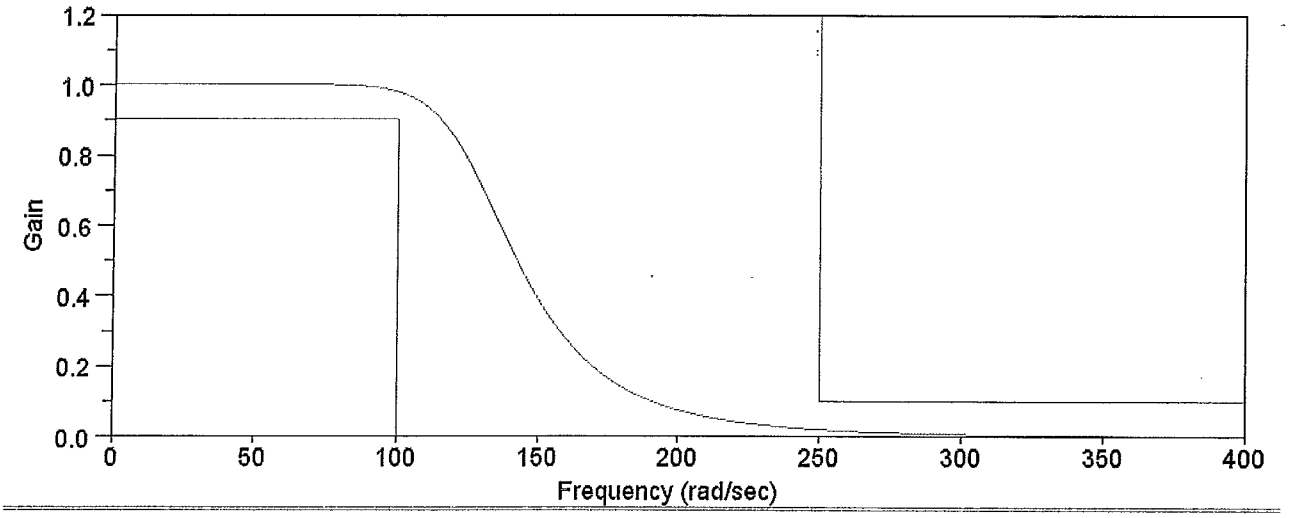
ECE 321 - Quiz #3: Name _____

Active Filters - April 23, 2015

1) Give the pole location for a 6th-order Butterworth low-pass filter which meets the following design specifications:

- $0 < w < 100$ rad/sec gain > 0.9
- $w > 250$ rad/sec gain < 0.1



Location of 1st pair of complex poles s = a + jb	Location of 2nd pair of complex poles s = c + jd	Location of 3rd pair of complex poles s = e + jf
$X \angle \pm 15^\circ$	$X \angle \pm 45^\circ$	$X \angle \pm 75^\circ$

