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UNIVERSITY EXAMINATIONS 2023/2024

FOURTH YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS, BACHELOR OF SCIENCE IN MATHEMATICS AND PHYSICS AND BACHELOR OF EDUCATION SCIENCE

SPH 3450: ELECTRODYNAMICS

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) i. State Ampere's law (2 Marks)
ii. Show that Ampere's law leads is an equation describing static fields. (6 Marks)
iii. Modify the equation in a (ii) above to a situation of rapidly varying fields. (6 Marks)

b) a soup bubble 10 cm in radius with a wall thickness of 3.3×10^{-6} cm is charged to potential of 100V. the bubble bursts and falls as a spherical drop. Estimate the potential of the drop. (8 Marks)

c) a metallic ring of cross-section 2.5 cm^2, mean radius 40 cm and relative permeability 1500 is wound uniformly with 300 turns of wise if a current of 1.6 A passes through the wire, find the mean $\vec{B}$ field and the sensitization in the ring. (8 Marks)

QUESTION TWO (20 MARKS)

a) write down Maxwell's equations in the presence of electric charge ρ and current density J. (4 Marks)

b) using equation in (a) above,

i. derive the wave equations for $\overrightarrow{E}$ and $\overrightarrow{B}$ and show that the wave epliactions reduce to free wave equations under appropriate or specified conditions. (10 Marks)

c) derive the continuity equation governing conservation of electromagnetic energy in terms of the pointing vector. (6 Marks)

QUESTION THREE (20 MARKS)

a) i. State Gauss' law in differential form. (2 Marks)

ii. Using Gauss' law in (a) (i) above, derive Laplace equations. (4 Marks)

i. Give the boundary conditions for potential $\varphi(\vec{r})$ with reference to a coaxial cable. (4 Marks)

ii. Calculate the potential $\varphi(\vec{r})$ at a point $\vec{r}$ for the above cable. (6 Marks)

b) The coaxial cable has an inner and outer conductor of radius $a = 1.5\,mm$ and $b = 3mm$ respectively. The outer conductor is earthed, calculate the potential of the cable at a point $\vec{r}$ $=2mm$ from centre of the cable given that potential difference between the inner and outer conductor is $0.2\,mV$. (4 Marks)

QUESTION FOUR (20 MARKS)

a) Show that maxwell's 4 equations of electrodynamics can be reduced to two coupled equations. (8 Marks)

b) State the Gauge conditions and show that the coulomb's Gauge condition applied to educed maxwell's equations in (c) above give rise to poisson equation. (5 Marks)

c) Consider a rectangular wave guide with internal dimensions of $a = 2cm$ and $b = cm$, suppose the frequency of a TE_{mn} mode is $f = 20GHZ$ with corresponding vacuum wavelength $\lambda_0 = 1.5$ cm. calculate the TE_{mn} modes that are accessible. (7 Marks)