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UNIVERSITY EXAMINATIONS 2022/2023

FIRST YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS

SPH 7150: CLASSICAL ELECTRODYNAMICS

DATE: AUGUST 2023 **TIME: 3 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Write down Maxwell's equations of electrodynamics. (4 Marks)

b) Show that Maxwell's equations in (1) above can be reduced to 2-coupled equations which may further decompose to poisson equation under specified conditions. (8 Marks)

c) Use Maxwell's equation in (1) above to obtain the energy density carried by an electromagnetic wave. (8 Marks)

d) Use Newton's second law to derive the principle of conservation of electric energy. (10 Marks)

QUESTION TWO (20 MARKS)

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

b) In analogy to Poisson equation, derive Bio-Savart law. (8 Marks)

c) Show that magnetic field propagates as wave in spacetime. (8 Marks)

QUESTION THREE (20 MARKS)

For the Lorentz boost and rotation matrices K and S show that:

i. $\left(\hat{\epsilon}.\vec{S}\right)^3 = -\hat{\epsilon}.\vec{S},$ (10 Marks)

ii. $\left(\hat{\epsilon}'.\vec{K}\right)^3 = \hat{\epsilon}'.\vec{K}$ (10 Marks)

Where $\hat{\epsilon}$ and $\hat{\epsilon}'$ are any real unit 3-vectors.

QUESTION FOUR (20 MARKS)

Two point charges q and –q are located on the z – axis at z=a and z=-a respectively.

a) Find the electrostatic potential as an expansion in spherical harmonics and powers of r for both $r > a$ and $r < a$. (8 Marks)

b) Keeping the product qa = p/2 constant, take the limit of as a approaches 0 and find the potential for $r \neq 0$. This is by definition a dipole along the z – axis and its potential. (4 Marks)

c) Suppose now that the dipole of part b is surrounded by a grounded spherical shell of radius b concentric with the origin. By linear superposition find the potential everwhere inside the shell. (8 Marks)