# TAP 227- 2: Tension and extension

Find out how the extension of a fibre varies with tension and find the breaking strength of your sample.  Make sure you test the nylon sample as you will need your results in a question that follows.

## Apparatus

- ✓ selection of different reels of fibres – cotton, nylon (or other man-made polymer), string, wool
- ✓ lengths of rubber (ideally of differing cross-section, as sold by model shops)
- ✓ G-clamp
- ✓ small wooden blocks for gripping end of fibre
- ✓ clamped pulley
- ✓ several 1 kg fixed masses (could be filled sandbags)
- ✓ sets of 0.1 kg slotted masses on hangers
- ✓ sets of 10 g or 20 g slotted masses on hangers
- ✓ Sellotape
- ✓ card
- ✓ metre rule
- ✓ scissors
- ✓ eye protection
- ✓ soft 'landing platform', e.g. thick foam sheet or cardboard box containing packing material

| | **Safety** |
|---|---|
|  | **The load should not be too high off the floor, and there should be a suitable soft 'landing platform' (not your feet!) if (when) the sample breaks.** <br><br> **Use eye protection – beware of the fibre 'whipping back' if it breaks. Do not lean over the stretched fibre.** |

**Set-up:**

'ℓ' is length under test
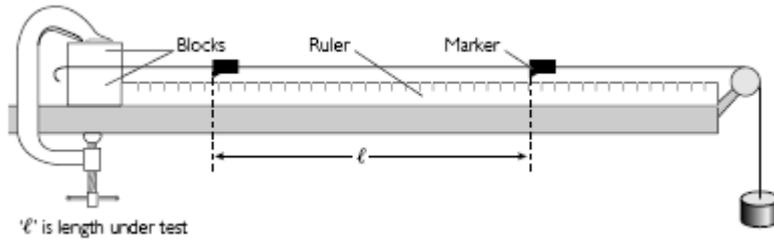
## What to do:

You will need to do a trial run to decide roughly on a suitable test length – the marker nearer the pulley may disappear over the edge! If the sample appears not to stretch very much, how could you improve matters? Take readings of load and extension as the load is gradually increased. ('Extension' means the total amount stretched from its original, natural, length – not the extra amount for each increase in load.) You will need a small (say 0.1 N) starting load just to take up the slack – ignore this in your load measurement (although it may well be insignificant anyway).

- If the load is reduced, is there any evidence of permanent stretch?

## Analysing the results

Decide on the best way of presenting your results in order to contrast the varying force–extension behaviour of the different samples.

Plot graphs of tension (*y*-axis) against extension. This may seem the 'wrong way round' since it is usual to put the independent variable (here tension) along the *x*-axis. Conventionally, results of experiments such as these have extension along the *x*-axis, since professional tensometers measure the force required to produce a controlled extension.

## Study the design of a climbing rope – why is it as it is?

Calculate the stiffness using a number of different *F–x* pairs for the same fibre. You are likely to obtain different values for the same fibre according to which point you select on the graph. Can you relate the stiffness, in general terms, to what the graph is doing and also to the nature of the fibre itself?

For many materials it is approximately true that at least over part of the range the stiffness is *constant*. To what extent is that true for your samples?

An 11.5 mm external diameter climbing rope is stated to have a breaking strength of 32 kN. Approximately how many nylon fibres are in the core if they have the same diameter as your sample?

## Practical Advice

This is a version of the 'standard arrangement' commonly used for testing metal wires. Even fine threads are surprisingly strong. To make this more 'real', student could test fine threads drawn from a climbing rope. Students left to their own devices may well end up with 4 or 5 kg hanging, with obvious hazards. It is possible to purchase stout bags with brass eyelets to be filled with 1 or 2 kg of sand for this type of testing – this is certainly preferable to delicately poised slotted masses.

## Hooke's law

You might like to discuss with students the status of a physical 'law' that is only obeyed in some circumstances, as opposed to Newton's laws of motion that are always obeyed.

If students are familiar with Ohm's law from pre-16 level they should appreciate that its status is rather like that of Hooke's law.

## External References

This activity is taken from Salters Horners Advanced Physics, Section HFS, Activity 18