PROPERTIES OF MATERIALS

This mobile revision pdf is based on detailed work found in the MATERIALS section.
Tap on the green link button below to go to the complete website section

Tap the blue button to view PROPERTIES covered by this Revision PDF

V.Ryan © www.technologystudent.com 2019

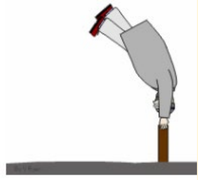
PROPERTIES OF MATERIALS

STRENGTH

The ability of a material to stand up to forces being applied without it bending, breaking, shattering or deforming in any way.

Our technology demonstrates the 'strength' of a material by performing a hand stand on a strong piece of timber (wood). It does not bend even under his weight. He has eaten pies and drunk a large amount of beer for twenty years and yet the strong material does not bend, flex or deform (change shape) in any way.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

ELASTICITY

The ability of a material to absorb force and flex in different directions, returning to its original position.

Our technology technician demonstrates the 'elasticity' of a material by springing up and down on a piece of steel rod. Do not try this at home as an accident may result. Our technician is an expert at demonstrating this property, as it is his hobby.

Tap the image for more information

Tap the blue button for the next PROPERTIES page.

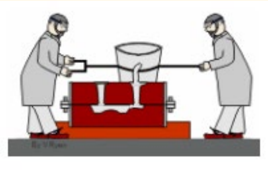
Tap the red button to return to the Contents page

PLASTICITY

The ability of a material to be change in shape permanently.

Our technology technician and his twin brother demonstrate the 'plasticity' of a molten aluminium by pouring it into a mould. Once the aluminium has cooled down, it can be removed from the casting sand. It has a new shape.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

DUCTILITY

The ability of a material to change shape (deform) usually by stretching along its length.

Our technician stretches the lead above his head. As it stretches if deforms (changes shape).

He thinks he is a strong man, little does he realise that lead is a very soft metal and stretches very easily. He performs these tricks in local pubs in an attempt to pass himself off as a 'hard man'.

Tap the image for more information

Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

TENSILE STRENGTH

The ability of a material to stretch without breaking or snapping.

Our technology technician demonstrates 'tensile strength' by stretching a piece of steel until it snaps. He thinks he is incredibly strong. However, his friends at work have substituted a sausage in place of the steel.

Tap the image for more information

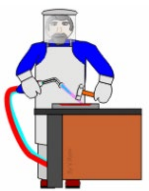
Tap the red button to return to the Contents page

MALLEABILITY

The ability of a material to be reshaped in all directions without cracking

Our technology technician demonstrates the 'malleability' of a material by heating a piece of mild steel until it is red hot. He then beats it with a large forging hammer to reshape it. Because of the high temperature it reaches while heating the steel becomes malleable, it can be reshaped permanently.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

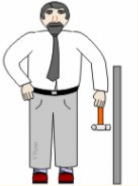
Tap the red button to return to the Contents page

TOUGHNESS

A characteristic of a material that does not break or shatter when receiving a blow or under a sudden shock.

Our technology technician demonstrates the 'toughness' of a material by hitting a piece or material to see if it will break or shatter. Ed has been known to test authentic Chinese Ming Dynasty pottery with the same technique. This is why he is often arrested in Museums and has been banned from the local Antique dealers.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

HARDNESS

The ability of a material to resist scratching, wear and tear and indentation.

Our technology technician, dressed in a kilt, slides along the floor to see if it will scratch. It will be considered to hard wearing if it resists scratching.

Tap the image for more information

Tap the blue button for the next PROPERTIES page.

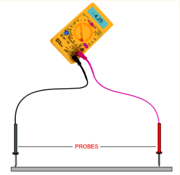
Tap the red button to return to the Contents page

CONDUCTIVITY

The ability of a material to conduct electricity.

A test for electrical conductivity is seen below. A voltmeter is used to measure resistance. The probes are set to the same distance on each sample. The resistance is a measure of the materials conductivity..

Tap the image for more information



Tap the red button to return to the Contents page

ABSORBENCY

The ability of a material to absorb another substance, that in itself is capable of being absorbed. Under normal circumstances this would mean a liquid or gas being 'absorbed' by a material.

