Investigation of Hooke's Law

**Background**

When an object is stretched its elasticity determines how easily it will return to its original shape. Objects which are highly elastic may be hard to stretch but will return to their original shape without any significant change to its properties. For example metal wires are harder to stretch than rubber bands but they will snap back to their original length more easily.

The amount of force, F, required to stretch a material a certain length ($∆x)$ is related by Hooke’s law. Hooke’s law states that for an elastic material the force exerted is directly proportional to the extension.

$$F=-k∆x$$

Hooke’s law includes a coefficient of proportionality, k, known as the spring constant. Objects that are difficult to stretch have a high k value compared to those that are easy to stretch.

**Aim**

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**Apparatus**

Steel spring Meter ruler 50 g Mass hanger

50 g masses Retort stand Clamp

**Procedure**

1. Set up the retort stand, spring, clamp and meter ruler as shown.
2. Measure the length of the spring, record this value in the table in the first row of table 1.
3. Estimate the uncertainty of the spring length
4. Add the 50 g mass hanger and record the new length of the spring.
5. Add a 50 g slot mass to the hook and record the position of the bottom of the spring as well as the mass.
6. Repeat step 4 with successive masses.

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**Results**

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| Length of spring (cm) | Mass applied (g) |
|  | 0 |
|  | 50 |
|  | 100 |
|  | 150 |
|  | 200 |
|  | 250 |
|  | 300 |

Uncertainty of spring length: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Analysis

1. Calculate the extension of the spring by subtracting the initial length of the spring from all of the measurements in table 1, convert these values to metres and then record these values in table 2.
2. Convert all masses to Newtons (divide the mass by 1000 and multiply by 9.8) record these values in table 2 including the uncertainty of each measurement.

Table 2

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| Extension of spring (m) | Force (N) |
| 0 | 0 |
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1. Plot all the data on the graph paper. *F* will be plotted in the vertical direction, while the extension will be plotted in the horizontal direction. **Label** the axes of your graph and include **units**. (Despite the mass being the independent variable the graph is plotted in this manner to allow for a simple calculation of k.)
2. Plot horizontal error bars for each point.
3. Take a ruler and draw a **single** "best fit" line through all the data points.
4. Measure the "rise over run" (the slope) of this line. This is your experimental value for the spring constant. In what units should *k* be reported?
5. Sketch a line of maximum gradient, determine the slope of this line.
6. Sketch a line of minimum gradient, determine the slope of this line.
7. Estimate the error of the gradient by finding the difference between maximum and minimum gradient and divide by two.
8. State the coefficient of stiffness with an estimate of uncertainty.

**Graph of data**

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**Calculations**

Slope calculation:

Maximum slope calculation:

Minimum slope calculation:

**Error Analysis**

Describe the amount of scatter of your points around your "best fit" line. The more they scatter, the poorer the precision.

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Does the graph form some other shape besides a straight line, such as a parabola? (This could mean that Hooke's Law is not valid for this spring.)

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What is your estimate of the error in *k* and how did you estimate this error?

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What are the sources of error for your data points and what is the relevance of these errors in your determination of *k*?

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**Conclusions**

Write down you general conclusions for this experiment. These conclusions should include the value of the spring constant *k* and an estimate of its error.

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