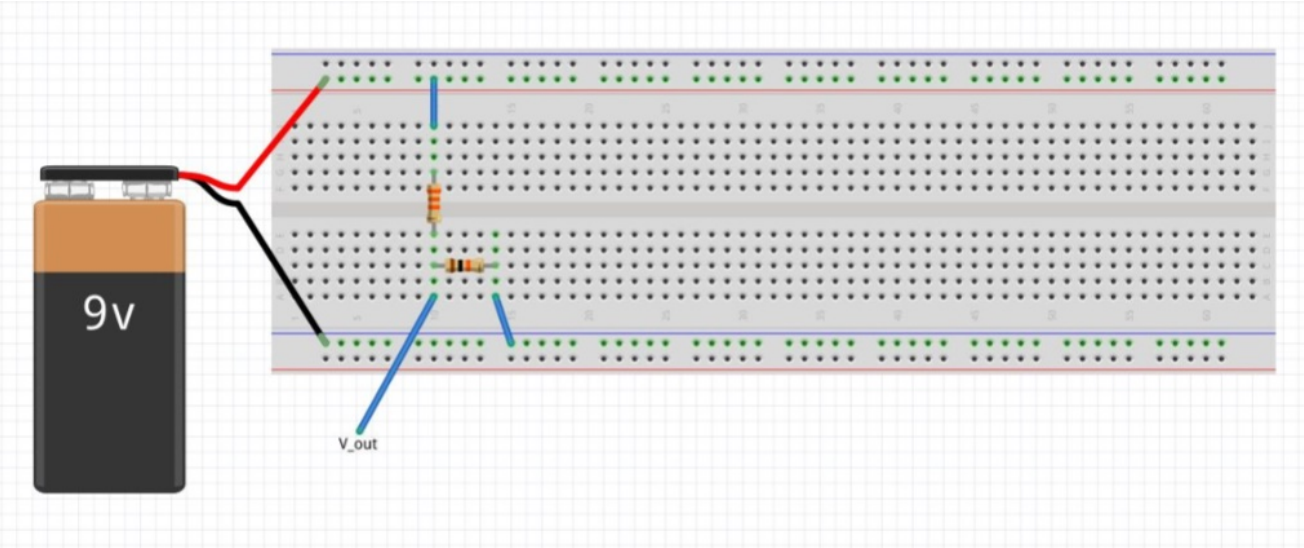
BioE 101 Lab 1 Prelab

Due before your lab through bCourses. Submit prelabs individually.

For your reference, if you need a little review about circuits, check out sections II and IV of the Circuits Reader on bCourses.

Circuit Analysis and Breadboarding

1. Voltage Divider

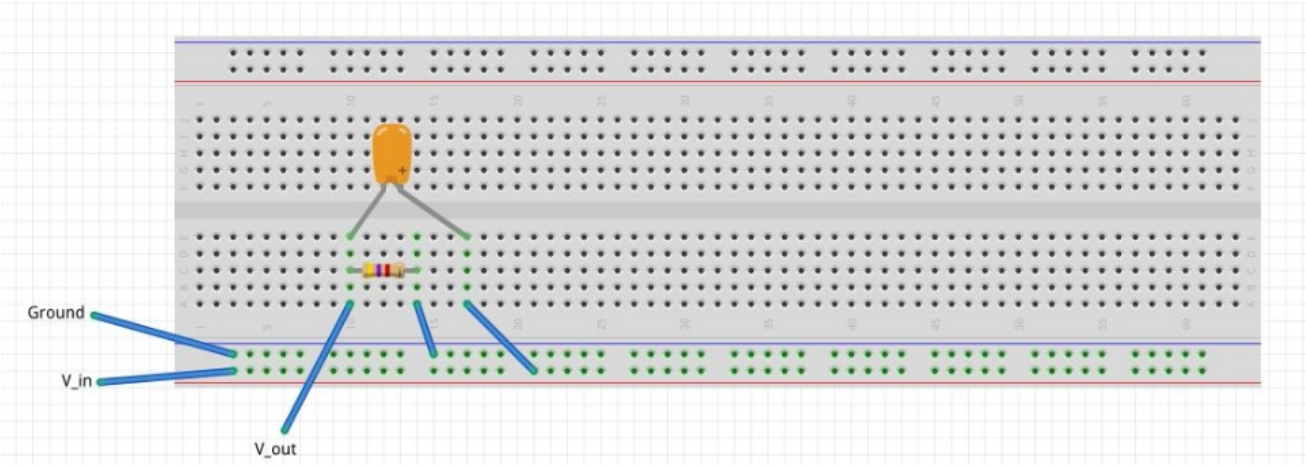


(a) Draw the circuit schematic from the breadboard view above, with labeled resistor values (use the chart in the lab protocol). The bands for the vertical resistor are orange, orange, orange, and gold. The bands for the horizontal resistor are brown, black, orange, and gold.

(b) What is V_{out} with reference to ground?

(c) If you wanted V_{out} to be exactly 4.5V, what ratio of resistors would you use?

2. RC Filters



(a) Draw the circuit schematic from the breadboard view above. The value of the capacitor is 1 microfarad. The resistor band colors are yellow, violet, red, gold.

(b) What is the transfer function $H(f) = \frac{V_{out}(f)}{V_{in}(f)}$?

(c) What type of filter is this, and what is the cut-off frequency? Draw a Bode plot of the filter. Include the magnitude plot in log-scale and a phase plot as well. Feel free to use MATLAB or Python. For your convenience, the next page contains some starter code for MATLAB and Python Bode Plots.

(d) Instead of taking the output at the resistor, you take the output at the capacitor instead. Now what type of filter is this and what is the cut-off frequency? Again, draw a Bode plot of the filter.

(e) If you combine a high-pass filter with a cut-off frequency f_1 and a low-pass filter with a cut-off frequency f_2 what types of filters do you get if $f_1 > f_2$ and $f_2 > f_1$, respectively?

MATLAB

```
H = tf([a1, a2, a3],[b1, b2, b3]);
bode(H,{1,100})
grid on
```

Replace `a1` thru `b3` with the coefficients of the numerator and denominator of the transfer function in the s-domain. For example, if your transfer function is $H(f) = \frac{1}{1+i2\pi f\tau}$, which is $H(s) = \frac{1}{1+s\tau}$ in the s-domain, then you would replace `H` with:

```
H = tf([1],[tau, 1]);
```

Don't forget to define `tau`!

Python

```
%matplotlib inline
from scipy import signal
import matplotlib.pyplot as plt
print("1a. 1st Order LPF")
s1 = signal.lti([1], [tau, 1])
w, mag, phase = signal.bode(s1)
plt.ylabel("Magnitude $20log(|H(\omega )|)$")
plt.xlabel("Frequency $\omega$")
plt.semilogx(w, mag) # Bode magnitude plot
plt.figure()
plt.ylabel("Phase $\phi$")
plt.xlabel("Frequency $\omega$")
plt.semilogx(w, phase) # Bode phase plot
plt.show()
```

Run the above code in an ipython notebook. **Don't forget to define** `tau`!