

# MIT 8.01T Physics I

### **Experiment 5B: Friction**

### Goal



To investigate the friction of a string wrapped around a cylinder, observe that it increases exponentially, and to measure the friction coefficient  $\mu$ .

(A theoretical expression is derived in the appendix to the write up for the experiment.)

### Starting *DataStudio*:

Create a new experiment. Plug a force sensor into the 750 and drag it to the input in the Setup window.



Double-click the Force Sensor icon.

### Force Sensor:

| Sensor Properties  |  |  |  |
|--|--|--|--|
| General Measurement Calibration  |  |  |  |
| Force Sensor   |  |  |  |
| Model:<br>CI-6537, CI-6746   |  |  |  |
| Sample Rate<br>10 Hz • Fast (> 1 Hz) Slow (< 1 Hz)<br>Slow Force Changes (Spring Tests)<br>Fast Force Changes (Collisions) |  |  |  |
| OK Cancel Help   |  |  |  |

| Sensor Properties  |   |   | × |
|--|---|---|---|
| General Measurement                                      | Calibration                               |   |   |
| Current Reading<br>Voltage:<br>-0.207<br>Value:<br>-1.29 | High Point<br>Voltage:<br>Value:<br>50.00 | Low Point<br>Voltage:<br>-8.000<br>Value:<br>-50.00<br>Take Beading |   |
| Name:<br>Force, Ch A (N)<br>Bance:                       |   | Sensitivity:  | ] |
| -8.00 to 8   | .00 N                                     | 0.01  |   |
| l  | OK  | Cancel Help   |   |

Set it for 10 samples/s and low sensitivity.



## Sampling Options:

| Sampling Options                         |  | × |
|--|--|---|
| Manual Sampling                          | Delayed Start Automatic Stop   |   |
| ☐ Keep data v<br>☐ Enter a ki<br>☐ Promp | values only when commanded.<br>eyboard value when data is kept.<br>ot for a value. |   |

#### No boxes checked.

| Sampling Options  | Sampling Options   |
|---|--|
| Manual Sampling Delayed Start Automatic Stop  | Manual Sampling Delayed Start Automatic Stop   |
| <ul> <li>None</li> <li>Time 10 Seconds</li> <li>Data Measurement</li> <li>Force, Ch A (N)</li> <li>Is Above 0 N</li> <li>Keep data prior to start condition. 0.000 Seconds</li> <li>Start Signal Generator before start condition.</li> </ul> | <ul> <li>None</li> <li>Time 10 Seconds</li> <li>Data Measurement</li> <li>Force, Ch A (N)</li> <li>Is Above 0 N</li> </ul> |

No delayed start.

Stop after 10 s.

Set Up :

Choose large or small cylinder.

Both kinds at each table.

100 gm brass weight + 5 gm holder = 1.03 N.



Small Cylinder



Large Cylinder

### Measuring technique:

Tare the force sensor.

Ensure string passes over pulley before all measurements.

Do not wrap the string over itself. Wrap string 2 <sup>1</sup>/<sub>4</sub> turns around cylinder.



Increase ccw torque on cylinder smoothly to the slipping point, then turn slowly for 1 or 2 seconds. Practice this, so you get 1 or 2 peaks of the force in 10 s, then record the force with *DataStudio*.

### Measuring the Friction:



Choose the largest <u>magnitude</u> of Force as the friction. Use the Smart Tool or the Statistics ( $\Sigma$ ) Tool.

### Recording the Friction:

Measure the friction for the string wrapped <sup>1</sup>/<sub>4</sub>, 1<sup>1</sup>/<sub>4</sub>, 2<sup>1</sup>/<sub>4</sub>, 3<sup>1</sup>/<sub>4</sub> and 4<sup>1</sup>/<sub>4</sub> turns. Express these in radians and type them as the independent variable, along with the friction force as the dependent variable, into a table in DataStudio.

Include the force of 1.03 N when the wrap angle is 0 as an entry in your table.

Plot the table on a graph and carry out a User-Defined Fit with the function  $1.03 * \exp(-C*x)$ .

### Fit Result (large cylinder):



### Fit Result (small cylinder):