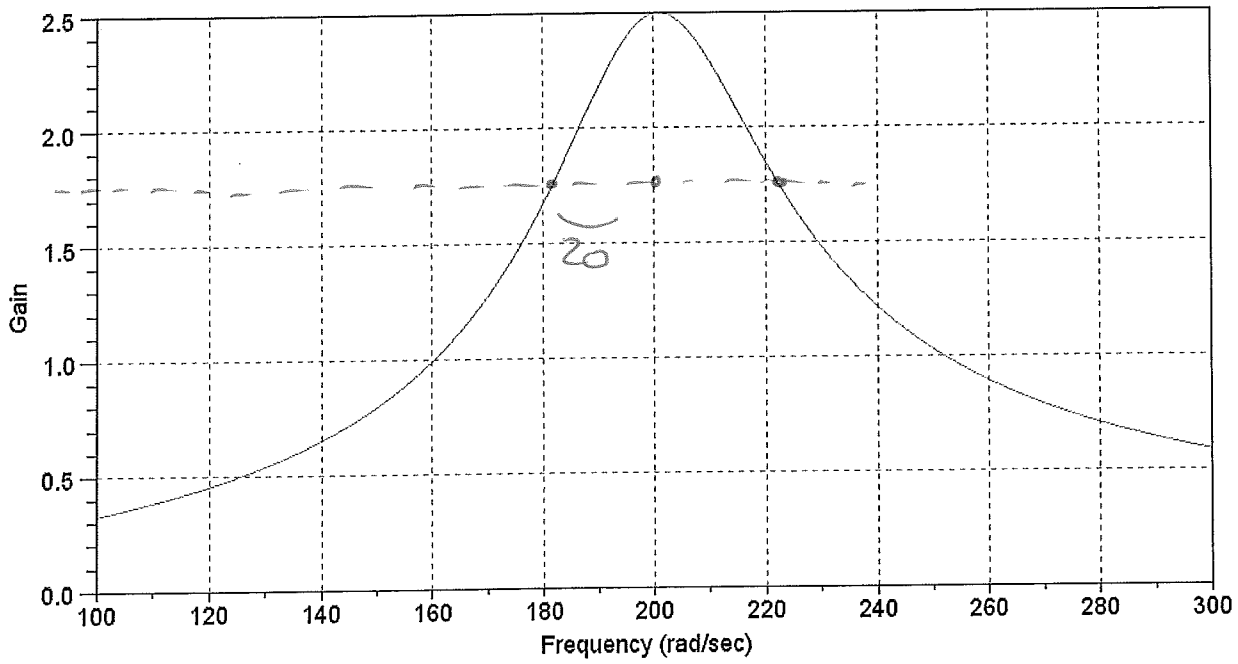
$\frac{180^\circ}{6} = 30^\circ$

$100 < X < 150$

anything in this range

2) Give the transfer function for a band-pass filter with the following gain vs. frequency

$$\frac{2000 \text{ or } 100s}{(s+20+j200)(s+20-j200)}$$



$\frac{2.5}{\sqrt{2}}$

gain at $s=j200 = 2.5$

3) The transfer function for a 5th-order Chebychev low-pass filter with a corner at 2 rad/sec is as follows:

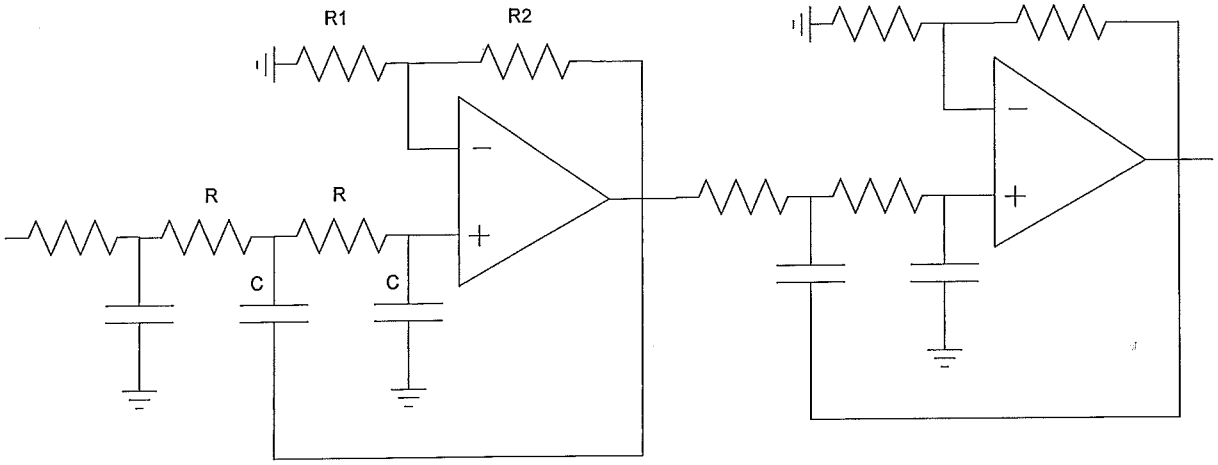
$$G = \left(\frac{1.81}{(s+0.327)(s^2+0.53s+1.489)(s^2+0.202s+3.72)} \right)$$

Let all capacitors be 1uF. Specify the resistors so that this filter implements the above transfer function where

$$k = 1 + \frac{R_2}{R_1}$$

Stage 1	Stage 2			Stage 3		
R	R	R1	R2	R	R1	R2
3.05m	819k	100k	256k	518k	100k	189k

