Physics 8B, Section 2 (Speliotopoulos)
First Midterm, Spring 2014
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 five problems, and each one is worth 20 points. Two of the problems ask you to calculate numbers. I have chosen the parameters in these two problems so that the answers can be expressed in terms of rational numbers. However, if you find that in your calculation of these problems you end up with an expression which you cannot evaluate, 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:

Name: ______________________________ *Disc Sec Number:* _______________________

Signature: ___________________________ *Disc Sec GSI:* __________________________

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

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

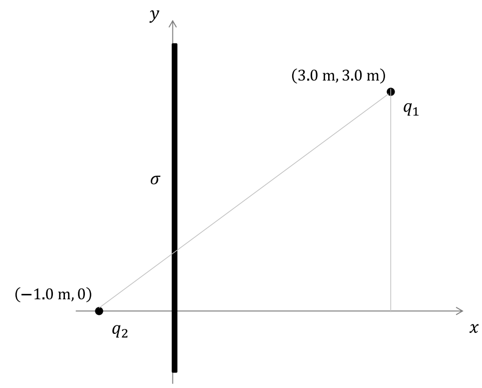
1. The figure to the right shows an ***infinite sheet of charge*** with a positive area charge density,

$$\sigma = \frac{2}{25\pi}\ \mathrm{C/m^2}$$

along with two charges, $q_1 > 0$ and q_2, at the positions shown. The force on q_1 is only along the y-axis.

a. Is q_2 positive or negative?

b. What is q_2?

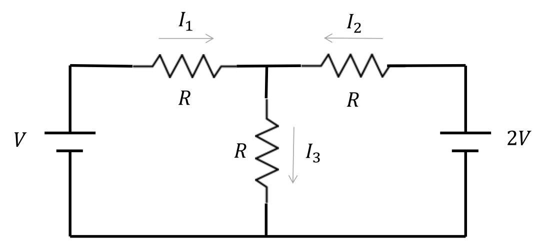


2. The circuit to the right shows three identical resistors connected to two voltage sources. The currents have been chosen already. (Parts a and b are worth 16 points, while part c is worth 4 points.)

a. Apply Kirchhoff's node law to the circuit.

b. Choosing the right number of loops, apply Kirchhoff's loop law to the circuit.

c. What is I_1?

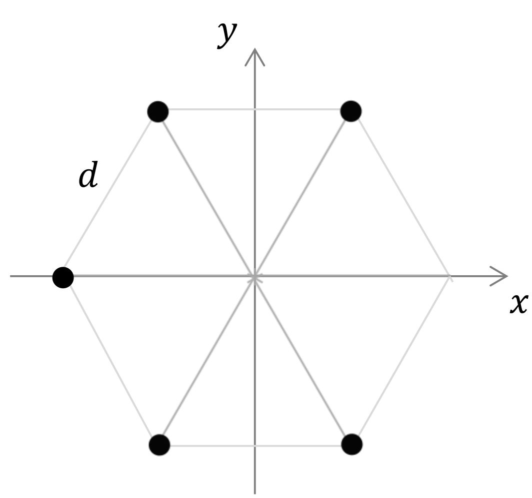


3. The figure to the right shows five identical particles with the same charge, $q > 0$, that are located at five of the six vertices of a regular hexagon with side d.

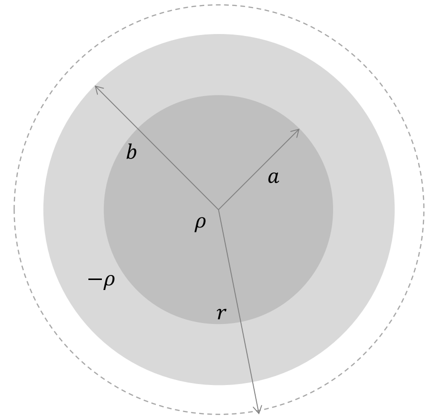
a. What is the electric field at the center of the hexagon? (Hint: Remember, symmetry is your best friend.)

b. What is the electric potential at the center of the hexagon? Take $V(\infty) = 0$.

c. A positive point charge, Q, with mass, m, is placed at the center of the hexagon, and let go. What is its velocity at a distance, $R \rightarrow$ infinity?



