Intermediate Dynamics
Exercises #4 MATLAB/Simulink/SimMechanics Modeling

1. The yoke and spider universal joint of Exercises #3, Problem #4 is shown in the diagram below (based on figure in Bedford & Fowler, *Dynamics*, 1999). Develop the following ***two*** kinematic models of this system using SimMechanics.

   a) ***Model 1***: Treat the system as a two-body system – left and right shafts only. Each shaft is connected to ground using a ***revolute*** joint, and the two shafts are connected to each other using a ***universal*** joint.

   b) ***Model 2***: Treat the system as a three-body system – left shaft, right shaft, and spider. The left and right shafts are connected to ground using ***revolute*** joints, and the spider is connected to each of the shafts also using ***revolute*** joints.

   Model Input: In both models, specify the motion of the right shaft to have a ***constant angular velocity*** of $\omega_R = 6\pi$ (rad/s), let the angle $\phi = 30$ (deg), and simulate the motion for 2 seconds.

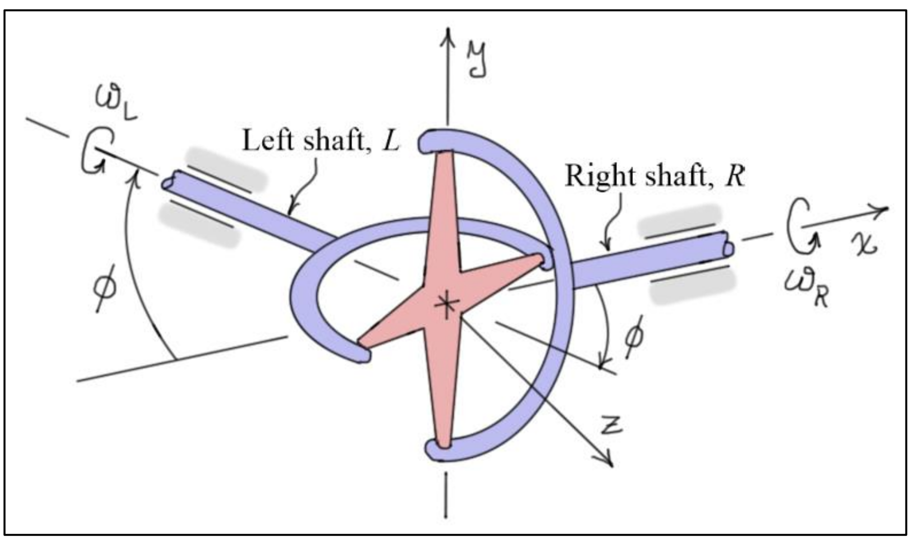
   Model 1 Output: ***Plot*** the angle (θ_R) and angular velocity (ω_R) of the right shaft and the angular velocity (ω_L) of the left shaft. ***Identify*** the maximum and minimum values of ω_L.

   Model 2 Output: ***Plot*** the angle (θ_R) and angular velocity (ω_R) of the right shaft and the angular velocity (ω_L) of the left shaft as functions of time. ***Identify*** the maximum and minimum values of ω_L. Also, ***plot*** the (x, y, z) components of the angular velocity and angular acceleration vectors of the spider as functions of time.

Model Validation and Reporting Results

a) Validate your model by comparing the initial values on your plotted output with your hand calculations of Exercises #3. You can identify the initial values on the plots by using the zoom feature. If the model is correct, your model results and hand calculations should be very close.

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



2. The three-dimensional slider crank mechanism of Exercises #3, Problem #1 is shown in the diagram (based on figure in Hibbeler, *Dynamics*, 1995). The (x, y, z) axes shown represent a fixed reference frame R. Develop a ***three-body*** model of this system using SimMechanics. The disk A is connected to the ground using a ***revolute*** joint, and the collar B is connected to ground using a ***cylindrical*** joint. Bar BC is connected to disk A using a ***spherical*** joint and is connected to collar B using a ***revolute*** joint.

   Model Input: Specify the motion of disk A to have a ***constant angular acceleration*** ${}^R\underset{\sim}{\alpha}_A = 5\underset{\sim}{k}$ (rad/s) with an ***initial angular velocity*** of ${}^R\underset{\sim}{\omega}_A = 10\underset{\sim}{k}$ (rad/s). Simulate the motion of the system for 2 seconds.

   Model Output: ***Plot*** the angular velocity of the disk (ω_A) and the angular acceleration of the disk (α_A) as functions of time. Also, ***plot*** the (x, y, z) components of the angular velocity $({}^R\underset{\sim}{\omega}_{BC})$ and angular acceleration $({}^R\underset{\sim}{\alpha}_{BC})$ vectors of the rod BC. Finally, ***plot*** the velocity (v_B) and acceleration (a_B) of the collar B as functions of time.

Model Validation and Reporting Results

c) Validate your model by comparing the initial values on your plotted output with your hand calculations of Exercises #3. You can identify the initial values on the plots by using the zoom feature. If the model is correct, your model results and hand calculations should be very close.

d) Execute your 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.