Our technician demonstrates absorbency, by submerging a sponge in water and then testing if it has increased by weight, a few minutes later.

Tap the image for more information

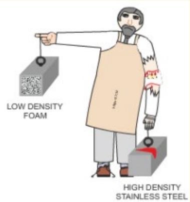
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

DENSITY

A material's 'mass', per unit of volume. Density is calculated by dividing a material's mass (in kilograms) by its volume (in cubic metres). Essentially, mass can be considered as the compactness of a material. For example, a cubic metre of a sponge is lighter and therefore much less dense, than a cubic metre of stainless steel, which is much heavier.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

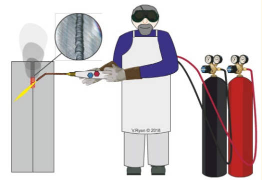
Tap the red button to return to the Contents page

FUSIBILITY

The ability of a material to be transformed from a solid state to a liquid state, due to the application of heat. This can mean fusing two metals together along a seam / joint (welding) OR fusing thousands of polymer pellets together, through the injection moulding process.

Our technician demonstrates fusibility by welding to metals together, forming a permanent joint.

Tap the image for more information

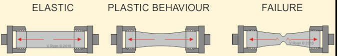


Tap the red button to return to the Contents page

YIELD STRENGTH

When a material is stretched (put under stress) during a 'materials test', it first exhibits 'elasticity' (stretches). When experiencing 'elasticity', the material is capable of returning to its original shape, if the test is stopped in time and the stress removed. If the test is continued, the material will eventually be unable to return to its original shape, as it will enter the stage called 'plastic behaviour'. At this point the deformation to the material cannot be reversed, it said to have reached 'yield strength' (also called 'yield stress'). Yield point, is the point at which a material / component fails

Tap the image for more information / exercise



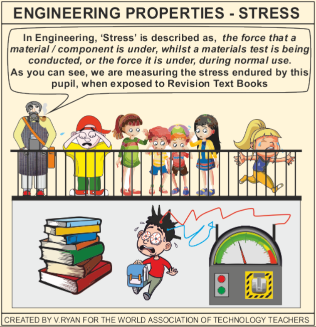
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

STRESS

This is the force that a material / component is under, whilst a materials test is being conducted, or the force it is under, during its normal use.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

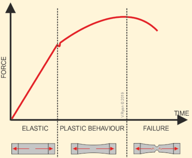
Tap the red button to return to the Contents page

ULTIMATE TENSILE STRENGTH

This occurs when a material reaches 'yield strength' and is the point when the material fails (snaps).

The graph below, shows the stages of a materials test on a sample.
Stage One - Elastic
Stage Two - Plastic Behaviour
Stage Three - Failure

Tap the image for more information



FORMULA

σ = F/A

$$STRESS = \frac{FORCE}{AREA}$$

Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

EXAMINATION QUESTION

Tap the link button for examination questions on Yield Strength and Ultimate Tensile Strength

Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

YIELD STRESS - MATHEMATIC APPLICATION

1. A sample of steel (from an engineering company) is given a stress test to assess its yield stress.

FORMULA

$\sigma = F/A$

$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}}$

The steel is a 20mm square section. The sample begins to yield at 30 000 Newtons. What is the yield stress?

Tap the answer to download a supplementary maths booklet including questions and answers

$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$

$\sigma = \frac{F}{A}$

$\text{STRESS} = \frac{30\,000\text{ N}}{20\text{ mm X }20\text{ mm}}$

$\text{STRESS} = \frac{30\,000}{400\text{mm}^2}$

$\text{STRESS} = 75\text{ N/mm}^2$

Tap the blue button for the next PROPERTIES page.

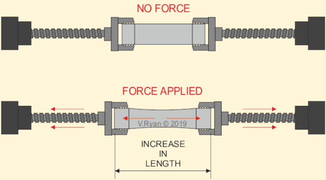
Tap the red button to return to the Contents page

STRAIN

Strain is described as, the change in the measurement of a sample of material, when a force is applied.

