EMBU UNIVERSITY COLLEGE

(A Constituent College of the University of Nairobi)

2015/2016 ACADEMIC YEAR

FIRST SEMESTER EXAMINATION

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 405: ELECTRODYNAMICS II

DATE: DECEMBER 9, 2015 **TIME: 14:00-16:00**

INSTRUCTIONS:

- **ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS**
- **The following constants maybe useful;**

Electrical conductivity of Cu $\sigma = 5.9\times107$ S/m
Relative permeability $\mu0=4\pi$ x 10-7 Hm-1
Relative permittivity $\varepsilon0=8.85$ x 10-12 Fm-1

QUESTION ONE

a) Distinguish between a linear polarization and circular polarization of a wave. (2 marks)

b) Define the following terms;

(i) Attenuation (2 marks)

(ii) skin depth (2 marks)

(iii)skin effect (2 marks)

c) The skin depth of 1MHz radio wave in pure copper is approximately 10^{-4}m at room temperature. Calculate the skin depth of a wave at 15K when the conductivity has increased by a factor of 10^4. (5 marks)

d) Give a concise account of generation of electromagnetic waves through the following processes;

(i) Synchrotron radiation (3 marks)

(ii) Bremsstrahlung radiation (3 marks)

e) Briefly, discuss the kinetic and dynamic properties in reflection and refraction of light. (6 marks)

f) With the help of a sketch, Show that the reflection coefficient R is given by;

$$R = \left(\frac{n\cos\theta - \cos\phi}{n\cos\theta + \cos\phi} \right)^2$$ where θ and ϕ incident and refraction angles (5 marks)

QUESTION TWO

a) Write down the general set of Maxwell's equations in differential form for time varying fields. (4 marks)

b) From the Maxwell's equations, derive the electromagnetic vector wave equations;

$\nabla^2 \vec{B} = \varepsilon_0 \mu_0 \frac{\partial^2 \vec{B}}{\partial t^2}$ and $\nabla^2 \vec{E} = \varepsilon_0 \mu_0 \frac{\partial^2 \vec{B}}{\partial t^2}$ in linear, isotropic and charge free medium.

(8 marks)

c) From the Maxwell's equations, derive the uncoupled inhomogeneous wave equations

$\nabla^2 \phi - \frac{1}{c^2}\frac{\partial^2 \phi}{\partial t^2} = -4\pi\rho$ and $\nabla^2 \mathrm{A} - \frac{1}{c^2}\frac{\partial^2 \mathrm{A}}{\partial t^2} = -\frac{4\pi}{c} J$ (8 marks)

QUESTION THREE

a) (i) Show clearly that Poynting theorem is described by the equation below

$$\boldsymbol{J.E} + \frac{\partial U}{\partial t} + \frac{1}{\mu_0}\nabla.(\boldsymbol{E} \times \boldsymbol{H}) = \mathbf{0}$$ (8 marks)

(ii) Give the physical interpretation of each term in the Poynting equation in (i) above (4 marks)

b) If the radio waves were being propagated in water where ε=80. At the same point in water, the amplitude of electric field is E = 0.1Vm^{-1}. What will be the poynting vector at that point? (take μ=1) (3 marks)

c) The electrical conductivity of sea water is about 4 S/m, what is the skin depth for low frequency radio waves of wavelength λ=3000m (5 marks)

QUESTION FOUR

Describe in details the propagation of electromagnetic waves in;

(i) Dielectric medium (10 marks)

(ii) Conducting medium (10 marks)

QUESTION FIVE

a) With the help of a simple sketch, write down the plane wave equations for fields denoted by $\vec{E}_I, \vec{B}_I, \vec{E}_R, \vec{B}_R, \vec{E}_T and \vec{B}_T$ for incident, reflected and transmitted electric and magnetic waves respective, for an em wave incident at a dielectric boundary. (8 marks)

b) From the equations in (a) above, show that

(i) $\frac{E_{oR}}{E_{oI}} = \frac{1-n}{1+n}$

(ii) $\frac{E_{oT}}{E_{oI}} = \frac{2}{1+n}$

(iii) $R = \left(\frac{1-n}{1+n}\right)^2$

(iv) $T = \frac{4n}{(1+n)^2}$ (12 marks)

Where $E_{oI}, E_{oR,} E_{oT}$ R and T are amplitudes of the waves, the reflection and transmission coefficients and n is the refractive index as may apply.

--END--