MATERIALS TESTING INDEX

BENCH TESTING MATERIALS

Materials have a number of important properties which can be tested. There is a test sheet for each property.

Property	Explanation
Malleability	Malleable materials can be deformed by compression (squashing).
Ductility	Ductile materials can be deformed by tension (stretching).
Bending	How much does the material bend under load? How many times or how much can you bend it before it breaks?
Hardness	A material is hard if it is not easily worn away or dented.
Toughness	A material is tough if it is not easily broken or bent by sudden shocks or blows.
Brittleness	A material is brittle if it is easily broken by sudden shocks or blows.
Elasticity	A material is elastic if it goes back to its original shape after it has been deformed.
Plasticity	A material is plastic if it does not go back to its original shape after it has been deformed.
Strength	This can be tensile (stretching), compressive (squashing), bending or shear.

MALLEABILITY

Definition
A material is malleable if it can be permanently deformed in all directions due to compression (squashing), without cracking or tearing. A malleable material can be hammered into a new shape.

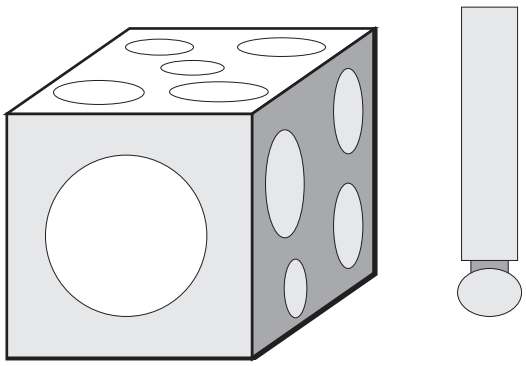
You will need a sheet of each material - suggest three metals - from aluminium, copper, mild steel, brass, a range of plastics and one thin ply. These sheets should all be the same size, 50 mm x 50 mm x 2 mm. It is especially important that each sample has the same thickness.

You will also need:

- A doming block.
- A vice.

You will be given a sheet of each material you are to test. You should make yourself accurate samples from these sheets with a minimum of waste.

Place your sample on a doming block.



Use the punch to hollow out or 'sink' a dome into each sheet:

- Does temperature have any effect on malleability?
- For which materials?

When you have tested each material, examine each sample carefully for signs of cracking or tearing.

CONCLUDING ACTIVITY

List the materials you have tested in order of their malleability
(reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

DUCTILITY

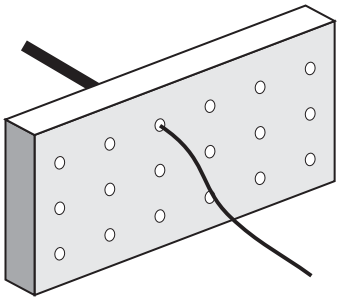
Definition
A material is ductile if it can be deformed by putting it under tension, bending, twisting or stretching without cracking or tearing.

You will need a wire or fibre of each material - suggest three metals - from silver, copper, mild steel, brass and one or two plastic fibres. The length of material that is tested should be 400 mm x 1 mm^2 in cross-section.

You will also need:

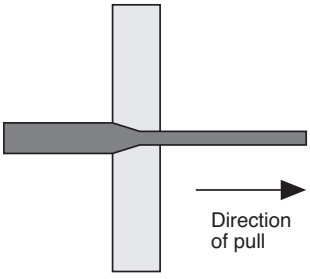
- A draw plate.
- A pair of tongs.

You will be given wires or threads of the materials you are to test. You must make yourself samples from these with a minimum of waste.



One end of each sample should be pushed through the wide end of a hole in a draw plate that is the same size (the end of the sample may need to be thinned a little).

This end should then be held firmly in a pair of tongs and pulled slowly through the plate until the whole sample has either been drawn through or it breaks:



