Electricity and Magnetism 1 [3811] Practice Midterm 1

Directions:

This exam is closed book. You are allowed a copy of the equation sheet posted on the course website. You may annotate your equation sheet.

Read all the questions carefully and answer every part of each question. Show your work on all problems – partial credit may be granted for correct logic or intermediate steps, even if your final answer is incorrect.

Unless otherwise instructed, express your answers in terms of fundamental constants like ε_0, rather than calculating numerical values.

If the question asks for an explanation, write at least one full sentence explaining your reasoning.

Please ask if you have any questions, including clarification about the instructions, during the exam.

This test is designed to be gender and race neutral.

Good luck!

Honor Pledge: I understand that sharing information with anyone during this exam by talking, looking at someone else's test, or any other form of communication, will be interpreted as evidence of cheating. I also understand that if I am caught cheating, the result will be no credit (0 points) for this test, and disciplinary action may result.

Sign Your Name_____

Print Your Name_____

Question 1 (25 points): Consider the electric field $E(\vec{r}) = x\hat{x}$.

1a (10 points). What is the corresponding charge density $\rho(\vec{r})$?

1b (15 points). Compute the surface integral $\int \vec{E} \cdot \overrightarrow{da}$ over the surface of a cube with sides of length 2, with the closest corner at $\vec{r}$ = (0,0,0) and the farthest corner at $\vec{r}$ = (2,2,2).

1c (5 points). By integrating the charge density $\rho(\vec{r})$, find the total charge enclosed in the cube. How is this related to your answer from 1b?

Problem 2 (15 points): Find the volume integral $\int (r^2 + \vec{r} \cdot \vec{a})\, \delta^3(\vec{r} - \vec{b})\, d\tau$ over all space ($\vec{a}$ and $\vec{b}$ are constant vectors).

Problem 3 (30 points): Consider a charged sphere of radius R, within which the volume charge density $\rho(\vec{r}) = kr$, where *k* is a constant.

3a (20 points). Use Gauss's law to calculate the electric field $\vec{E}(\vec{r})$ both inside (r<R) and outside (r>R) of the sphere.

3b (10 points). Compute the electric potential difference between infinity and the surface (r = R) of the sphere.

Problem 4 (30 points). Consider an infinitely long charged cylinder with radius R, within which the electric potential $V(\vec{r}) = s\,sin\phi$ (where s is the radial coordinate from the center of the cylinder).

4a (15 points). Compute the electric field inside the cylinder.

4b (15 points). Compute the total electrostatic energy per unit length W/L inside the cylinder.