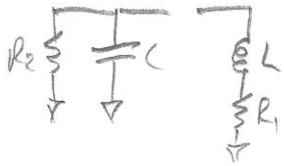
ECE 145B Homework #6 Solutions

#1



$$\frac{1}{sL+R_1} + sC + \frac{1}{R_2} = 0$$

$$s^2LC + sCR_1 + s\frac{L}{R_2} + \frac{R_1}{R_2} + 1 = 0$$

$$s^2LC + s\left[C\frac{R_1R_2}{R_1+R_2} + \frac{L}{R_1+R_2}\right] + 1 = 0$$

$$\omega^2 = \frac{1}{LC\frac{R_2}{R_1+R_2}} = \frac{R_1+R_2}{LCR_2}$$

$$C = \frac{1}{L\omega^2}\left(1+\frac{R_1}{R_2}\right)$$

$$\frac{1}{L\omega^2}\overbrace{\left(1+\frac{R_1}{R_2}\right)}^{\frac{R_1+R_2}{R_2}}\left(\frac{R_1R_2}{R_1+R_2}\right) + \frac{L}{R_1+R_2} < 0$$

$$\frac{R_1}{L\omega^2} + \frac{L}{R_1+R_2} < 0$$

$$R_1 + \frac{L^2\omega^2}{R_1+R_2} < 0$$

$$R_1^2 + R_1R_2 + L^2\omega^2 < 0$$

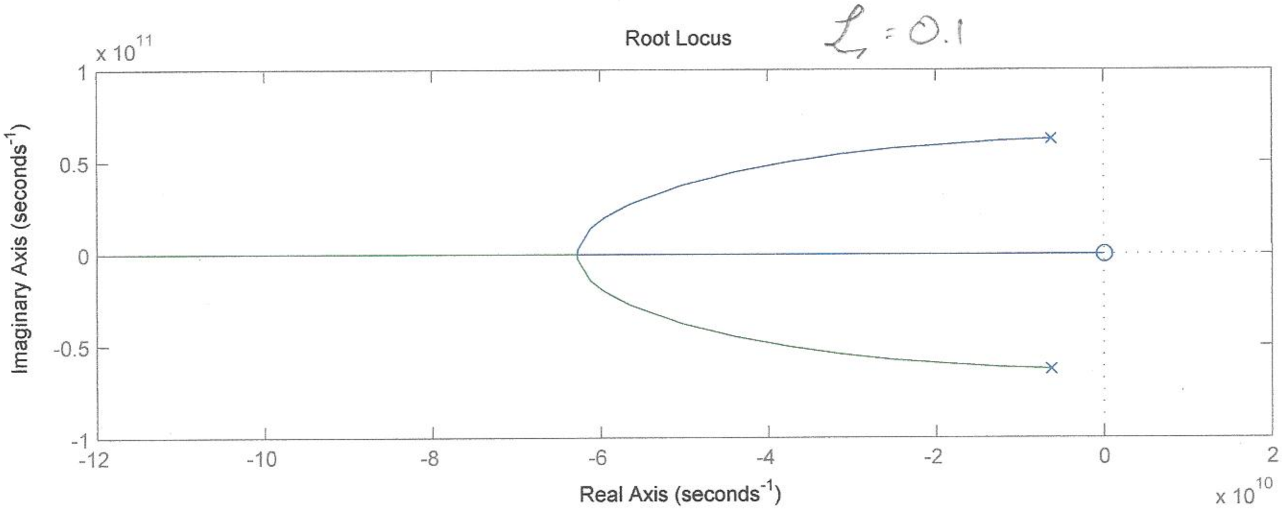
$$R_2 > \frac{L^2\omega^2 + R_1^2}{R_1}$$

