Question:	1	2	3	4	5	6	7	Total
Points:	15	20	40	70	40	25	25	235
Score:								

University of Rochester
PHY114 - General Physics II
Examination I

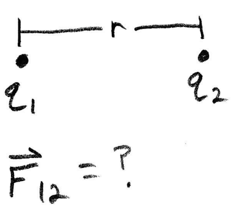
July 23, 2008

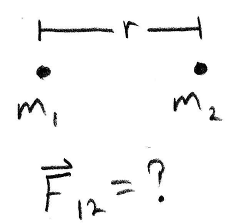
Name:

Answer the questions in the Blue Books provided. If you redo a problem, *clearly* indicate which attempt you wish graded and which ignored. We will only grade one attempt and will not search to find which is more correct.

If you cannot solve a problem because you need a previous result which you were unable to find, go ahead and describe what you would do if you had the needed result. If possible, work through the problem as far as possible using a generic form for the unknown result (e.g., just use $\vec{E}$ if you don't have the actual expression).

1. Electrostatics and Gravity





$\boxed{7}$ (a) Write down the equation of force between two electrical charges q_1, q_2 due to the electrostatic force (Coulomb's Law).

$\boxed{2}$ (b) Write down the equation of force between two masses m_1, m_2 due to Newtonian Gravity.

$\boxed{6}$ (c) How are these formulas similar? How are the different? Why does gravity dominate large scale interactions (planets), while electrostatics is much more important for very small interactions (chemistry)?

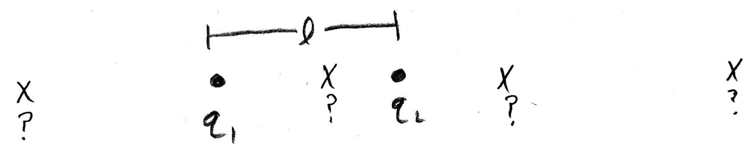
2. Point Charges

$\boxed{5}$ (a) What is the electrical field generated by a point charge q_1 at a distance r?

$\boxed{5}$ (b) What is the electrical potential *difference* generated by a point charge q_1?

$\boxed{5}$ (c) What is the work required to bring a new charge q_2 from infinity to a distance r from q_1.

(d) 2 charges q_1 and q_2 are separated by a distance ℓ. Making only assumptions about the signs of the charges (not their magnitude), describe where their fields cancel if:

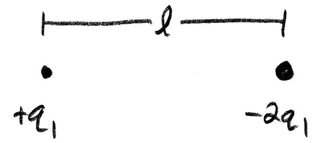


$\boxed{3}$ i. the charges are the same sign.

$\boxed{2}$ ii. the charges are of opposite sign.

Think carefully about how to express the distance to each charge.

3. Visualisations



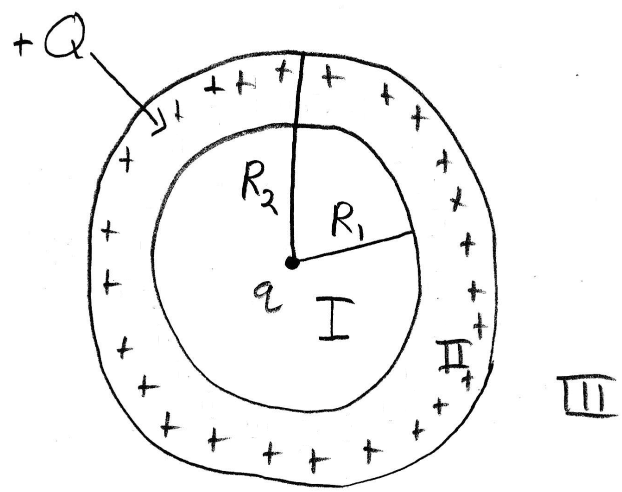
$\boxed{15}$ (a) Draw the electric field lines for a system consisting of 2 charges, $q_1 > 0$ and $q_2 = -2q_1$ separated by a distance ℓ.

$\boxed{5}$ (b) Draw the equipotential lines for the above system. Remember how the two can be related.

$\boxed{15}$ (c) Draw the electric field lines for a charged conductor (charge $+Q$) shaped like an American Football.

$\boxed{5}$ (d) Draw the equipotential lines for the conductor above.

4. Consider the system pictured. A point charge q sits at the center. It is surounded by a thick conducting charged (charge $+Q$) shell with inner radius R_1 and outer radius R_2.



$\boxed{5}$ (a) What is the charge density σ on the conducting shell?

(b) Electric Field

$\boxed{10}$ i. What is the electric field in Region I, $0 < r < R_1$?

$\boxed{10}$ ii. What is the electric field in Region II, $R_1 < r < R_2$?

$\boxed{10}$ iii. What is the electric field in Region III, $R_2 < r < \infty$?

$\boxed{10}$ iv. Plot the magnitude of the electric field in each of the 3 regions.

