Electricity and Magnetism 1 [3811] Midterm 1
Wednesday September 26th, 2018

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.

<u>This test is designed to be gender and race neutral.</u>

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 potential $V(\vec{r}) = x^2y + y$.

1a (10 points). What is the vector electric field $\vec{E}(\vec{r})$?

1b (15 points). Compute the line integral $\int \vec{E} \cdot \overrightarrow{dl}$ along a straight line from $\vec{r}$ = (0,0,0) to $\vec{r}$ = (2,2,2).

1c (5 points). Calculate the electric potential difference V(2,2,2)-V(0,0,0) and compare to your answer to part 1b. How should these quantities be related?

Problem 2 (15 points): Consider an arrangement with one point charge *+q* at source position $\vec{r}_1$ and a second point charge -*q* at source position $\vec{r}_2$. Use Dirac delta functions to write the corresponding total volume charge density $\rho(\vec{r})$ as a function of position $\vec{r}$.

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

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

3b (10 points). Compute the electric potential difference between the center (s = 0) and the surface (s=R) of the cylinder.

Problem 4 (30 points). Consider a sphere of charge with radius R, within which the electric field $\vec{E}(\vec{r}) = r\ sin\theta\ \hat{r}$.

4a (15 points). Compute the volume charge density $\rho(\vec{r})$ inside the sphere.

4b (15 points). If a conducting shell with no net charge (with inner radius a and outer radius b both greater than R) was placed around the sphere, what total charges would be induced on the inner and outer surfaces of the conducting shell? Note $\int_0^\pi sin^2\theta d\theta = \int_0^\pi cos^2\theta d\theta = \pi/2$.