$$\boxed{R_2 > 26.58\,\Omega}$$

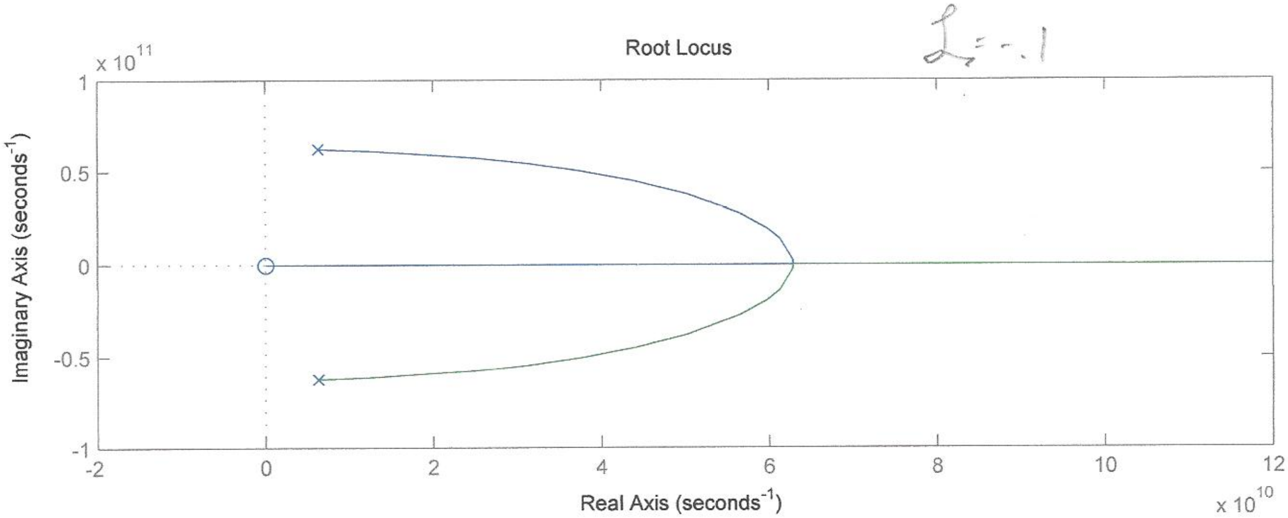
for $R_{2,min}$:

$$\boxed{C = 1.5\text{pF}}$$

#2



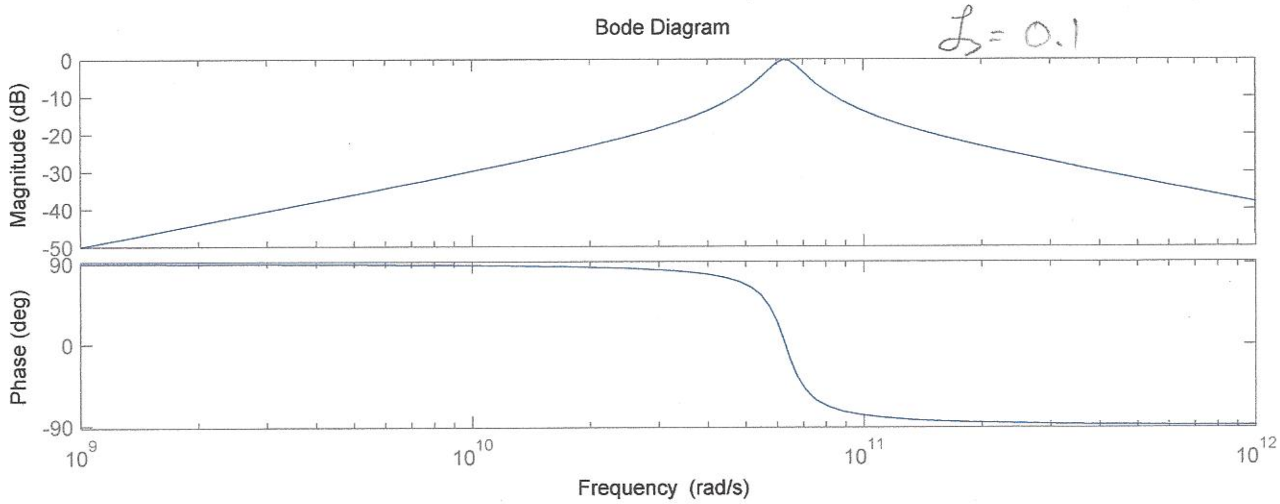
Root Locus
$\mathcal{L}_1 = 0.1$
x 10^11
1
0.5
0
-0.5
-1
Imaginary Axis (seconds^-1)
-12
-10
-8
-6
-4
-2
0
2
Real Axis (seconds^-1)
x 10^10



