Physics 8B, Lecture 1 (Speliotopoulos)
First Midterm, Spring 2018
Berkeley, CA

Rules: *This midterm is closed book and closed notes. You are allowed two sides of one-half sheet of 8.5" x 11" paper on which you can write whatever notes you wish. You are* ***not*** *allowed to use calculators of any type, and any cellular phones must remain off and in your bags for the duration of the exam.* ***Any violation of these rules constitutes an act of academic dishonesty, and will be treated as such.***

Numerical calculations: *This exam consists of four problems, and each one is worth 25 points. Two of the problems ask you to calculate numbers. I have chosen the parameters in these three problems so that the answers can be expressed in terms of rational and irrational numbers. If you find that in your calculation of these problems you end up with an expression which you cannot evaluate numerically—such as one containing an irrational number—simplify the expression as much as you can and leave it.*

We will give partial credit on this midterm*, so if you are not altogether sure how to do a problem, or if you do not have time to complete a problem, be sure to write down as much information as you can on the problem. This includes any or all of the following: Drawing a clear diagram of the problem, telling us how you would do the problem if you had the time, telling us why you believe (in terms of physics) the answer you got to a problem is incorrect, and telling us how you would mathematically solve an equation or set of equations once the physics is given and the equations have been derived. Don't get too bogged down in the mathematics; we are looking to see how much physics you know, not how well you can solve math problems.*

If at any point in the exam you have any problems, just raise your hand, and we will see if we are able to answer it.

Before the exam begins, fill in the following information on your bluebook:

Name: ______________________________ *Disc Sec Number:* ______________________

Signature: ___________________________ *Disc Sec GSI:* _________________________

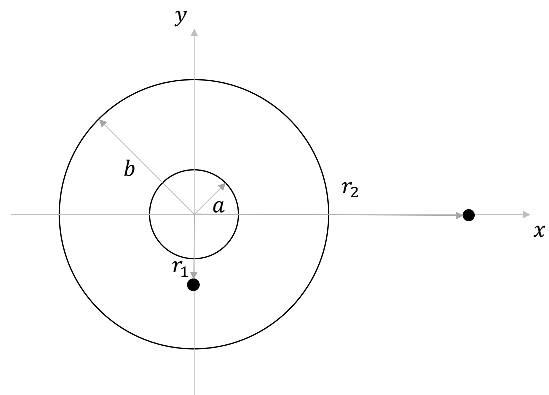
Student ID Number: ___________________ *Disc Sec Time:* _________________________

Write the following grading table on the front of your bluebook:

1	
2	
3	
4	
Total	

You must show your student ID when you hand in your exam!

1. The figure to the right shows (not to scale) two concentric, conducting spheres, one with radius $a = 1.0\ cm$ and charge $Q_a = 50\ mC$ and the other with radius $b = 5.0\ cm$ and charge $Q_b = 10\ mC$.

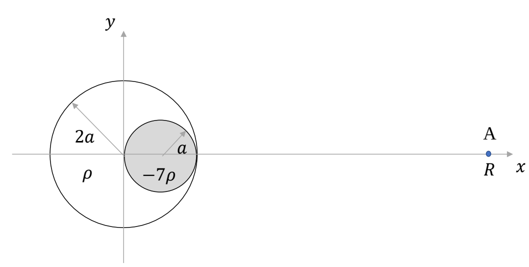


   a. What is the electric field (direction and magnitude) at the two points shown where $r_1 = 2.0\ cm$ and $r_2 = 10.0\ cm$?

   b. A small metal wire is used to connect the inner and outer spheres. After all the charges have finished moving, find the charges Q_a' and Q_b' on the inner and outer spheres now. (Make sure that you justify any assertions that you make.)

c. What is the electric field at the points r_1 and r_2 now?

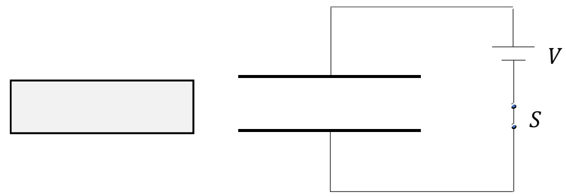
2. The figure on the right shows a sphere of radius a within a larger sphere of radius $2a$. Both spheres are insulators. The shaded region has a charge density of -7ρ, while the unshaded region has a charge density of ρ. (Remember superposition.)



   a. Taking $R \gg a$, *calculate* the electric field at point A shown. (You may want to use $(1+u)^p \approx 1 + pu$ for $u \ll 1$.)

b. At the point A, the two spheres are equivalent to a dipole. What is the dipole moment (magnitude and direction) of this dipole?

