February 2, 2003

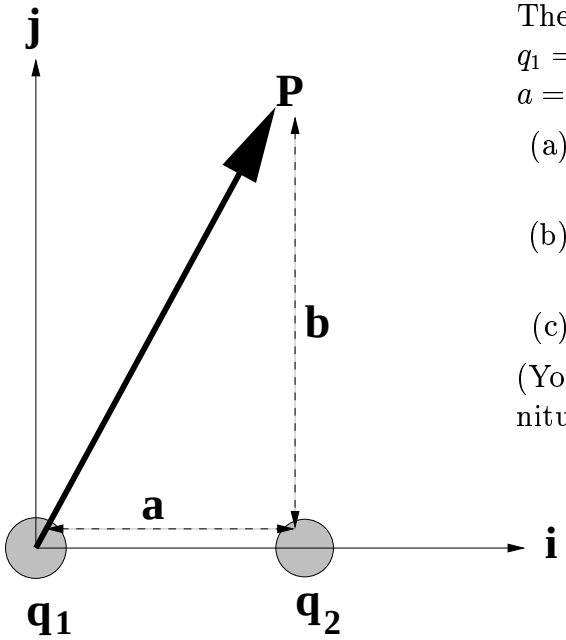
PHY 114 – First Hour Test

Note: This exam has 5 problems each worth 20 points. Please record all of your work (diagrams, mathematical manipulations, and numerical work) in the exam booklet. Please show your intermediate steps so that partial credit can be awarded if appropriate. When your work is completed, please turn in: (1) the exam booklet, (2) your equation sheet, and (3) this exam paper. It is assumed that all work will be done under the guidelines of the honor code.

Useful constants

Coulomb Constant: $k_e \equiv \frac{1}{4\pi\epsilon_0}$: 8.98755×10^9 N $\cdot$ m^2/C^2
Permittivity constant: ϵ_0: 8.854×10^{-12} C^2/N $\cdot$ m^2
Elementary charge e: 1.602177×10^{-19} C
Mass of electron m_e: 9.10939×10^{-31} kg
Mass of proton m_p: 1.6726×10^{-27} kg
Area of a circle of radius r: πr^2
Area of a sphere of radius r: $4\pi r^2$

1.



The figure on the left shows the placement of two charges, $q_1 = +1\times10^{-6}C$, and $q_2 = -3\times10^{-6}C$ with the distances $a = 0.3$ m and $b = 0.7$ m.

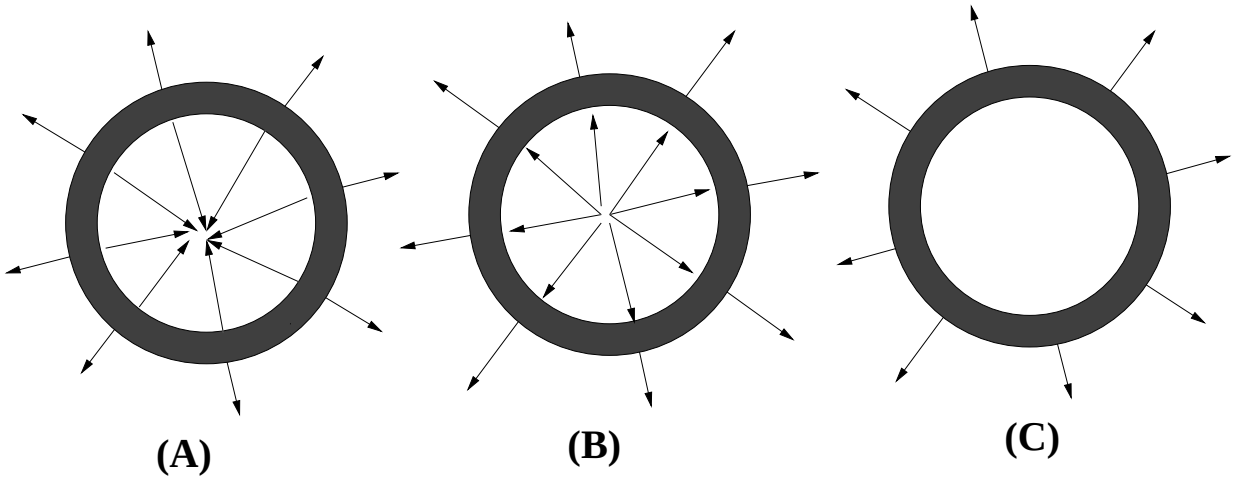
(a) Find the electrostatic field **E** at the point $\mathbf{P} = a\hat{\mathbf{i}} + b\hat{\mathbf{j}}$.

