

# Friction

## Learning Aims

| Knowledge                                                                                                                                                                                                                                                                                                                          | Skills                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Friction is a Force which acts to resist movement</li><li>• Friction is a contact force which is affected by the surface materials</li><li>• Friction may be increased by load, and decreased by lubrication</li><li>• Where is Friction desirable, and where is it undesirable?</li></ul> | <ul style="list-style-type: none"><li>• Working collaboratively</li><li>• Selecting appropriately scaled instruments</li><li>• Using Analogue Force Meters</li><li>• Reading linear scales</li><li>• Gaining confidence in practical skills</li><li>• Evaluating data quality</li></ul> |

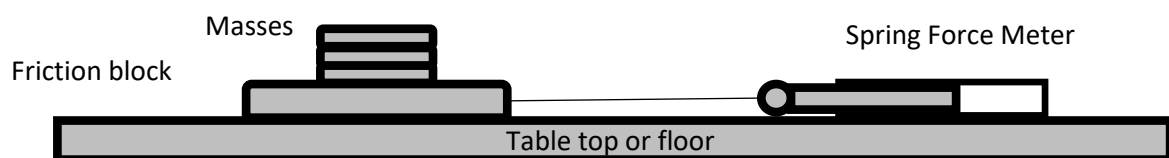
### **Simplifying:**

Students may be given one material and conduct tests to measure the effect of increasing load. Class results can be shared for the different materials. Pre-prepared graph axes can be provided.

### **Extending:**

Gather sets of results for multiple materials and plot multiple lines on single graph. Use range bars on the data points to show experimental uncertainty. Calculate the coefficient of friction for several interactions.

Students could go on to investigate differences and similarities between static friction, kinetic friction and rolling friction



# Friction

This Teaching Guide supports the delivery of the Friction classroom PowerPoint presentation

| Duration      | Teaching Guide                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0-15 minutes  | <p><b>Slides 1-3</b><br/>Introduce theme of friction. Explain how it has benefits and disadvantages<br/>Encourage students to suggest examples of friction in everyday life, i.e. Grips on the soles of shoes, car tyres</p> <p><b>Slide 4</b><br/>Describe how friction is caused by the interaction between two surfaces</p> <p><b>Slide 5</b><br/>Share the concept that Friction does not exist if the object is not under any force, but that Friction is a force which arises a reaction to a driving force</p> <p><b>Slide 6 &amp; 7</b><br/>Explore how the heat generated by friction is either good or bad. <i>See the Notes page on the PowerPoint slides for the slide build information and explanations.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 10-15 minutes | <p><b>Slide 8</b><br/>Explain the experiment apparatus:<br/>Select your material board and attach a Force Meter with a suitable scale.<br/>Record the Force <b>as the board moves at constant speed</b><br/>Add masses in 100 g steps up to 1000g</p> <p><b>Basic level - Slide 9</b><br/>Basic level: Students select a surface to test and create a table of results for 100-1000g added mass. Calculate averages and identify trends. Compare results with other groups who tested different materials</p> <p><b>Normal level – Slide 9 &amp; 10</b><br/>Students select one or more surfaces to test and create a table of results for 100-1000g added mass. Calculate averages and plot graphs of Average friction force against load. Identify results are directly proportional. Compare results with other groups</p> <p><b>Advanced level – Slides 9 to 13</b><br/>Students select several surfaces to test and tabulate results of measured load (N) against maximum static friction force (N). Plot graphs of average results including range bars. Calculate the coefficients of friction for the materials tested and compare values with examples given</p> <p><b>Slide 12</b><br/>Explain the difference between static and sliding (kinetic) friction</p> |
| 15-30 minutes | Students gather their own data. Slide 6 could be returned to the screen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 5 minutes     | <p><b>Slide 15</b><br/>Introduce Lubrication: a solid, liquid (or gas) which is used to decrease friction by separating the surfaces</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 10-15 minutes | <p>If there is time, students test one or more of the lubricants supplied to measure how effective they are at reducing Friction (compared with earlier results)<br/>Compare findings to Slide 9. Are their values still directly proportional?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 5-10 minutes  | Put equipment away, tidy-up and clear surfaces                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 5-10 minutes  | <p><b>Slides 17 &amp; 18</b><br/>Review the learning in the context of the Greenpower Car: where is Friction good, where is it bad? How will lubrication help performance and where could it be hazardous? Feedback ideas to the whole class.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

# Friction

|                                                                                                                                                                             |                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Selection of Force Meters (0-2.5, 0-10, 0-50)                                                                                                                               | Timstar         |
| Selection of masses (100g) x 10                                                                                                                                             | Timstar         |
| Materials boards prepared: 100x100mm wooden board with variety of materials stuck to one surface (rubber, sand paper, HDPE, cloth, plain wood)<br>Hook and string attached. | Locally sourced |
| Selection of lubricants (water, thin oil, grease, fine sand, talcum powder, liquid soap)                                                                                    | Locally sourced |
| Graph paper. Axes could be pre-plotted for lower ability students                                                                                                           | Locally sourced |

## Notes:

- Students should be encouraged to use the Force Meter with a scale suitable for their conditions, and to change meters as the force increases with load.
- By testing several times, students will gain an appreciation of uncertainty about the true value.
- By plotting graphs of the results, students will be able to see trends more clearly, and identify anomalous results which may be worth retesting
- Open Learning: students could be encouraged to be imaginative and perhaps test other objects (eg their own shoe, a chair, a doorstop)

## Safety:

| Hazard                | Likelihood | Injury         | Action Recommended                                                                                  |
|-----------------------|------------|----------------|-----------------------------------------------------------------------------------------------------|
| Weights dropping      | Possible   | Impact on foot | Instruct students to conduct their tests well away from table edges or to do the tests on the floor |
| Slipping on lubricant | Possible   | Falls          | Lubricants cleared up immediately after use. Experiments not conducted in footway                   |

## Typical Results

| Material | Load (grams) | Maximum Friction Force (Newtons) |        |        |         |
|----------|--------------|----------------------------------|--------|--------|---------|
|          |              | Test 1                           | Test 2 | Test 3 | Average |
| Rubber   | 0            | 0.6                              | 0.7    | 0.7    | 0.67    |
|          | 100          | 0.8                              | 0.9    | 0.8    | 0.83    |
|          | 200          | 1.2                              | 1.1    | 1      | 1.10    |
|          | 300          | 1.3                              | 1.5    | 1.5    | 1.43    |
|          | 400          | 1.6                              | 1.6    | 1.7    | 1.63    |
|          | 500          | 1.9                              | 1.9    | 1.9    | 1.90    |
|          | 600          | 2.2                              | 2.4    | 2.4    | 2.33    |
|          |              |                                  |        |        |         |