2507/305
ELECTROMAGNETIC FIELD THEORY
Oct./Nov. 2018
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;
Drawing instruments;
Mathematical tables/Non-programmable scientific calculator.
*This paper consists of **EIGHT** questions.*
*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 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) State the laws of electrostatics. (4 marks)

(b) The $\alpha-$particles are 10^{-13} m apart in free space. The charge of each $\alpha-$ particle is 3.2×10^{-19} C and its mass is 6.68×10^{-27} kg.

Determine the:

(i) electrostatic force of repulsion between the two particles;

(ii) force of gravitational attraction between the two particles if the gravitational constant is $6.67\times10^{-11}\ N-m^2/kg^2$.

(6 marks)

(c) State Gauss's law and write its equation in integral form. (3 marks)

(d) (i) Sketch the magnetic field pattern between:

I. North and South poles;
II. North and North poles.

(4 marks)

(ii) State **three** factors that determine the force between two magnetic poles in a medium. (3 marks)

2. (a) State Faraday's law and write its equation in integral form. (4 marks)

(b) Sketch the magnetic field patterns for two parallel conductors carrying current in the same direction when placed close to each other. (6 marks)

(c) Two long straight parallel wires placed 2 m apart in air, carry current I_1 and I_2 in the same direction. The magnetic intensity at a point midway between the wires is 7.95 AT/m. The force on each wire per unit length is $2.4\times10^{-4}\ N$.
Determine current I_1 and I_2. (8 marks)

(d) Table 1 shows the analogy between electric and magnetic circuit parameters. Complete the table.

Table 1

S/No	Electric circuit	Magnetic circuit
1.	Current	flux
2.	Inductance	Reluctance

(2 marks)

3. (a) Highlight **four** properties of an electromagnetic wave. (4 marks)

(b) Describe each of the following media:

(i) lossy medium;

(ii) lossless medium.

(4 marks)

(c) Describe each of the following Maxwell's equations:

(i) Gauss's law for the magnetic field; $\nabla \cdot D = \rho$

(ii) Ampere law. $\nabla \times H = J_c + \frac{\partial D}{\partial t}$

(6 marks)

4. A parallel - plate capacitor has plates 0.15 mm apart and a dielectric with relative permittivity of 3. The surface plate charge is $5 \times 10^{-4}\ \mu C/cm^2$. Determine the: $\varepsilon_0 \varepsilon_r$

(i) electric field intensity;

(ii) voltage.

(6 marks)

5. (a) With the aid of a diagram, describe the step by step method of determining hysteresis loop. (10 marks)

(b) Table 2 shows values of $H(AT/\mu)$ and $B(Wb/m^2)$:

(i) plot the curve;

(ii) determine from the curve the value of:

I. coercive force;
II. remanent flux;
III. saturation flux.

(10 marks)

Table 2

$B[Wb/m^2]$	0	0.15	0.4	0.52	0.56	0.6	0.6	0.55	0.35	0.25	0.1
$H[ATm]$	0	100	300	500	700	800	700	300	100	0	-100

0	-0.2	-0.42	-0.5	-0.5	-0.4	-0.2	0.1	0.3	0.5	0.6
-200	-300	-500	-700	-600	-200	0	200	400	600	300

5. (a) Table 3 shows parameters of different electromagnetic waves. Complete the table.

Table 3

S/No.	Radiation Type	Wave length (m)	Frequency (Hz)
1.	Radio wave		
2.	Microwave		
3.	Infra-red wave		
4.	Ultra violet wave		

(8 marks)

(b) With the aid of waveforms, distinguish between constructive and destructive electromagnetic interferences. (6 marks)

(c) A circular cross-section conductor of radius 1.5 mm carries a current.

$I_c = 5.5\sin[4 \times 10^{10} t]\mu A$.

The conductivity of the conductor is $35\ MS/m$ and its relative permittivity is 1. Determine the amplitude of the displacement current density. (6 marks)

6. (a) State **two** applications of each of the following waves:

(i) radio;

(ii) infra-red;

(iii) ultra violet. (6 marks)

(b) Highlight **two** sources of electromagnetic radiation. (2 marks)

(c) With the aid of a diagram, describe the operating principle of an electromagnetic flowmeter. (7 marks)

(d) An electromagnetic flowmeter is used to measure the average flow rate of an affluent in a 50 mm diameter pipe. The velocity profile is symmetrical and uniform. The flux density in the liquid has a peak value of $0.1\ Wb/m^2$. The output from the flowmeter electrodes is fed to an amplifier of gain 1,000. The impedance between the electrodes is $250\ k\Omega$ and the load is $2.5\ M\Omega$. Determine the:

(i) voltage under load conditions;

(ii) effluent average velocity when the peak to peak voltage at the amplifier output is 0.2 V. (5 marks)

7. (a) (i) State the law of conservation of energy. (2 marks)

(ii) Describe **two** forms of energy. (4 marks)

(b) A surface, S consists of that part of the cylinder $x^2 + y^2 = 9$ between z = 0 and and z = 4 for $y \geq 0$ and the two semi-circles of radius 3 in the planes z = 0 and z = 4.
The magnetic field on the surface is given by:

$F = zi + xyj + xzk$.

(i) sketch the surface;

(ii) evaluate $\int_s$ curl F.ds over the surface. (10 marks)

(c) Describe **two** limitations associated with the Poyntings vector analysis. (4 marks)

8. (a) (i) Describe the Poynting theorem.

(ii) Show that the work done by an electromagnetic wave is given by:

Work done = qv.E

Where q= charge; V = Volume; E = Electric field.

(8 marks)

(b) Table 4 shows various waves of electromagnetic spectrum. Complete the table.

(6 marks)

Table 4

S/No	Radiation	Detector	Use
1.	Gamma Rays		
2.	X-rays		
3.	Infra-Red Rays		

(c) A material has relative permeability and relative permittivity of 1 and 8 respectively. The conduction current density is 0.25 pS/m. The frequency of propagation is 1.6 MHz. Determine the propagation constant, γ, of the material.

(6 marks)

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