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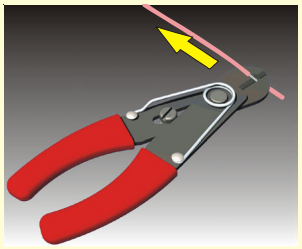
Properties of Materials

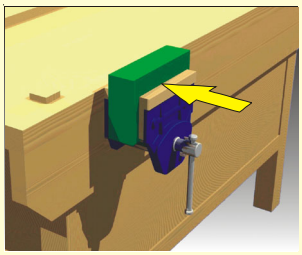
A property is a characteristic of a material. A material will possess a range of different properties. Designers use properties to help them select a material for a particular purpose. The range of properties can be divided into mechanical, physical and aesthetic properties. When selecting a material for a particular product it is necessary to consider the properties required for both its use and manufacture.

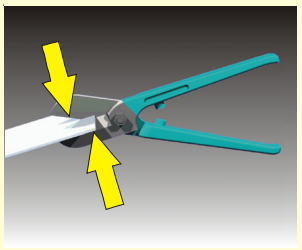
Mechanical Properties

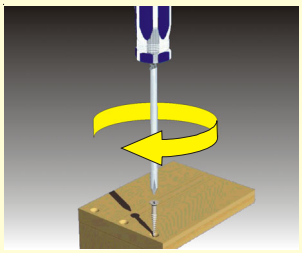
Mechanical properties: these describe how a material will respond to different types of forces.

- Tensile strength – ability to withstand pulling (stretching) forces.
- Compressive strength – ability to withstand pushing (squashing) forces.
- Shear strength – ability to withstand forces which try to cut the material.
- Torsional strength – ability to withstand twisting (rotary) forces.
- Bending strength – ability to resist bending forces.
- Hardness – the ability of a material to withstand indentation or scratching. This is a requirement when a product needs to have good wear resistance such as twist drills, chisels and bearings
- Toughness – is how well a material can withstand impact forces. The opposite of toughness is brittleness. Brittle materials have low resistance to impact loads. Toughness is important for products such as hammers.
- Machineability - this is how easily a material can be cut using machine tools.
- Ductility – the ability of a material to be permanently deformed by cold-working. This can be achieved by bending, twisting or pulling materials through a die. Materials for wires need to be ductile. Metals for car bodies need also to be ductile so that they can be press formed.
- Malleability – the ability of a material to be hammered or forged into shape. The material may be shaped hot or cold.









Aesthetic Properties

These relate to appearance:

- Colour
- Surface texture
- Surface decoration
- Brightness

Physical Properties

These describe how a material will respond to physical influences other than force.

- Optical properties – how well light can pass through a material. A material can be transparent, translucent or opaque.

Materials

- Resistance to corrosion – How well a material will resist corrosion. Rusting is the main form of corrosion in steels. Most steels have to be protected against rusting.
- Thermal conductivity – How well a material will conduct heat. Soldering iron tips and saucepans need good thermal conductivity properties so that they can transfer heat quickly. Metals are good conductors of heat.
- Electrical conductivity – How well a material conducts electricity. Electrical wires and terminals need to be good electrical conductors. Copper, gold and silver are examples of good conductors. Insulators are materials which do not conduct electricity.

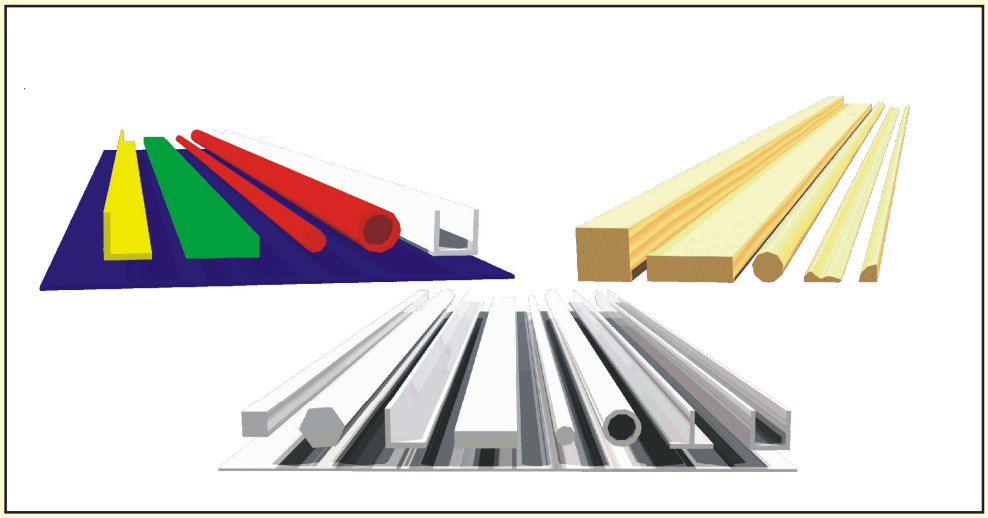
Material Choice in Design

Selecting the best material for a particular product is an important part of design. Material choice depends upon a variety of factors including-

