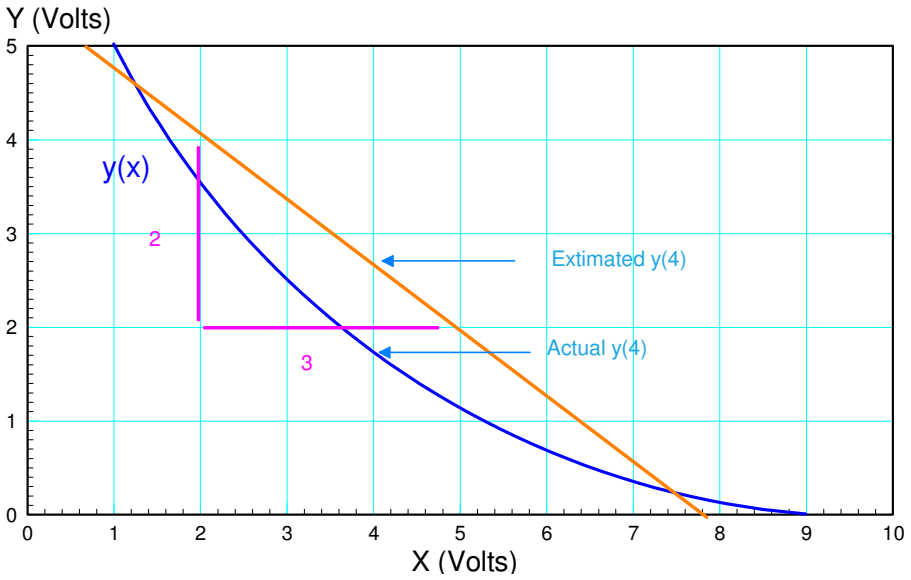
ECE 321 - Quiz #3 - Name _____

Calibration, Active Filters, Poles & Zeros. Due midnight, April 22, 2020

Calculators, Matlab, tarot cards permitted. Just not someone else.

1) Calibration: Given y(x) shown below, determine the following:

Straight-line approximation for y = f(x)	calibration function y = ax + b	actual y when x=4	estimated y when x=4
show on graph	**y = -0.667x + 5.33**	**1.8**	**2.67**



Step 1) Draw a line to approximate y(x) (shown in orange)

Step 2) Determine the slop

$$\text{slope} = \left(\frac{\text{change in y}}{\text{change in x}}\right) = \left(\frac{4-2}{2-5}\right) = -0.667$$

Step 3) Determine the offset. Plug in a point (any point). Pick (x = 5, y = 2)

$$y = ax + b$$

$$2 = (-0.667)(5) + b$$

$$b = 5.333$$

so

y = -0.667x + 5.33

2) Calibration: A thermistor has the followint resistance vs. temperature

degrees C (T)	0C	10C
Ohms (x)	4695.4 Ohms	2832.4 Ohms

2a) Use endpoint calibration to determine the resistance vs. temperature between 0C and 10C in the form of

T = ax + b *x = resistance in Ohms*

2b) From your curve fit, determine the temeprature if the resistance is R ohms where

- R =1000 + 100 * (your birth month) + (birth date). May 14th gives R = 1514 Ohms.

a	b	R 1000 + 100 * mo + day	temperature when x = R
-0.00537	**25.2**	**1514**	**17.07C**

y = ax + b

Step 1) Determine the slope

$$slope = \left(\frac{\text{change in y}}{\text{change in x}}\right) = \left(\frac{10C - 0C}{2832.4 - 4695.4}\right) = -0.00537\ \frac{\text{degree}}{\text{ohm}}$$

