

PHY 434



OFFICE OF THE DEPUTY VICE CHANCELLOR
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2024 /2025 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER REGULAR MAIN
EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION
SCIENCE

COURSE CODE: PHY 434

COURSE TITLE: ELECTROMAGNETIC THEORY

DATE: 22ND APRIL 2025

TIME: 14:00 -17:00

INSTRUCTION TO CANDIDATES

- SEE INSIDE

THIS PAPER CONSISTS OF 4 PRINTED PAGES

PLEASE TURN OVER

MAIN- EXAM

PHY 434: ELECTROMAGNETIC THEORY

STREAM: BED (Science)

DURATION: 3HRS

INSTRUCTIONS TO CANDIDATES

- i. Answer **TWO** questions in section A and any other **THREE** questions in section B.
- ii. You may need to use the following constants
- $h = 6.63 \times 10^{-34} \text{ Js}$, $c = 3 \times 10^8 \text{ m/s}$

SECTION A (28 MARKS)**Question One (14 Marks)**

- (a) Show that $\nabla \cdot \mathbf{J} + \frac{\partial \rho}{\partial t} = 0$ is contained in Maxwell's equation (5 Marks)
- (b) Write down the expression for calculating electric and magnetic force (2 Marks)
- (c) What's the force on a 0.1 C charge moving at velocity $\mathbf{v} = (10\hat{j} - 20\hat{k})\text{ms}^{-1}$ in a magnetic field $\hat{\mathbf{B}} = (-3\hat{i} + 4\hat{k}) \times 10^{-4}\text{T}$ (5 Marks)
- (d) Define a magnetic vector potential (2 Marks)

Question Two (14 Marks)

- (a) List the four properties of electromagnetic waves (4 Marks)
- (b) With aid of a diagram, describe the spectrum of electromagnetic radiation with respect to order of frequency and wavelength (4 Marks)
- (c) Calculate the magnitude and direction of the magnetic field when $\vec{\mathbf{E}} = 750 \text{ N/C}$ and is in the y direction (3 Marks)
- (d) Sketch the electromagnetic wave showing the $\vec{\mathbf{E}}$ and $\vec{\mathbf{B}}$ components (3 Marks)

SECTION B (42 MARKS)**Question Three (14 Marks)**

- (a) Write down the four Maxwell's equations (4 Marks)
- (b) Derive the Poisson's and Laplace equations (4 Marks)
- (c) A monochromatic source of 60 W is radiating equally in all directions in a vacuum as a function of field and the distance. Calculate the amplitude of the electric field at the distance 2m from source. (6 Marks)

Question Four (14 Marks)

- (a) State Coulomb's Law of electrostatics in mathematical form (1 Mark)

- (b) Determine the force electric field If we have several point charges q_1, q_2, \dots, q_n , at distances r_1, r_2, \dots, r_n from Q. (4 Marks)
- (c) Find the electric field a distance z above the midpoint between two equal charges (q), a distance d apart Figure 1 below. (4 Marks)

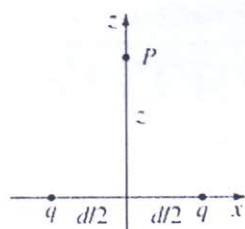


Figure 1

- (d) State and prove the First uniqueness theorem of boundary condition (5 Marks)

Question Five (14 Marks)

- (a) Find the gradient of $r = \sqrt{x^2 + y^2 + z^2}$ (the magnitude of the position vector) (3 Marks)
- (b) Find the energy of a uniformly charged spherical shell of total charge q and radius R (4 Marks)
- (c) Calculate the line integral of the function $v = y^2 \hat{x} + 2x(y + 1) \hat{y}$ from the point $a = (1,1,0)$ to the point $b = (2,2,0)$, along the path (1) and (2) shown in figure 2 below

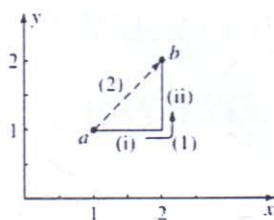


Figure 2

What is $\oint V \cdot dI$ for the loop that goes from a to b a long (1) and return to a along (2)? (7 Marks)

Question Six (14 Marks)

- (a) Explain and write down the expression of the reflection coefficient and transmission coefficients (4 Marks)
- (b) (i) Write a mathematical statement for Biot-Savart law (1 Mark)
- (ii) Estimate the magnetic field a distance S from a long wire carrying a steady current I as shown in Figure 3. (5 Marks)

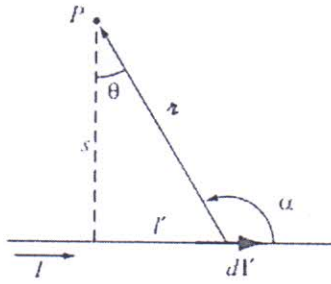


Figure 3

- (c) Derive the equation for estimating the retarded potentials (4 Marks)

✓ Question Seven (14 Marks)

- (a) Define the term Poynting vector (2 Mark)
- (b) Write and proof the mathematical statement of Poynting theorem (9 Marks)
- (d) With aid of a diagram describe the hysteresis loop formation (3 Marks)