MATERIAL PROPERTIES

Choosing Materials

When a product is being designed, one problem is choosing the most suitable materials for the job. A material should not be chosen just because it looks nice. Using royal blue candle wax for making a door handle is not a good choice! Doors handle needs to be able to resist the heat from a hand and also the twisting and pulling forces required to operate it. It is therefore important to understand the various properties of materials, so that you can make a sensible choice of which materials to use when you are designing a product.

PHYSICAL PROPERTIES

Physical properties are the basic properties of each material.

Density is the amount of matter (mass) in a material. A cube made from a high density material will be heavier than the same size cube made from a low density material.

MELTING POINT	MATERIAL
High	Tungsten Chromium
Medium	Copper Steel
Low	Zinc Lead

Fusibility

is a measure of how easy it is to melt the material. The temperature at which the material normally melts is known as the **melting point**.

Note: A highly fusible material has a low melting point.

Thermal Conductivity is a measure of how fast heat can travel through a material. A material is known as an **insulating** material if heat travels through it very slowly.

THERMAL CONDUCTIVITY	MATERIAL
High	Copper Aluminium
Medium	Mild steel Tin
Low	Woods Polystyrene

Electrical Conductivity is a measure of how fast electricity travels through a material. Generally a good conductor of heat is also a good conductor of electricity. A poor conductor is an **Insulator**.

MELTING POINT	MATERIAL
High	Gold Copper
Medium	Steel Zinc
Low	Woods Nylon

Thermal Expansion is the amount of expansion that occurs when the material is heated. A high expansion material will become noticeably larger when heated.

THERMAL EXPANSION	MATERIAL
High	Polythene Nylon
Medium	Aluminimum Tin
Low	Woods Titanium

Optical Properties

Most materials do not let any light pass through them; these are known as **Opaque** materials. Others like glass can let light pass easily through them, these are known as **transparent** (see-through) materials. There are also materials like some plastics or frosted glass that let some light through, but detail of what is on the other side of the material cannot be seen, these are known as **Translucent** materials.

THERMAL EXPANSION	MATERIAL
High	Copper Aluminimum
Medium	Mild steel Bronze
Low	Woods Thermoset plastics

MECHANICAL PROPERTIES

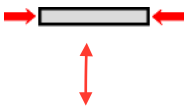
Mechanical properties are connected with how a material reacts to forces applied to it.

A force will **deform** a material. If the deformation is temporary and the material returns to its original state then it is said to be **elastic**, if it is permanent and the material stays in its new state, it is said to be **plastic**.

Strength

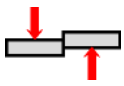
A measure of how well a material can withstand force without permanently bending or breaking. There are different types of strength measurements.

Tensile strength - resists being crushed e.g. cast-iron

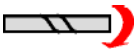


Compressive strength - resists being crushed e.g. cast iron

Shear strength - resists sliding forces such as those made by scissors e.g. stainless steel



Torsion strength - resists twisting e.g. tool steel



Bending strength - resists bending - is **rigid** e.g. woods

Malleability

A measure of how easily a material can be permanently deformed by compressive forces e.g. hammering, without cracking.

Ductility

A measure of how easily a material can be permanently deformed, without cracking or breaking, by bending, stretching or twisting.

DUCTILITY	MATERIAL
High	Polypropylene Copper
Medium	Mild steel Bronze
Low	Woods Thermoset plastics

Hardness

A measure of how well a material resists scratching and being worn away by other materials.

HARDNESS	MATERIAL
High	Diamond Chromium
Medium	Mild steel Bronze
Low	Woods Thermoplastics

Toughness

A measure of how well a material can stand up to sudden forces, e.g. a hammer blow, without cracking. A material that is not tough is called **Brittle.**

TOUGHNESS	MATERIAL
High	Polycarbonate Copper
Medium	Mild steel Brass
Low	Glass Polyester resin

Durability

A measure of how well a material stands up to weathering (the sun, cold, wind, rain, corrosion and rotting).

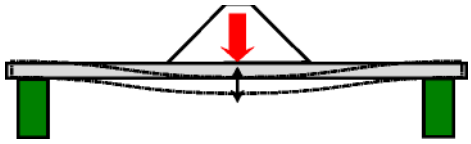
DURABILITY	MATERIAL
High	Gold Tin
Medium	Ceramics Bronze
Low	Mild steel Soft woods

MATERIALS TESTING

In industry, materials are put through a series of tests to test all of the properties mentioned in this chapter to see if they are suitable for the product being designed. Special machines are used to test tensile strength, brittleness and hardness etc.

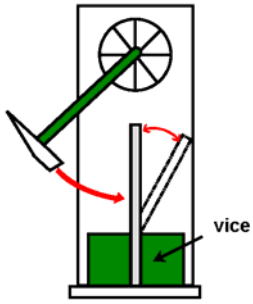
Bending strength (rigidity)

Cut identical lengths (samples) of the materials you wish to test and place each over the same length gap. Place the same weight over the middle and measure the amount the sample has bent from the horizontal. The most rigid will have moved the least.



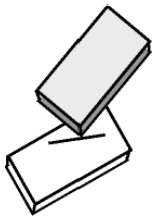
Toughness

Use identical samples of different materials, place in the vice and lift the suspended hammer to the same height each time. Let it go and then measure the angle that the sample has been bent to, the smaller the angle the tougher the material.



Hardness

Find samples of each material, they do not have to be identical, just have a sharp corner. Then use each sample in turn to try and scratch the other samples. The hardest is the one that all the other samples cannot scratch. Using this method you can put the samples into rank order of hardest to softest.



KEY WORDS Density: Fusibility: Conductivity: Insulating: Malleability: Ductility: Deformation: Toughness

1. Define the term 'density' and give two examples of a dense material.
2. How would you describe a fusible material? Give two examples of easily fused materials.
3. Give two examples of materials that are good heat insulators.
4. If I wish to make switch contacts that will conduct electricity well, which materials might I use?
5. What do you understand by the term 'translucent'?
6. Explain what an elastic material is.
7. With the aid of diagrams, explain the terms 'tensile strength', 'shear strength and 'bending strength'.
8. What property allows a material to be stretched until it becomes a long thin wire or fibre?
9. What is the property that makes a material a malleable material?
10. Explain what is meant by a 'tough' material. Describe the sort of materials that are the opposite of tough.

A. Describe, with the aid of diagrams and notes, a test that you could carry out at school to measure heat conductivity in different materials.

B Describe, with the aid of diagrams and notes, a test that you could carry out at school to measure the durability of different materials in water.

C What are the properties required by the materials that are used to make a garden fork. Take each part in turn (handle, shaft and the fork head), state what you think they are made from and then list their properties.

Worksheet 5b