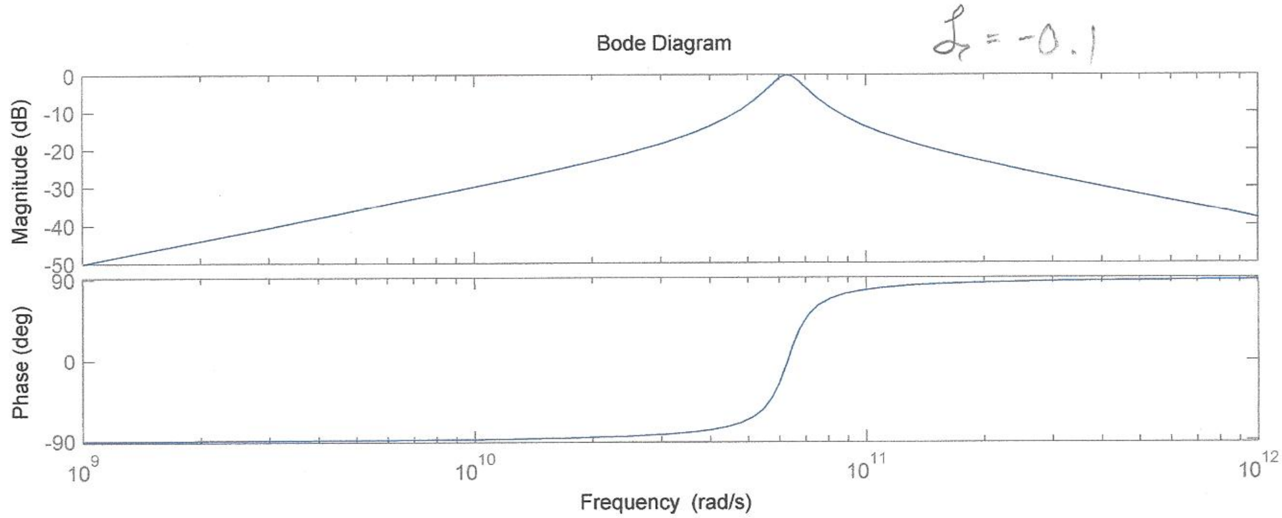
Root Locus
$\mathcal{L}_1 = -.1$
x 10^11
1
0.5
0
-0.5
-1
Imaginary Axis (seconds^-1)
-2
0
2
4
6
8
10
12
Real Axis (seconds^-1)
x 10^10

#2

$L_2 = 0.1$

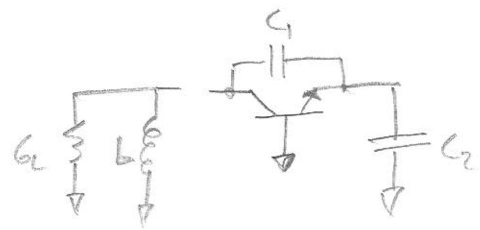


$L_2 = -0.1$



magnitudes are identical, phases are opposite.

