THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

MAIN EXAMINATION

SEPTEMBER –DECEMBER 2021

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FACULTY OF SCIENCE

DEPARTMENT OF NATURAL SCIENCES

REGULAR PROGRAMME

PHY 302: ELECTROMAGNETISM

Date: DECEMBER 2021	Duration: 2 Hours
INSTRUCTIONS: Answer Question ONE and any TWO Questions	

Q1.

(a)   State:

    i.   Gauss's law for electrostatics

    ii.   Faraday's law

    iii.   Ampere's law

    iv.   Biot Savart law

    v.   Two properties of equipotential surfaces   **(10marks)**

(b)   (i) By what power of distance does the strength of electric field fall off?   **(2marks)**

    (ii) How does this compare to a single point charge? Briefly explain a reason for the difference

    between these two cases.   **(2marks)**

(c)   Show that τ=**P** x **E** where the symbols have their usual meaning   **(4marks)**

(d)   Determine if the vector field $F(x,y)=(2xe^{xy}+x^2ye^{xy})i+(x^3e^{xy}+2y)j$ is   conservative

    (4marks)

(e) Consider a wire of radius *a* carrying a current of uniform current density **J.**

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(i)   Determine the magnetic field of the wire both inside and outside the wire at a distance $r > a$ **(6marks)**

(ii)   Draw a sketch graph of the relationship between the magnetic field strength and the radius.   **(2marks)**

Q2.

(a)   State

(i)   Earnshaw's theorem   **(2marks)**

(ii)   Laplace's and Poisson's equations   **(4marks)**

(b) Starting from Gauss' law, derive the Poisson's equation   **(4marks)**

(c)   State the physical significance of

(i)   Divergence   **(2marks)**

(ii)   Curl   **(2marks)**

(d) Find $\nabla . \nabla x F$ for $F = y z^2 i + xyj + yzk$ **(6marks)**

Q3.

(a) (i) Define the term Vector potential   **(2marks)**

(ii) Obtain an expression for the vector potential of a solenoid   **(8marks)**

(b) (i) Define the term "Electric field"   **(2marks)**

(ii) State Stoke's theorem   **(2marks)**

(iii)   Show that Faraday's law can be expressed as $xE = \dfrac{-dB}{dt}$

(6marks)

Q4.

(a) Define

(i) Electric flux density (D)   **(2marks)**

(ii) Permittivity $\left(\varepsilon \right)$ **(2marks)**

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(iii) Dipole moment (P) **(2marks)**

(b) Name four differences between Polar and Non - Polar molecules **(4marks)**

(c) (i) explain the term electronic polarization **(2marks)**

(ii) Show that $\mu_e = \alpha_e E$ where $\alpha_e = 4\pi\varepsilon_o R^3$ is the electronic polarization **(4marks)**

(d) Explain the term "conservative field" and name two conservative fields **(4marks)**

Q5.

(a) State

  (i) Ampere's law **(2marks)**
  (ii) The divergence theorem **(2marks)**
  (iii) Stoke's theorem **(2marks)**

(b) Show that Ampere's law can be written as $\nabla x H = J$ where the symbols have their usual meaning **(6marks)**

(c) Using Biot - Savert law, derive an expression for the magnetic field strength at a point on the axis of a circular loop of a wire of radius a carrying a current I as a function of the distance x measured along the axis from the center of the circle. **(8marks)**

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END