**Determining Young Modulus for a Metal**

**Introduction**

In this experiment students 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.

They 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 and skills covered**

* To determine the Young modulus for a metal wire
* Use of calipers and micrometers for small distances using digital and Vernier scales
* Use of appropriate digital instruments to measure mass

**Intended class time**

* 60 to 90 minutes

**Links to Specification**

**Physics A**

* 3.4.2(c) stress, strain and ultimate tensile strength
* 3.4.2(d) Young modulus = tensile stress/tensile strain

**Physics B**

* 3.2a(iv) One method of measuring Young modulus
* 3.2b(i) Make appropriate use of the terms stress, strain, Young modulus
* 3.2b(ii) Stress – Strain graphs
* 3.2b(iii) Make appropriate use of tables comparing materials and properties
* 3.2c(ii) Make calculations and estimates involving stress, strain, Young modulus
* 3.2d(ii) Experiment to determine Young modulus

**Practical Skills**

* 1.2.1(c) Follows written procedures
* 1.2.1(d) Makes and records observations
* 1.2.1(e) Keep appropriate records of experimental activities
* 1.2.1(f) Present information and data in a scientific way
* 1.2.1(g) Use appropriate software and tools to carry out research and report findings
* 1.2.1(h) Researches
* 1.2.1(i) Correctly cite sources of information
* 1.2.2(a) Using appropriate analogue apparatus to record length and distance and to interpolate between scale marks
* 1.2.2(b) Use of appropriate digital instruments to measure mass
* 1.2.2(c) Use methods to improve accuracy of measurements
* 1.2.2(e) Use callipers and micrometers for small distances, use digital or Vernier scales

**CPAC**

* (1) Follows written procedures
* (3) Safely uses a range of practical equipment and materials
* (4) Makes and records observations
* (5) Researches, references and reports

**Mathematical skills**

* M0.1 Recognise and make use of appropriate units in calculations
* M0.2 Recognise and use expressions in standard form
* M0.3 Calculate percentage uncertainties
* M1.1 Use an appropriate number of significant figures
* M1.2 Find arithmetic means
* M1.5 Identify and combine uncertainties
* M2.3 Substitute numerical values into algebraic equations using appropriate units
* M3.1 Translate information between graphical, numerical and algebraic forms
* M3.2 Plot two variables from experimental or other data
* M3.4 Determine the slope of a linear graph

**Equipment**

* test wire (for example 28 swg bare 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, the F denoting designed for impact

Kits of apparatus are available. An example being SciChem XPS070010

Alternative arrangements are shown on the link <http://tap.iop.org/mechanics/materials/228/page_46520.html>

**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.

The centre should determine the maximum load to be applied to the wire to reduce the risk of breaking.

This experiment is referred to in the “Mainly Physics” section of the CLEAPSS Laboratory Handbook, section 12.18 *Stretched wires etc*.

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

A box with bubble wrap provides a suitable cushion for dropping masses and students should avoid standing close to the masses.

**Notes**

* These practical activities are not controlled assessments, should not be carried out in exam conditions and can be adapted by the centre. Students can collaborate during the activities which should take place as part of the normal teaching sequence. They are intended to be formative with students acquiring and practising skills throughout the course.
* To achieve a pass in the Practical Endorsement each student is required to demonstrate competence in all the skills, apparatus and techniques listed in section 1.2 of the specification and assessed against the Ofqual Common Practical Assessment Criteria (CPAC) at the end of the course.
* The skills, apparatus and techniques can be demonstrated during any practical work undertaken during the A Level course whether an OCR practical activity or not.
* It is possible to carry this out as a class activity providing each learner demonstrates the practical skills required. The individual readings are then shared for analysis by each learner
* Learners are expected to take a number of readings for diameter, both along the length of the wire and perpendicular to each other to account for possible variations along the length and for it not being circular.
* Learners often find calculating the area challenging with measurements in millimetres, particularly in the correct units for the result. Working in standard form overcomes this.
* Learners also have difficulty in understanding the process for combining uncertainty in diameter to arrive at uncertainty for area, being twice the uncertainty in radius, and then adding all uncertainties to arrive at a final value of uncertainty for Young modulus.

**Recording**

* Learners should not need to re-draft their work but rather keep all their notes as a continuing record of Practical Activity.
* Learners should have evidence of the data collected from their individual readings, as well as the combined class data, in a clear and logical format.

In addition, to support the assessment of practical work in the written examinations:

* They should plot a graph of stress against strain.
* They should have used the data collected and plotted to calculate a value for the Young modulus, explaining clearly how they have used the data in the calculation.
* They should identify sources of uncertainty in each method.
* They should combine the uncertainties.