ECE 321 - Quiz #3 - Name ____________________

Filters, Common Emitter Amplifiers. April 25, 2019

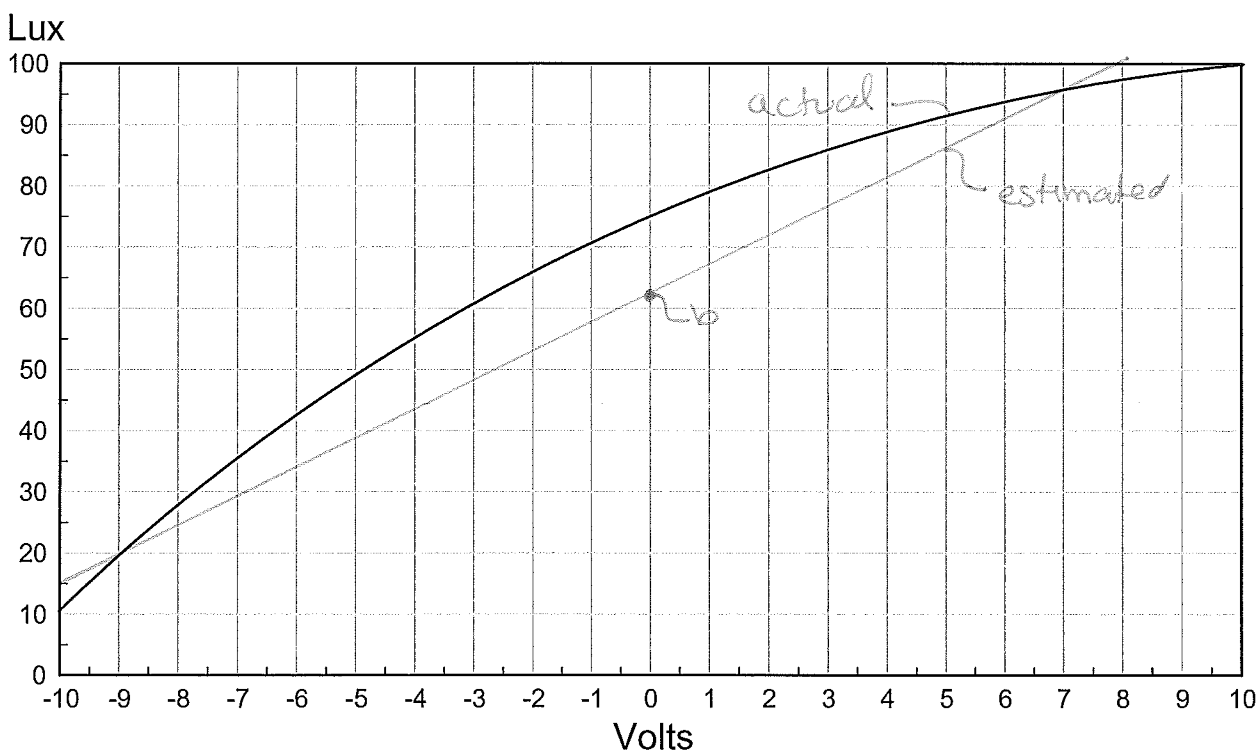
1) Calibration. Assume a circuit is built which outputs -10V to +10V as light changes from 10 Lux to 100 Lux.

- Determine a calibration function of the form

$$Lux \approx aV + b$$

- What is the light level (actual and estimated) when V = 5.0V?

Lux = aV + b		Lux when V = 5.00V	
a	b	Actual Lux	Estimated Lux from curve fit
4.72	62	92	86



$$\text{Slope} = \frac{\delta Lux}{\delta Volts} = \frac{100-15}{8-(-10)} = 4.72$$

