

PHYSICS 8B – Fall 2009
Mid-term 1
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Wednesday, October 7, 2009
7pm-9pm

Problem 1 – Electric field

Let's consider a discrete distribution of 4 point-charges located at $A(2d;0)$, $B(-2d;0)$, $C(0;-d)$ and $D(0;d)$. The numbers in parentheses next to the points indicate the point's x - and y -positions, and d is a length.

A and B each carry a charge $-q$, whereas C and D carry charges $+2q$ and $+q$, respectively.

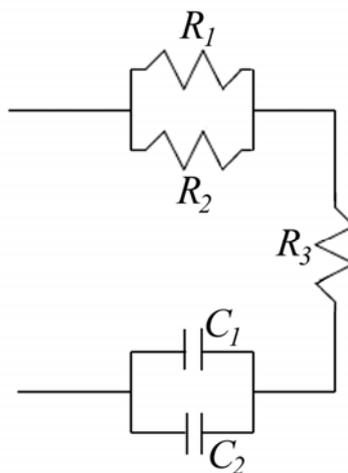
- a) Draw, qualitatively, the 4 individual electric field vectors created by each of the charges at point O , the origin, as well as the resulting electric field vector at O .
- b) Calculate the vector $\vec{E}(O)$.
- c) Do you know another way of getting the electric field? You don't need to make the calculation.

Problem 2 – Capacitor

A capacitor is made of 2 parallel plates of surface area A , separated by a distance d , and carrying the charges $+Q$ and $-Q$ respectively.

- a) Assuming that the geometry of the system allows us to consider these plates as uniformly charged flat sheets of infinite size (in other words, the side lengths of the plates is much bigger than the plate separation), determine the electric field inside and outside the capacitor. Make a drawing.
- b) Express the voltage across the capacitor.
- c) Determine the capacitance C of the capacitor. (Use your answer to part (b), *don't* just write down the formula for the capacitance of a parallel plate capacitor!)

Problem 3 – RC circuit



$R_1 = R$; $R_2 = 3R$; $R_3 = R/2$; $C_1 = C$; $C_2 = 2C$; where R and C are respectively a resistance and a capacitance.

- a) Draw a simplified version of that electrical circuit using only one resistor of equivalent resistance R_{eq} and one capacitor of equivalent capacitance C_{eq} . Express R_{eq} and C_{eq} as a function of R and C .

- b) If this is connected to a battery that provides an emf \mathcal{E} , what is the maximal electric power dissipated by the equivalent resistance?
- c) What is the maximal electric energy that can be stored by the equivalent capacitor?
- d) Before the battery is connected to the circuit, the capacitors are uncharged. Determine the current going through the equivalent circuit and the charge on the equivalent capacitor in the following two cases:
- Immediately after the battery is connected to the circuit.
 - A long time after the battery is connected to the circuit.

Problem 4 – Magnetic field

Imagine that you have to reproduce the original experiment performed by Oersted showing the existence of a magnetic field created by a current flowing through a wire.

- Make a drawing with all the pieces of equipment you would need to run your experiment, and explain how you would proceed to get your conclusions. (If you can't remember Oersted's experiment, try to think up a new experiment to prove the existence of a magnetic field created by a current!).
- How could you visualize the field lines around the wire? There is more than one correct solution.

Problem 5 – Electromagnetic induction

Four metallic rods are horizontally arranged to make a rectangular loop of resistance R , and one of the rods, initially (at $t=0$) on top of the parallel fixed rod, is manually moved with a constant velocity v . A constant, uniform magnetic field, of magnitude B is pointing upwards, perpendicular to the frame, as shown in the figure below.

- What is the magnetic flux through the loop as a function of time?
- Calculate the induced current and make a drawing to show it.
- Determine the magnetic force acting on the moving rod. Does it satisfy the Lenz's law?
- What work do you have to apply to the moving rod to carry out the motion described above?

