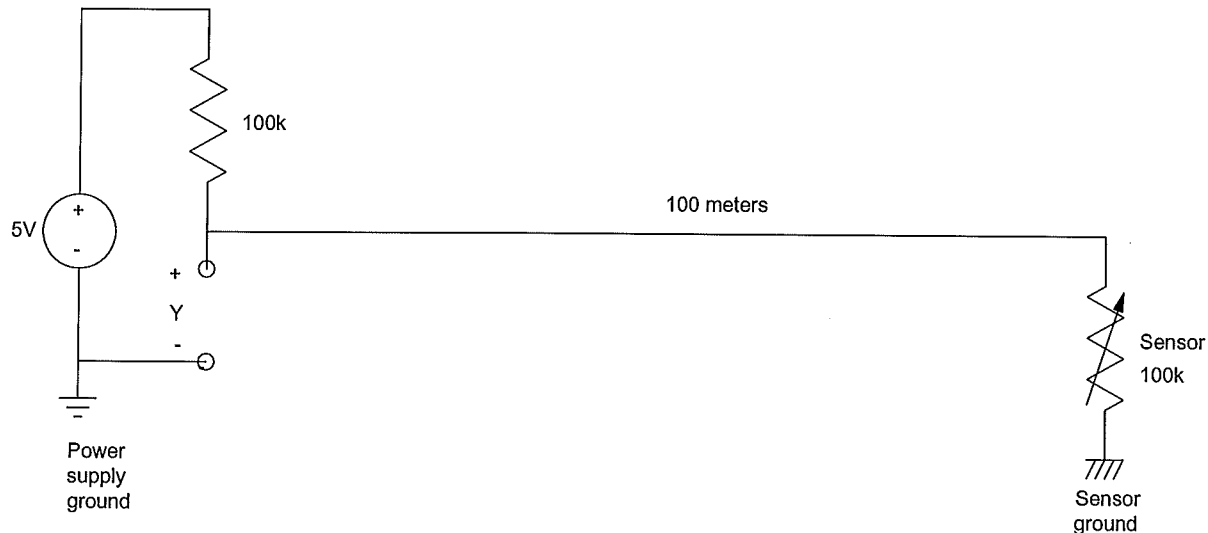Sensors, Calibration, & Filters.   November 29, 2018

1) Noise. The following circuit will have a large amount of noise. Suggest three things you could do to reduce the noise level at Y.

- Shorten the wire
- use a single ground (requires 2 wires)
- use twisted pair wires
- use shielded twisted pair wires
- use a current (vs voltage) source
- use frequency modulation (FM vs AM radio)
- add a filter (filter y)
- use lower resistors (more current)
- use higher voltages (more signal)

2a) Calibration: Determine a calibration curve fit for the following function:
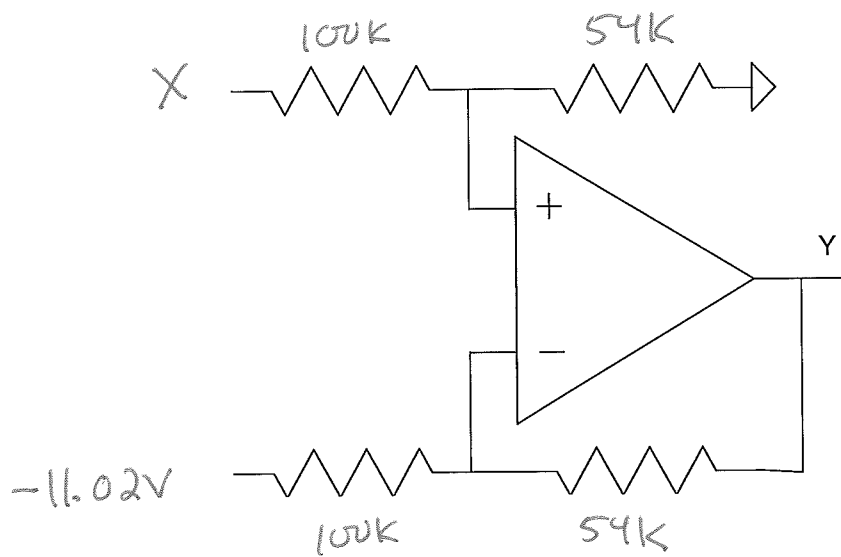
$$y \approx ax + b$$
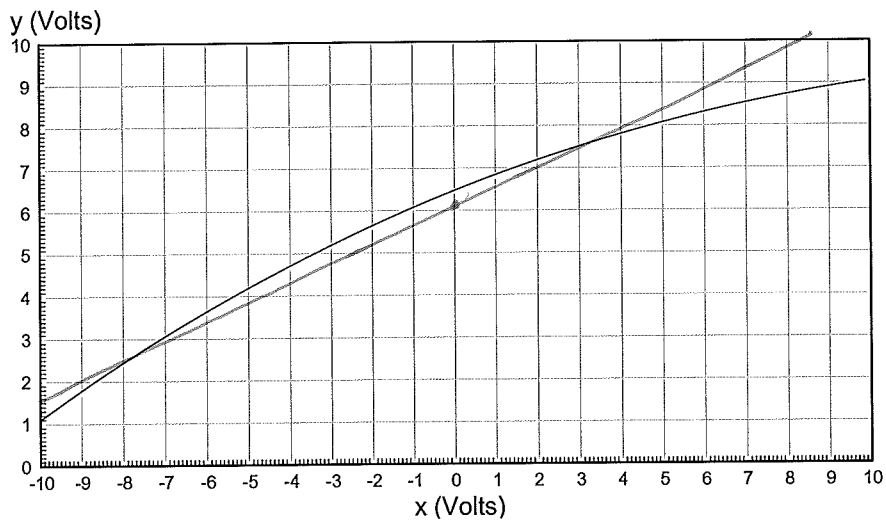
$$y = 0.54x + 6$$
$$= 0.54(x - (-11.02))$$