2) X and Y are related by the following filter

$$Y = \left(\frac{5}{s^2+3s+2}\right)X = \left(\frac{5}{(s+1)(s+2)}\right)X$$

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

$$(s^2+3s+2)Y = 5X$$

$$y'' + 3y' + 2y = 5x$$

b) Find y(t) assuming

$$x(t) = 10 + 15\cos(3t)$$

DC

$X = 10$

$Y = \left(\frac{5}{(s+1)(s+2)}\right)_{s=0} \cdot 10$

$Y = (2.5)\cdot 10$

$Y = 25$

AC

$X = 15 + j0$

$Y = \left(\frac{5}{(s+1)(s+2)}\right)_{s=j3} \cdot (15 + j0)$

$Y = (.438\angle -127^\circ)\cdot(15)$

$Y = 6.578\angle -127^\circ$

$= -4.038 - j5.192$

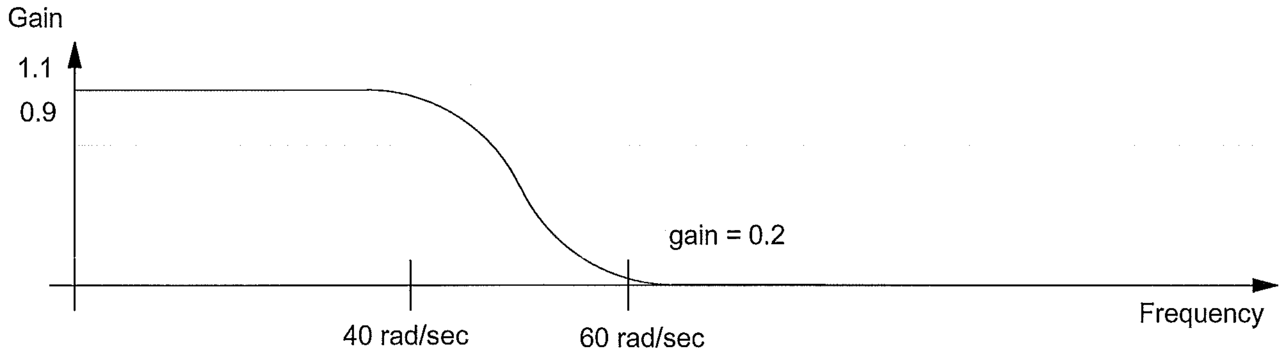
$$y(t) = 25 + 6.578\cos(3t - 127^\circ)$$

– or –

$$y(t) = 25 - 4.038\cos(3t) + 5.192\sin(3t)$$

3) A filter is to meet the following requirements

- 0.9 < Gain < 1.1 for frequencies below 40 rad/sec
- Gain < 0.2 for frequencies above 60 rad/sec



a) How many poles does this filter need?

$$\left(\frac{40}{60}\right)^n < 0.2$$

$$n > 3.96$$

(4)

$$\boxed{n \geq 4}$$

b) Give the transfer function for a Butterworth low-pass filter which meets these requirements (note: the corner frequency might need adjusting)

$n = 4$

$\theta = 180/4$

$\theta = 45°$

$$\frac{40^4}{(s + 40\angle \pm 22.5°)(s + 40\angle \pm 67.5°)}$$

(2) (2) (2)