- Its intended use. - This includes the physical propeties. For example the material for a bike frame needs to be rigid, strong, lightweight and corrosion resistant.
- How it will be manufactured. - To ensure that the product can be made with the available equipment. For example, mild steel cannot be cast using the equipment in school and thermosetting plastics cannot be injection-moulded.
- Its environmental impact. - Including whether the material is a scarce resource (finite) and its use will deplete them further (e.g. using hardwoods). Whether the material will be harmful to the person using it (e.g. lead-based paints). Whether the material is disposable after use (e.g. using biodegradable materials such as PLA). Whether the material can be easily recycled (e.g. scrap steel can be recycled easily).
- The costs. - Material costs are an important factor in materials selection. Costs include the cost of buying the material and the cost of manufacture. Some manufacturing processes, such as the extrusion or pressing of metals, use more energy than many plastic processing methods. This usually makes the metal option more expensive.

Material Availability / Forms

Materials are generally available as standard sections and parts.
Metals come in: plates, strips, bars, tubes, angle irons and channels.
Woods come in: dowels, sheets, planks and squares.



Softwood are sold in a range of sizes. Hardwoods tend to be sold by volume. Timber can either be bought rough sawn (usually for use in the building trade for stud walls, rafters etc.) or planed accurately to size: Planed All Round / Planed Square Edge (PAR / PSE) or Planed Both Sides (PBS)
Plastics can come in a range of forms from films and rolls to sheets, extrusions and granules.

Designs are often influenced by what sectional shapes are available from suppliers.

Q4U2Do. (A)

1. Describe what the following properties mean;
Tensile strength

Compressive strength

Shear strength

Torsional strength

Hardness

Ductility

2. List the Aesthetic properties of materials

3. Describe some of the environmental consideration that need to be taken into account when selecting a material.

4. List the stock forms for each of the material groups listed below

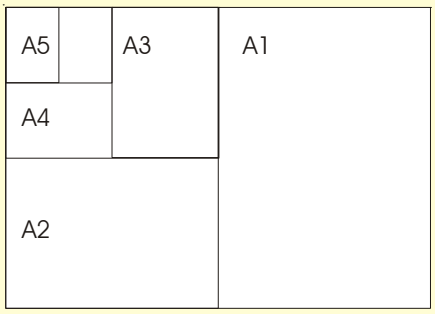
Metals

Woods

Plastics

Paper and Card

Graphic products are often made from paper and boards (card). There is an enormous variety of these but at school we only have a limited range.
Paper and boards come in a variety of sizes, colours, weights and finishes. The most common sizes are in the metric system: A0, A1, A2, A3, A4 etc.
A0 is a square metre in area with each size in turn being a half of the area of the one before.



Types of Paper and Board

It is important to choose the right type of paper and board to achieve the best quality finish. Papers come in various weights as well as sizes. For example photocopying paper usually weighs 80 grams per metre squared whereas a better quality letter paper may be 120 g/m$^{2.}$ Anything over 200 g/m^2 is classed as board.
The most common Papers and Boards are as follows;

- Tracing Paper - Transparent, hard and strong, its translucency makes it suitable for tracing drawings and other graphics.
- Corrugated Card - Two or more layers of card with a fluted inner section to add strength with very littles increase in weight. Used for packing objects which need protection during transportation.
- Cartridge Paper - Good quality surface for pencils, pens and markers. The soft surface can also be used with crayons, pastels, inks, watercolours and gouache. Used for design drawings, sketching etc.
- Bleed-Proof Paper - Has similar qulities to cartridge paper but is very good at isolating water based paints and pens so they don't 'run'.
- White Board - This is a strong medium whose surface has been bleached to provide an excellent surface for printing. Use on good quality packaging.
- Duplex Board - This provides a less expensive alternative to white board and also a different texture for printing. Used mainly in food packaging since recycled material can't be used for this purpose.
- Layout Paper - A thin fairly transparent white paper which provides a cheap medium for designers to use for sketching and developing ideas.

