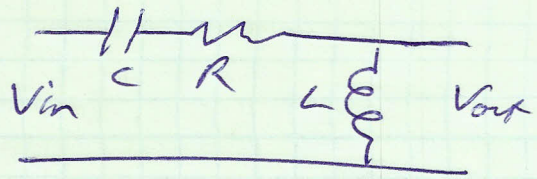
ECE 106 | Midterm 1 | Fall 2012

Question #1



a) $\frac{V_{out}}{V_{in}} = \frac{sL}{sL + R + \frac{1}{sC}} = \frac{s^2LC}{1 + sCR + s^2LC}$ high-pass

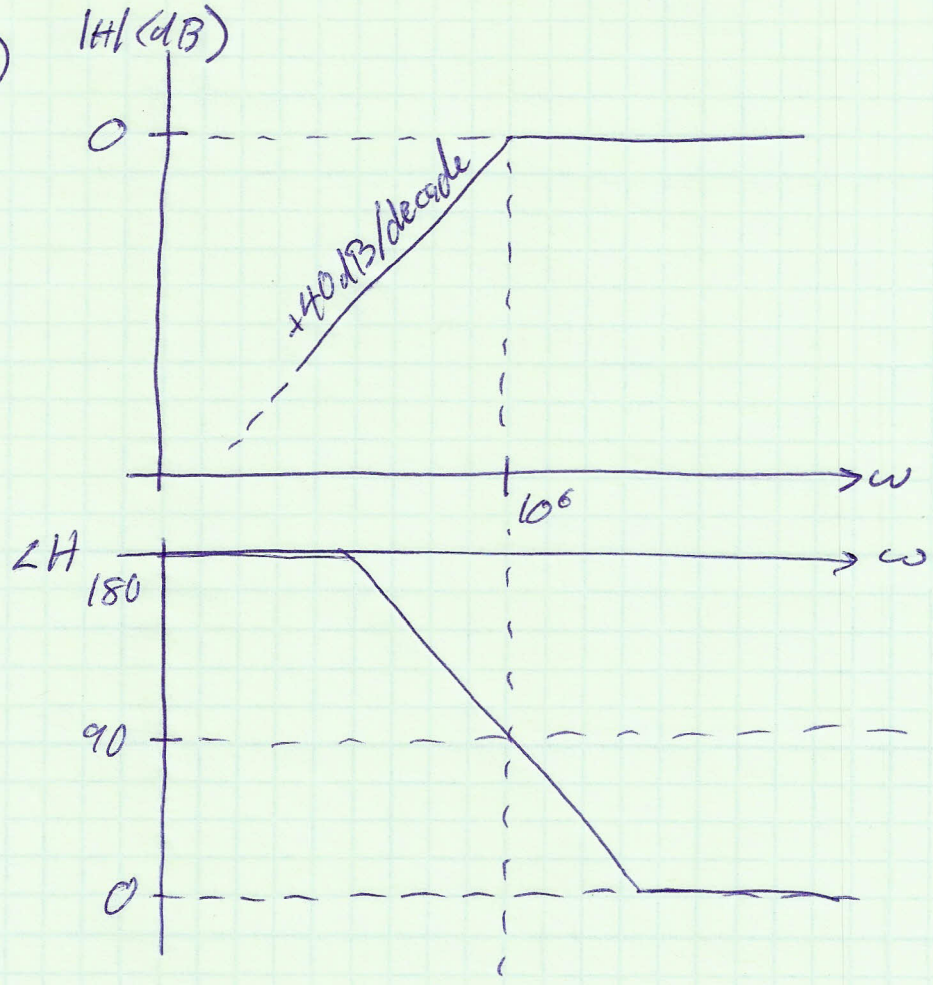
b) $\omega_0 = \frac{1}{\sqrt{LC}} = 10^6$

$C = \frac{1}{L \cdot 10^{12}} = \frac{1}{10^{-4} \cdot 10^{12}} = 10^{-8}$ $C = 100\,pF$

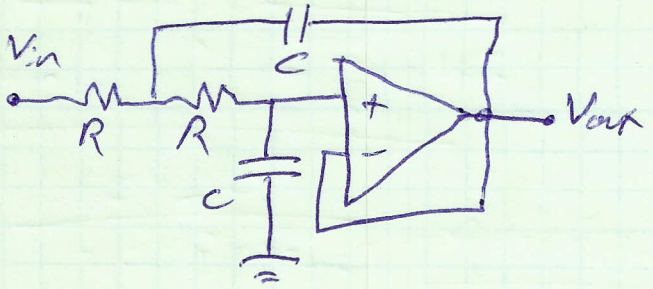
Butterworth $\rightarrow \zeta = \frac{1}{\sqrt{2}}$