1:2.56 1:1.89



(All capacitors = 1uF)

$$\left(\frac{\frac{1}{RC}}{s+\frac{1}{RC}} \right) \qquad \left(\frac{k\left(\frac{1}{RC}\right)^2}{s^2+\left(\frac{3-k}{RC}\right)s+\left(\frac{1}{RC}\right)^2} \right) \qquad \left(\frac{k\left(\frac{1}{RC}\right)^2}{s^2+\left(\frac{3-k}{RC}\right)s+\left(\frac{1}{RC}\right)^2} \right)$$

1.489

gain=2.56

gain=2.89

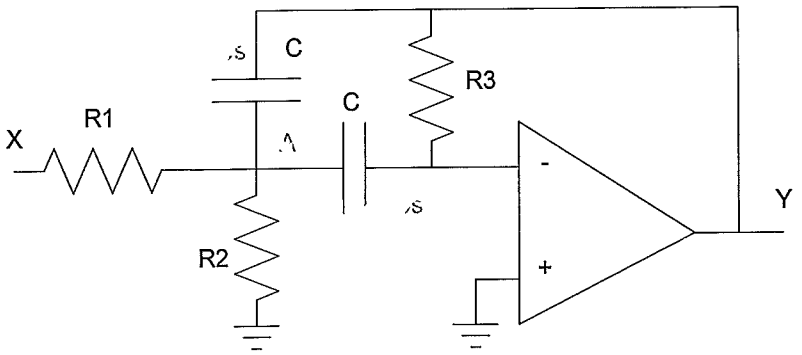
4) The transfer function for a band-pass filter which passes 50 rad/sec with 3dB down frequencies of 45 and 55 rad/sec is

$$Y=\left(\frac{-20s}{s^2+10s+2500}\right)X = Y=\left(\frac{-\left(\frac{1}{R_1C}\right)s}{s^2+\left(\frac{2}{R_3C}\right)s+\left(\frac{R_1+R_2}{R_1R_2}\right)\left(\frac{1}{R_3C^2}\right)}\right)X$$

Find R and C to implement this filter. The transfer function for this filter is

R1	R2	R3	C
50k	2k	200k	1μF

given C find R



$\frac{2}{R_3C} = 10$

$R_3 = \frac{2}{10}$

$\frac{R_1+R_2}{R_1R_2}\left(\frac{1}{R_3C^2}\right) = 2500$

$(R_1 \| R_2) = 2000$

5) Square waves are easy to produce. Sine waves are hard. In order to approximate a sine wave, a square wave is passed through a filter. Assume the square wave can be expressed as:

$$x(t) = 5 + 6.36\sin(t) + 2.12\sin(3t) + 1.27\sin(5t) + 0.91\sin(7t) + \ldots$$

$$y(t) \approx 6.36\sin(t)$$

Give the transfer function for a filter which passes the sin(t) term and rejects the remaining terms:

G(s):

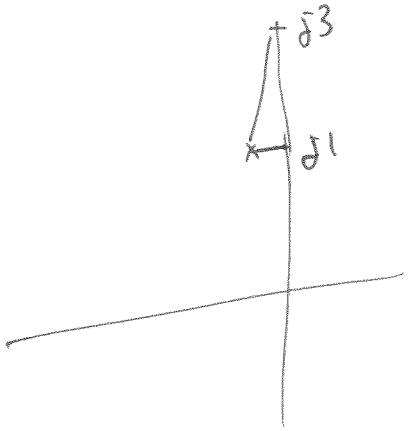
- Gain > 0.9 w = 1 rad/sec
- Gain < 0.1 w = 0, 3, 5, 7, 9, etc

gain at $s = j1$ = 1 (70.9)

$$\frac{0.2s}{(s+0.1+j)(s+0.1-j)}$$

Complex part = j 1

real part ≤ 0.2



$\frac{2}{x} = \frac{10}{1}$

$x = 0.2$

Bonus! The mission statement of the U.S. Environmental Protection Agency (EPA) is to protect human health and the environment. Within 20%, how many EPA field offices are there in North Dakota?

zero