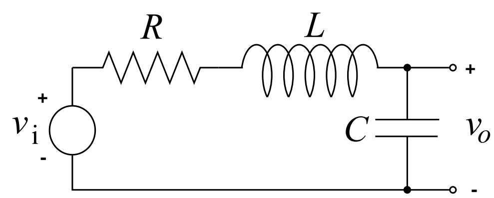
Quiz #2 on Friday April 19th in Rm. 4-135

Quiz #2 Review session Wed. April 17th 6-8pm Rm. 5-234

The review session will be geared around reviewing the solutions to the sample problems. Please do the sample problems before the review. The sample problems have been written and presented in what is likely to be the style of the quiz. As you will note, the sample problems mostly follow the material this term (the first 3 problems were borrowed from Fall 2001 which presented the class material in a slightly different manner), but often force you to work a problem in reverse. I.E. you are presented with what you have considered a solution and are asked to work the problem in reverse. This is a dirty trick frequently used by Profs here to test if you really understand the material. Get used to it, because even if it does not happen on this exam it will happen to you in another class.

Try and solve the circuit problems using both impedance and voltage and current methods

Problem 1 - RLC circuit analysis



1. Write the transfer function, $\frac{V_{out}(s)}{V_{in}(s)}$, for the circuit shown above.

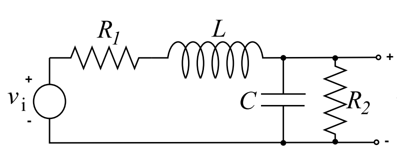
2. Given $C = 1x10^{-6}\ F$, find the values of R and L such that $\zeta = 0.707$ and the undamped natural frequency is 5 kHz. (*Don't forget to convert to rad/sec!!!*)

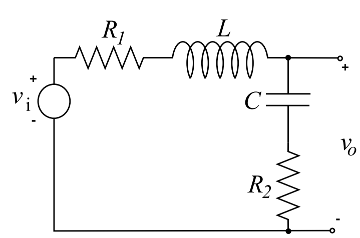
3. Using the same values of L and C from part(b), find the locations of any system pole(s) and zero(s) given $R = 1000\Omega$. Sketch the unit step response, clearly indicating the time and magnitude scaling. (Hint: use a dominant pole approximation.) Use the IVT and FVT to show that your response starts and ends at the appropriate values.

4. Sketch the log Magnitude vs log frequency, and linear phase vs log frequency (Bode plot) for this system based on your calculated poles from part 3. Show that your plot approaches the correct values of magnitude both as $\omega \to 0$ and $\omega \to \infty$.

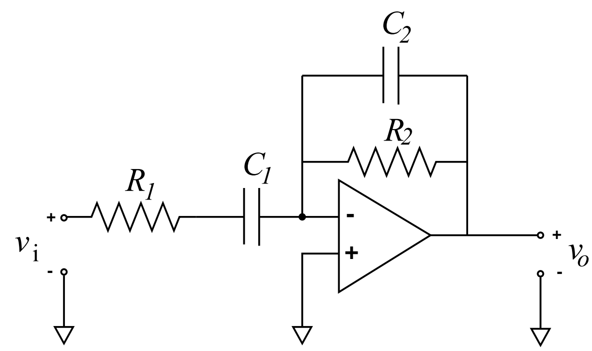
5. Again using $C = 1x10^{-6}\ F$ and $R = 1000\Omega$, now let $L = 0\ H$. (i.e. Remove the inductor from the circuit) Calculate the location of the pole and compare this to the dominant pole found in part 2.

6. Write the transfer function, $\frac{V_{out}(s)}{V_{in}(s)}$, for the two circuits shown below.





Problem 2 - Op Amp analysis

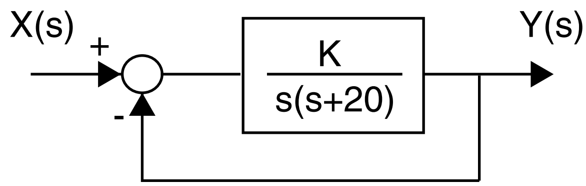


$$R_1 = 1M\Omega,\ R_f = 100k\Omega,\ C_1 = 1\mu F,\ C_2 = 1nF$$

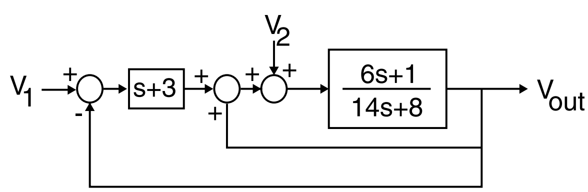
1. Derive the Transfer function H(s) relating V_o to V_i (assume the Op-amp acts as an infinite gain).
2. Derive the expressions for the magnitude and phase as a function of frequency.
3. make a bode plot of the system indicating the major points.
4. Determine the pole and zero locations(s) and plot them on the s-plane.

