Since electricity is "invisible" and it is sometimes hard for people to envision it, a common analogy used to explain its character is the Hydraulic Analogy. In this description, electrical voltage is considered the same as pressure, and electrical current is the same as fluid flow.

At first this might seem kind of simplistic it is, except as far as the system character is concerned, the analogy is accurate. So the amount of flow through a pipe is a function of the pressure difference between two points and the constriction or resistance in the pipe. Similarly the current flow through any wire is a function of the voltage difference between the two ends of the wire divided by the resistance of the wire. This is shown in Figure A-1.

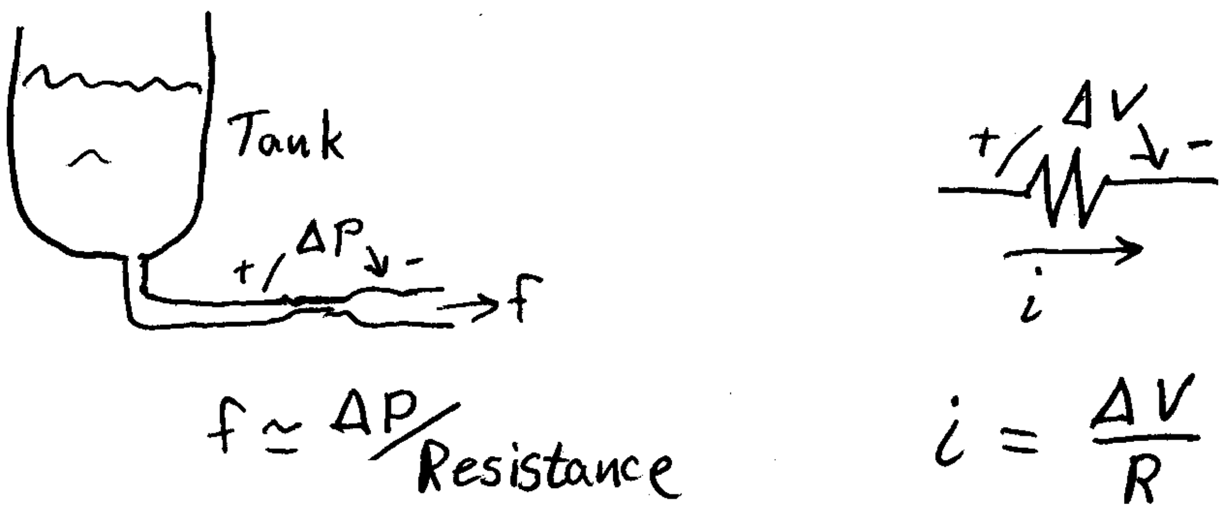
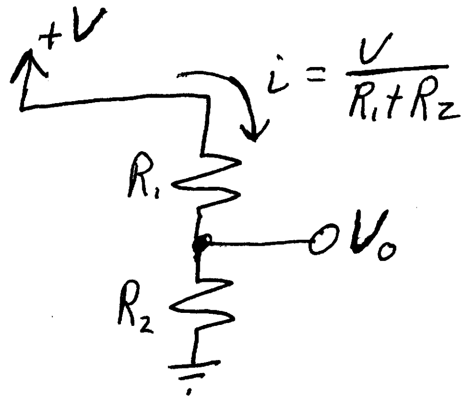


Figure A-1. Pressure-Flow Analogous to Voltage-Current.

In this graphic we can see that concept of a tank of water providing pressure on a water line, then the flow of water through a constriction. A similar process applies to voltage applied to a wire, voltage forces electrons through the material of the wire. The material, length and cross-sectional diameter of the wire will determine the flow of electrons through the wire. Now if we consider the what we can do with this simple process, consider a voltage source with two resistors attached to it as shown in Figure A-2.

In this Figure, we see that the current would be equal to the voltage divided by the resistance, which works out to be the sum of the two resistors. Then the output voltage is the lower resistance times the current or $V_o = \frac{R_2}{R_1 + R_2} * V$, which is commonly called a voltage divider.

