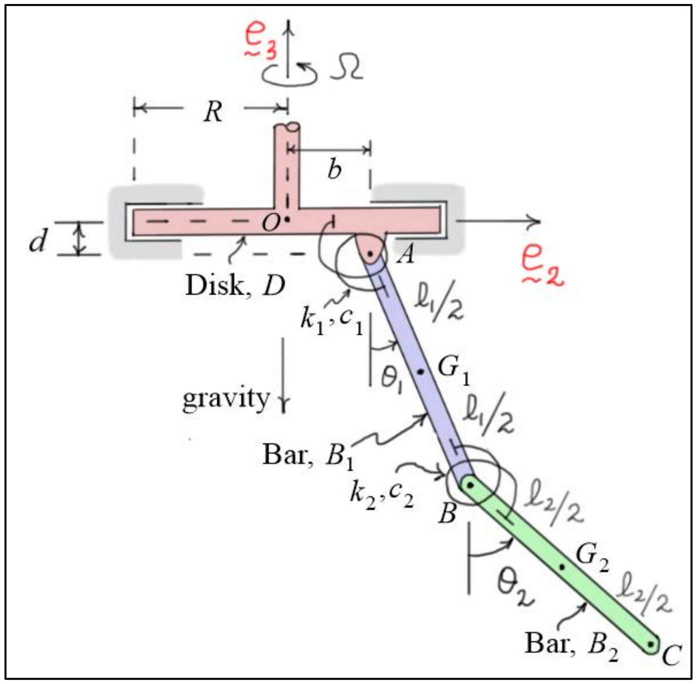
Intermediate Dynamics
Exercises #9 MATLAB/Simulink/SimMechanics Modeling

A three-body mechanical system is shown in the diagram. The disk D is connected to the ground with a revolute joint allowing rotation only in the fixed $\underset{\sim}{e}_3$ direction. Bar B_1 is connected to the disk and bar B_2 is connected to bar B_1 with revolute joints allowing relative rotations only in the rotating $\underset{\sim}{e}_1$ (i.e. $\underset{\sim}{e}_2 \times \underset{\sim}{e}_3$) direction. The disk rotates at a ***constant*** rate of $\Omega = 2\pi$ (rad/s), while the motions of the bars are free. The attached ***torsional springs*** and ***dampers*** restrain motion of the bars. Develop a dynamic model of the system using the following data and ***SimMechanics***. The model should be developed using the physical data provided, and it should produce the required output.



Model Input and Assumptions:

- Disk physical dimensions: $R = 1$ (ft), $b = 0.5$ (ft), $d = 0.2$ (ft)
- Disk mass: $m = 0.2$ (slug)
- Disk inertia: disk is assumed to be a thin circular disk
- Disk angular velocity: $\Omega = 2\pi$ (rad/s) = constant
- Bars' physical dimensions: lengths $\ell = 2$ (ft) and radii $r = 0.1$ (ft)
- Bars' masses: $m = 0.1$ (slug)
- Bars' inertias: bars are assumed to have cylindrical shape with the given length and radius
- Bar B_1 spring and dampers: $k_1 = 50$ (ft-lb/rad) and $c_1 = 4$ (ft-lb-s/rad)
- Bar B_2 spring and dampers: $k_2 = 5$ (ft-lb/rad) and $c_2 = 0.4$ (ft-lb-s/rad)
- Initial conditions for bars: both bars hang vertically downward (i.e. $\theta_1 = \theta_2 = 0$)

Model Output: All output should be plotted over the time interval $0 \le t \le 6$ (sec)

- $\theta_1(t)$, $\theta_2(t)$, $\dot{\theta}_1(t)$, $\dot{\theta}_2(t)$ - from these graphs identify the ***final values*** of the angles θ_1 and θ_2.
- ***Inertial components*** of the angular velocities ${}^{R}\underset{\sim}{\omega}_{B_1}$ and ${}^{R}\underset{\sim}{\omega}_{B_2}$ as functions of time. Using these graphs, identify the final angular velocities of the bars.
- ***Disk-fixed components*** of the ***driving*** and ***reaction torques*** acting on the disk as functions of time. Using these graphs, identify the steady-state torque acting on the disk.

Model Validation and Reporting Results

a) In this case, no hand calculations are available to which comparisons can be made. However, the analyst can still ask whether the results make sense (at least from a qualitative point of view). Analyze the results to see if they seem reasonable.

b) Execute the model using an M-file and "publish" the results to a PDF file. ***All plots*** should be ***labeled*** to indicate which variable is plotted on that graph. Make sure to include the results of your model validation as well.