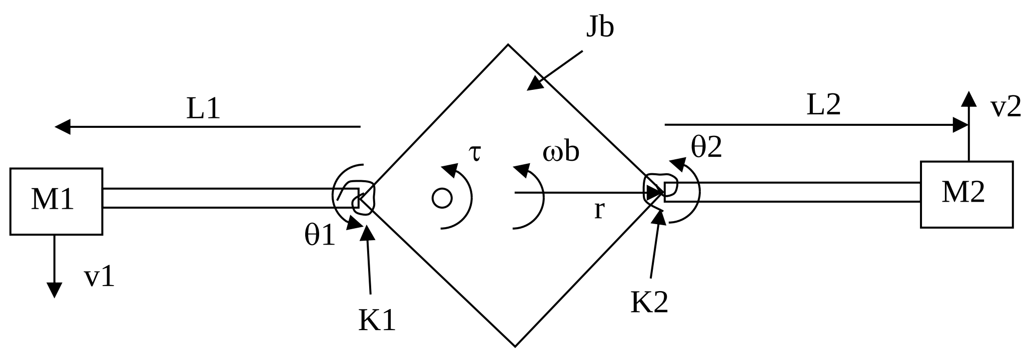
ASEN 4114/5114 Experiment 6

Due: Friday, February 25, 2022 at the beginning of lab

1) Measure the empirical frequency response of the spacecraft mockup using the "All_Spin_Module_Labs.vi", 'System ID' tab on LabVIEW. Set the Signal Selector to Rate Gyro. Use a frequency range of 0.1 Hz to 15 Hz and an amplitude of ~10 mNm. Note this program applies sinusoidal torque commands to the motor controller, in units of mNm. However, the sinusoidal output measured is the rate gyro reading [rad/sec], not the angular position of the body. Hence you must convert the measured frequency response to the frequency response of interest, i.e., from input torque to output angle θ_b. You may need to adjust frequency range, input amplitude, and number of frequency steps to see the resonance/anti-resonance modes clearly, especially near the higher frequencies. The resulting overall frequency response may then be a composite of several measured over smaller frequency intervals. Note what the body and the solar arrays are doing physically at the resonance/anti-resonance frequencies.
2) Use the direct state space method to develop a flexible-body model for the spacecraft mockup relating input reaction wheel torque τ to output body angular displacement θ_b. Assume the solar arrays can be modeled as a lumped mass, lumped spring equivalent, as shown in the diagram below, where a torsional spring models the solar array attachment to the body producing a moment (torque) proportional to angular displacement from the unstretched (untwisted) angular position: $\tau_s = K_s\theta$. The angles θ_1 and θ_2 are the solar arrays measured relative to the body, with zero angle when the arrays are in their normal (unflexed) positions. The array beams are assumed rigid in this model (flexing is modeled by deflection of these torsional springs). The v1 and v2 are inertial velocities of the masses M1 and M2, respectively.



3) Estimate the values of all parameters in your analytical lumped mass spacecraft model. Using these parameter estimates, generate the transfer function from reaction wheel torque τ [Nm] to output angular deflection θ_b [rad]. Plot the empirical frequency response from part 1) on the same plot as the analytic frequency response of the transfer function found here, and comment on any differences in the major features.
4) Adjust the physical parameters in your analytic model so that the analytic and empirical models match near the first (lowest) resonance/anti-resonance frequencies. Are the resulting physical parameters in this model realistic?