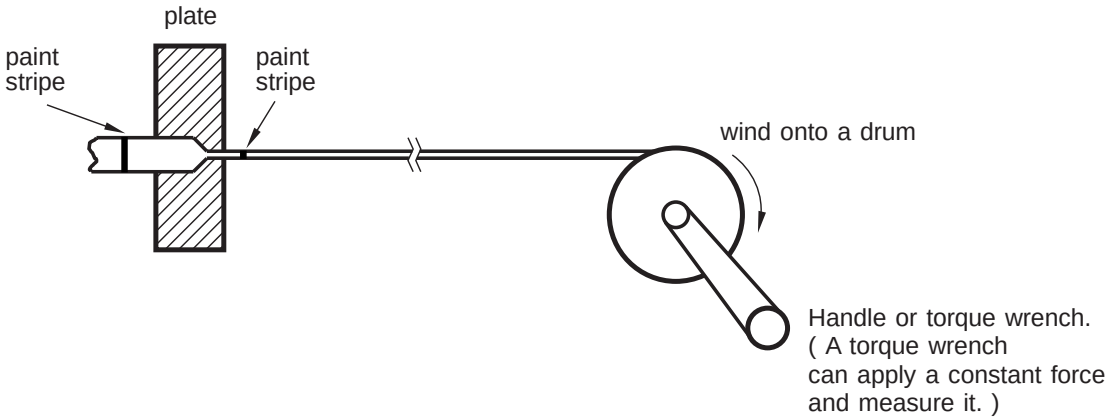
When you have tested each material, measure the **elongation** (how much it has stretched) of each sample and examine the stretched area (or the breaking point) carefully .

CONCLUDING ACTIVITY

List the materials you have tested in order of their ductility
(reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

A more accurate method is:



You can measure:

- The force used.
- The amount of stretching using paint stripes
- The distance moved by each stripe.
- The thickness before and after using a micrometer.

CONCLUDING ACTIVITY

List the materials you have tested in order of their ductility (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

HARDNESS: A BALL INDENTATION TEST

Definition
Hardness is a material's capacity to resist penetration.

The UNILAB Materials Tester allows you to do an indentation test called the Brinell hardness test.

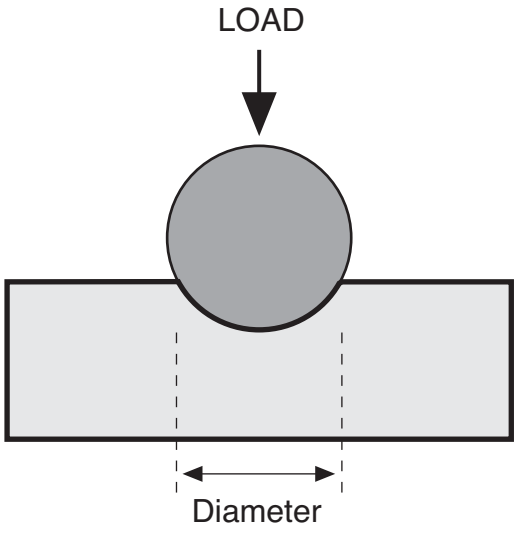
In this test, a small sphere of tungsten carbide (a very hard alloy) is pushed against the sample with a constant force of 1000 Newtons (N) for 15 seconds.

Your teacher will show you how to use the materials tester.

It is important to make sure you test each sample in the same way. You will probably need to do the test a few times, in different places, on each sample.

Make sure you keep the force as close to 1000 N as you can - you will need to keep adjusting the testing machine during the 15 seconds.

You will find the materials tester has left a small dent in your sample for each test you did. Measure the diameter of the dents with the help of a magnifier and some vernier callipers. You should be able to measure to the nearest tenth of a millimetre.



Find the average diameter of the dent for each sample you test.

CONCLUDING ACTIVITY

List the materials you have tested in order of their hardness (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

Compare these results with the scratch test for hardness. Do you get the same results?

HARDNESS: A POINT INDENTATION TEST

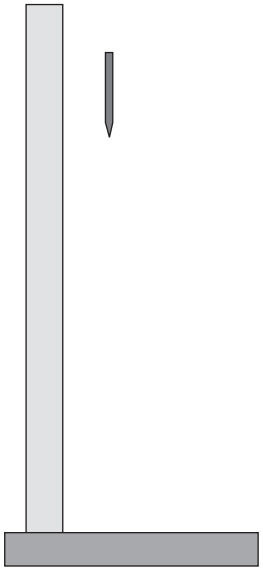
Definition
Hardness is a material's capacity to resist penetration.

Drop a centre punch onto the sample from a height of 500 mm:

You need to make sure you test each sample in the same way so that the comparison is fair.