40 to 50 ish

$n = 5$

$\theta = 180/5$

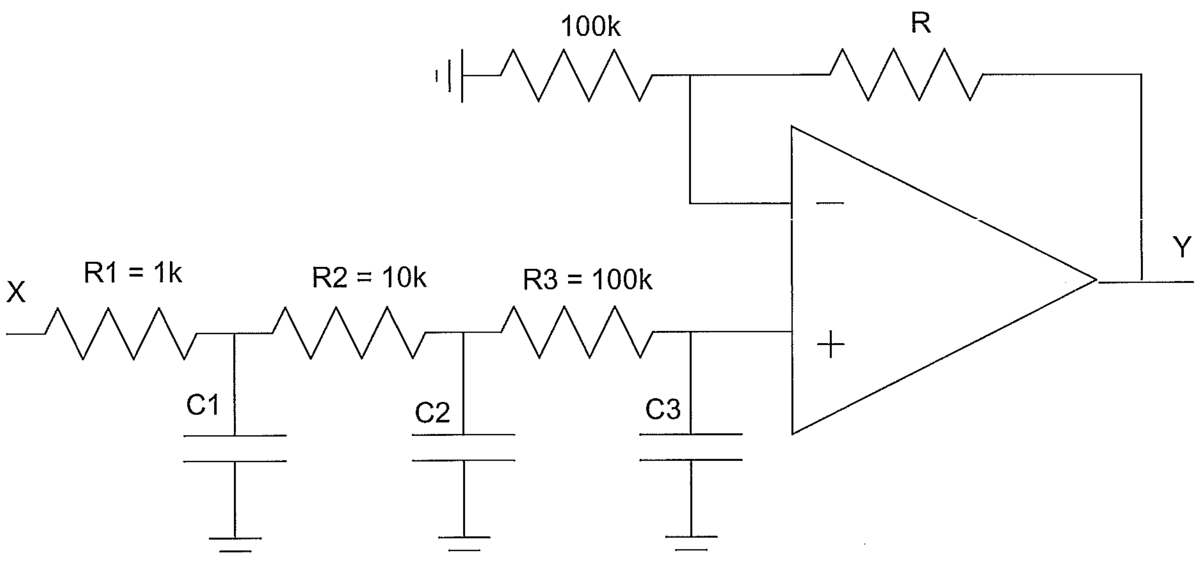
$\theta = 36°$

$$\frac{40^5}{(s+40)(s + 40\angle \pm 36°)(s + 40\angle \pm 72°)}$$

4) Find R and C so that the following filter has the transfer function of

$$Y = \left(\frac{1000}{(s+4)(s+6)(s+8)}\right)X$$

C1	C2	C3	R
250uF	16uF	1.25uF	420.8K



$$Y \approx \left(\frac{1+\frac{R}{100k}}{(R_1C_1s+1)(R_2C_2s+1)(R_3C_3s+1)}\right)X$$

$\frac{1}{R_1C_1} = 4$ $\frac{1}{R_2C_2} = 6$ $\frac{1}{R_3C_3} = 8$

$C_1 = 250uF$ $C_2 = 16uF$ $C_3 = 1.25uF$

DC gain $= \left(-\right)_{s=0} = 5.208$

$= 1 + \frac{R}{100k}$

$R = 420.8k$

5) The transfer function for a 4th-order Chebychev low-pass filter with a corner at 100 rad/sec is

$$Y = \left(\frac{72^2 \cdot 111^2}{\left(s+72\angle 38.5^0\right)\left(s+72\angle -38.5^0\right)\left(s+111\angle 77.8^0\right)\left(s+111\angle 77.8^0\right)} \right) X$$

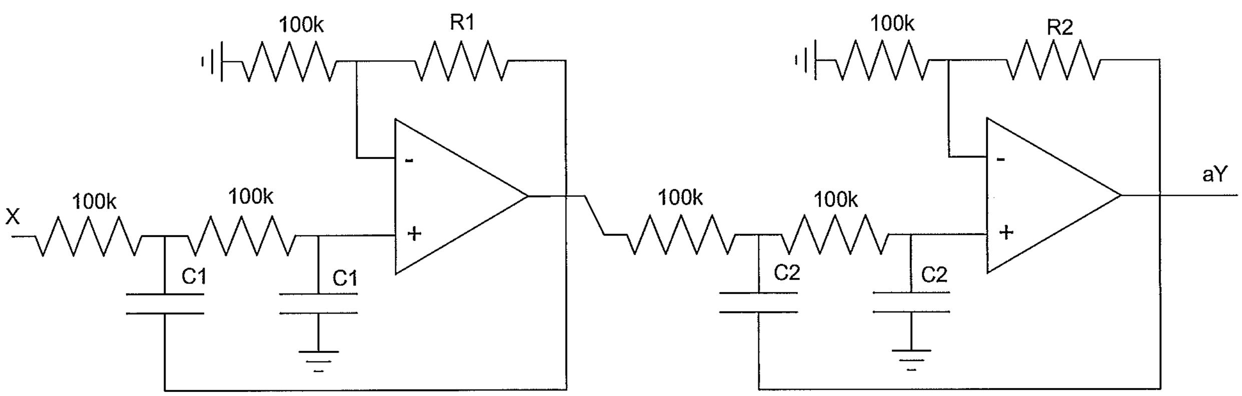
Find R and C to implement this filter

C1	R1	C2	R2
139nF	43.5k	90.09nF	157k

Note: The transfer function for the first stage is

$$\left(\frac{k\left(\frac{1}{RC}\right)^2}{s^2+\left(\frac{3-k}{RC}\right)s+\left(\frac{1}{RC}\right)^2} \right) \qquad k = 1 + \frac{R_1}{100{,}000}$$

$$3 - k = 2\cos\theta$$



$\frac{1}{R \cdot C_1} = 72$

$C_1 = 139nF$

$3-k = 2\cos(38.5°)$

$k = 1.435$

$R_1 = 43.5k$

$\frac{1}{RC_2} = 111$

$C_2 = 90.09nF$

$3-k = 2\cos(77.8°)$

$k = 2.577$

$R_2 = 157.7k$

Bonus: Which is more:

- The number of Democrats who have announced that they are running for President in 2020, or
- The number of Godzilla movies that have been made?