The material sample below, has been placed in a tensile testing machine. It is 'longer' when a tensile force (a stretching force) has been applied to it.

Tap the image for information / questions



FORMULA

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

STRAIN - MATHEMATIC APPLICATION

FORMULA

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

The sample metal (previous slide) being tested, is 200mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 210mm. What is the 'strain'.

Tap the answer to download a supplementary maths booklet including questions and answers

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

$$\varepsilon = \frac{210\text{mm} - 200\text{mm}}{200\text{mm}}$$

$$\varepsilon = \frac{10\text{mm}}{200\text{mm}}$$

$$\varepsilon = 0.05 \text{ or } 5.0 \times 10^{-2}$$

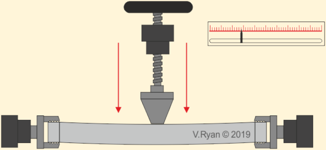
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

STIFFNESS

When force is applied to a material (in the way shown below), it tends to bend. Most materials tend to resist a force, up to a point. The ability to resist bending is a mechanical property called 'stiffness'. This is related directly to the strength of a material, as the stronger the material the more it resists bending and the greater it's 'stiffness'.

Tap the image for information/ questions



Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

YOUNG'S MODULUS

Young's Modulus, is the direct relationship between the 'stress' and 'strain' of a material (the ratio of 'stress' to 'strain'). It is shown by the formula below and measures the 'stiffness' of a solid material.

$$\text{Young's Modulus (E)} = \frac{\text{stress } (\sigma)}{\text{strain } (\varepsilon)}$$

Tap the link button to download examination questions on Strain, Stiffness and Young's Modulus

Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

CALCULATING YOUNG'S MODULUS

1. A cylindrical test piece of nylon has been sent to your Materials Testing Laboratory. You have been asked to calculate the Young's Modulus of the test piece.

Radius = 25mm Force applied = 200 kN and strain at this point = 3.1×10^{-4}

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}} \qquad \text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{CROSS SECTION AREA} = \pi r^2$$

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

$$\text{CROSS SECTION AREA} = \pi r^2$$

Pi (π) = 3.14

RADIUS = 25mm

$$\text{CROSS SECTION AREA} = 3.14 \times (25 \times 25)$$

$$\text{CROSS SECTION AREA} = 3.14 \times 625$$

$$\text{CROSS SECTION AREA} = 1962.5 \text{ mm}^2$$

THEN CALCULATE THE STRESS OF THE TEST PIECE

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

FORCE = 200kN

$$\text{STRESS } (\sigma) = \frac{200}{1962.5}$$

$$\text{STRESS } (\sigma) = 0.102 \text{ kN/mm}^2$$

NOW YOU CAN CALCULATE YOUNG'S MODULUS OF THE TEST PIECE

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

Strain at this point = 3.1×10^{-4}

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{0.102}{3.1 \times 10^{-4}} = \frac{0.102}{0.00031} = 329 \text{kN/mm}^2$$

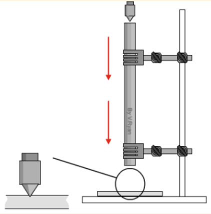
Tap the answer opposite to download a supplementary maths booklet including questions and answers

Tap the red button to return to the Contents page

MATERIALS - HARDNESS TESTING

A sophisticated method of measuring the hardness of a material, is to drop a 'plug' down a tube. When the 'plug' hits the material below, the surface will suffer an indent. The indent produced on different materials, can be compared. Consequently, the smaller the indent, the harder the material.

Tap the image for more ways of testing



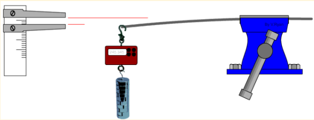
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

TENSILE TESTING

A simple workshop test can be seen below. A piece of material is clamped in a vice. A fixed weight is hung from the end. The amount of deflection, is a measure of its resistance and tensile strength. A selection of materials of the same section, cut to exactly the same size, can be tested in this way.

Tap the image for more information



Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

ELASTICITY TESTING

A simple workshop test for elasticity can seen below. A piece of material is clamped in a vice. A fixed weight is hung from the end and the material bends / deflects. When the weight is quickly removed, the material 'springs back'. The amount of deflection, is a measure of its elasticity. A selection of materials of the same section, cut to exactly the same measurements, can be tested in this way.

