Back Paper Examination

Electrodynamics
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June 05$^{\text{th}}$, 2025 (Morning Session)
Duration: 120 minutes.
Total points: 60

Please give arguments where necessary. If it is unclear from your answer why a particular step is being taken, full credit will not be awarded. Grades will be awarded not only based on what final answer you get, but also on the intermediate steps.

1. A square loop of side a lies on a table. It is located at a distance s from a very long straight wire, carrying a current I. See Figure 1.

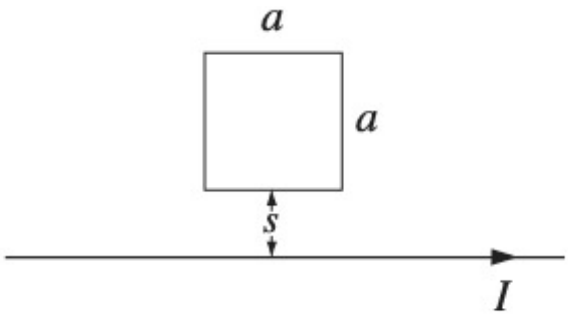

Figure 1: A square loop lying on a table next to a wire.

   (a) Find the magnetic flux through the loop.
   (b) If the loop is pulled away from the wire at a speed v, find the magnitude and direction (clockwise or counterclockwise) of the EMF generated.
   (c) Find the EMF generated if the loop is pulled to the right, i.e., in the direction of the current.

   6 + 6 + 3 = 15 points

2. A sphere of radius R is filled with a dielectric medium of dielectric constant ε. Its surface has a uniform charge density given by $\sigma = \sigma_0$.

(a) Find the electric field everywhere.

(b) Find the polarization charge density everywhere, including volume and surface charges.

9 + 6 = 15 points

3. A ring of charge of radius R and uniform charge density per unit length λ lies on the x-y plane.

(a) Find the electric field on the symmetry axis.

(b) The rind now rotates counterclockwise with an angular speed ω. Find the magnetic field on the symmetry axis.

(c) Discuss, from your results, the symmetry properties of the electric field and the magnetic field under an active reflection transformation about the $z = 0$ plane.

5 + 5 + 5 = 15 points

4. Imagine an ideal point dipole to be situated at the origin, pointing in the $+\hat{e}_z$ direction. See Figure 2. A charged particle of mass m and charge

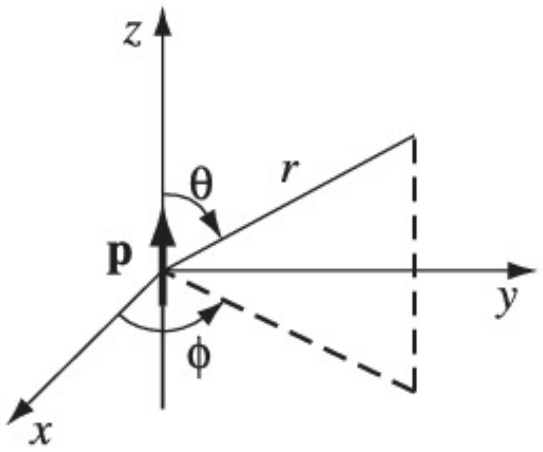

Figure 2: Point dipole at the origin.

q is released from rest from a point P (different from the origin) in the $z = 0$ plane. Find the subsequent motion of the particle.
15 points