3. The figure on the right shows a parallel plate capacitor with area A and separation d connected through a switch S to a voltage supply V. To one side is a slab of dielectric with dielectric constant $K = 5$, area A, and thickness d. The switch was initially closed. The following steps were then taken:



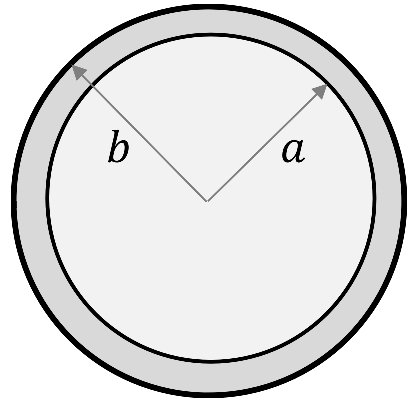
I. The dielectric is slipped into the capacitor.
II. The switch is opened.
III. The dielectric is then removed from the capacitor.

If U_0 is the energy stored in the capacitor before the dielectric was placed in it, and U_f is the energy stored in the capacitor after the dielectric was removed from it, what is

$$\frac{\Delta U}{U_0} = \frac{U_f - U_0}{U_0} \; ?$$

You will get a number. (I strongly recommend that you draw a picture of the circuit after each step.)

4. The figure on the right shows an infinitely long cylinder of radius a filled an insulator with a uniform, constant charge density ρ. Around this cylinder is a conducting cylindrical shell with inner radius a and outer radius b. What is the electric potential everywhere? *Be sure to tell the grader at which point you chose the zero of potential to be.*

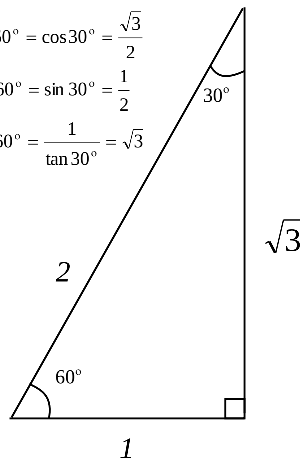


Physics 8B Math Info Sheet

$$\sin 60^{o} = \cos 30^{o} = \frac{\sqrt{3}}{2}$$

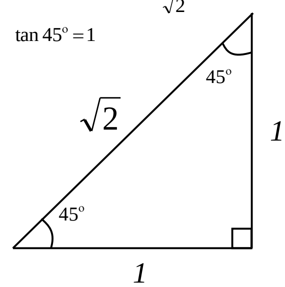
$$\cos 60^{o} = \sin 30^{o} = \frac{1}{2}$$

$$\tan 60^{o} = \frac{1}{\tan 30^{o}} = \sqrt{3}$$



$$\sin 45^{o} = \cos 45^{o} = \frac{1}{\sqrt{2}}$$

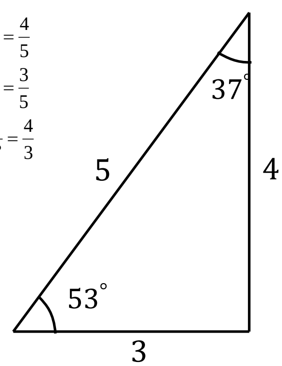
$$\tan 45^{o} = 1$$



$$\sin 53^{o} = \cos 37^{o} = \frac{4}{5}$$

$$\cos 53^{o} = \sin 37^{o} = \frac{3}{5}$$

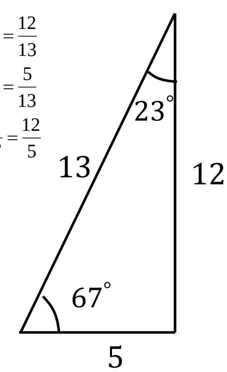
$$\tan 53^{o} = \frac{1}{\tan 37^{o}} = \frac{4}{3}$$



$$\sin 67^{o} = \cos 23^{o} = \frac{12}{13}$$

$$\cos 67^{o} = \sin 23^{o} = \frac{5}{13}$$

$$\tan 67^{o} = \frac{1}{\tan 23^{o}} = \frac{12}{5}$$



Quadratic Equations:

The solution of the quadratic equation $ax^2 + bx + c = 0$ is

$$x = \frac{1}{2a}\left(-b \pm \sqrt{b^2 - 4ac}\right)$$

Derivatives:

$$\frac{d(x^n)}{dx} = nx^{n-1}$$

Integrals:

$$\int x^n \, dx = \frac{x^{n+1}}{n}, n \neq -1, \qquad \int \frac{dx}{x} = \ln x$$