Step 2) Determine the offset (b). Plug in a point

$$T = ax + b$$

$$0C = \left(-0.00537\frac{C}{\Omega}\right)(4695.4\Omega) + b$$

$$b = 25.203\Omega$$

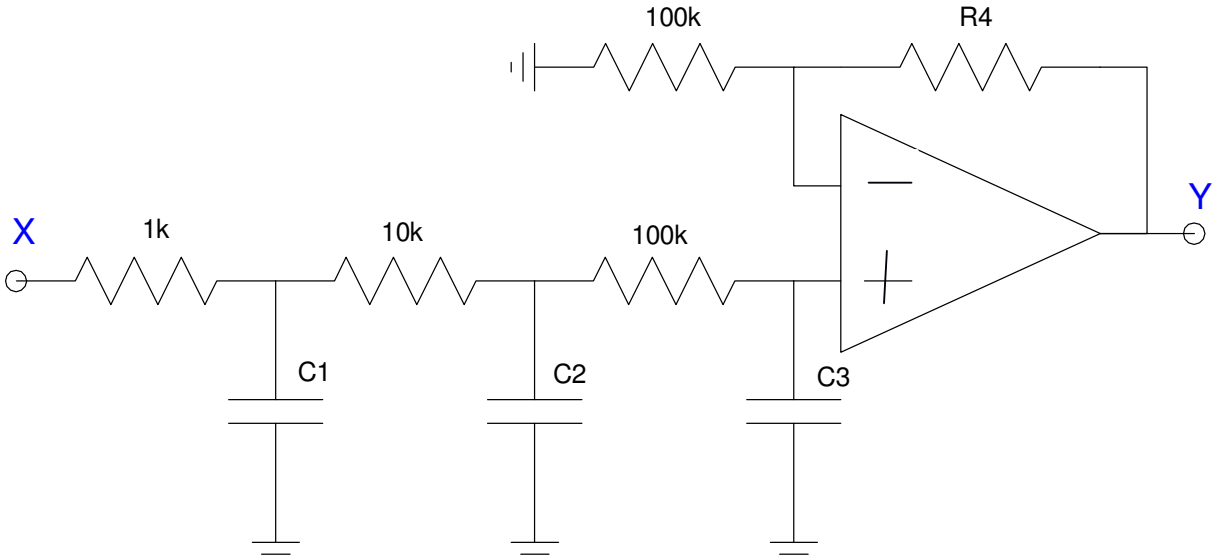
3) Active Filters. Real Poles. Find R and C to implement

$$Y = \left(\frac{10{,}000}{(s+10)(s+m)(s+d)}\right) X$$

where

- m is your birth month (1..12), and
- d is your birth date (1..31)

m birth month	d birth day	C1	C2	C3	R4
5	**14**	**100uF**	**20uF**	**0.714uF**	**1.3285M**



$$\left(\frac{1}{R_1 C_1}\right) = 10$$

R1 = 1k

C1 = 100uF

$$\left(\frac{1}{R_2 C_2}\right) = m = 5$$

R2 = 10k

C2 = 20uF

$$\left(\frac{1}{R_3 C_3}\right) = d = 14$$

R3 = 100k

C3 = 0.714uF

DC gain

$$\left(\frac{10{,}000}{(s+10)(s+m)(s+d)}\right)_{s=0} = 14.285 = \left(1 + \frac{R_4}{100k}\right) \qquad \text{R4 = 1.3285M}$$

4) Active Filters: Complex Poles: Find R and C to implement

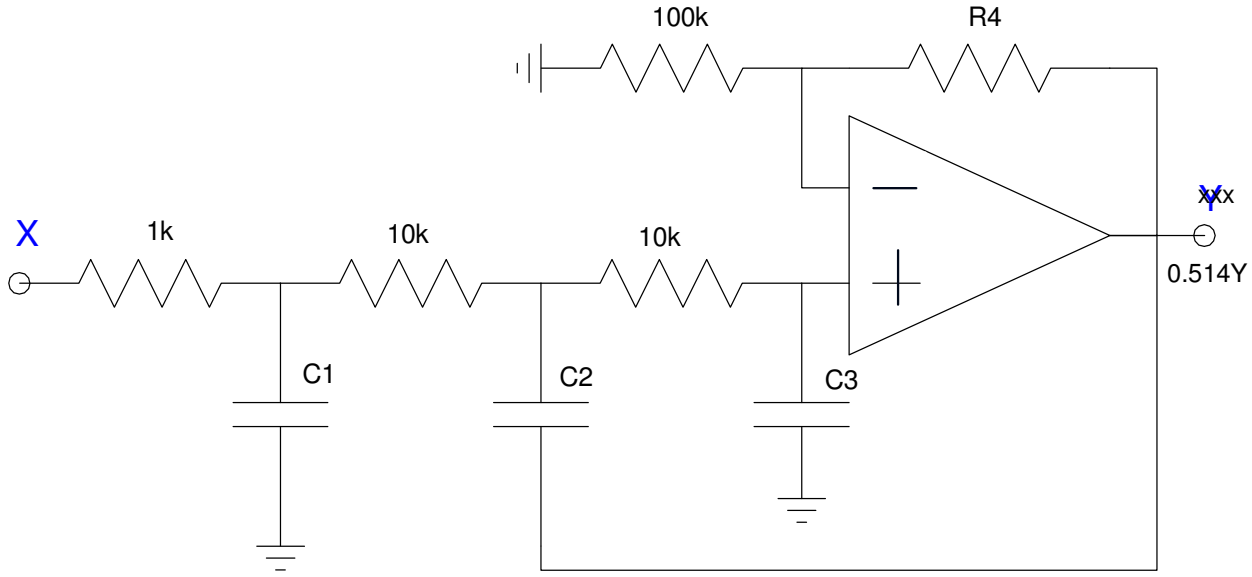
$$Y = \left(\frac{10{,}000}{(s+10)(s+m+jd)(s+m-jd)}\right)X$$

$$Y = \left(\frac{10{,}000}{(s+10)(s+5+j14)(s+5-j14)}\right)X = \left(\frac{10{,}000}{(s+10)\left(s+14.87\angle\pm 70.34^0\right)}\right)X$$

where

- m is your birth month (1..12), and
- d is your birth date (1..31)

m	d	C1	C2	C3	R4
5	**14**	**100uF**	**6.72uF**	**6.72uF**	**132.7k**



$$\left(\frac{1}{R_1 C_1}\right) = 10$$

R1 = 1k C1 = 100uF

$$\left(\frac{1}{R_2 C_2}\right) = 14.87$$

R2 = 10k C2 = 6.72uF

$$3 - k = 2\cos(70.34^0)$$

$$k = 2.327 = 1 + \frac{R_4}{100k}$$ R4 = 132.7k

Note: The output has a DC gain of 2.327 (vs. 4.52249), meaning the output is actually 0.514Y

