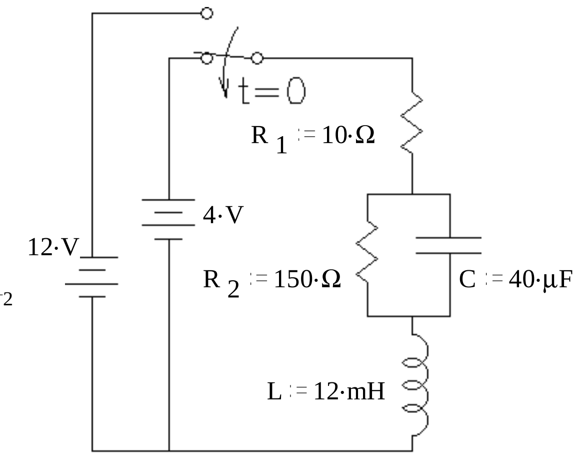
ECE 2210 Homework 2ndTr4 Due: Tue, 11/7/23 A.Stolp

2nd - Order Transients Name______________________________ c

1. Analysis of the circuit shown yields the characteristic equation below. The switch has been in the top position for a long time and is switched down at time $t = 0$. Find the initial conditions and write the full expression for $i_L(t)$, including all the constants that you find.



$$0 = s^2 + \left(\frac{1}{C\cdot R_2} + \frac{R_1}{L}\right)\cdot s + \left(\frac{R_1}{L\cdot C\cdot R_2} + \frac{1}{L\cdot C}\right)$$

$$\left(\frac{1}{C\cdot R_2} + \frac{R_1}{L}\right) = 1000\cdot sec^{-1} \qquad \left(\frac{R_1}{L\cdot C\cdot R_2} + \frac{1}{L\cdot C}\right) = 2.222\cdot 10^6 \cdot sec^{-2}$$

$$0 = s^2 + 1000\cdot\frac{1}{sec}\cdot s + 2.222\cdot 10^6\cdot\frac{1}{sec^2}$$

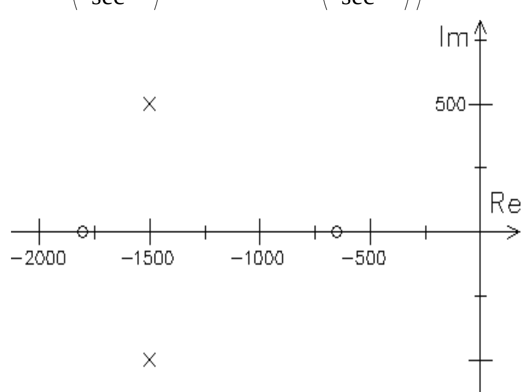
2. What value of R_1 would make the above circuit critically damped?

Answers

1 $i_L(0) = 75\cdot mA$ $\quad v_C(0) = 11.25\cdot V$ $\qquad i_L(t) = 25\cdot mA + e^{\frac{-500}{sec}\cdot t}\cdot\left(50\cdot mA\cdot\cos\left(\frac{1404}{sec}\cdot t\right) - 457\cdot mA\cdot\sin\left(\frac{1404}{sec}\cdot t\right)\right)$

2. $R_1 = 36.64\cdot\Omega$

3. a) Zeroes: -691 & -1809 Poles: $-1500 \pm 500\cdot j$ b)



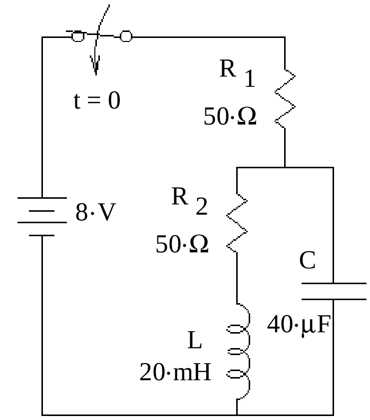
4. a) $\dfrac{G\cdot(s+60)}{s^2 + 90\cdot s + 1800 + G\cdot 10}$ b) poles: -31.8 & -58.2
zero: -60

