Assignment VI, PHYS 112 (General Physics II)
Fall 2020
Due via pdf upload to OAKS prior to Friday, October 9th at 10:00 AM

General instructions:
For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit. You do not need to upload the sheet with the questions on it, but please clearly number your problems and circle or box your final answers. I encourage you to collaborate with classmates to discuss how to approach a particular question, but the mathematical steps to generate your final answer on your submitted work should be your own. If I see the same simple mistake on multiple homework assignments, I will take off more points for that error than I normally would. Please include *words* in your answers. When you get answer keys back from me, you'll see that there are explanations, ideas, commentary, and thought processes included – not just a set of equations one after another. Finally, please ensure that all numerical answers have units.

Since several people in class asked for this, here are some suggested (but ungraded) extra problems from the textbook for practice: (All problems out of Halliday, Resnick, and Walker, 10th Extended Edition, "Fundamentals of Physics"). (I chose all odd-numbered problems since the answers to those problems are in the back of the book and that's a good way to check if your practice is accurate.) No need to turn these in, but if you are looking for extra things you can work on if you want to practice problem solving some more, here's what I would advise.

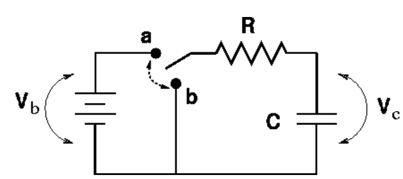
Chapter 27, problems 57, 61, 79, 85.
Chapter 28, problems 1, 3, 5, 9, 11, 17, 27

1. Below is a picture of an RC circuit. Let the capacitor be initially uncharged and assume the switch is toggled to the "a" position at time $t = 0$.

   a) Find an expression for the voltage drop over the *resistor* as a function of time.

   b) Use your answer to part (a) to determine the time at which the voltage drop over the resistor is exactly one half of the voltage supplied by the battery (V_b). Leave your answer in terms of R and C.

   c) If $R = 3.3$ kΩ, $V_b = 1$ kV, and $C = 20$ μF – how much charge is on the positive plate of the capacitor when $t = 10$ milliseconds?



2. Refer back to the RC circuit presented on the previous page. Assume that the switch has been aligned so that the switch is connected to point "a" for a very long time – so long that no more current runs in the circuit because an equilibrium has been reached. Now, at time $t = t_\circ$, the switch is moved to position "b".

   a) Write an expression for $|I(t)|$ for this circuit, assuming $t > t_\circ$. (Leave your answer in terms of V_b, R, C, $t_\circ$, and t).

   b) If $R = 4.7$ kΩ, $V_b = 500$ V, and $C = 50$ μF, how much total charge moves through the resistor between $t = t_\circ$ and $t = t_\circ + 3\tau$? (Hint...your answer to part (a) might be helpful here). (Don't worry about the sign of the charge). (Note. Just in case I didn't mention it in class $\tau \equiv RC$, the "natural timescale" for this system).

3. Again look at the same picture of the RC circuit on the previous page for reference. Below is a picture of $V_C(t)$ (in volts) as a function of t (in seconds) after switching the switch to position "a". (You may assume that the capacitor was initially uncharged). Based on the plot below and the circuit above, answer the following:

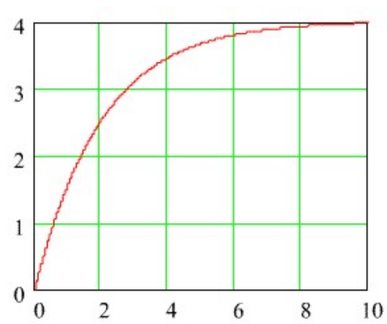
   a) What is the voltage of the battery?

   b) If the resistor has a resistance of 3300 Ω, what is the Capacitance of the capacitor?

   c) If the resistor has a resistance of 3300 Ω, how much charge resides on the surface of the capacitor after $t = 3$ seconds?

   d) If the resistor has a resistance of 3300 Ω, how much energy is stored in the capacitor after $t = 10$ seconds?

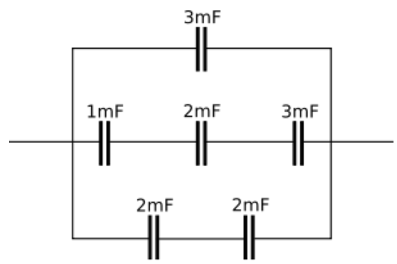
   e) Let's say the capacitor is charged as implied in parts (a)-(d) above and then removed from the circuit (while still retaining its charge). The capacitor is then put in a very simple circuit, in series with a lightbulb of resistance 7 Ω. (This is actually reasonable for a small light bulb like the ones you probably used in lab when first learning about circuits). Technically, current runs through this new circuit forever, but at some point it doesn't appear like the bulb is lit any longer. The brightness of the bulb is related to the instantaneous power being dissipated by the bulb. If the bulb does not appear to be lit up when its instantaneous power drops below 0.1 W, how long can the capacitor keep the bulb lit?



4. Please see figure of a portion of a circuit below.

   a) What is the total capacitance of the circuit below?

   b) How much energy would be stored in this capacitor network if it was connected directly to a 15 V battery?



5. A particle with a charge of 32 μC experiences a force of 7.3×10^{-5} N when it moves at right angles to a magnetic field with a speed of 18 m/s. What force does this particle experience when it moves at a speed of 3.7 m/s at an angle of 62° relative to the magnetic field?

6. A 5.70 μC particle moves through a region of space where an electric field of magnitude 1320 N/C points in the $\hat{\imath}$ direction and a magnetic field of 0.79 T points in the $\hat{k}$ direction. If the net force acting on the particle is 3.79×10^{-3} N in the $\hat{\imath}$ direction, find the magnitude and direction of the particle's velocity. (Assume that the particle's velocity is in the $x - y$ plane).

7. A proton with kinetic energy K moves perpendicular to a magnetic field of magnitude $B_\circ$. What is the radius of its circular path? (Leave your answer in terms of K, $B_\circ$, and fundamental constants only).