- Sugar Paper - Coloured paper which has contrasting colours for use in tonal drawings. Used mainly for display work and mounting drawings.
- Ink-Jet Card - This type of card is treated so that it can be passed through ink-jet printers.
- Cardboard - This is a cheap, recyclable, stiff board with a good surface to print onto. Used for packaging, boxes and cartons.
- Foam core board- is made by sandwiching expanded polystyrene foam between 2 thin layers of card. It is stiff and lightweight and can be used for modelling or mounting posters.
- Foil-lined board is a board with an aluminium lining. It is often used in food packaging.

Lamination

Paper and Board can be used in conjunction with layers of foil and plastic to form a lamination rather like plywood. Many boards are built-up from layers, some giving strength, some the desired surface. Specialist applications may include aluminium layers to ensure that a package is watertight.

Surface finishes

Papers such as cartridge can be rough surfaced through being allowed to dry naturally when first 'laid down' in pulp form. Or they can be polished by spinning rollers or given a shiny top laminate.

Special surface treatments include: high quality stationery being embossed to give raised lettering or logos; menu cards in restaurants being coated with plastic film to make them easy to clean and glossy finishes applied to expensive brochures to make them look and feel stronger and more attractive.

Q4U2Do. (B)

5. What type of board would you use for making the packaging for a personal attack alarm? Why would you use this material?

6. What type of board would you use to package a hot pizza from a 'take away' shop? Why would you use this material?

Metals and Alloys

Metals are classed as either ferrous or non-ferrous. Ferrous metals contain iron, Non-ferrous metals do not. Ferrous metals tend to corrode and therefore need some form of protection against corrosion. Non-ferrous metals do not tend to corrode to the same extent.
Metals are available in pure or alloy form. Pure metals, such as pure aluminium or pure copper, contain only one type of metal. They are not mixed with any other metal. Alloys are mixtures of two or more pure metals. Alloys tend to have better strength properties than pure metals. Alloys and pure metals often have special physical properties. For example, pure copper is used where electrical conductivity is required.

Ferrous Metals

The range of ferrous metals includes plain carbon steels, tool steels, stainless steels and cast irons.
Plain carbon steels are alloys of iron and carbon. They can be divided up into Three main groups: mild steel (low carbon), medium carbon steel and high carbon steel.
Increasing the carbon content in the steel increases its hardness and toughness but reduces its ability to be cold-worked (shaping it without heating it up first).
Cast irons are generally used in sand-cast products.
Tool steels have other additions such as tungsten. This helps to increase their wear resistance.
Stainless steels are alloys of iron and carbon but also contain chromium or nickel. Stainless steels do not corrode. They are used for applications such as sinks and kitchen utensils.



Heat Treatment of Metals

Heat treatment processes can be used to improve the properties of some metals. They are also used to help soften the metal for use in processes such as cold rolling, cold extrusion and drawing. During heat treatment the metal is heated and cooled in a controlled way to give the required properties.
The main heat treatment processes are:



- The annealing of metals to make them less brittle
- The hardening and tempering of some steels to improve toughness on impact.

Finishing Materials

As well as for aeshetics, there are a variety of reasons why finishes might be applied to a product including:

- protecting the materials against corrosion;
- making the materials water repellent;
- improving the materials resistance to wear and fatigue;
- improving the materials ability to reflect or absorb heat;
- improving the materials ability to insulate against heat or electricity.

Q4U2Do. (C)

7. What is the difference between ferrous and non ferrous metals?

8. Name a ferrous metal which does not rust. Why is this?

9. Name a heat treatment process which can be used to soften materials that have been 'work hardened'?

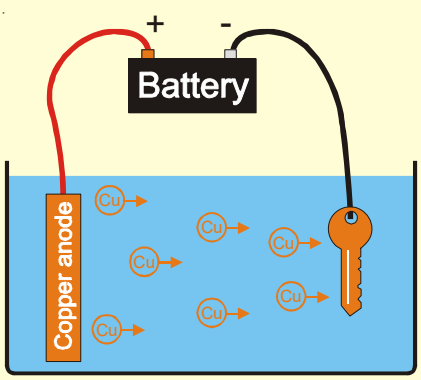
Finishing metals

Natural barriers

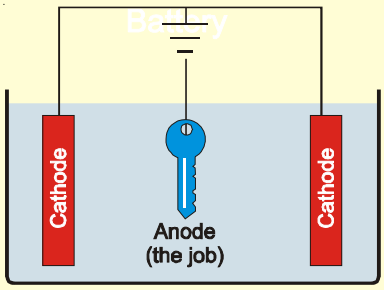
Metal oxides already exist on most metals and are usually a barrier against environmental effects. This is not the case with steels, where the oxide layer is porous and allows moisture to come into contact with the metal so it continues to oxidise (rust).
A useful oxide layer can be formed on steels by 'blueing' them. This involves heating the steel up to 300 °C and then quenching in oil. The result is a fine oxide layer that helps protect the material against atmospheric effects.

