2507/305
ELECTROMAGNETIC FIELD THEORY
June/July 2020
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 4 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 **four** sources of electromagnetic radiations. (4 marks)

(b) Draw the electromagnetic spectrum in the order of reducing wave length. (6 marks)

(c) (i) Define Gauss's law.

(ii) Four electric charges Q_1, Q_2, Q_3 and Q_4 having charges 6pC, 5pC, 3pC and -2pC respectively, are enclosed in a surface. Determine the total flux enclosed by the surface.

(7 marks)

(d) Outline **three** uses of electromagnetic waves. (3 marks)

2. (a) (i) Define 'electric field intensity' as used in electrostatic fields.

(ii) Derive the expression for electric field intensity due to a live charge.

(6 marks)

(b) Three point charges are situated 0.12 m apart in a straight line.

$Q_1 = 3\mu C, Q_2 = -2\mu C, Q_3 = 3\mu C.$ Charge Q_2 is at the centre.

(i) draw the arrangement;

(ii) determine the force on each charge due to the other two.

(9 marks)

(c) A parallel plate capacitor has a constant voltage V applied across the plates. Determine the expression for stored energy in the electric field. (5 marks)

3. (a) Describe each of the following as used in electromagnetic waves:

(i) transverse electromagnetic;

(ii) transverse electric waves.

(4 marks)

(b) (i) Define 'wave' with reference to electromagnetic fields.

(ii) State **four** properties of a plane wave.

(6 marks)

(c) A parallel plate wave guide consists of two parallel perfectly conducting infinite plates situated 9 cm apart. Assuming free space between the plates and the frequency of propagating wave is 5000 MHz; determine the TE_{mo} modes for the wave. (7 marks)

(d) Describe electromagnetic shielding as applied to electromagnetics. (3 marks)

4. (a) Explain Biot-Savart's law in magnetostatic fields. (4 marks)

(b) A square loop of $25\,cm^2$ has 20 turns and carries a current of 15 amperes. Determine the flux density at the centre of the loop. (3 marks)

(c) Explain each of the following in magnestostatics:

(i) magnetic flux;
(ii) magnetic field strength.

(6 marks)

(d) (i) State ampere's circuit law in magnetostatics.
(ii) The magnitude of $\overline{H}$ at a radius of 2 m from a long linear conductor is 2 amperes per meter. Determine the current in the wire.

(7 marks)

5. (a) Write Maxwell's equation for static fields in differential and integral forms.

(8 marks)

(b) Describe 'displacement current' in time varying fields. (6 marks)

(c) A homogeneous region has $\mu_r = 1, \varepsilon_r = 55$ and $\lambda = 1.82$. Determine the:

(i) value of propagating frequency;
(ii) phase velocity.

(6 marks)

6. (a) (i) State the divergence theorem as used in electromagnetic field theory.
(ii) Write the expression in mathematical form in (i).

(4 marks)

(b) State **three** properties of a curl with reference to electromagnetic waves. (3 marks)

(c) In free space $\overline{E} = 40\cos(\omega t - 60x)\hat{a}y\,V/m$. Determine:

(i) the value of displacement current density;
(ii) angular velocity ω.

(6 marks)

(d) Determine the magnetic field strength H for the vector $\overline{E}$ in (c). (7 marks)

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

(b) Explain poynting theorem is relation to electromagnetic waves. (4 marks)

(c) From the total energy density $= \frac{1}{2}(\in \overline{E^2} + \mu H^2)$, derive the expression for the power flow for a plane wave. (6 marks)

(d) A uniform plane wave of an electric field with amplitude 280 V/m is propagating along the z − axis. If $\overline{E} = E\hat{a}_x$ and $\omega = 1.2\, m\, rad/$ sec; determine the:

(i) frequency of propagation;
(ii) wavelength;
(iii) time period.

(8 marks)

8. (a) With the aid of a diagram, describe the hysteresis loop. (7 marks)

(b) (i) State Faraday's law as used in electromagnetic fields.
(ii) Write the mathematical expression of (b) (i).

(4 marks)

(c) A lossless transmission line is 0.2 m long and operates at a frequency of 650 MHz. The line parameters are:

Inductance $L = 0.2\, \mu H/m$ and
Capacitance C = 100pF/m.

Determine the:

(i) characteristics impedance;
(ii) phase velocity.

(9 marks)

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