frequency f = 100 MHz at the surface of a conductor and is located at Z > 0. Conductivity $\sigma = 58$ M S/m

Determine the:

(I) magnitude of the field at depth Z;
(II) depth of penetration.

(9 marks)

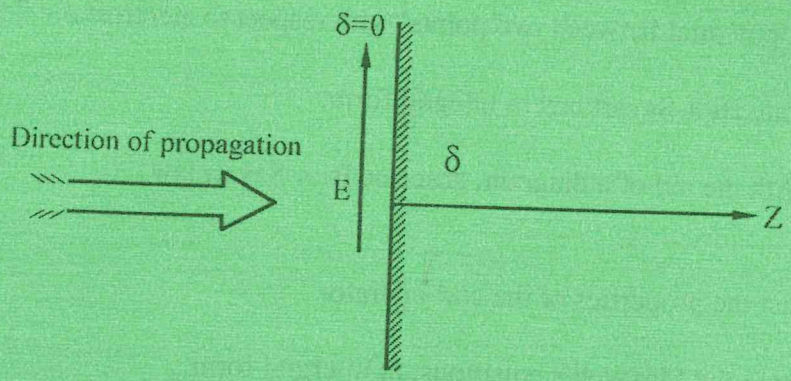

Fig. 1

(c) Define each of the following as used in electromagnetic waves:

(i) wavelength;
(ii) phase velocity;
(iii) propagation constant.

(3 marks)

(d) Describe each of the following types of radio waves:

(i) space;
(ii) ground.

(4 marks)

6. (a) State the following with respect to electromagnetic waves:

(i) Faraday's law;
(ii) Ampere's law.

(4 marks)

(b) Table 2 shows values obtained from a magnetisation test.

(i) Draw the hysteresis curve.
(ii) From the hysteresis curve, determine the:

(I) residual flux;
(II) coercive force;
(III) negative saturation.

(9 marks)

Table 2

H (A_{TIM})	0	1000	2000	3500	5000	2500	500	0	-500	-1500	-3000	-4500	-5000	-6000	-3000	0	1500	3000	4500	5000
B (wb/m^2)	0.0	0.4	0.7	0.9	0.9	0.85	0.7	0.55	0.4	0	-0.4	-0.8	-0.82	-0.82	-0.75	-0.5	0	0.6	0.9	0.9

(c) An iron ring of 20 cm mean diameter having a cross section of 100 cm^2 is wound with 400 turns of wire. The flux density established is 1 wb/m^2.
The relative permeability of iron is 1,000.
Determine the:

(i) exciting current;
(ii) energy stored in the ring.

(7 marks)

7. (a) Describe Energy Density as applied in electromagnetic field. (3 marks)

(b) (i) Describe magnetostatic field energy as used in electromagnetic waves.

(ii) A lossless air dieletric waveguide for an S-band radar has inside dimensions a = 7.214 cm, and b = 3.404 cm.

A transverse mode (TM_{11}) wave propagates at an operating frequency that is 1.1 times the cut off frequency of the mode.

Determine the:

(i) critical wave number;
(ii) cut off frequency;
(iii) operating frequency;
(iv) propagating constant.

(10 marks)

(c) (i) With the aid of a schematic diagram describe Ohmic heating.

(ii) List **two** merits of Ohmic heating.

(7 marks)

8. (a) Describe radiometry as applied in electromagnetic wave theory. (2 marks)

(b) (i) Distinguish between radiance and irradiance as used in electromagnetic waves.

(ii) With the aid of a diagram, describe the photometric detection as used in electromagnetic waves. (9 marks)

(c) Four identical point charges of Q = 4nC are placed at the corners of a square of side 1m. Determine the:

(i) stored energy;
(ii) stored energy when two charges at opposite corners are removed.

(9 marks)

THIS IS THE LAST PRINTED PAGE.