Determining the Young modulus for a metal

Introduction

In this experiment you will be taking measurements of different orders using a range of techniques. There are alternative physical layouts for the experiment, but the procedure follows the same pattern.

You are expected to be familiar with the concept of the application of a force leading to the extension of an elastic material in tension and the further concepts of stress and strain giving a measure for the material, independent of the sample length or cross sectional area.

There is an opportunity for evaluation of potential uncertainties in readings and the combination of individual uncertainties into the uncertainty of the final result.

Aim

- To determine a value for the Young modulus of a metal

Intended class time

- 60 to 90 minutes

Equipment

- test wire (for example 28 swg copper)
- fixed wire to hold measuring apparatus
- Vernier measurement system to measure extension
- metre rules
- masses
- bench pulley (if working horizontally along bench)
- G clamp (if working horizontally along bench)
- micrometer
- safety goggles to EN166F

Health and Safety

Safety goggles or spectacles (as provided by the centre) must be worn at all times due to the risk of the tensioned wire snapping and causing damage to the eyes.

Your teacher will have determined a maximum load to be applied to the wire to reduce the risk of breaking.

Avoid standing next to the masses and make provision to cushion their landing.

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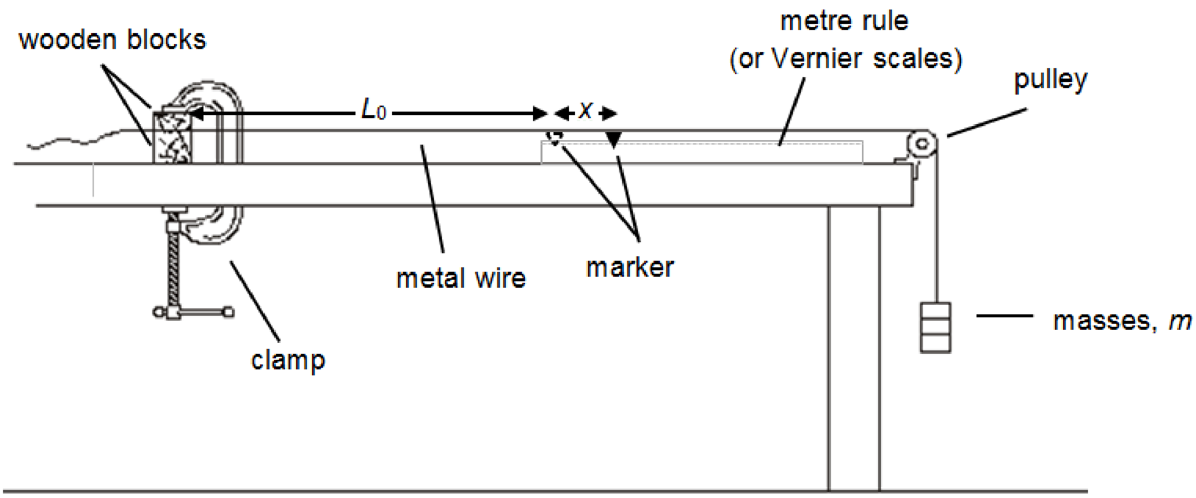
Procedure

The apparatus is set up as shown below. Alternative apparatus arrangements can be used, see https://spark.iop.org/episode-228-young-modulus#gref for an example.

In each case the original length, L_0, extension, x, and mass, m, should be identified.

Note that L_0 should be as long as practical for your particular arrangement.



1. Measure the diameter of the test wire using a micrometer detailing the steps you have taken to improve the repeatability of your result.
2. Use this measurement to calculate the cross sectional area of the wire. Record the result clearly with the appropriate units.
3. The original length L_0 of the test wire is established and clearly marked or measured at that length so that any extension can be established. This may require a small load on the wire to straighten it.
4. The load is increased in stages up to a maximum determined by your teacher.
5. Record your results of mass, force applied (calculated from the mass), extension, stress and strain in a table, complete with all units appropriately detailed.
6. Plot a graph of stress (on the y-axis) against strain (on the x-axis).
7. Calculate the value of the gradient with appropriate units. This is the Young modulus.

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Evaluation

Detail the percentage uncertainty in F, A, x and L_0 showing how you determine each value.

Combine these uncertainties to give a percentage uncertainty for the Young modulus.

Extension Opportunities

Compare your value to an accepted value from a table of materials data.

Comment on the comparison between your result and the accepted value, taking your estimated uncertainty into account.

Recording

As evidence for the Practical Endorsement you should have the data collected from your group and additionally any class data required to allow graphical representation in a clear and logical format. All work should be clearly dated.

In addition, in preparation for the assessment of practical work in the written examinations and to help develop your understanding of physics, you should have used the data collected to calculate a value for the Young modulus, explaining clearly how you have used the data in the calculation.

You should be able to calculate the percentage difference between your calculated values and the accepted value.

You should be able to identify sources of uncertainty in each method and combine them to give an overall assessment of uncertainty.

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