$\frac{2\zeta}{\omega_0} = sCR$ $R = \frac{\sqrt{2}}{10^6 \cdot 10^{-8}} \approx 140$ $R = 140\,\Omega$

c)



Question #2



a) $R_1 = R_2 = R$

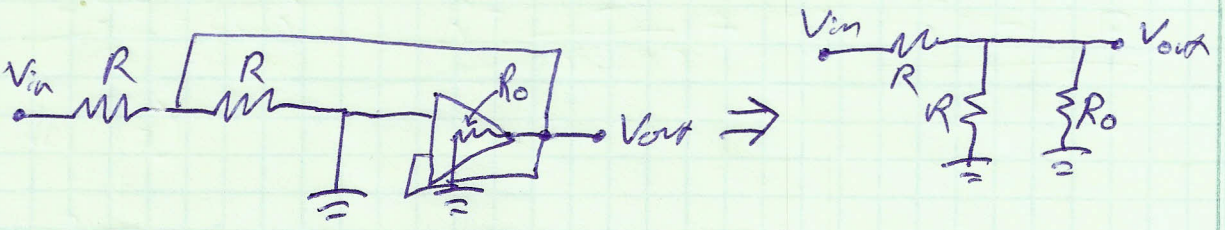
$C_1 = C_2 = C$

$$\omega_0 = \frac{1}{\sqrt{R^2C^2}} = \frac{1}{RC}$$

$$\frac{2\zeta}{\omega_0} = sC(2R) \qquad \zeta = CR \cdot \frac{1}{RC}$$

$$\underline{\zeta = 1, \ \omega_0 = \frac{1}{RC}}$$

b) $C \rightarrow$ short and $A \rightarrow 0$ for $\omega \rightarrow \infty$



$$\frac{V_{out}}{V_{in}} \simeq \frac{R_o}{R_o + R} \simeq \frac{R_o}{R}$$

c) $\left|\frac{V_{out}}{V_{in}}\right| \rightarrow -40dB$

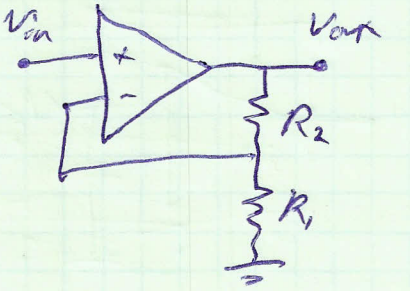
$$\left|\frac{V_{out}}{V_{in}}\right|^2 = \left(\frac{R_o}{R}\right)^2 = 10^{-4}$$

