Lab 5

MATLAB Simulink

Objectives:
- Gain familiarity with MATLAB Simulink for discrete-time systems

Files Provided:
- datalog1.xlsx
- datalog2.xlsx
- datalog3.xlsx
- datalog4.xlsx
- lab5accel.slx

Assignment:

This lab will introduce Simulink by using some familiar equations and data, which will allow you to verify correct operation of the model and directly compare and contrast implementations in Matlab scripts versus Simulink.

There are countless video introductions to Simulink. If you want more background and demos on Simulink, a quick search will turn up thousands of hours of video tutorials. It is strongly recommended that you find a few high-rated intro videos to watch before diving in.

As a disclaimer, there is far more capability in Simulink that you will use in this course. Here are a few points to keep in mind for this lab:

- A Simulink model behaves much like a function in MATLAB. Therefore, the name of the file ***must*** be limited to standard variable naming conventions. For example, the supplied file is “lab5accel.slx”, which is valid since you may name a variable “lab5accel”. The file name “lab 5 accel.slx” may be acceptable to your operating system, but Simulink will throw an error since spaces are never allowed in variable names.

- We don’t need to explicitly pass data to a Simulink model like you do with functions. The model may use “source” blocks to grab existing variables from the workspace, and it can create variables in the workspace using “sink” blocks.

- In the Simulink Library Browser, the categories that are most likely to be relevant are:
  - Simulink->Math Operations
  - DSP System Toolbox -> Sources

1. Note: Part 1 only provides an example for you. There is no deliverable for this part.
   Open the file lab5accel.slx provided on Canvas. The Simulink file shows two different methods for acquiring data.

   a. The "From Spreadsheet" block reads the data directly from an Excel file. Double-click on the box to see its properties, and its operation should be straightforward. Note that it assumes the left column is a time stamp. To reproduce exactly what was done in earlier labs, the Excel files provided have been modified by adding a *count* column on the left. This is basically the "n" referenced in the difference equations below.

   b. The second method imports values from variables that already exist in the workspace. The simulation reads times and speeds as arrays that must exist ***before*** the simulation is started. These can be easily generated from Excel files with

      ```
      >> times = xlsread('datalog1.xlsx', 'B:B');
      >> speeds = xlsread('datalog1.xlsx', 'H:H');
      >> count = length(times);
      ```

      The *count* variable is used in the Simulink *Simulation->Model Configuration Parameters* to limit the length of the simulation.

The model implements the difference equation below twice, once for each type of input data.

$$acc[n] = A\frac{speed[n] - speed[n-1]}{time[n] - time[n-1]}$$

The two methods use sink-type blocks to write the output arrays back to the workspace. If you run the simulation, you can compare the two arrays. Note that you can use this to compare the output of the Simulink model to the code output from earlier labs to validate your work.

2. There is information in the log file that may be used to determine a second measure of velocity. The log file contains both the engine RPM and the current gear. Using the gear ratios and information about the car's tires, this may be used to calculate velocity. Design a Simulink model to output the calculated speed according to the following difference equation. Each conversion factor in the equation below must be implemented as a separate gain block in Simulink with appropriate labels to improve readability of the model.

Assume 245/40R18 tires which are 25 inches in diameter and that tire diameter in the equation below is in inches.

If gear[n] ≠ 0.

$$speed_{calc}[n] = \frac{RPM[n] * \frac{60min}{s} * \pi * diameter_{tire}}{\frac{5280ft}{mile} * \frac{12in}{ft} * ratio(gear[n]) * finalRatio}$$

given

First Gear Ratio (:1)	3.45
Second Gear Ratio (:1)	1.95
Third Gear Ratio (:1)	1.30
Fourth Gear Ratio (:1)	0.97
Fifth Gear Ratio (:1)	0.78
Sixth Gear Ratio (:1)	0.67
Final Drive Axle Ratio (:1)	4.11

If gear[n] = 0, $speed_{calc}[n] = speed_{meas}[n]$

The Simulink model must output this calculated speed to an array in the workspace. The model must also contain a single scope which shows the measured and calculated speeds on two separate plots (I.e. the scope has two inputs that allow both plots to be displayed in the same window simultaneously.)

3. The log file does not show distance traveled. The distance in miles may be calculated from the difference equation below, given that speed is in miles/hour and time is in seconds.

$$distance[n] = distance[n-1] + 0.5speed[n] + 0.5speed[n-1] * \frac{(time[n] - time[n-1])}{3600\ sec/hr}$$

$$given\ initial\ condition\ distance[0] = 0$$

Design a Simulink model to calculate the distance traveled as shown above. The model must output this distance as an array in the workspace. Use the original measured values of speed from the file, not the calculated speeds from part 2. The model must contain a single scope to display the speed and the distance on separate plots.

Deliverables:

Upload an electronic copy of the deliverables to Canvas per the lab submission requirements. Please note: **ALL** deliverables must be present in the single PDF report, and the m-file and the figure window must also be included as separate files with logical names.

- 2 Simulink file from part 2 with images of the scopes' figure windows using two different data files.
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  Scoring:
  10 points – Compliance with Submission Guidelines
  45 points – Part 2
  45 points – Part 3