P2110A: Tutorial 1 activity

September 18, 2018

Greetings, and welcome to this tutorial series in using MATLAB for physicsing! For this first activity, we will be playing with Hooke's Law, which we will define here as:

$$F_s = kx + \epsilon \tag{1}$$

where F_s is the applied force, k is the spring constant, x is displacement and the additional term ϵ is the measurement uncertainty. (Note that Hooke's Law is normally negative, but here we keep it positive for simplicity.)

In this example, you are asked to help Captain Hooke find the spring constant of the spring in his prosthetic peg leg (since he wants a replacement, and *Legs 'Arrr Us* only sells them in terms of spring constant).

Open a new script, and do the following:

1. First, you will need to load the data containing the applied force and displacement for Hooke's prosthetic leg. The data is located in 'Hooke.mat'. You can the data in MATLAB by the command:

```
load 'Hooke.mat'
```

This will give you 2 new variables: force (in Newtons) and displacement (in meters).

2. Plot this data, with each point as an 'x'.

3. Now, we will use least squares to find a trend of best fit for the data. To do this, we want to find a fitted function of the form:

$$yf_i = a \cdot x_i + b \tag{2}$$

Using least squares, the coefficients are [1]:

$$a = \frac{\Sigma_{i=1}^{n}(x_i \cdot y_i) - n \cdot \bar{x}_i \cdot \bar{y}_i}{\Sigma_{i=1}^{n}(x_i^2) - n \cdot \bar{x}_i{}^2} \tag{3}$$

$$b = \frac{\bar{y}_i \cdot \Sigma_{i=1}^{n}(x_i^2) - \bar{x}_i \cdot \Sigma_{i=1}^{n}(x_i \cdot y_i)}{\Sigma_{i=1}^{n}(x_i^2) - n \cdot \bar{x}_i{}^2} \tag{4}$$

where n is number elements in each array. Calculate these coefficients for force and displacement. What is the calculated spring constant?

4. Plot yf_i as a solid line on the same plot.

5. *Optional*: Spruce up the plot window. Look up how to add a title, x and y-axis labels, and a legend.

[1] A full derivation is given at `http://mathworld.wolfram.com/LeastSquaresFitting.html`. Note that a and b are swapped in this example.