Electricity and Magnetism 1 [3811] Midterm 2
Wednesday November 7th, 2018

Directions:

This exam is closed book. You are allowed a copy of the latest 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 μ_0 and 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.

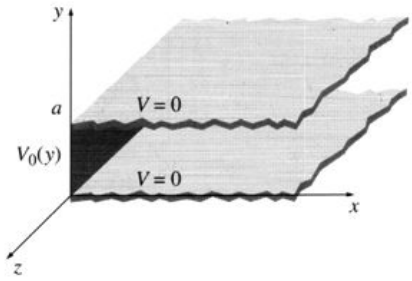
Good luck!

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 a slot with no charge inside it, formed by infinite grounded plates at $y = 0$ and $y = a$, and an end-cap held at a fixed electric potential $V_0(y)$ at $x = 0$. If $V_0(y) = \sin(3\pi y/a)$, find the solution for $V(x,y)$ in the pipe



Question 2 (35 points): Consider a uniformly polarized dielectric sphere of radius R, with no free charge inside it or on its surface, placed in an initially field-free vacuum. The electric potential on the surface of the sphere is $V(R,\theta) = V_0 cos\theta = V_0 P_1(cos\theta)$.

2a (10 points). What is $V(r,\theta)$ inside (*r*<*R*) and outside (*r*>*R*) of the sphere?

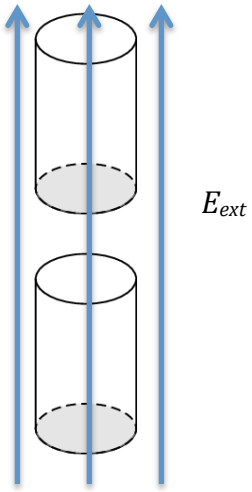
2b (10 points). What is the electric field $\vec{E}(r,\theta)$ inside and outside of the sphere?

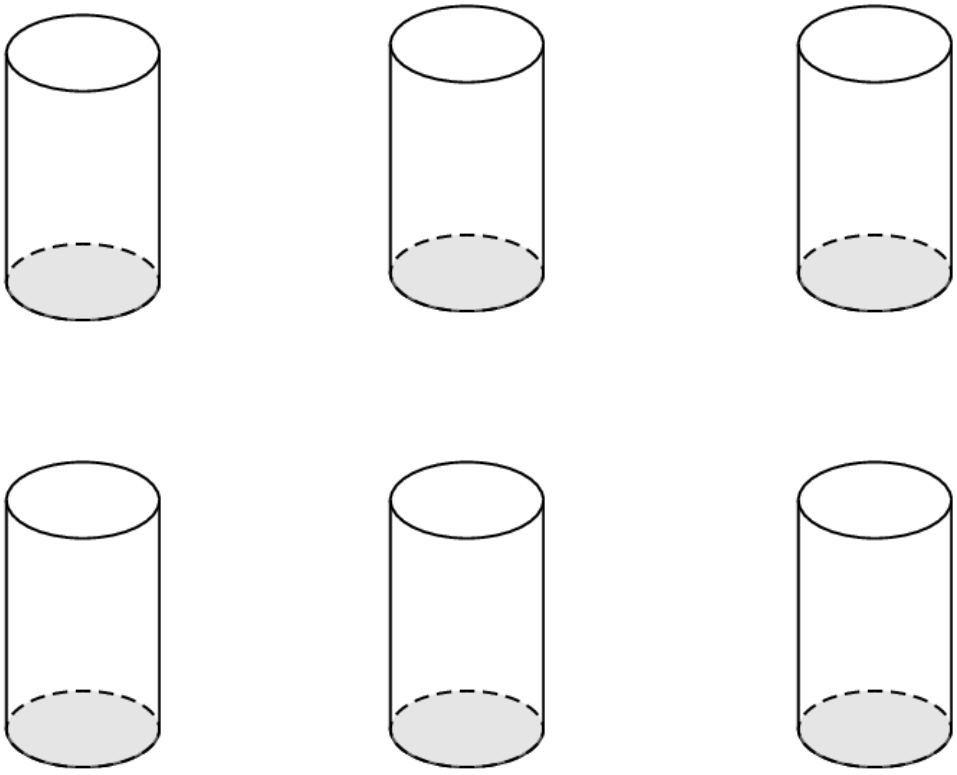
2c (5 points). If $\vec{P} = P\hat{z} = P[cos\theta\hat{r} - sin\theta\hat{\theta}]$ in the sphere, what is the electric displacement $\vec{D}(r,\theta)$ inside and outside of the sphere? *Do not assume a linear dielectric.*

2d (10 points): Utilize the boundary conditions for $\vec{D}(r,\theta)$ at r = R to derive the value of P, in terms of V_0.

Question 3 (10 points): Compute the dipole moment (magnitude and direction) for an arrangement of three charges, *+3q* at (*x,y*) = (*d/2,0*), +2q at (0,0), and *+q* = (*-d/2,0*).

Question 4 (20 points): Consider an infinitely long cylinder of linear dielectric (with no free charge) immersed in a uniform external electric field E_{ext} directed along its axis. Now imagine that you remove a small portion of the cylinder to leave a gap. Fill in the three diagrams below, showing the lines of polarization *P*, electric field resulting from the polarization E_{int}, and total electric field $E_{tot} = E_{ext} + E_{int}$ inside and outside the cylinder and the gap. On the polarization diagram, sketch the location of bound charge. *Make sure your sketches are qualitatively accurate, with more lines in regions of stronger field. If you're worried about your drawing skills, feel free to annotate the diagram to make it clear.*





Question 5 (10 points): Consider a solenoid, as shown at right. Will the magnetic force between adjacent loops of current-carrying wire act to compress the coil or to expand the coil (in the lengthwise direction - parallel to the axis of the coil)? Justify your answer.