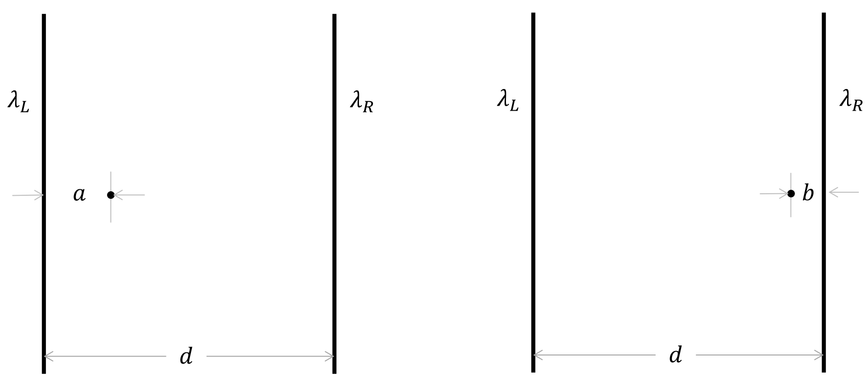
4. The figure to the right shows two concentric spheres made from insulators. One has radius a, and the other has radius b. The inner sphere has a positive charge density, ρ, while the insulator region between the inner and outer spheres has a negative charge density, $-\rho$.
   a. You are told that the electric field outside of the spheres is zero for all $r > b$. What is $\frac{b^3}{a^3}$?
   b. What is the electric field, $\vec{E}_I(r)$, in the region where $0 \le r < a$?
   c. What is the electric field, $\vec{E}_{II}(r)$, in the region where $a \le r < b$?



5. The figure below shows two ***infinite line charges***, one with a charge per unit length, $\lambda_L > 0$, and the other with a charge per unit length, $\lambda_R > 0$. The two line charges are separated by a distance, d. A point charge, $q > 0$, is placed at a distance, $a = d/4$, from the left line charge, and is released from rest. It travels until it reaches point at a distance, $b = d/8$, from the right line charge. The ratio of the linear charge densities is found to be

$$\frac{\lambda_R}{\lambda_L} = -\frac{\ln A}{\ln B},$$

where A and B are numbers. Using conservation of energy between the initial and final positions of the point charge, determine A and B. (The math info sheet has a list of properties of logarithms to which you may want to refer.)

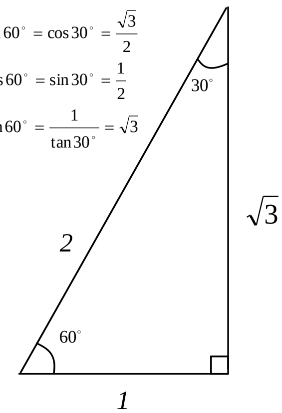


Initial

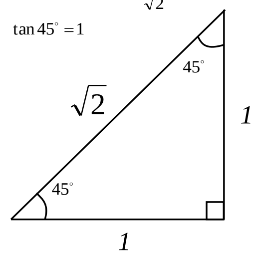
Final

Physics 8B Math Info Sheet

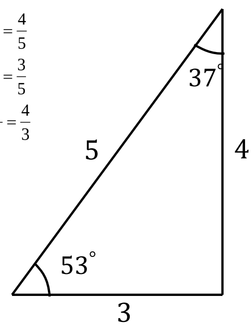
$$\sin 60^\circ = \cos 30^\circ = \frac{\sqrt{3}}{2}$$
$$\cos 60^\circ = \sin 30^\circ = \frac{1}{2}$$
$$\tan 60^\circ = \frac{1}{\tan 30^\circ} = \sqrt{3}$$



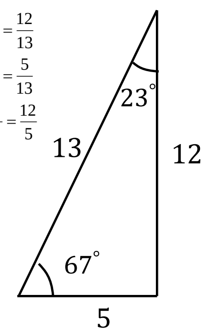
$$\sin 45^\circ = \cos 45^\circ = \frac{1}{\sqrt{2}}$$
$$\tan 45^\circ = 1$$



$$\sin 53^\circ = \cos 37^\circ = \frac{4}{5}$$
$$\cos 53^\circ = \sin 37^\circ = \frac{3}{5}$$
$$\tan 53^\circ = \frac{1}{\tan 37^\circ} = \frac{4}{3}$$



$$\sin 67^\circ = \cos 23^\circ = \frac{12}{13}$$
$$\cos 67^\circ = \sin 23^\circ = \frac{5}{13}$$
$$\tan 67^\circ = \frac{1}{\tan 23^\circ} = \frac{12}{5}$$



Logarithms:

$$\ln(ab) = \ln a + \ln b$$
$$\ln\left(\frac{a}{b}\right) = \ln a - \ln b$$

Small Angle Approximations:

$$\sin x \approx x, \qquad \tan x \approx x, \qquad \cos x \approx 1$$

for $x \ll 1$ rad.

Quadratic Equations:

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

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

Volume of Sphere:

$$V = \frac{4\pi}{3} r^3$$