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UNIVERSITY EXAMINATIONS 2022/2023

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

SPH 3450: ELECTRODYNAMICS

DATE: APRIL 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Describe the concept of a 4-dimension spacetime in relation to continuity equation in electrodynamics. (5 Marks)

b) Show that Ampere's law in integral form can be reduced into Ampere's law in differential form for:
   i. Time non-varying fields (3 Marks)
   ii. Time varying fields (10 Marks)

c) i. State Ampere's law in integral form (2 Marks)
   ii. Show that Ampere's law in c) above can be modified in the presence of a magnetic material into differential form of free currents. (10 Marks)

QUESTION TWO (20 MARKS)

a) write down the solution to poisson equation (2 Marks)

b) in analogy to a) above, derive the Bio-Savart's law (13 Marks)

c) use Bio-Savart law or otherwise to obtain the magnetic field due to a finite wire currying a current. (5 Marks)

QUESTION THREE (20 MARKS)

Consider a plane polarized wave propagating along the z-direction given by $\vec{E} = \vec{E}_0 e^{i(wt-kz)}$ where $\vec{E}_0$ is the amplitude and $\vec{k}$ is the wave vector

a) Calculate the corresponding magnetic field induction $\vec{B}$. (10 Marks)
b) Consider a rectangular waveguide with internal dimensions of $a = 2cm\ and\ b = 1cm$. Suppose the frequency of a $TE_{mn} is\ f = 20GHZ$ with corresponding wavelength of $\lambda_0 = 1.5cm$. calculate the TE_{mn} modes that are accessible? (10 Marks)

QUESTION FOUR (20 MARKS)

a) Write down Maxwell's equations of electrodynamics. (4 Marks)
b) Show that Maxwell's equations in (a) above can be reduced to 2-coupled equations which may further decompose to poisson equation under specified conditions. (8 Marks)
c) Use Maxwell's equations in (a) above to obtain the energy density carried by an electromagnetic wave. (8 Marks)