Control System Lab (EEE F 245)

Experiment 7

Title: Measurement of servo speed and pendulum moment of inertia

This experiment is originally designed to determine the moment of inertia of a pendulum by measuring its speed data. Since the measured speed is going to be "noisy" in nature due to various reasons, and the noise typically lies in the high frequency band, the data is first low-pass filtered before being used for the calculations. However, due to the online nature of the current semester, we will instead be using the "System Identification" toolbox in MATLAB to determine the moment of inertia of a load spun by a motor, which will be modeled as a standard second-order system, given two time series pertaining to its input and output. These time series will be provided to you via a .m file.

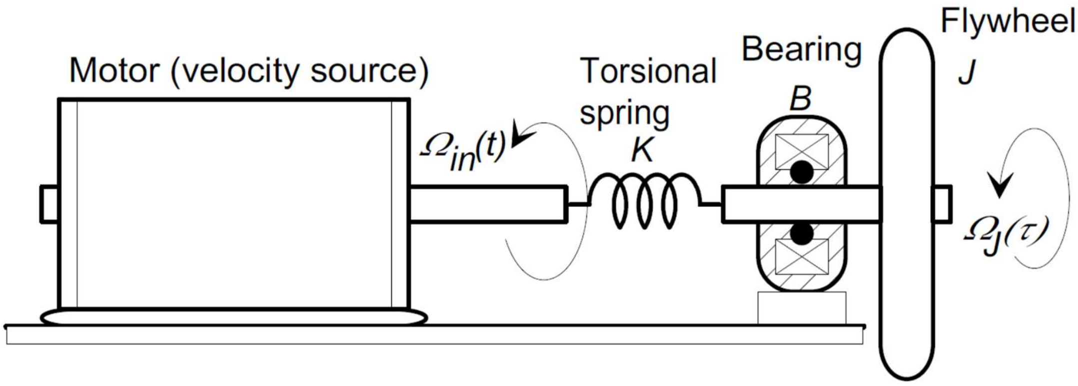


Fig. 1: A caricature of a typical rotational system: a flywheel being rotated by a motor

Consider the rotational system given in Fig. 1, wherein a flywheel having a moment of inertia J is driven by a motor. The objective of this experiment is to determine the moment of inertia J, given time series pertaining to an input-output pair of the system. For this system, the transfer function can be derived to be

$$H(s) = \frac{\Omega_J(s)}{\Omega_{in}(s)} = \frac{\frac{K}{J}}{s^2 + \left(\frac{B}{J}\right)s + \frac{K}{J}}.$$

Using the System Identification toolbox, you will first estimate the transfer function of the system that generated the given data, assuming that the data was generated by a second-order system.

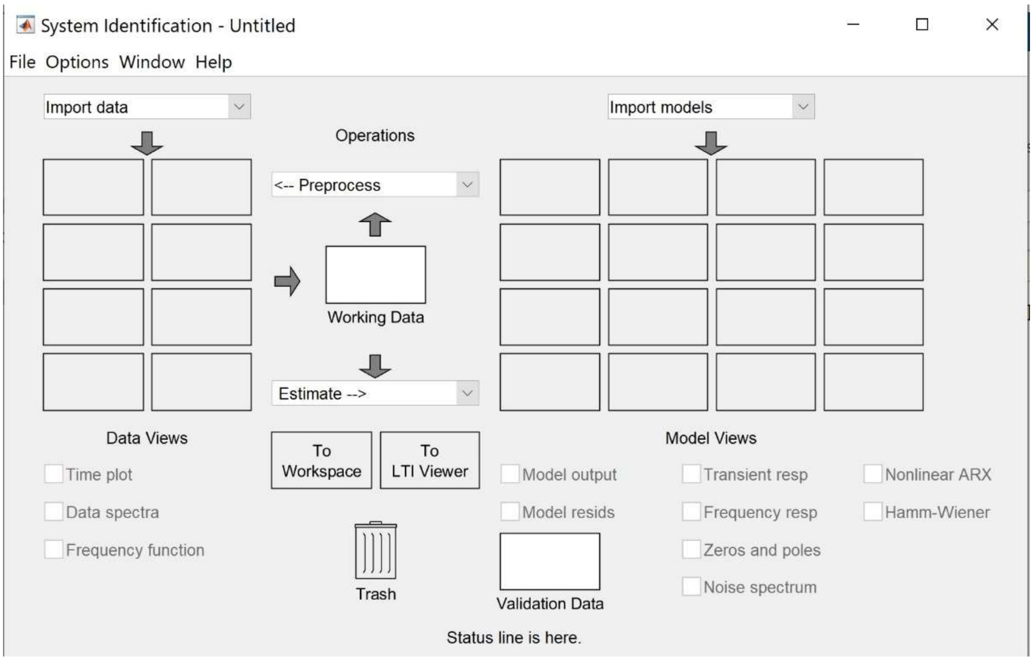
Comparing the obtained transfer function with the one mentioned above, you will find the moment of inertia of the flywheel. Assume that the spring constant has a value of 15 N-m/rad and the friction coefficient to be 1.2 N-m-s/rad.

