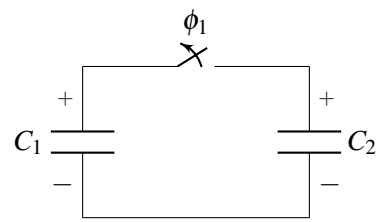
1. Capacitors and Charge Sharing

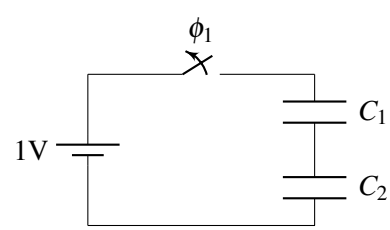
(a) Consider the circuit below, with $C_1 = C_2 = 1\mu F$. Suppose initially C_1 is charged to $+1V$, and C_2 is charged to $+2V$. How much charge is on C_1 and C_2? How much energy is stored in each of the capacitors? What is the total stored energy?



(b) Now the switch is closed (i.e. the capacitors are connected together.) What are the voltages and charges on C_1 and C_2? What is the total stored energy?

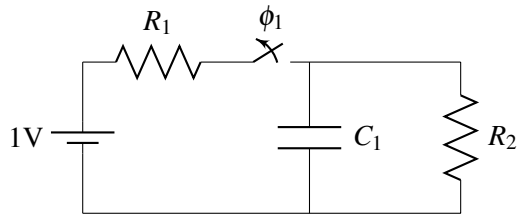
(c) Is this more or less energy than before the switch was closed? Why?

(d) Consider the following circuit, with $C_1 = 1\mu F$, $C_2 = 3\mu F$. Suppose both capacitors are initially uncharged ($0V$).



What are the voltages across the capacitors after the switch is closed? What are the charges on the capacitors?

(e) Consider the below circuit, with $C_1 = 1\mu F, R_1 = 1k\Omega, R_2 = 1k\Omega$.



After the switch is closed, and the circuit is allowed to settle, what is voltage across and current through all circuit elements? Note that "settled" here means that the voltages and currents are no longer changing.

2. Timer Circuit

As we will soon see, keeping track of the amount of that has elapsed between the occurrence of two events can be extremely useful. Therefore, in this problem we will explore the design of a circuit that can produce a periodic voltage waveform, where the period of that waveform will be set by the values we choose for our components. In particular, we want to design a circuit that will output +5V for half of the period, and -5V for the other half of the period - i.e., your circuit should output a square wave with a 50% duty cycle.

In order to realize this circuit, you are allowed to use any combination of the following components:

- Op-amps (as comparators)
- Current Sources
- Capacitors
- Switches
- Batteries (i.e., voltage sources)

If you need some control signals (like those we used in the touchscreen lab from the Launchpad) that drive some switches in order to reset and/or initialize some voltages within your circuit, please feel free to utilize those as well.

(a) Sketch a design for a circuit that achieves the timer functionality described above. Don't worry about setting the value of the period yet or the values of the any of the components yet - just show a schematic for the circuit.
(*Hint*: If driven by a fixed current, how does the voltage across a capacitor change over time?)

(b) Now select component values for your design such that the period of your timer circuit is $100\,\mu$s.