(c) Electric Potential

5 i. What is the electric potential in Region III, $R_2 < r < \infty$? What else you have to specify in order to make this answer meaningful?

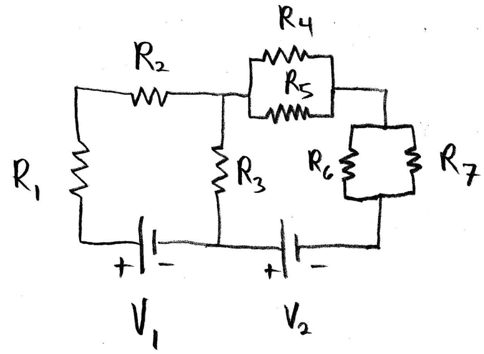
5 ii. What is the electric potential in Region II, $R_1 < r < R_2$?

4 iii. What is the electric potential in Region I, $0 < R_1$?

1 iv. Why did I ask for the potentials in that order? (Thats a hint!)

10 v. Plot the electric potential in each of the 3 regions.

5. For the circuit pictured, use the given resistances and voltage differences.



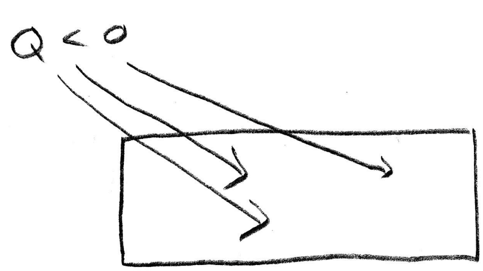
R_1	R_2	R_3	R_4	R_5	R_6	R_7	V_1	V_2
1Ω	2Ω	6Ω	4Ω	2Ω	4Ω	2Ω	$6V$	$12V$

30 (a) Find the current through each resistor.

10 (b) How would you find the change in potential across each resistor? Don't actually calculate it for each one, just tell me how you would.

If you find yourself getting bogged down in the algebra, *don't worry about it.* There are better uses of your time on this exam. If you are on the right track, you'll get most of the credit.

6. Imagine that I have a block of material with a special property. This property is that above a certain temperature T_0, the material is a perfect insulater: it doesn't conduct a bit. Below that temperature, the material becomes a good conductor. While my block of material is at a warm temperature $T_{Warm} > T_0$, I place a charge (negative, they are electrons) distribution evenly throughout the material. Then, I put the block of material into a rapid freezer which will bring the temperature down to some $T_{Cold} < T_0$.

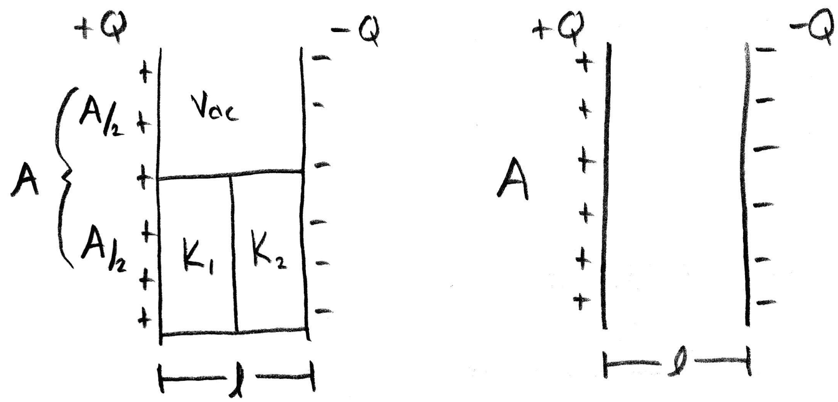


10 (a) Draw the initial charge distribution ρ_{Warm} at T_{Warm} before cooling and separately draw the charge distribution ρ_{Cold} at T_{Cold} after the block has entirely cooled down.

10 (b) If we assume the cooling process is even and near-instantaneous such that the block as a whole T_{Warm} (Non-conducting) one moment and entirely T_{Cold} (Conducting) the next, draw qualitatively how you expect the electrons to move in the moments following the cooling.

5 (c) Now assume that the cooling process is slow and *non*uniform. This means that the outside will cool down and become conducting while the inside is still a warm non-conductor. Draw an intermediate charge density for when the block is about half cooled and half warm.

7. *Extra Credit:* Consider the parallel plate capacitor pictured. Its interior has 3 regions: one filled with vacuum, and one each with materials having dielectric constants K_1, K_2.



(a) Dielectric Free

5 i. What is the electric potential between the two plates in the absence of dielectrics? Where are you measuring the potential difference from? (What is your reference point for the voltage?)

2 ii. Find the capacitance C_0 this capacitor would have if $K_1 = K_2 = 0$.

3 iii. How much energy is stored in the capacitor without dielectrics?

(b) With Dielectrics

8 i. What is the capacitance of the section containing dielectrics K_1 and K_2 (but not the vacuum half)?

5 ii. What is the capacitance of the entire capacitor, with dielectrics?

2 iii. How much energy is stored in the capacitor with dielectrics?