<u>The steps to be performed on MATLAB to estimate the transfer function from the time series data is outlined next.</u>

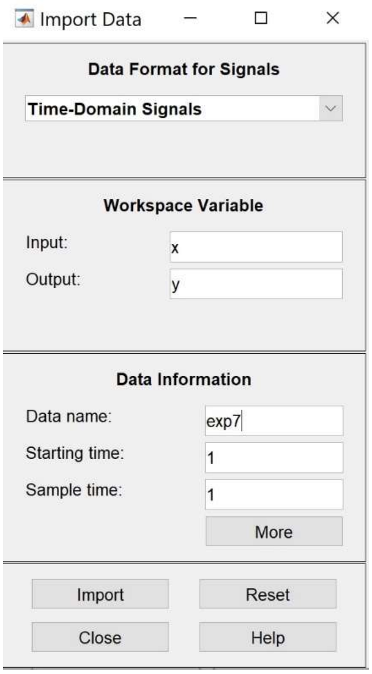
<u>Note:</u>

The '.m' file containing the synthetic input and output data will be shared with the lab manual. Also, this experiment requires the "System Identification Toolbox" to be installed.

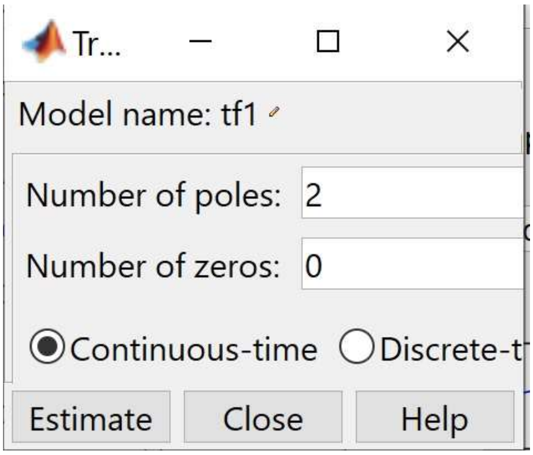
1) Load the input and output variables into the workspace by running the provided .m file. The input variable is ***x*** and the output variable is ***y***.
2) Type the command "***systemIdentification***" in the Command Window. This will open a new tab containing various options for system identification.



3) Click on the down arrow next to "Import data" and select "Time domain data" from the dropdown menu. A new tab will open. Enter the names of the input and output variables, as present in the Workspace. Name the data appropriately. Click "Import." You will now see the data in the left side of the System Identification tab.



4) In the System Identification tab, click on the down arrow next to "Estimate" and select "Transfer function models" from the dropdown menu. A new tab will open. Enter 2 poles, 0 zeros and continuous-time transfer function and click on "Estimate." In the System Identification tab, the transfer function appears as "tf1" (default name). Drag and drop this icon on the "To Workspace" box. This will create a variable "***tf1***" in the Workspace.



5) Type "tf1" in the Command Window to view the 2nd order transfer function with no zeros estimated from the input-output data provided. From this transfer function, calculate the damping ratio assuming a natural resonant frequency of 1 rad/sec. Finally, estimate and note down the value of the moment of inertia.