Electromagnetism Final Exam

Instructions

- This exam has 8 questions and is worth 0 points. The total time allowed is 4 pages.

- Show all work and provide clear explanations for your answers.

- Write your answers in the space provided. If you need more space, use the back of the page and clearly indicate where your answer can be found.

- You may use a calculator and a formula sheet. Calculators must be cleared of all data before the start of the exam.

- Cheating will not be tolerated and will result in a grade of zero on the exam and possible further disciplinary action.

1. (10 points) A point charge q is located at a distance d from an infinite plane conductor. Determine the electric field at a point P located a distance h above the plane and directly above the charge.

2. (15 points) A long, thin cylindrical shell with radius a carries a uniformly distributed total charge Q. A point charge q is located at a distance r from the axis of the shell.

(a) Determine the electric field at a point inside the shell, at a distance s from the axis, where $s < a$.

(b) Determine the electric field at a point outside the shell, at a distance s from the axis, where $s > a$.

3. (10 points) Two parallel plates carry opposite charges of magnitude Q. The plates are separated by a distance d. Find the potential difference between the plates and the electric field between them.

4. (15 points) A long straight wire carries a current I and is surrounded by a cylindrical surface of radius r. Use Ampere's law to determine an expression for the magnetic field magnitude as a function of distance r from the wire.

5. (20 points) A solenoid is made by tightly wrapping n turns of wire of radius a around a long cylindrical core of radius R, where $a \ll R$. The wire is wrapped in a way that the current flows around the solenoid in the direction of the solenoid's axis.

   (a) Determine the magnetic field inside the solenoid as a function of distance from the axis.

   (b) Determine the magnetic field outside the solenoid.

6. (10 points) A particle of charge q and mass m moves in a uniform magnetic field $\vec{B}$ with velocity $\vec{v}$. Show that the motion of the particle is circular.

7. (10 points) A circular loop of wire with radius a lies in the x-y plane with its center at the origin. The loop carries a current of magnitude I. Find the magnitude and direction of the magnetic field at the origin.

8. (10 points) Consider a capacitor with two parallel plates of area A and separation d. The plates are charged with a charge Q and $-Q$. Calculate the energy stored in the electric field between the plates.