



# THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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**MAIN EXAMINATION**

**JANUARY – APRIL 2015 TRIMESTER**

**FACULTY OF SCIENCE**

**DEPARTMENT OF NATURAL SCIENCES (PHYSICS)**

**SCHOOL FOCUSED PROGRAM**

**PHY 302: ELECTROMAGNETISM**

<b>Date: April 2015</b>	<b>Duration: 2 Hours</b>
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<b>Instructions: Answer Question ONE and any other TWO Questions</b>
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Q1 a) The flux of  $\vec{E}$  through a surface S is given by

$$\phi_E = \int_s \vec{E} \cdot d\vec{a}$$

Give the physical interpretation of  $\phi_E$ ,  $\vec{E} \cdot d\vec{a}$  and  $d\vec{a}$ .

**(3 marks)**

b) i) Electric potential obeys the superposition principle. Explain.

**(1 mark)**

ii) Find the potential inside and outside a spherical shell of radius R, which carries a uniform surface charge. Set the reference point at infinity.

**(6 marks)**

c) A point charge q is placed a distance r from a neutral atom of polarizability  $\alpha$ . Find the force of attraction between them.

**(4 marks)**

d) Give poisson's and laplace's equations under what circumstances does poisson's equation reduce to Laplace's equation.

**(3 marks)**

e) i) For currents with appropriate symmetry which magnetostatic law offers an efficient means of calculating the magnetic field?

**(1 mark)**

ii) Find the magnetic field a distance s from a long straight wire, carrying a steady current I.

**(3 marks)**

- f) i) Show that the divergence of the magnetic vector potential given as  $\vec{B} = \nabla \times \vec{A}$  yields amperes law. **(3 marks)**
- ii) A short solenoid (length  $L$ , and radius  $a$ , with  $n_1$  turns per unit length) lies on the axis of a very long solenoid (radius  $b$ ,  $n_2$  turns per unit length). Current  $I$  flows through the solenoid. What is the mutual inductance in this case? **(4 marks)**
- g) State the following laws:
- i) Faraday's Law **(1 mark)**
- ii) Lenz's Law **(1 mark)**
- Q2. a) Find the electric field a distance  $Z$  above the center of a circular disk of radius  $R$ , which carries a uniform surface charge  $\sigma$ . What does your formula give in the limit  $R \rightarrow \infty$ ? **(10 marks)**
- b) Use Gauss's Law to find the field outside a uniformly charged solid sphere of radius  $R$  and total charge  $q$ . **(9 marks)**
- c) Comment on the result obtained in (b) above. **(1 mark)**
- Q3. a) Derive the expression for the potential produced by a piece of polarized material. **(10 marks)**
- b) Find the magnetic field a distance  $S$  from infinitely long straight wire carrying a steady Current  $I$ , (Apply Biot – Savart Law). **(10 marks)**
- Q4. a) Find the electric field a distance  $Z$  above the midpoint of a straight line segment of length  $2L$ , which carries a uniform line charge  $\lambda$ . **(8 marks)**
- b) State Gauss's Law in integral and different forms. **(2 marks)**
- c) A primitive model of an atom consists of a point nucleus (+ $q$ ) surrounded by a uniformly charged spherical cloud (- $q$ ) of radius  $a$ . Calculate the atomic polarizability of such an atom. **(7 marks)**
- d) Find the magnetic field a distance  $Z$ . above the center of a circular loop of radius  $R$ , which carries a steady current  $I$ . **(3 marks)**

- Q5. a) A spherical shell of radius  $R$ , carrying a uniform surface charge  $\sigma$ , is set spinning at angular velocity  $\omega$ . Find the vector potential it produces at point  $r$ . **(15 marks)**
- b) Find the electric field a distance  $z$  above the midpoint between two equal charges,  $q$ , a distance  $d$  apart. **(5 marks)**

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