In the next Lab, we will want to be able to supply a voltage to our device that we could control. So a simple way to do this is to have a physically long resistor and have a contact that moves along the resistor. As the contact moves from one end to the other we would have a voltage that would vary from V to 0 volts. This device is called a potentiometer and is shown schematically in Figure A-3.



$$V_o = i \cdot R_2 = \frac{V}{R_1 + R_2} \cdot R_2$$

$$= \frac{R_2}{R_1 + R_2} V \text{ (Voltage Divider)}$$

Figure A-2. Voltage Divider Setup.

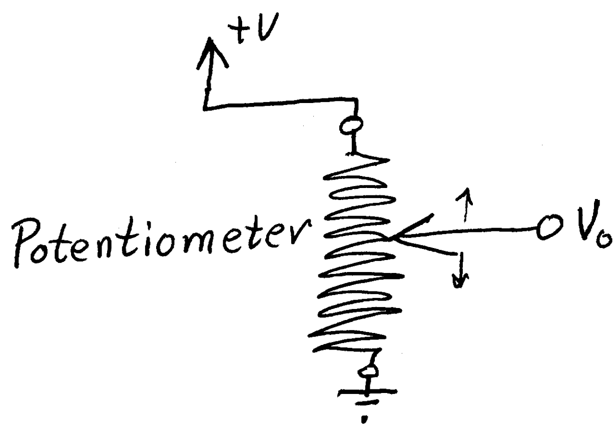


Figure A-3. Potentiometer Schematic.

Now some components don't respond instantaneous to a voltage, or have a constant voltage supply. Once such component is the capacitor, which acts as a tank for holding charge. Figure A-4. shows the form of this analogy. In the left-hand side, we see two tanks connected through a restrictive water line. A valve in the line is opened at a point in time, after which the water flows from one tank to another, until the two tanks have the same level of water. When the valve is first opened, the high water level in the first tank will cause the water to flow quickly through the pipe, and the level of the second tank will start filling quickly. Once the second tank becomes filled to where it matches with the level in the first tank, the flow will drop off and the filling of the tank will slow.

The capacitor circuit on the right-hand side follows a similar form, when the switch is closed. Once the switch is closed, current flows to the capacitor. The capacitor charges up, until its voltage (charge) will match the voltage of the supply.