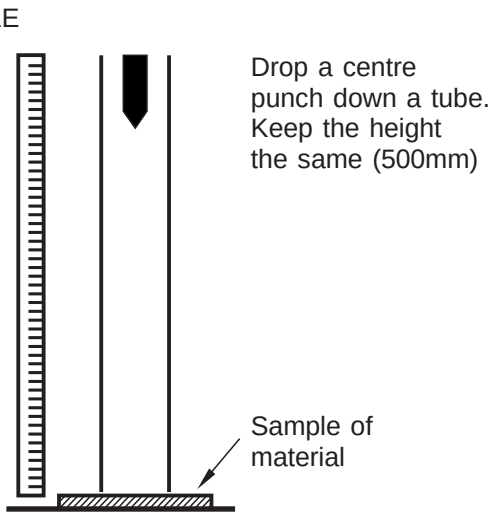
Examine the dents you have made. You may find a magnifier useful.

Do the concluding activity.



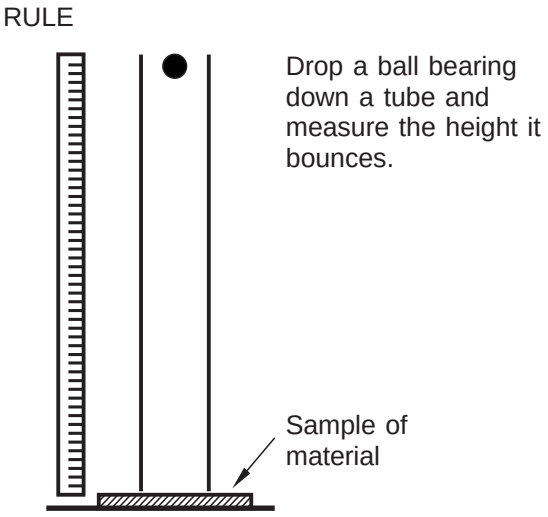
Drop a centre punch down a tube. Keep the height the same (500 mm).

Compare the dents. You may need to use a magnifying glass. The bigger the dent - the softer the material.

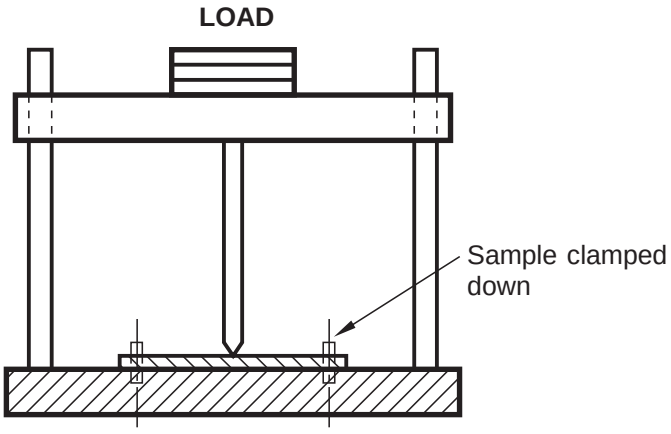


Drop a ball bearing down a tube and measure the height it bounces.

It is possible to use a moveable magnet to catch the ball bearing to help you measure the height of the bounce. The higher the bounce - the harder the material.



A more accurate method is shown right.



CONCLUDING ACTIVITY

List the materials you have tested in order of their hardness
(reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

HARDNESS: A SCRATCH TEST

Resistance to scratching can give an indication of the hardness of a material.

You will need a square rod of each material - suggest at least three metals as well as plastics and wood. These should all be roughly the same size, 800 mm x 15 mm x 6 mm. (This is to fit the UNILAB tester - test C - and provide a large enough target for test B.)

You will also need:

- A magnifier.
- A scriber.
- A centre punch.
- A pair of vernier callipers.

You will be given rods of the materials you are to test. You must make yourself samples from these with a minimum of waste.

You will treat each sample to some or all of the following tests.

The amount of force that you use to make the scratches must be the **same** for each material.

How can you make sure this is the case?

Scratch the surface of the sample with a scriber. You need to make sure you scratch each sample in the same way so the comparison is fair.

Examine the scratches you have made. You may find a magnifier useful.

CONCLUDING ACTIVITY

List the materials you have tested in order of their hardness (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

TOUGHNESS OR BRITTLENESS

Definition
A material is tough if it is not easily broken or bent by sudden shocks or blows.

A material is brittle if it is easily broken by sudden shocks or blows.

To compare the toughness of materials, you need a round rod of each material - suggest at least three metals - as well as plastics and wood. These should all be the same size, 50 mm x 6 mm in diameter, with a notch filed or sawn in the rod halfway along 3 mm deep and 5 mm across at the edge.

