Elastic properties of rubber

While conducting this experiment, you will be assessed for CPAC3: Working safely.

Theory

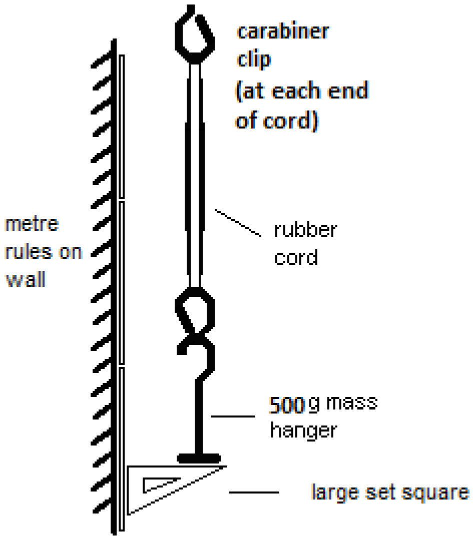
If a graph of force against extension is plotted for both loading and unloading a sample of rubber, then the two lines do not coincide. This phenomenon is known as 'elastic hysteresis'. The area of the hysteresis loop produced is a measure of the energy dissipated in the loading / unloading cycle.

Also an estimate of the Young modulus of rubber can be obtained from the average gradient of the line and the dimensions of the rubber loop. The Young Modulus is given by:

$$\text{Young Modulus} = \frac{\text{Force x Original Length}}{\text{Extension x Cross-Sectional Area}}$$

Apparatus required

A large rubber cord loop (US 'trash can' rubber band) is suspended from a carabiner clip attached to a metal chain suspended from the ceiling of the centre of the laboratory.



You will also require 500 g masses and a micrometer screw gauge.

Before conducting the experiment, identify the main safety risk and write down 2 precautions below. Have this checked by your teacher before proceeding.

Method

Using the metre rules fixed to the wall and the set square, take a series of readings for the extension of the cord for both loading and unloading. Start with the mass hanger to keep the band taut (ignore this in your mass readings) and also record the initial length of the band which you will need for the Young Modulus. The force can be found from the load multiplied by g, the acceleration due to gravity.

Carefully try to measure the thickness with a micrometer so that you can calculate the cross sectional area – note that there are two sides to the loop!

Processing of results

Tabulate all your values, including the final results of force against extension.

Plot a graph of force against extension showing clearly the loading and unloading sections.

Use the graph to calculate the energy dissipated per cycle of loading and unloading. You will need to count the squares contained within the hysteresis loop and multiply this by the energy corresponding to one square from your graph axes.

Also measure the average gradient of the graph to calculate an order of magnitude estimate for the Young Modulus of rubber.

Discussion and Conclusion

Check in a textbook or in your notes that the graphs have the correct shape. Why must the curve for stretching lie above the one for unloading?

Does your value for the Young modulus of rubber seem sensible? How does it compare with the values for a typical metal? Explain why the value you have obtained is only an order of magnitude approximation.