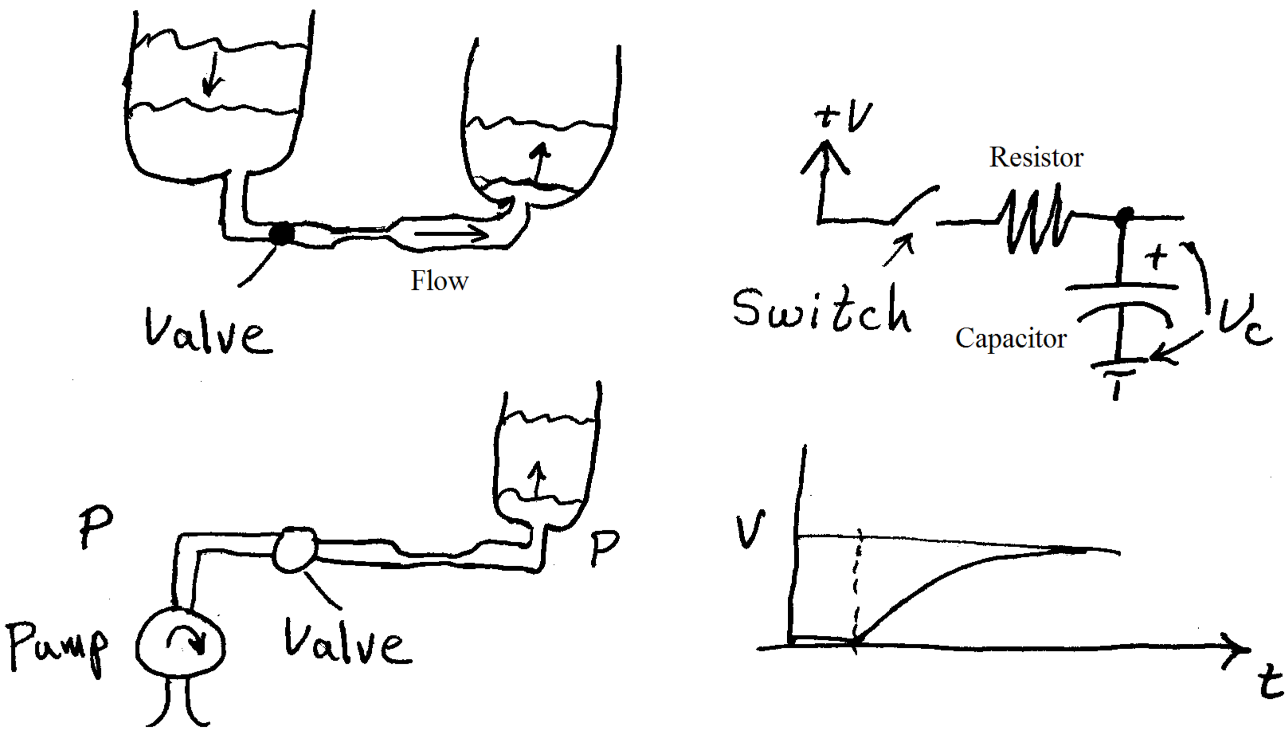


Figure A-4. Capacitor Tank Analogy Display.

In the lab we will be using a resistor-capacitor (RC) circuit to create a voltage from one of our pins. The circuit is shown in Figure A-5. The two switches on the left are a simple model of an output pin, with one switch closed at a time.

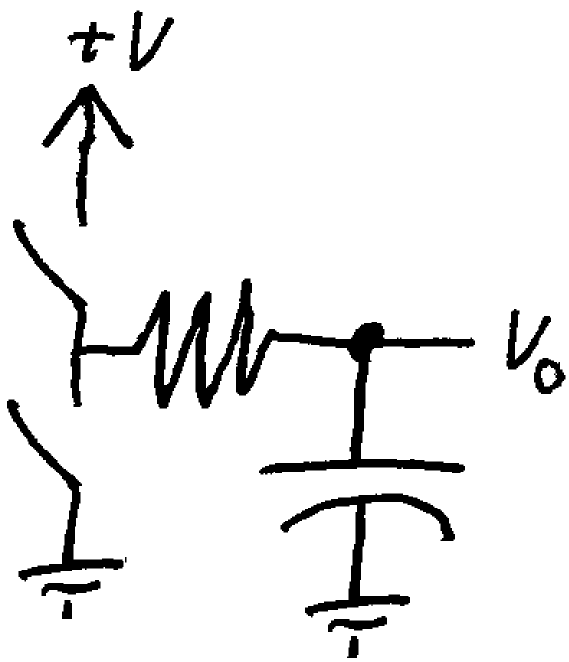


Figure A-5. RC Circuit as Attached to Output Pin.

If the pin is driven by a PWM signal we will get signals similar to those shown in Figure A-6. From this we can see that as the duty cycle (percent of time the signal is high) will effect the average voltage level of output voltage.

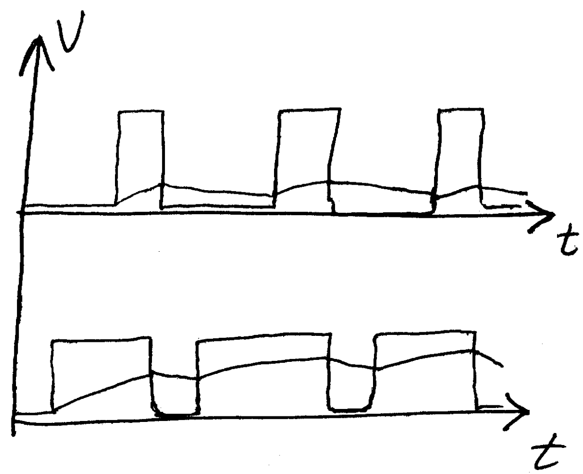


Figure A-6. Waveforms for RC Circuit Driven by a PWM Signal with Different Duty Cycles.

For other examples of the electricity-hydraulic analogy, look at these websites.

https://en.wikipedia.org/wiki/Hydraulic_analogy

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/watcir.html