5) Filters: Assume X and Y are related by the transfer function

$$Y = \left(\frac{100}{(s+m)(s+d)}\right)X = \left(\frac{100}{(s+5)(s+14)}\right)X = \left(\frac{100}{s^2+19s+70}\right)X$$

where

- m is your birth month (1..12) and
- d is your birth day (1..31).

a) What is the differential equation relating x and y?

$$y'' + 19y' + 70y = 100x$$

b) Determine y(t) assuming

$$x(t) = 3 + 4\cos(5t) + 6\sin(5t)$$

m	d	diffy eq	y(t)
5	**14**	**y'' + 19y' + 70y = 100x**	**4.825 - 3.529 cos(5t) + 5.882 sin(5t)**

x(t) = 3

$$Y = \left(\frac{100}{(s+5)(s+14)}\right)_{s=0} \cdot (3)$$

$$Y = 4.285$$

x(t) = 4 cos(5t) + 6 sin(5t)

s = j5

X = 4 - j6

$$Y = \left(\frac{100}{(s+5)(s+14)}\right)_{s=j5} \cdot (4 - j6)$$

$$Y = -3.529 - j5.882$$

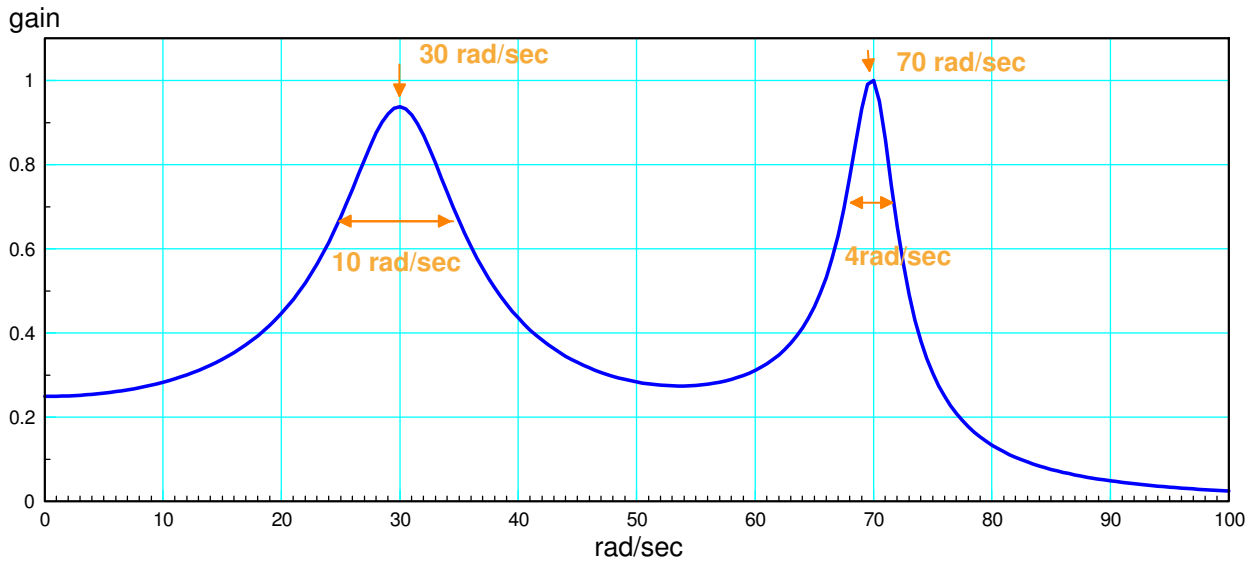
$$y(t) = -3.529\cos(5t) + 5.882\sin(5t)$$

The total answer is DC + Ac

$$y(t) = 4.825 - 3.529\cos(5t) + 5.882\sin(5t)$$

6) Determine the poles of a filter with the following gain vs. frequency (Bode) plot.

pole 1	pole 2
-5 + j30, -5 - j30	**-2 + j70, -2 - j70**



1st pole:

max gain = 30 rad/sec = complex part of pole

bandwidth (70% gain) = 10 rad/sec = 2 x real part of pole

pole = -5 + j30, -5 - j30

2nd pole

max gain at 70 rad/sec = comples part of pole

bandwidth = 4 rad/sec = 2 x real part of pole

pole = -2 + j70