Capacitors

Along with resistors and diodes, ***capacitors*** round out the 'big three' basic electrical components. To fit them into the fluid analog requires a little bit of creativity (though there are many other examples on the internet and in various text books.)

Capacitors have the ability to store a certain amount of electric potential — i.e. they have a certain *capacity*. In plumbing this would equate to a water tower, or on a smaller scale to a rubber bladder. You can pump water into the tower or bladder faster than it drains out, and then still have some water flow after the pumping stops.

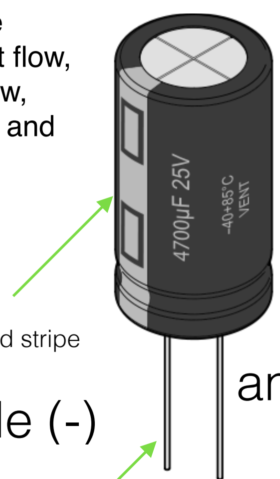
Capacitors act the same way, electricity flows in, fills up the available capacity and then flows out. And after it stops flowing in, it can continue to flow out until the stored supply is used up.

In some ways this is very much like a rechargeable battery. However, they are able to very rapidly charge and discharge their potential, can do so millions of times (vs 100s for batteries), and can be created with very specific amounts of electrical storage capacity. And typically their storage capacity is only a fraction of even a small battery.

There are various types of capacitors, each using different physical properties and having different storage capacities and charging characteristics.

Many larger capacitors, caps for short, operate optimally when current flows in a particular direction through them. These caps have an Anode and Cathode just as a battery or LED will. These are called **polarized** capacitors. The term polarized in this context simply means that current should flow in a particular direction — diodes are polarized by definition, whereas resistors are not.

Capacitors have a variety of uses. Some common ones include smoothing current flow, providing temporary boosts in current flow, blocking DC flow while allowing AC flow, and creating resonating pulses.



Capacitance is measured in ***Farads***. Since one Farad represents a fairly large amount of electric potential, many capacitors will be labeled in μF, microfarads (one millionth), or mF, millifarad (one thousandth). pF, picofarad, and nF, nanoFarad sized caps may also be found in digital electronics.

A Farad is a one Coulomb per Volt. A ***Coulomb*** is a time based measurement of current, which, as we saw earlier is related to Amps. If fact, it is equal to one Ampere in one second.

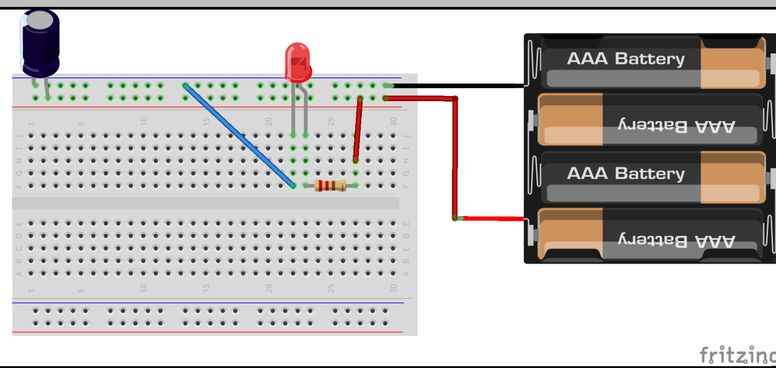
There are many unique properties of the different types of capacitors, as well as many other standard properties which should be considered when designing analog circuits; charging time, q-factor, charging time in an RC Circuit, etc. While the discussion of these are all outside the scope of this document, it explains why capacitors of the same Farad rating may have different sizes, shapes, and construction types.

Not all capacitors can operate at all voltages. Typically a maximum voltage will be listed on the package. Similarly since the internal components may consist of a gel or liquid, the valid operating temperature range is often listed. Exceeding that temperature will shorten the life of the capacitor.

Large capacitors, often used in switching power supplies can be dangerous to work with, as they can store substantial energy for long periods of time, and discharge all of that potential when touched.

Although capacitors have a long life compared to rechargeable batteries, they are typically the shortest-lived components in any modern circuit. Many older pieces of electronics can be repaired by 'recapping', i.e. replacing some or all of the capacitors (especially the 'can' style ones). If you have some failed LED or CFL light bulbs that were supposed to last 5-30 years, but only made it for 1 or 2, it is probably because the capacitors in the driving circuit have failed.

Experiment: Capacitors

Components	**Wiring Diagram**
✓Battery Pack ✓Breadboard ✓Any single-color LED ✓Resistor ✓Capacitor	

Connection Instructions
Insert your capacitor onto the power rail so that the Cathode (-) pole is connected to the blue (-) rail and the Anode (+) is connected to the red (+) rail. Make sure your battery pack is still correctly connected to the power rail, and power it on with the switch. Verify that the LED lights, you can leave it on for a few seconds. Now switch off the battery pack.

Sketch(es)	— —

Analysis Questions
Did the LEDs overall brightness change? How long did the LED stay lit after disconnecting the battery? Replace your resistor with a jumper and briefly touch the battery pack’s negative line to the blue power rail, just long enough for the LED to light, then release it. Did the LED stay lit for a longer or shorter time?

Programming Tasks
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