#3



$$\frac{C_1C_2}{C_1+C_2} = 300fF$$

$I_c = 1mA$

from notes: $G_{neg} \approx -g_m\left(\frac{C_1}{C_1+C_2}\right) + g_m\left(\frac{C_1}{C_1+C_2}\right)^2$

$$x = \frac{C_1}{C_1+C_2}$$

$$\frac{dG_{neg}}{dx} = 0 = -g_m + 2g_m x$$

$$x = \frac{1}{2} = \frac{C_1}{C_1+C_2}$$

$$\Rightarrow \frac{1}{2}C_2 = 300fF$$

$$\boxed{C_1 = C_2 = 600fF}$$

$$\omega = \frac{1}{\sqrt{LC_{eq}}} \Rightarrow L = \frac{1}{\omega^2 C_{eq}} = \frac{1}{(2\pi(1GHz))^2(300fF)}$$

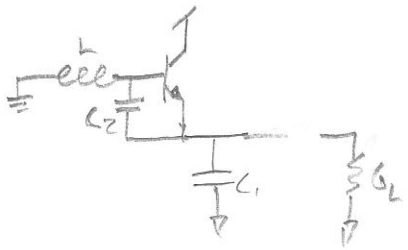
$$\boxed{L = 844.3pH}$$

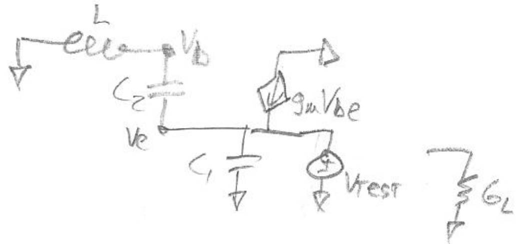
$$g_m = \frac{I_c}{V_T} = 38.7mS$$

$$G_{neg} = -(38.7mS)\left(\tfrac{1}{2}\right) + (38.7mS)\left(\tfrac{1}{2}\right)^2$$

$$\boxed{-G_{neg} = G_{L,max} = 9.675\ mS}$$

#4 (original)





$$I_{TEST} = V_{TEST}\left(1/sC_1 + \frac{1}{1/sC_2 + sL} + g_m(V_e - V_b)\right)$$

$$I_{TEST} = V_{TEST}\left[\frac{1}{sC_1} + \frac{sC_2}{1+s^2LC_2} + g_m\left(\frac{s^2LC_2}{1+s^2LC_2} - 1\right)\right]$$

$$Z_{IN} = \frac{V_{TEST}}{I_{TEST}} = \left(\frac{1}{sC_1} + \frac{sC_2 - g_m}{1+s^2LC_2}\right)^{-1}$$

$$\frac{1}{Z_{in}} + G_L = 0 \quad \Rightarrow \quad as^3 + bs^2 + cs + d = 0$$

solvable w/ Routh Hurwitz

#4 (replacement) same as #3

$\omega = 2\pi\, 1\,GHz$

$\Rightarrow L = 84.4\,nH$

#5

assume $Y_{amp} = \begin{bmatrix} 10^{-3} & -10^{-2} \\ -10^{-2} & 10^{-3} \end{bmatrix}$

from notes:

$$B_{in} = 0 = B_{11} + \frac{\left(G_{a21}(B_{a12} - B_f) + G_{a12}(B_{a21} - B_f)\right)G_{a22} - (\cdots)B_f^{\nearrow 0}}{\left(G_{a22}^2 + B_{22}^2\right)}$$

$$B_{22} = B_f + B_0$$

$$B_0 = B_f = 0$$

$$G_{in} = G_{a,11} - \frac{\left(G_{a12}G_{a21} - (\cancel{B_{a12}} - B_f)(\cancel{B_{a21}} - B_f)\right)G_{a22} - \left(G_{a21}(\cancel{B_{a12}} - B_f) + G_{a12}(\cancel{B_{a21}} - B_f)\right)B_{22}}{\left(G_{a22}^2 + B_{22}^2\right)}$$

$$G_{in} = 10^{-3} - \frac{10^{-3}(10^{-4} - B_f^2) - (B_0 + B_f)\left[10^{-2}B_f + 10^{-2}B_f\right]}{\left(10^{-6} + (B_0 + B_f)^2\right)}$$

for $B_f = B_0 = 0$.

$$G_{in} = 10^{-3} - \frac{10^{-7}}{10^{-6}} = -.0995$$