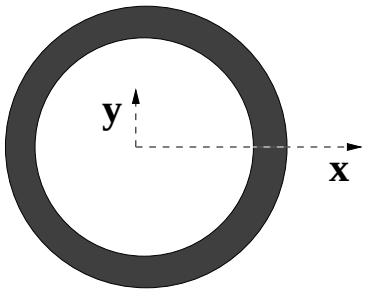
(b) Find the electrostatic potential V at the same point **P**.

(c) Find the force that q_2 exerts on q_1.

(You may express vector quantities in terms of their magnitude and direction or in component form.)

2.





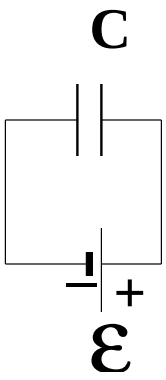
This figure represents a cross-sectional view of a uniformly charged spherical shell made from an electrically insulating material. The outer radius of the shell is $R = 0.1$ m and its charge per unit area is $\sigma = 5 \times 10^{-6}$ C/m^2.

(a) Which of the diagrams (A, B, or C) most closely represents the electric field lines for this charged shell? Briefly explain the reasoning for your choice.

(b) Find the electrostatic field at the point labeled "**x**" which is located a distance of 0.15 m from the center of the shell along the $x-$axis.

(c) Find the electrostatic field at the point labeled "**y**" which is located a distance of 0.05 m from the center of the shell along the $y-$axis.

3.



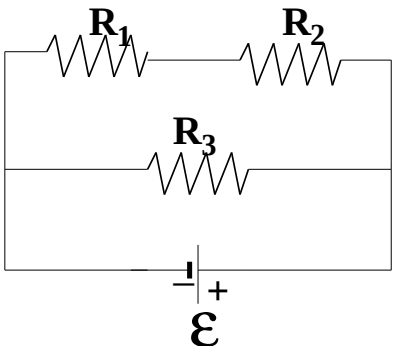
The figure on the left shows a circuit diagram for a capacitor with $C = 4 \times 10^{-6}$ F connected with a conducting wire to a voltage source $\mathcal{E} = 100$ V.

(a) What is the voltage on the capacitor?

(b) What is the charge on the capacitor?

(c) How much energy is stored by the capacitor?

4.



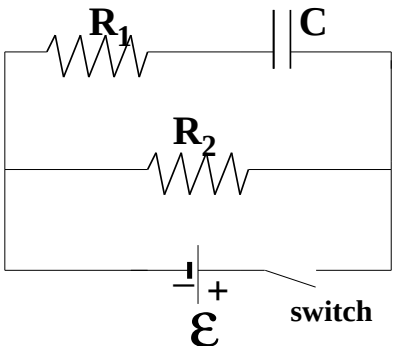
The figure on the left shows the circuit diagram of three resistors, $R_1 = 5\Omega$, $R_2 = 20\Omega$, and $R_3 = 30\Omega$, connected as shown by conducting wires to a voltage source $\mathcal{E} = 100$ V.

(a) What is the total current of this circuit?

(b) What are the voltage differences V_1, V_2, and V_3 the resistors R_1, R_2, and R_3?

(c) What is the power generated by this circuit?

5.



The figure on the left shows the circuit diagram of two resistors, $R_1 = 10\Omega$ and $R_2 = 20\Omega$, and a capacitor $C = 30 \times 10^{-6}$ F, connected as shown by conducting wires to a voltage source $\mathcal{E} = 100$ V. Initially, the switch is open and the capacitor is discharged.

(a) Suppose that at $t = 0$, the switch is closed. How long will it take for the charge on the capacitor to reach 63% ($100 \times (1 - e^{-1})$) of its final charge?

(b) What will be the charge on the capacitor a long time after the switch is closed?

(c) Find expressions for the currents $I_1(t)$ and $I_2(t)$ as a function of time through resistors R_1 and R_2.

******Extra credit******

Consider the circuit in problem #5. Suppose that some time after the capacitor reaches its maximum charge, the switch is then opened. Describe in quantitative expressions what happens to the capacitor charge as a function of time.

********************End of Exam*********************