   c) overdamped d) 22.5 e) underdamped

5. a) $1000\cdot\dfrac{s+40}{s^2 + 65\cdot s + 1000 + 200\cdot F}$ b) 0.281

   c) $1000\cdot\dfrac{s+40}{s^2 + 65\cdot s + 1040}$ d) -28.5 or -36.5 e) -40

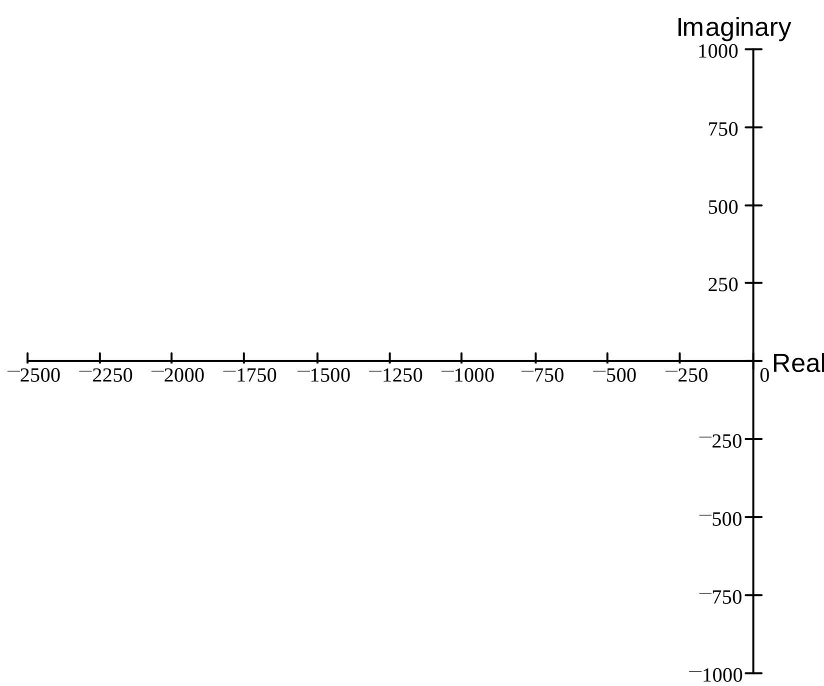
ECE 2210 homework 2ndTr4 p3



3. Look at the circuit in Hw2ndTr3, problem 1. Change R_1 and R_2 to 50Ω and consider the voltage across R_1 to be the output voltage. The transfer function would be:

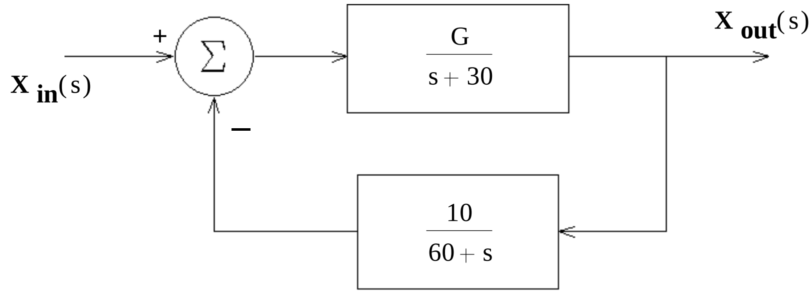
$$\mathbf{H}(s) = \frac{\mathbf{V}_{\mathbf{R1}}(s)}{\mathbf{V}_{\mathbf{in}}(s)} = \frac{s^2 + \frac{R_2}{L}\cdot s + \frac{1}{L\cdot C}}{s^2 + \frac{R_1\cdot R_2\cdot C + L}{R_1\cdot L\cdot C}\cdot s + \frac{R_1 + R_2}{R_1\cdot L\cdot C}} = \frac{s^2 + 2500\cdot s + 1.25\cdot 10^6}{s^2 + 3000\cdot s + 2.5\cdot 10^6}$$

a) What are the poles and zeros of this transfer function?



b) Plot these poles and zeros on the complex plane.

4. A feedback system is shown in the figure.



a) What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{\mathbf{X}_{out}(s)}{\mathbf{X}_{in}(s)} = ?$$

Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial.

b) $G := 5$ Find the poles and zeroes of the system.

c) What type of damping response does this system have?

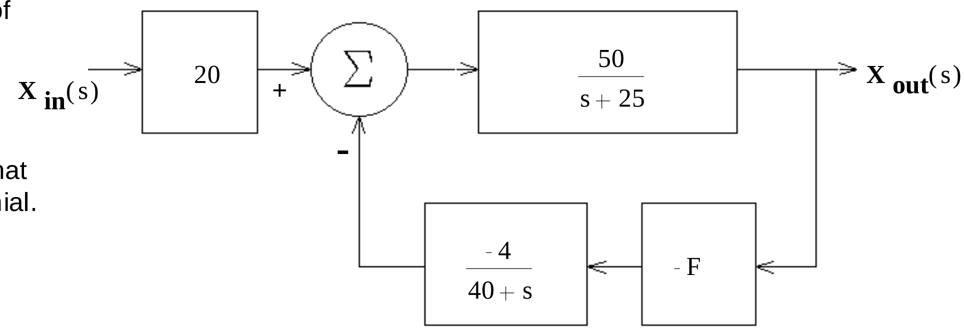
d) Find the value of G to make the transfer function critically damped.

e) If G is double the value found in part d) what will the damping response of the system will be?

5. a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{\mathbf{X}_{\mathbf{out}}(s)}{\mathbf{X}_{\mathbf{in}}(s)} = \ ?$$

Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial.



b) Find the maximum value of F so that the system does not become underdamped.

c) Find the transfer function with $F := 0.2$

d) With $F = 0.2$, at what value of **s** can the system produce an output even with no input?
(That is, what value of **s** makes $\mathbf{H}(s) = \infty$?)

e) Does the transfer function have a zero? Answer no or find the s value of that zero.