ECE 321 - Quiz #2 - Name _____

Instrumentation Amplifiers, Calibration, Strain Sensors, Filters, Due midnight, April 23, 2020

Calculators, internet, Matlab permitted.

Please sign pledge if able (i.e. you did not work with anyone else)
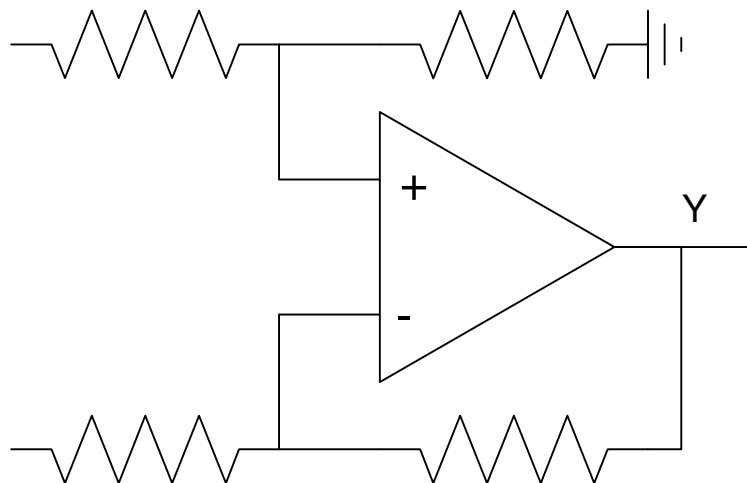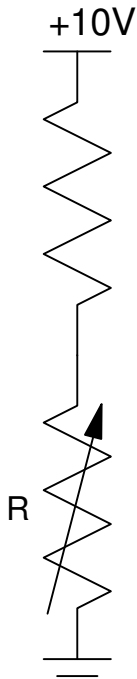
No aid given, received, or observer: _____

1) Instrumentation Amplifier: A strain gage has the temperature - resistance relationship of

$$R = 1000 \ \exp\left(\frac{3905}{T+273} - \frac{3905}{298} \right) \ \Omega$$

where T is the temperature in degrees C. Design a circuit so that the output is

- -10V at -10C
- +10V at +10C
- Proportional for -10C < T < +20C

2) Calibration. For your circuit of problem #1, determine a calibration funtion of the form

$$T = aV^2 + bV + c$$

where C is the temperature in degrees C over the range of -10C to +10C. Also determine the maximum error of your calibration scheme

a	b	c	mean error mean(T - B*A)	standard deviation std(T - B*A)

3) Strain Sensor: A metal beam deflects by 20mm when a force of 100N is applied to it. Determine the radius of curvature, the strain, and the resistance of a strain gage placed on the ourside edge

- Length of beam: 380mm
- Thickness of beam: 3mm
- Deflection: 20mm
- $R = 120(1 + 2.14\varepsilon)$

Radius of Curvature	Strain on Outside Edge	Resistance of Strain Gage
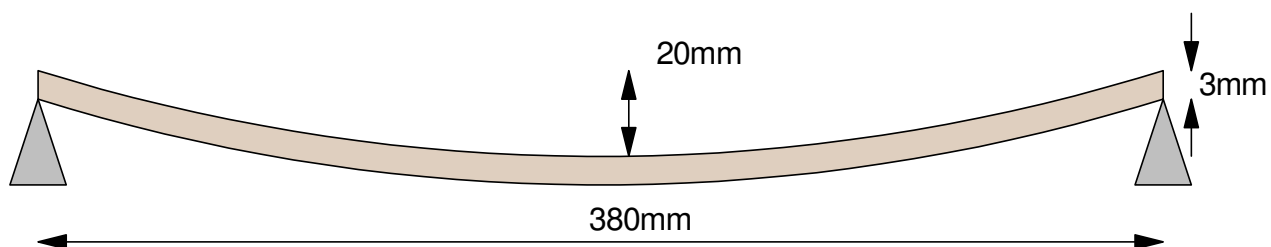
4) Filter Analysis: Assume X and Y are related by the following transfer function

$$Y = \left(\frac{5000}{(s+10)(s+15)(s+20)} \right) X$$

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

4b) Determine y(t) assuming

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

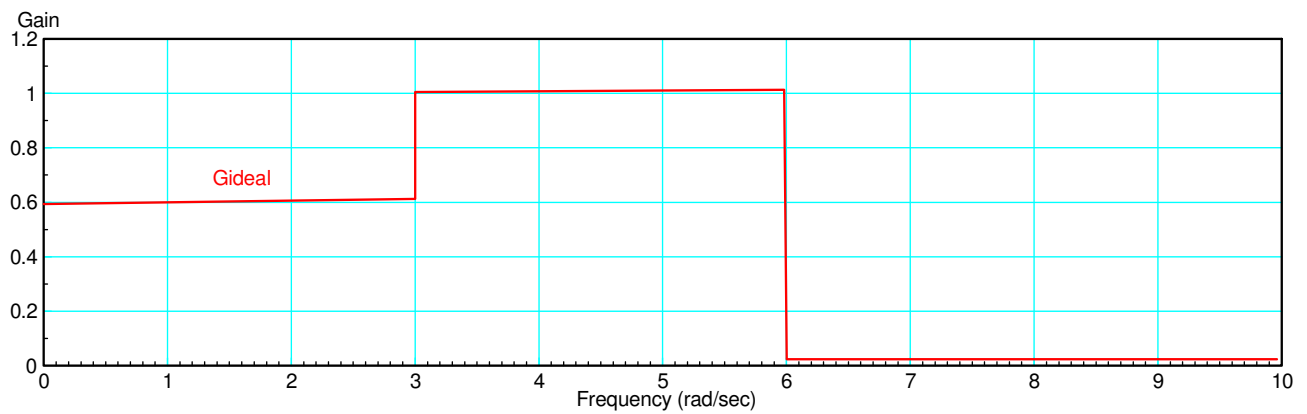5) Filter Design using fminsearch: Design a filter of the form

$$Y = G(s)X = \left(\frac{a}{(s+b)\left(s^2+cs+d\right)\left(s^2+es+f\right)} \right) X$$

to approximate

$$|G(jw)| = \begin{cases} 0.6 & 0 < w < 3 \\ 1.0 & 3 < w < 6 \\ 0 & 6 < w < 10 \end{cases}$$

over the rainge of $0 < w < 10$. Give
- The resulting filter, G(s), and
- The resulting gain vs. frequency of G(s)

6) Filter Implementation: Design an op-amp circuit to implement the following filter:

$$Y = \left(\frac{450}{\left(s^2+4s+15\right)\left(s^2+2s+30\right)} \right) X$$

C1	R1	C2	R2	Resulting DC gain

100k   R1

100k   100k
C1   C1

100k   100k
C2   C2

100k   R2