$$\frac{R_o}{R} = 10^{-2}$$

$$R = 100 R_o = 10k\Omega$$

high frequency gain $\leq -40dB$ for $\underline{R \geq 10k\Omega}$

Question #3



a) $V_- = V_{out} \cdot \frac{R_1}{R_1+R_2} = BV_{out}$

$B = \frac{R_1}{R_1+R_2}$

$V_{out} = A(V_+ - V_-)$

$V_{out} = A(V_{in} - BV_{out})$

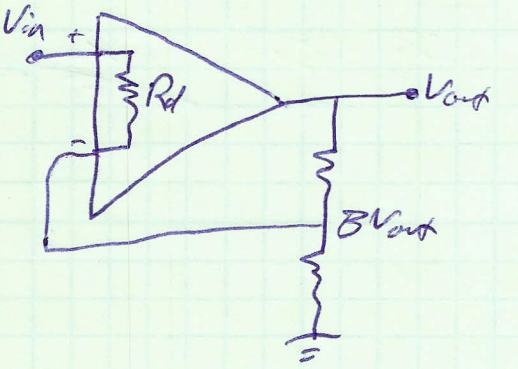
$V_{out}(1+AB) = AV_{in}$

$\frac{V_{out}}{V_{in}} = \frac{A}{1+AB}$ where $B = \frac{R_1}{R_1+R_2}$

b) $I_{in} = \frac{V_{in} - BV_{out}}{R_d}$

$= \frac{V_{in}}{R_d}\left(1 - \frac{AB}{1+AB}\right)$

$= \frac{V_{in}}{R_d}\left(\frac{1}{1+AB}\right)$



$Z_{in} = \frac{V_{in}}{I_{in}} = R_d(1+AB)$

$Z_{in} = R_d\left(1 + \frac{GB}{s}\right)$

c) Input impedance is series RC circuit

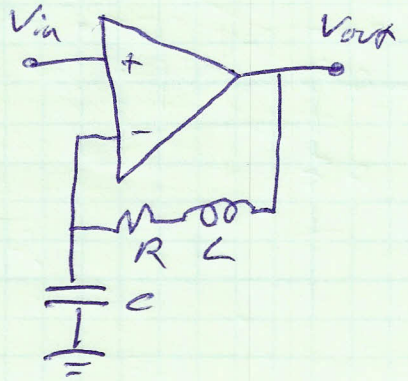
$Z_{in} = R_d + \frac{R_d GB}{s} = R_d + \frac{1}{sC_{eff}}$

$C_{eff} = \frac{1}{R_d GB}$

$C_{eff} = \frac{1}{10^4 \cdot 10^6 \cdot 10^{-1}} = 10^{-9}$

$C_{eff} = 1nF$

Question #4



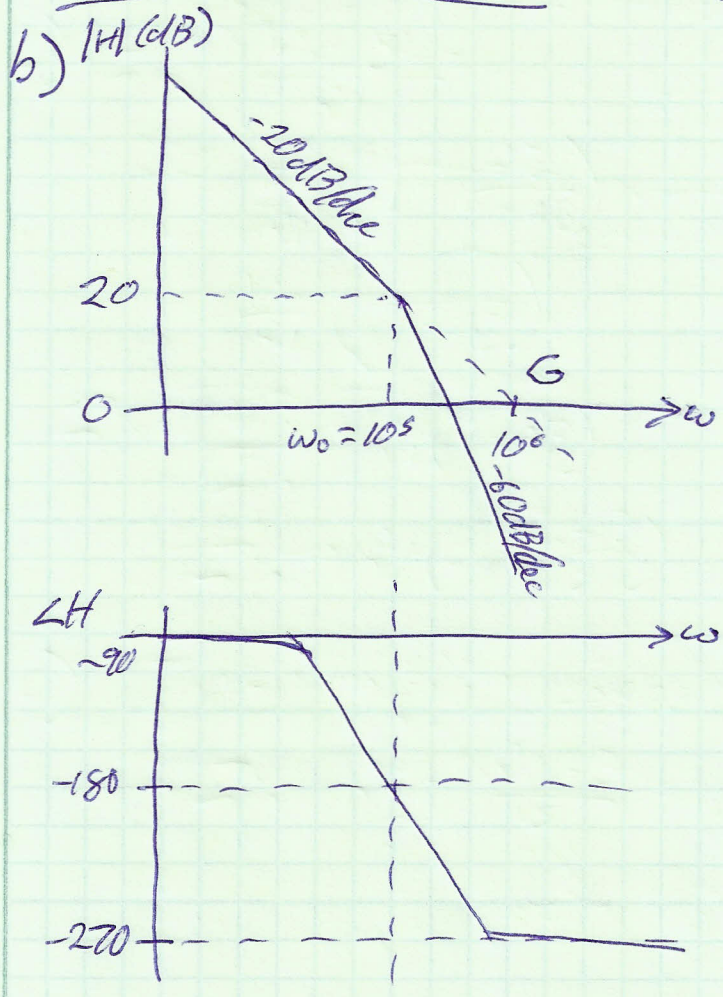
a) $B = \dfrac{\frac{1}{sC}}{\frac{1}{sC} + R + sL}$

$B = \dfrac{1}{1 + sRC + s^2LC}$

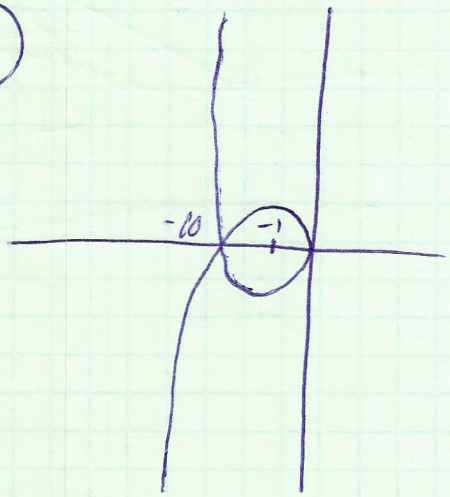
$AB = \dfrac{G}{s(1 + sRC + s^2LC)}$

$\omega_0 = \dfrac{1}{\sqrt{LC}} = \dfrac{1}{\sqrt{10^{-4} \cdot 10^{-6}}} = 10^5$

b)



c)



Nyquist plot encircles -1 so circuit is unstable