JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY UNIVERSITY EXAMINATIONS 2013

4TH YEAR 1ST SEMESTER EXAMINATION OF BACHELOR OF EDUCATION (SCIENCE)

REGULAR

COURSE CODE: SPH 410

COURSE TITLE: ELECTRODYNAMICS

DATE: 15/8/13 **TIME: 9.00 -11.00 AM**

DURATION: 2 HOURS

INSTRUCTIONS

1. **This paper contains five (5) questions in section A and Section B.**
2. **Answer question 1 (compulsory) and ANY other TWO questions.**
3. **Write all answer in the booklet provided.**

SECTION A: This section is **COMPULSORY (30 marks).**

1. a) (i) What does an electromagnetic wave carry? **(2 marks)**
(ii) Write the relationship between the quantities carried in the wave above**. (2 marks)**

b) (i) What does Gauss' theorem depend on? **(1 mark)**
(ii) Evaluate $\int\int (3x\mathbf{i} + 2y\mathbf{j}).d\mathbf{A}$ where s is the sphere $x^2+y^2+z^2 + 9$ using Gauss' theorem. **(7marks)**

c) (i) Differentiate between divergence and curl of vector field **A (2 marks)**
(ii) Calculate divergence and curl of a vector field **F**(-y,xy,z) **(3 marks)**

d) (i) Write the integral form of Maxwell's equations in a free space. **(4 marks)**
(ii) Specify which laws the equations in (i) above represent **(2 marks)**

e) (i) What does Poynting vector represent? **(2 marks)**
(ii) Write the equation for Poynting vector. **(1 mark)**

f) (i) A centre-fed Hertzian dipole is excited by a current $I_0 = 20A$. If the dipole is $\lambda/50$ in length, determine the maximum radiated power density at a distance of 1km away. **(4marks)**
(Let $\eta_0 = 377$)

(Total: 30 marks)

SECTION B: Answer only **TWO** questions from this section. Each question is **20 marks**.

2. A parallel plate capacitor consists of two circular plates each with radius R, separated by a distance d as shown in figure 1

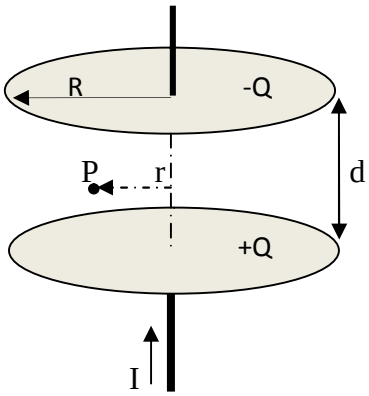

Fig.1

A steady current I is flowing towards the lower plate and away from the upper plate, charging the plates.

a) What is the magnitude of the electric field **E** between the plates? (Ignore fringing fields due to edge effects) **(5 marks)**

b) What is the total energy stored U_E in the electric field of the capacitor? **(4 marks).**

c) What is the rate of change of the energy stored in the electric field**?** **(3 marks)**

d) (i) Calculate the magnitude of the magnetic field **B** at point P located between the plates at radius r < R. **(6 marks)**.

(ii) As seen from above, what is the direction of **B**? Explain your answer. **(2 marks)**

(Total: 20 marks)

3. a) The electric field of a plane electromagnetic wave in a vacuum is

$E_y = 0.5\cos[2\pi x10^8(t-x/c)]$ V/m.

Determine:

(i) its wavelength λ **(4 marks)**

(ii) the state of polarization **(1 mark)**

(iii) the direction of the propagation **(1 mark)**

b) By setting the source in the Maxwell's differential equations in a vacuum to zero, derive the wave equations for the electric **E** and magnetic **B** fields. **(8 marks)**

c) Equation for the conservation of charge derived from Ampere's law is $\partial\rho/\partial t + \nabla \mathbf{J} = 0$, where ρ = charge density.
State the consequences or interpretation of this equation. **(4 marks)**

d) You are given the momentum density **p,** electric field **E** and magnetic field **B**. Give an equation that relates them in vector form. **(2 marks)**

(Total: 20 marks)

4. A coaxial cable consists of two concentric long hollow cylinders of zero resistance; the inner has a radius a, the outer has radius b, and the length of both is ℓ, with $\ell >> b$ as shown in figure 2.

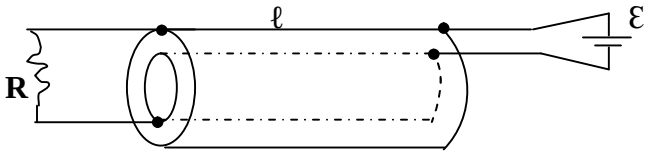

Fig.2

The cable transmits DC power from a battery to a load. The battery provides an electromotive force Ɛ between the two conductors at one end of the cable, and the load is a resistance R connected between the two conductors at the other end of the cable. A current I flows down the inner conductor to a charge -Q and the outer conductor to a charge +Q.

a) Find the direction and magnitude of the electric field **E** everywhere. **(3 marks)**
b) Find the direction and magnitude of the magnetic field **B** everywhere **(3 marks)**
c) Calculate the Poynting vector **S** in the cable. **(5 marks)**
d) By integrating **S** over appropriate surface, find the power that flows into the coaxial cable. **(4 marks)**
e) Through calculation, show how your result in (d) above compare to the power in the cable. **(5 marks)**

(Total: 20 marks)

5. a) Consider two infinitely long parallel wires carrying currents that are in the x–direction. (see figure 3)

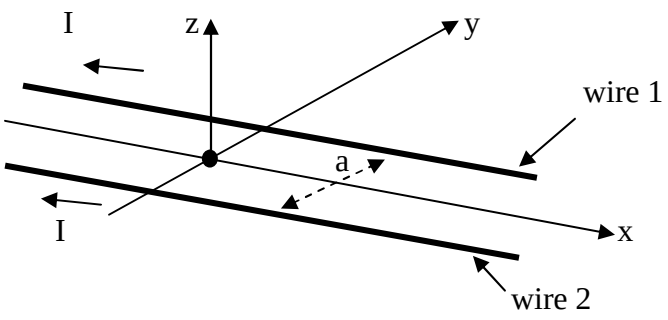

Fig. 3

(i) Plot the magnetic field pattern in the yz plane. **(1 mark)**
(ii) Find the distance d along the z axis where the magnetic field is maximum. **(9 marks)**

b) (i) Compute the self-inductance of a solenoid with N turns, length ℓ and radius R with a current I flowing through each turn as shown in figure 4. **(8 marks)**

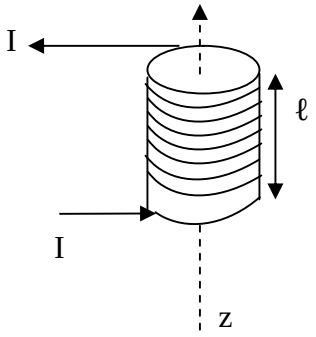

Fig. 4

(ii) Find the magnetic energy stored in the system. **(2 marks)**

(Total: 20 marks)