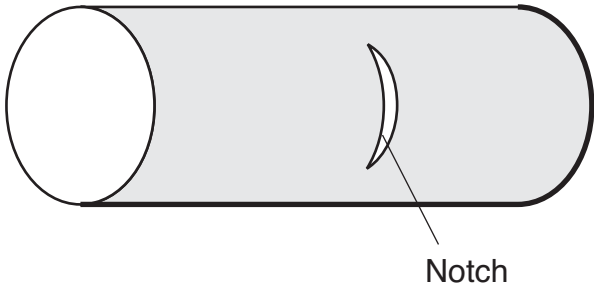
You will also need:

- A vice.
- A hammer.

You will be given rods of the materials you are to test. You must make yourself accurate samples from these with a minimum of waste.

If the diameter of the rod is too big, you will need to prepare it on a centre lathe.

The notch is designed to give a weak spot in the material, so it very important that it is exactly the same size on each sample.



CONCLUDING ACTIVITY

List the materials you have tested in order of their toughness (reread the definition of the property you are testing to remind yourself what it means).

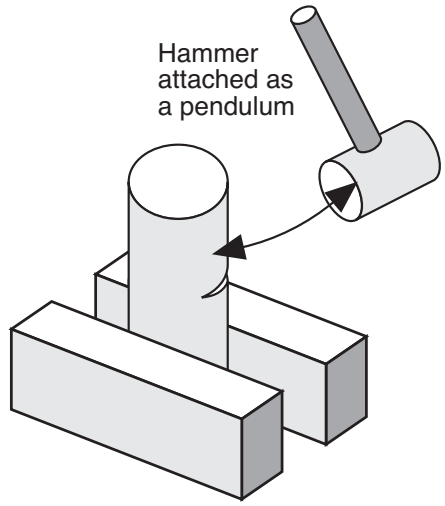
Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

TOUGHNESS OR BRITTLENESS

Definition
A material is tough if it is not easily broken or bent by sudden shocks or blows.

A material is brittle if it is easily broken by sudden shocks or blows.

The sample is tested by fixing it in a vice and allowing a hammer to swing down so that it hits the sample just above the notch:



The hammer should be allowed to swing down under its own weight - you just need to hold the end of the handle.

Repeat the test up to ten times on each sample - or until the sample breaks or bends so that the hammer no longer hits it.

Record what happened to each sample in the test.

CONCLUDING ACTIVITY

List the materials you have tested in order of their toughness (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

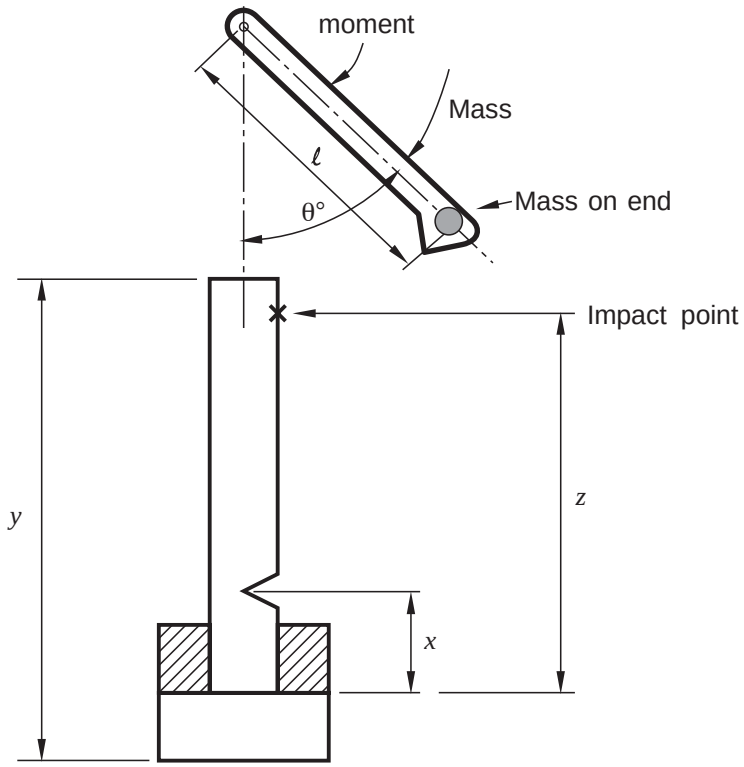
Do the concluding activity for brittleness too.

There will probably be some materials that you have tested that are neither tough or brittle - those that bent in the test without breaking. These materials are ductile - see that test for more information about ductility.

TOUGHNESS OR BRITTLENESS

Definition
A material is tough if it is not easily broken or bent by sudden shocks or blows.

