

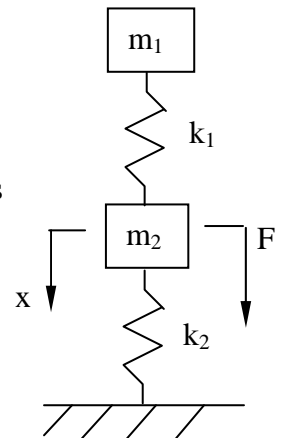
MECH 3140
Homework #7

From Palm (Chapter 8)

Problems: 1,6,18, 23, 28-30, 37, 42, 57-58

Transfer Functions (should have already done)

1. Find the transfer function from F to x_1 and F to x_2 for the following systems
2. (if you need more practice) Find the transfer function for other HW problems (1 and 2 DOF)



Frequency Response (by Wednesday 11/2/07)

1. Sketch the bode plot for the RC-low pass circuit.
(Input=Voltage In, Output=Voltage across the resistor)
What is the BW or Corner Frequency for the low pass filter?
2. Sketch the bode plot (frequency response) for your car suspension.
(with and without the tire mode)
3. Design a filter that has infinite DC gain, a gain of one from 1Hz to 100 Hz and filters (1st order) any signals above 100 Hz.
 - a) Sketch the bode plot
 - b) Sketch the s-plane
 - c) write the transfer function of the filter
 - d) write the differential equation
 - e) write out the unforced transient response
 - f) write out the frequency response

4. An engineer builds a light detection system. To avoid problems with sunlight (DC light) and lights from the building (60 Hz), the engineer pulses the transmitter at 600 Hz. Design an amplifier for the receiver that filters out light below 6 Hz, notches out signals at 60 Hz, amplifies signals at 600 Hz and filters (2nd order) signals above 6 kHz. For practical purposes use $\zeta=0.2$ for all 2nd order roots)

- Sketch the bode plot
- Sketch the s-plane
- write the transfer function of the filter
- write the differential equation
- write out the unforced transient response
- write out the frequency response

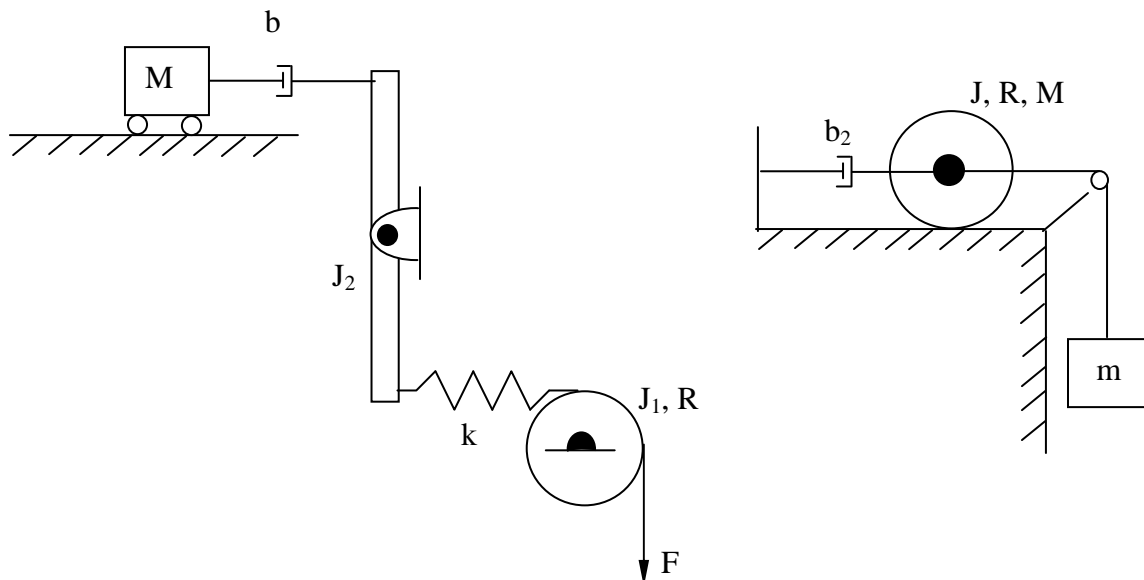
5. An engine turning at 3600 rpm causes the support structure to vibrate very badly. Design a dynamic vibration absorber to reduce the amount of vibration. The mass of the turbine and support structure is 1000 kg. The structure has a natural frequency of 60 Hz with a damping ratio of 0.1.

- Sketch the bode plot of the original system (verify with Matlab).
- Sketch the bode plot of the new system (verifying with Matlab, verify you have removed the resonant peak at 60 Hz)
- List 2 different ways you could have fixed this problem (other than a dynamic vibration absorber)

6. Estimate the natural frequency of the tire mode (on vertical motion of the vehicle) if a tire of radius 0.3 meters hits its resonance at 55 mph.

More Modeling Problems (if you need them)

(Note: You should be able to find the eigenvalues of the system that are first or second order, transient response, transfer function, etc.). If there are any old HW problems you have not worked – I suggest working them – there are some good problems in there!



Matlab Assignment (Due 11/2/2011)

1. Develop the model for the RC Low Pass Circuit. Select “real” RC values to give a bandwidth of 10 Hz. Look at the Digikey catalog (on line or in my office).
 - a) Develop the equation for the gain (from volts in to volts out) and phase shift and plot them using Matlab. Remember that the Gain and frequency should be on a log scale (semilogx for the phase plot and loglog for the gain plot). Use subplot(2,1,1) to place both graphs on one page.
 - b) Create a 1 Hz input signal (with amplitude of one). Corrupt the input signal with signals greater than or equal to 100 Hz and/or random noise. Use randn(length(v_in,1))
 - c) Simulate the filter using a sample rate (del_t) of 1 ms.
 - d) How much attenuation of the 100 Hz signal should you get theoretically? Do you see this attenuation in your results?
 - e) How well does it filter random noise?
 - f) On one page (subplot(3,1,1)) plot the true signal, the corrupted signal and the filtered signal. Note: this is how “Digital Filtering” is performed to filter signals in a computer without an actual RC circuit. It is easy to program more complicated filters than to build them using RC components.

2. Design a second order filter with a natural frequency of 10 Hz, a damping ratio of 0.707 and a DC gain of 1 (known as a second order butterworth filter).
 - a) Simulate the filter to corrupted signals as was done in Problem #1.
 - b) How does the performance of this filter compare to the RC filter? Why?
 - c) Develop the equation for gain and phase (as a function of frequency) and plot them using Matlab as was done in Problem #1-aNote: Digital filters can easily be designed to out perform a simple RC filter!