

## Information on the second midterm

The second midterm will be held in class (136 Loomis) on Wed, March 12. In my opinion, it will be slightly harder than the first midterm

The exam is open book, and open notes. Work the three problems in the examination booklets and circle or box your final answer. Be sure to cross out or erase any incorrect work. Simplify your algebraic answers as much as practical. You can receive partial credit for incorrect answers provided that the work is legible and understandable. No calculator will be necessary. If you will arrive on time, you will have 50 minutes to work the exam.

### How to prepare for the second midterm.

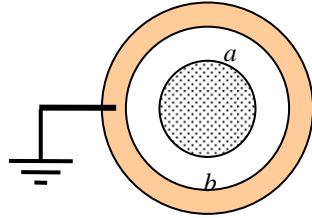
The best way is to review all of the homework and posted homework solutions and the enclosed review problem with the following in mind:

1. Be familiar the physics of conductors and know how to evaluate the surface charge and pressure on a conductor. Know how to compute the net force on a piece of a conductor by integrating the surface pressure.
2. Be familiar with the separation of variable solution to Laplace's Equation in rectangular, spherical, and cylindrical coordinate coordinates. (Cylindrical was covered in a homework problem). Be familiar with the method of images applied to a grounded, conducting plane.
3. Understand how to apply boundary conditions to eliminate unknowns in separation of variable solutions. These include finiteness, constant or zero potentials for conductors, and derivative discontinuity for surface charge glued on insulated surfaces.
4. Know how to apply orthogonal functions to develop infinite series solutions to the Laplace Equation in rectangular, spherical, and cylindrical coordinate coordinates
5. We won't have any questions on the multipole expansion on this exam.

Next is a practice problem that will be discussed during March 7 lecture to help you prepare for the 2<sup>nd</sup> midterm. **Unfortunately, the March 7 lecture will be held in room 252 MEB** (Mechanical Engineering building) due to some regrettable conflict with Engineering Open House. MEB is about two buildings west of Loomis on the same side of Green Street. Enter from the east staircase

Some parts are harder than the exam problems. (Hope my answers are right!)

### Midterm 2 Review Problem



A

A charge density of the form  $\sigma = \sigma_0(3\cos^2\theta - 1)$  is glued to the surface of an insulating sphere of radius  $a$ . We also have a concentric, grounded, conducting, spherical shell of inner radius  $b$ . Assume the potential for this charge distribution can be written as  $V(r) = (3\cos^2\theta - 1)(Ar^2 + B/r^3)$ . Use  $A$  and  $B$  for  $V(a < r < b)$  and  $A'$  and  $B'$  for  $V(r < a)$ .

a) Write  $B$  in terms of  $A$  using the fact that the outer sphere is grounded and write the outer potential entirely in terms of  $A$ .

b) Argue that  $B'$  must vanish based on an important boundary condition.

c) Express  $A'$  in terms of  $A$  using continuity of  $V$  at  $r = a$ .  $A' = A(1 - b^5/a^5)$

d) Solve for  $A$  in terms of  $\sigma_0$  using the discontinuity of  $\partial V / \partial r$  at  $r = a$ .

$$V(a < r < b) = -\frac{a^4 \sigma_0}{b^5 \epsilon_0} (3\cos^2\theta - 1)(r^2 - b^5/r^3)$$

e) Find the surface charge density on the surface  $r = b$

$$\sigma_b = -\frac{a^4 \sigma_0}{b^4} (3\cos^2\theta - 1)$$

f) Calculate the electrostatic  $F_z$  on the “northern hemisphere” of the inner surface of the grounded shell. What is the  $F_z$  on the entire (north + south) inner surface? Is there a non-zero  $F_z$  on the outer surface of the northern hemisphere?

$$F_z^{\text{northern}} = -\frac{a^8 \pi \sigma_0^2}{2\epsilon_0 b^6}$$