A material is brittle if it is easily broken by sudden shocks or blows.



Set up the pendulum test

All dimensions set. This enables accurate representation of forces.

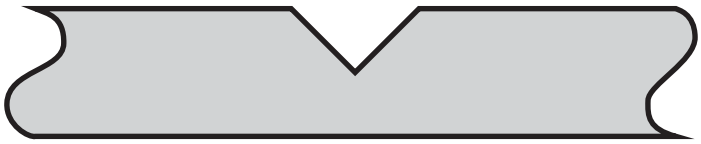
Compare materials.

CONCLUDING ACTIVITY

List the materials you have tested in order of their toughness
(reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

Cut notch on miller
using a gear cutting wheel

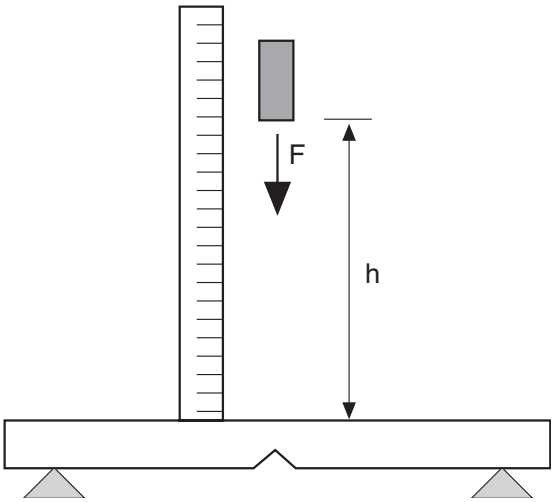


TOUGHNESS OR BRITTLENESS

Definition
A material is tough if it is not easily broken or bent by sudden shocks or blows.

A material is brittle if it is easily broken by sudden shocks or blows.

Weight dropped from specified height.



- How resistant is it to shock loading?

Compare shock loading from 300 mm to static loading.

CONCLUDING ACTIVITY

List the materials you have tested in order of their toughness (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples.
Explain how you made the test fair.

ELASTICITY AND PLASTICITY

Definition
A material is elastic if it goes back to its original shape after it has been deformed.

A material is plastic if it doesn't go back to its original shape after it has been deformed.

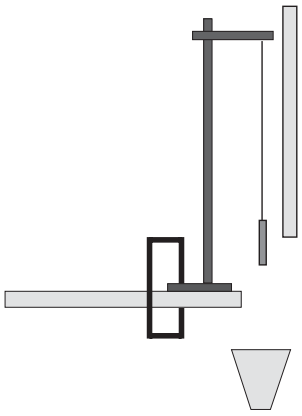
You will need a wire or fibre of each material - suggest at least three metals as well as plastics fibres. The length of material tested should be 500 mm x 1 mm^2 in cross-section. However, you will need to take a sample 50 mm longer than this to allow you to fix the wire to the test equipment.

You will also need:

- A G clamp.
- A set of 100 gram masses + hanger.
- A sand bucket!

One end of each sample should be fixed on a stand securely clamped to the bench or table. From the other end you will be hanging masses so fix a mass hanger to it. Place a sand bucket underneath to catch the masses if your sample breaks. Hang a 100 gram mass on the hanger. Leave it for 30 seconds. Remove the mass. Measure and record the length of your material.

Repeat this process with an extra 100 grams on the hanger. Remember to record the length of your sample **after** you have removed the masses.



Keep doing this until either the sample breaks or you have one kilogram (10 x 100 g) hanging on your sample.

When you have tested each material examine any stretched area and breaking point carefully.

CONCLUDING ACTIVITY

List the materials you have tested in order of their elasticity (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

Make a similar list in order of plasticity. Compare your lists and explain what you notice about them.

STRENGTH: TENSILE, COMPRESSIVE, SHEAR, BENDING

Definition
A material is strong if it can resist a force without breaking or permanently bending.

TESTS ON STRENGTH

Because there are different kinds of force, there are different kinds of strength. Each kind of strength needs its own test.

You may want to test the strength of some materials to find out which is the best material for you. Or you may want to test the strength of different shapes of the same material to see which will be the strongest.

TEACHERS' NOTE

This section introduces students to different static forces and their effects on materials and shows them that it is possible to test the properties of materials to a high degree of accuracy.

The tests on the following pages are mainly based on quantitative testing using the UNILAB (or similar) materials testing rig. This could be based in either Science or Technology and provides opportunity for explicit mathematical work (in the area of relationships between two variables, gradients of graphs...).

