UNIVERSITY OF EMBU

2016/2017 ACADEMIC YEAR

SECOND SEMESTER EXAMINATION

FIRST YEAR EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS

SPH 604: ELECTRODYNAMICS

DATE: APRIL 11, 2017 **TIME: 2:00-5:00PM**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants:

$c = 3.0\times10^{8}$ m/s

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg

Plank's constant $h = 6.6 \times 10^{-34}$ JS

$\square_0 = 8.86 \times 10^{-12}$ C^2/Nm^2

QUESTION ONE (30 MARKS)

a) Describe plasmas. (4 marks)

b) Explain scalar potential. (3 marks)

c) Describe the propagation of electromagnetic waves in space. (4 marks)

d) What is an electric dipole? (3 marks)

e) Explain the property of polarization in dielectrics. (4 marks)

f) Show that an electrostatic field is vortex free. (4 marks)

g) Compare wave guides and transmission lines with respect to their applications. (4 marks)

h) A lossless air-dielectric waveguide for an S-band radar has inside dimensions a=7.214 cm and b=3.404 cm. for $TM_{\|}$ mode propagating at an operating frequency that is 1.1 times the cutoff frequency of the mode. Find:

i) Critical wave number. (2 marks)

ii) Cut off frequency. (2 marks)

QUESTION TWO (20 MARKS)

a) Consider that

$$y'' = -\lambda y, \qquad 0 < x < 1$$
$$y(0) = y(1) = 0$$

Find the solution(s) to the boundary value problem. (8 marks)

b) Show that the electric field in the electromagnetic field is expressed through the totality of scalar and vector potentials. i.e. (12 marks)

$$E = -\nabla\emptyset - \frac{1}{C}\frac{\partial A}{\partial t}$$

QUESTION THREE (20 MARKS)

a) Show that Poisson's equation reduces to Laplace's equation. (10 marks)

b) Derive a set of four Maxwell's equations for classical dynamics.

(10 marks)

QUESTION FOUR (20 MARKS)

a) Explain the transmission of waves through wave guides. (10 marks)

b) When an electromagnetic wave travelling in a vacuum is incident normally on a plane interface of a material of refractive index η, the reflection power coefficient is given by

$$R = (\frac{\eta - 1}{\eta + 1})^2$$

Derive the reflection power coefficient. (10 marks)

QUESTION FIVE (20 MARKS)

a) Consider a charge density ^{c}(t,x) and current density j(t,x) in an otherwise empty space in coulomb's gauge $\nabla . A = 0$

i) Write down the wave equation for the vector potential A(t,x) (5 marks)

ii) Obtain a closed form expression for the scalar potential $\emptyset(t, x)$ with respect to dependence on time. (5 marks)

b) Discuss the propagation of a plane electromagnetic wave in a homogenous isotropic medium.

(10 marks)

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