2b) Design an op-amp circuit to implement this function

3) Filters with Real Poles: X and Y are related by the following transfer function

$$Y = \left(\frac{30}{(s+1)(s+5)} \right) X = \left(\frac{30}{s^2+6s+5} \right) X$$

3a) What is the differential equation relating X and Y?

$$y'' + 6y' + 5y = 30x$$

3b) Determine y(t) assuming

$$x(t) = 5 + 6\cos(7t)$$

$$X = 5$$

$$S = 0$$

$$\left(\frac{30}{s^2+6s+5} \right)_{s=0} = 6$$

$$y = 6 \cdot 5$$

$$y = 30$$

$$X = 6\cos(7t)$$

$$X = 6 + j0$$

$$S = j7$$

$$\left(\frac{30}{s^2+6s+5} \right)_{s=j7} = .49\angle -136°$$

$$y = (.49\angle -136°)(6 + j0)$$

$$y = 2.95 \angle -136°$$

$$y(t) = 2.95\cos(7t - 136°)$$

$$\boxed{y = 30 + 2.95\cos(7t - 136°)}$$

4) Filters with Complex Poles: X and Y are related by the following transfer function

$$Y = \left(\frac{2s+7}{(s+1+j6)(s+1-j6)}\right)X = \left(\frac{2s+7}{s^2+2s+37}\right)X$$

4a) What is the differential equation relating X and Y?

$$y'' + 2y' + 37y = 2x' + 7x$$

4b) Determine y(t) assuming

$$x(t) = 5 + 6\cos(7t)$$

$$X = 5$$

$$S = 0$$

$$\left(\frac{2s+7}{s^2+2s+37}\right)_{s=0} = .1892$$

$$y = (.1892)\,5$$

$$y = .9459$$

$$X = 6\cos(7t)$$

$$X = 6 \angle j0$$

$$S = j7$$

$$\left(\frac{}{}\right)_{s=j7} = .8489\angle{-67^\circ}$$

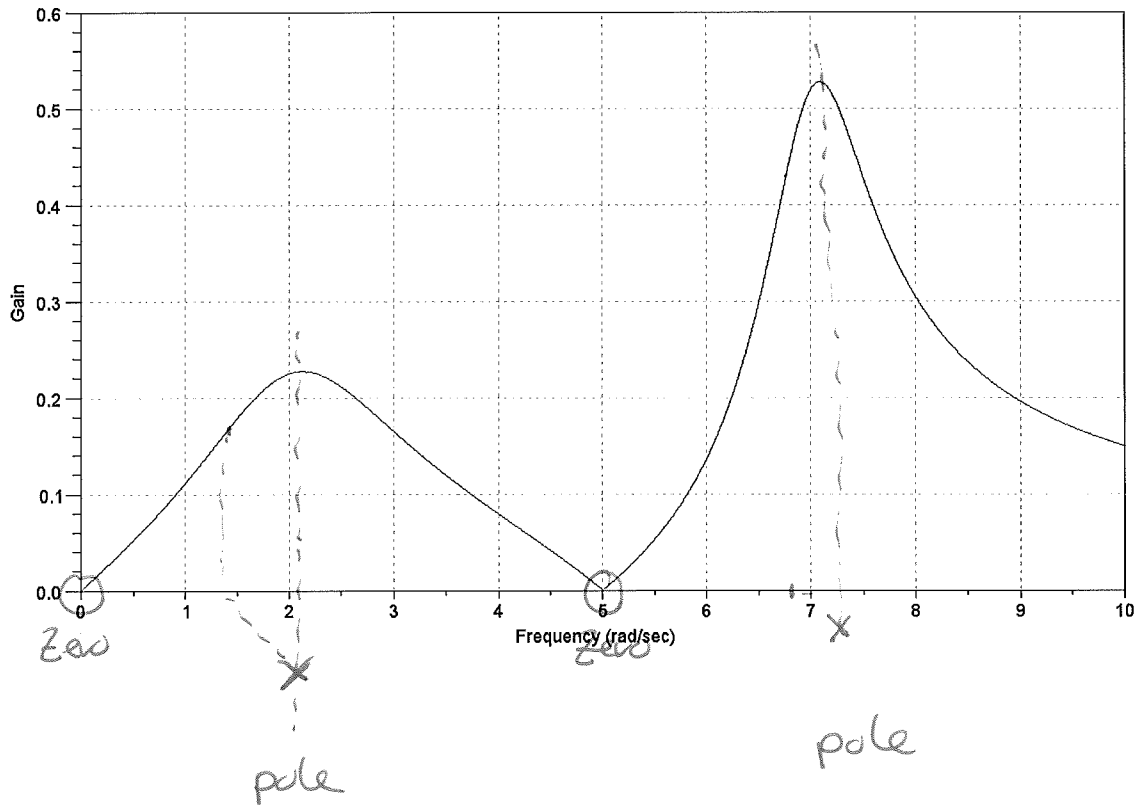$$y = (.8489 \angle{-67^\circ})(6 \angle j0)$$

$$y = 5.0932 \angle{-67^\circ}$$

$$y(t) = 5.0932 \cos(7t - 67^\circ)$$

$$\boxed{y = .9459 + 5.0932 \cos(7t - 67^\circ)}$$

5) Poles and Zeros: Where would you place the poles and zeros of a transfer function to get the following gain vs. frequency?

pole(s)	zeros(s)
$-1 \pm j2$ $-.5 \pm j7$	0 $\pm j5$

Industrial Hemp Bonus! Which country was the first to use hemp for clothing?

China   8000 BC