The activity is grounded in the utility of the information gained for:

- selecting appropriate materials for a task;
- working materials to a high quality.

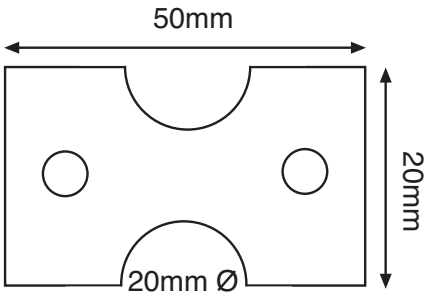
It is not anticipated that students will necessarily work their way through all of these tests, but rather will choose those that are relevant to identifying the most appropriate material for the task they are engaged in. They should, however, have experience of at least one of these tests so that they are aware of the potential of the rig for accurate testing of some properties of materials.

STRENGTH:TENSILE

Definition
How strong a material is when it is in 'tension' (being stretched)

To test the tensile strength of a range of materials, you will use a machine that needs test pieces that are exactly the correct size.

The dimensions of the test piece are shown below:



The thickness of the test piece should be between 1 - 3 mm. To give a fair comparison between samples, they must all be the same thickness.

Use the UNILAB apparatus to test each sample until it breaks. Write down the force needed to break the sample.

When you have tested each material, examine any stretched area and breaking point carefully.

CONCLUDING ACTIVITY

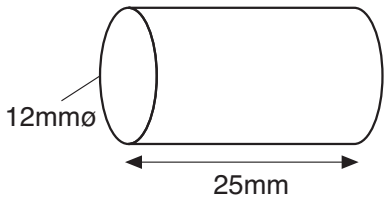
List the materials you have tested in order of their strength (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

STRENGTH: COMPRESSIVE

Definition
How strong a material is when it is in 'compression' (being squashed).

To test the compressive strength of a range of materials, you will use a machine that needs test pieces that are exactly the correct size.



The test piece should be 25mm long by 12mm diameter. Use the UNILAB apparatus to examine the deformation of the sample.

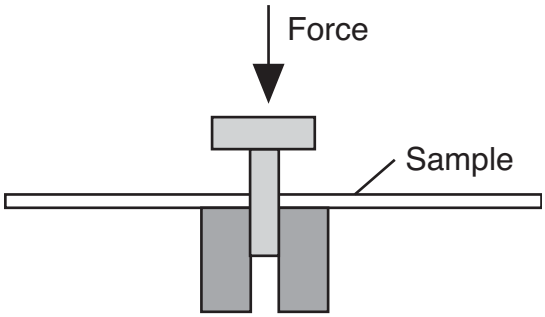
When you have tested each material, examine the bulging or, in the case of brittle material, the fracture.

STRENGTH: SHEAR

Definition
How strong a material is when it is in 'shear' (has two opposite forces on it)

To test the shear strength of a range of materials, you will use the UNILAB Materials Testing Machine.

This punches a small hole in the sample and allows you to measure the force needed to make the hole:



The thickness of the test piece should be 1 mm. To give a fair comparison between samples they must be all the same thickness.

Use the UNILAB apparatus to test each sample until it breaks. Write down the force needed to break the sample.

When you have tested each material, examine the hole carefully.

CONCLUDING ACTIVITY

List the materials you have tested in order of their strength (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.

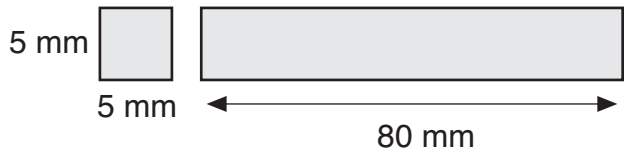
STRENGTH: BENDING

Definition
How strong a material is when it has a bending force on it.

To test the bending strength of a range of materials, you will use the UNILAB Materials Testing Machine.

This puts a force on the sample and allows you to measure how much the material bends.

The test pieces should have approximately the dimensions shown below:



To give a fair comparison between samples. they must all have exactly the same dimensions.

Use the UNILAB apparatus to place a force of 1000 N on your sample. Write down how far the sample deflects.

When you have tested each material, examine the samples carefully for signs of permanent bending.

CONCLUDING ACTIVITY

List the materials you have tested in order of their strength (reread the definition of the property you are testing to remind yourself what it means).

Write a short description, with diagrams, of how you tested the materials and what the test did to the samples. Explain how you made the test fair.