Problem 3 - Block Diagrams

1. Reduce the block diagram below to derive the transfer function for the system. Find the value of K that will result in a critically damped response.

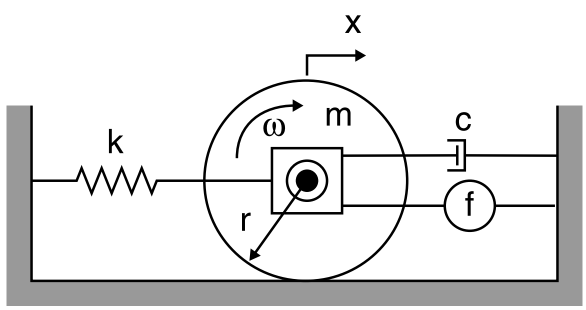


2. Derive the transfer functions $\frac{V_{out}(s)}{V_1(s)}$ and $\frac{V_{out}(s)}{V_2(s)}$ for the block diagram shown below. (Hint, you can always label individual positions along the block diagram with variable names and write out and solve the relevant algebraic equations.)

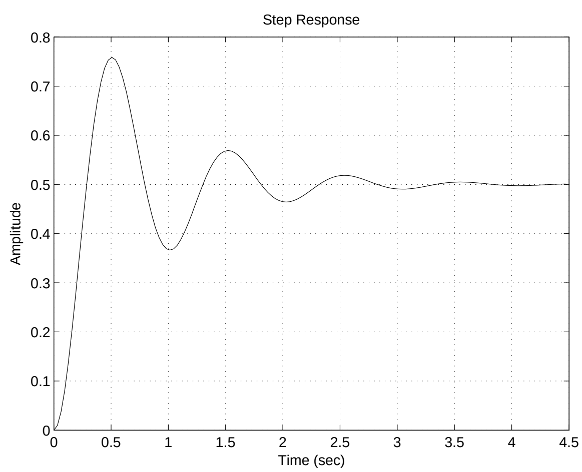


3. Write the complete differential equation for $V_{out}(t)$ in terms of $V_1(t)$ and $V_2(t)$.

Problem 4 - Step response

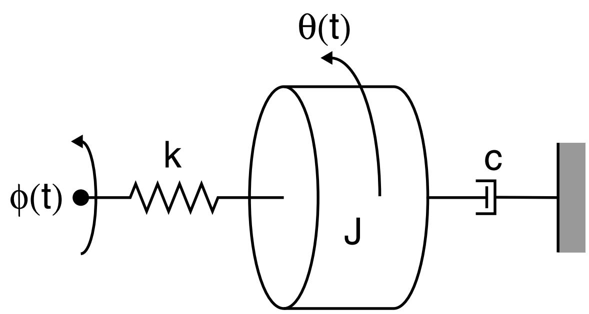


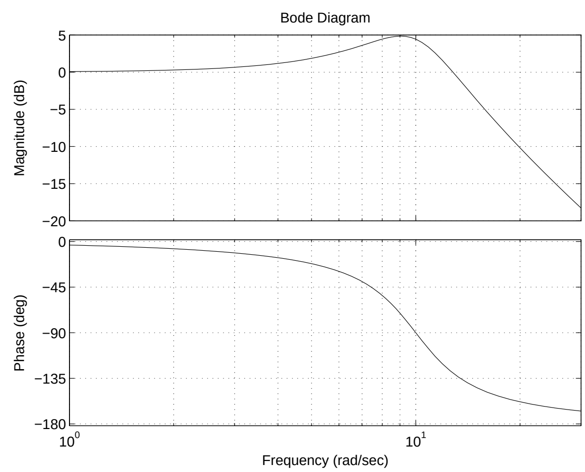
You have been given the system illustrated above. The system consist of a cylinder with a mass (m) with a radius (r=0.5 m) which spins about an axel. The cylinder rolls without slip on the ground. Attached to the axel housing are a damper (c), a spring (k=200 N/m), and a force source (f). You measure the following response x(t) to a step input of the force source.



1. Using the provide parameters and the step response, determine the damping constant (c) and the equivalent mass (m_{eq}), where m_{eq} is mass equivalent of the combined inertia and mass.
2. If the cylinder has a m=3 kg, determine the inertia of the cylinder.

Problem 5





You perform a frequency analysis of the system shown above and obtain the bode plot shown above. The inertia J=15 N/m^2.

1. Using the data in the bode plot determine, ζ and ω_n for this system.
2. Using J and the values determined in part 1, determine c and k for the system.
3. Determine an expression for the system output $\theta(t)$ when $\phi(t) = sin(\omega t)$ and $\omega = 1.1, 10$, and 20 rad/s.