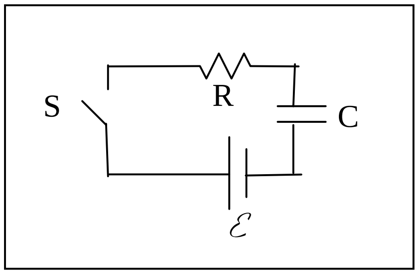
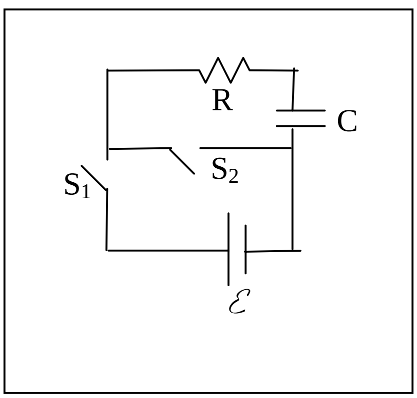
Physics 206b

Homework Assignment IX
Due October 12, 2007

1. In the circuit below, the resistance is $37k\Omega$ and the capacitor is 14 nF. After switch S is closed, how long will it be before the voltage difference across the capacitor is ½ $\mathcal{E}$?



2. Now consider the circuit below. Initially, S_1 is closed and S_2 is left open. After a long time, S_1 is opened and S_2 is immediately closed. (This is usually accomplished by a single switch just "shunting" to a different path.) Make a sketch of the charge held by the capacitor as a function of time after S_2 is closed. Use the values for R and C from the previous problem. Be sure to indicate on your sketch the time at which the charge will be at the $\frac{1}{e}$ level. If $\mathcal{E} = 3V$, after 300 microseconds, what will be the charge remaining on the capacitor (this will be an actual value, not just a fraction)?



3. A 56 mF capacitor is attached to a 3 V battery for a very long time. The battery is then removed and the capacitor is used to power a small lightbulb. It is known that the bulb dissipates 1 W when driven by a 1.5 V battery. How long after the bulb is attached to the capacitor will it be before the power dissipated by the bulb falls to ½ of the power it dissipates immediately after the capacitor is attached to it? Assume that the resistance of the bulb is not affected by its temperature.

4. A 37 mF capacitor is wired in series with a battery and a resistor. It is noted that the current passing through the resistor drops to 1/6 of its initial value in 500 ms. What is the resistance of the resistor?

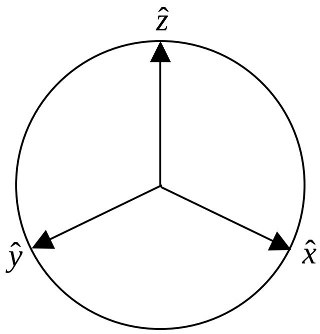
5. A 37 mF capacitor is attached to a 12 V battery for a very long time. The battery is then removed. The capacitor is then discharged through a 10 kΩ resistor for 15 seconds. Then, the 10 kΩ resistor is replaced by a 130 Ω resistor. After two seconds, what is the potential across the resistor? What is the current through it? What is the charge remaining on the capacitor?

6. Write down, in words, Ampere's Law.

Below is a set of math problems provided to give you practice with a new skill set. These problems will not be graded. There is no need to hand them in with your assignment. However, I urge you to approach them with the same level of seriousness that you bring to the other problems you are assigned! The skills represented in these problems will be essential to solving the problems you will see in future assignments.

Some important properties of the cross product:

$$\vec{a}\times\vec{b} = -\vec{b}\times\vec{a}$$
$$\vec{a}\times\vec{a} = 0$$
$$\hat{x}\times\hat{y} = \hat{z}$$
$$\hat{y}\times\hat{z} = \hat{x}$$
$$\hat{z}\times\hat{x} = \hat{y}$$



7. Using the right hand rule (RHR), what is size and direction of $\vec{a}\times\vec{b}$ if $\vec{a}$ is a vector of length 2 pointed in the $\hat{x}$ direction and $\vec{b}$ is a vector of length 5 making an angle of 20° with $\vec{a}$ in the *x*-*y* plane?
8. Now, use the two vectors above to perform the same calculation algebraically.
9. Perform the following cross products:
   a. $(27\,\hat{x}+3\,\hat{y})\times(9\,\hat{x}+1\hat{y})$
   b. $(27\,\hat{x}+3\,\hat{y})\times(9\,\hat{x}-1\hat{y})$
   c. $(3\hat{x}+5\,\hat{y}+7\hat{z})\times(11\hat{x}-13\hat{y}+6\hat{z})$
10. By directly performing the following cross products in two different orders, show that, in general $(\vec{a}\times\vec{b})\times\vec{c} \neq \vec{a}\times(\vec{b}\times\vec{c})$
    a. $5\hat{x}\times 3\hat{z}\times 9\hat{z}$
    b. $(2\,\hat{x}+5\,\hat{y}+8\hat{z})\times(9\,\hat{x}-13\hat{y}+11\hat{z})\times(-6\hat{x}+7\,\hat{y}+17\hat{z})$
11. Taking $\vec{\tau}=\vec{d}\times\vec{F}$, find $\vec{\tau}$ when
    a. $\vec{F}=80\,N$ in the $-\hat{y}$ direction and $\vec{d}=1m$ at an angle of 17° relative to the *x* axis in the *x*-*y* plane. Sketch the force, the moment arm (*d*), and the torque ($\vec{\tau}$).
    b. $\vec{F}=12N\,\hat{x}-3N\,\hat{y}+5N\,\hat{z}$ and $\vec{d}$ is 4 meters long and makes a 45° angle with all three of the Cartesian axes (i.e., it points out of the corner of the cube formed of *x*, *y*, and *z*.)