Tap the image for more information

Tap the blue button for the next PROPERTIES page.

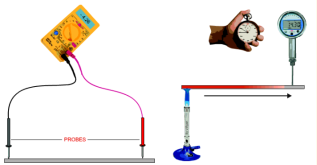
Tap the red button to return to the Contents page

CONDUCTIVITY TESTING

A test for electrical conductivity is seen below. A voltmeter is used to measure resistance. The probes are set to the same distance on each sample. The resistance is a measure of the materials conductivity.

A test for heat conductivity/transfer is seen below. A bunsen burner is placed at one end of a piece of material and a temperature meter at the other end. The time it takes for the temperature to change at the opposite end of the material is recorded.

Tap the image for more information



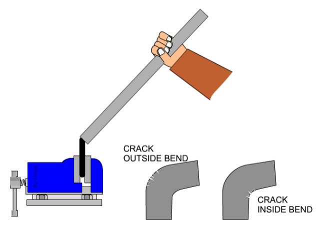
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

DUCTILITY AND MALLEABILITY

A piece of tube is placed over a piece of material and used as a lever. The material is folded to 90 degrees. Cracks / damage on the outside of the bend represents a lack of ductility. Cracks / damage on the inside of the bend represents a lack of malleability.

Tap the image for more information



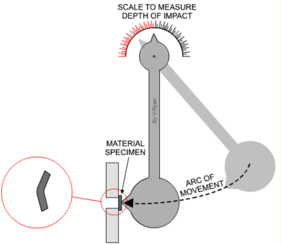
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

TOUGHNESS TESTING OF MATERIALS

The industrial device below measures toughness. The pendulum is allowed to 'swing' from a set starting position. The resulting 'distortion' to the sample material can be measured on the scale. This gives an indication of the materials toughness.

Tap the image for more ways of testing

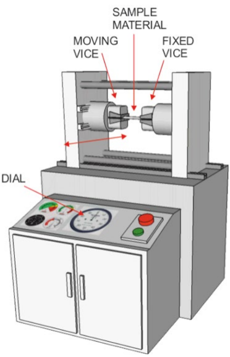


Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

TESTING MATERIALS IN INDUSTRY

Tap the image for a range of testing machines and methods.



Tap the red button to return to the Contents page

COLD WORKING (PLASTIC DEFORMATION) OF METALS

Cold working of metals, is when a metal is rolled, folded, deformed, reshaped, without the need for the application of heat. A very good example of cold working, is when a length of steel is placed in a vice and simply 'folded' to an angle, by the force of hammer blows (see the next slide / page)

However, the resulting metal may become 'brittle', a metal that loses some of its 'elasticity' and can quite simply break or crack, if the cold working process is incorrectly applied.

Cold working stretches the crystalline structure within the metal, permanently. The metal becomes stronger, because the crystalline structure resists further change.

Tap the blue button for the next PROPERTIES page.

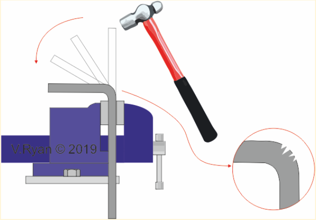
Tap the red button to return to the Contents page

COLD WORKING OF METALS CONTINUED

Cold working increases the tensile strength of the metal, but reduces its ductility / flexibility.

Example below - Cracks appear after incorrect cold working (see below)

Tap the image for information / an exercise



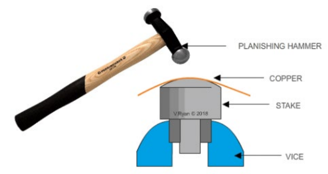
Tap the blue button for the next PROPERTIES page.

Tap the red button to return to the Contents page

COLD WORKING - PLANNISHING

Another example of cold working, can be seen with the technique called planishing. Planishing a sheet metal such as copper, reshapes it and leaves it work hardened and less flexible. It is a decorative process.

Tap the image for information / an exercise



Tap the red button to return to the Contents page