JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

4TH YEAR 1ST SEMESTER 2013/2014 ACADEMIC YEAR

MAIN SCHOOL BASED

COURSE CODE: SPH 410

COURSE TITLE: CLASSICAL ELECTRODYNAMICS

EXAM VENUE: CR 1 **STREAM: (BED)**

DATE: 03/05/14 **EXAM SESSION: 9.00 – 11.00 AM**

TIME: 2.00 HOURS

Instructions:

1. **Answer Question 1 (compulsory) and ANY other 2 questions**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

QUESTION ONE (Compulsory) **(30 Marks)**

a. A vector field $\vec{F}$ is given by $\vec{F} = x^2 y\vec{i} + xyz\vec{j} - x^2 y^2 \vec{k}$

i) Compute $div\vec{F}$ (3 marks)

ii) Ascertain whether $\vec{F}$ is a conservative or a non-conservative vector field. (3marks)

b. Given the vector field $\vec{H} = yz^2\vec{i} + xy\vec{j} + yz\vec{k}$,

Verify that $div\left(Curl\vec{H}\right) = 0$ (3 marks)

c. Distinguish between scalar and vector fields giving examples of each. (3 marks)

d. State the Stokes' theorem (2 marks)

e. Write down the basic Maxwell's equations in their integral form explaining the implication of each (4 marks)

f. i) Derive the Gauss's law for continuous charge density $\text{°}(x)$ in its integral form given by

$$\oint_s \vec{E}.nda = 4\text{®}\int_v \text{°}(x)d^3x$$ (5 marks)

ii) Beginning with the integral form obtained in (i) above, obtain the differential form of the Gauss law. (4 marks)

g. Briefly explain how electromagnetic waves are generated from a Hertzian dipole antenna (3 marks)

QUESTION TWO

Maxwell's equations are **four** mathematical equations that relate the Electric Field (**E**) and magnetic field (**B**) to the charge density (ρ) and current density (**J**) that specify the fields and give rise to electromagnetic radiation.

i. Derive the ***four*** Maxwell's equations with sources in free space. (12 marks)

ii. Obtain the Maxwell's equations in vacuum (8 marks)

QUESTION THREE

Beginning with the Maxwell's Curl equations;

$$\nabla \times \vec{E} = \frac{\partial \vec{B}}{\partial t} \qquad \text{and} \qquad \nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$$

Obtain both the **point** and **integral forms** of the **Poynting's theorem**. (14 marks)

a. Briefly give an account of the above forms of **Poynting's theorem**. (6 marks)

QUESTION FOUR

A point charge ***q*** is brought to a position a distance, ***d,*** away from an infinite plane conductor held at zero potential. Using the method of images, find:

(i) The surface-charge density induced on the plane; (5marks)

(ii) The force between the plane and the charge by using Coulomb's law for the force between the charge and its image; (5 marks)

(iii) The total force acting on the plane by integrating $\frac{\pm^{2}}{2\P_{0}}$ over the whole plane; and (5marks)

(iv) the work necessary to remove the charge, q, from its position to infinity; (5 marks)

QUESTION FIVE

A localized electric charge distribution produces an electrostatic field, $\vec{E} = -\nabla\Phi$. Into this field is placed a small localized time-independent current density $\vec{J}(x)$, which generates a magnetic field $\vec{H}$.

(a) Show that the momentum of these electromagnetic fields can be transformed to

$$\vec{P}_{field} = \frac{1}{c^{2}} \int \Phi \vec{J} d^{3}x$$

provided the product Φ**H** falls off rapidly enough at large distances. (10 marks)

(b) Assuming that the current distribution is localized to a region small compared to the scale of variation of the electric field, expand the electrostatic potential in a Taylor series and show that

$$\vec{P}_{field} = \frac{1}{c^{2}} \vec{E}(0) \times m$$

Where $\vec{E}(0)$ is the electric field at the current distribution and m is the magnetic moment caused by the current. (10 marks)