Electroplating

Other metals can be used to coat the base metal. The method used is electroplating. This is an electrochemical process that allows ions from the coating material to form on the base material giving it the finish of the coating metal. An example of this is chromium plating that is used to enhance the properties of bathroom taps, kitchen equipment and vehicle components.
Metals that can be used as coating materials in this way include: gold, silver, tin, zinc and copper.



Anodising



Some metals, such as Aluminium, can be anodised in order to enhance their natural barriers. This process makes the surface of the aluminium more durable and resistant to scratches. Anodising is done in an electrochemical cell. Sulphuric acid solution is the electrolyte, the aluminium product is the anode and a lead cathode. Passing an electric current through the electrolyte solution effectively builds up a tough oxide layer that will accept dies.

Metal Coating

Metals can be coated with other metals by dipping or spraying in conjunction with some kind of heating system.
Examples include:

- Zinc plating: (or **galvanising)** Involves dipping steel in molten zinc heated to 450-460 °C. It forms a layer of protection which prevents corrosion. It is often used for metal fencing and gates;
- Tin plating: Tin is applied by passing the sheets of steel through baths of molten tin at 315-320 °C. This is used in the manufacture of food cans.

Enamelling

Enamelling is a process where finely ground glass is sprayed onto a metal product, e.g. components for cookers or for pressed steel baths. It is then fired, so that the coating becomes a continuous layer of heat and scratch resistant material.

Painting

Acrylic or cellulose paints can be used. Clear lacquer can be applied on top for extra protection and to provide a glossy finish. For paints to be applied successfully the metal surface must be thoroughly cleaned first, this ensures that the primer (the first layer) keys into the material's surface. The second layer is an undercoat. This helps give a good finish to the topcoat. Paints can be brushed on or sprayed.
Car bodies are generally made from mild steel. Nowadays they last many years before corrosion takes place because of all the layers of protection that have been applied to them.
Special paints such as 'Hammerite' have been developed especially for metals. These paints do not require a primer or undercoat and can be applied directly to the metal surface. The finish achieved can be a smooth or hammered effect.

Powder coating



Powder coating is a method of applying paints to a product that has been statically charged. This is a dry process where a powder is used instead of wet paint. The powder is sprayed through an airgun. The powder is positively charged while the product is negatively charged. Once coated, the product is baked in an oven where the heat melts the powder over the product producing a harder and tougher finish than is obtainable with conventional paints. Domestic 'white

goods' such as fridges and washing machines are often painted in this way. As it is is a dry process with no solvents or propellants and any excess coating materials can be recovered, it is an environmentally friendly option.

Plastic coating

Plastic dip coating can be used on a range of products. For example, a plastic handle on a screw driver.
The process involves heating the metal component to around 230 °C. The fine plastic granules are fluidised by passing air through them. This helps provide an even coating of material over the component being coated. The product is dipped into the fluidised polymer and removed. Heat from the product melts the plastic material, which cools in air providing an even coating over the product.



Q4U2Do. (D)

10. Describe the different methods of finishing metals and give an example of the application of each.

Plastics

Plastic materials can be classed as either thermoplastics or thermosetting plastics. Thermoplastics have the ability to return to their original shape when reheated. Thermosets cannot be reformed when reheated. Thermoplastics can be recycled whereas thermosetting plastics cannot. Thermosetting plastics can generally withstand higher operating temperatures than thermoplastics.

Thermoplastics

When a thermoplastic is heated and reshaped the atomic bonds between the molecules are weakened. The molecules can then slide, move and re-align themselves into new positions. If the plastic is re-heated the bonds can be weakened again. This will allow further re-shaping or a return to its original shape.

Thermosetting Plastics (Thermosets)

In order for thermosetting plastics to be formed they need to go through a curing stage. During curing links are formed between the original long chain molecules. This is called cross-linking. Cross-linking is irreversible and so thermosetting plastics cannot be re-formed once curing has taken place, because of this they are usually manufactured by compression moulding.
Thermosetting plastics tend to be more rigid than thermoplastics and they can also withstand higher temperatures.

Manufacturing in Plastics

It is important that manufacturers check that there are no imperfections when producing injection mouldings. The sort of things to look out for are:

- Flash – wafer thin material where two halves of the mould join
- Split line – a fine line where two halves of the mould join
- Feed point – this marks where the material flowed into the tool
- Sinkage - uneven surfaces usually found above a rib
- Distortion – a large area of the part is twisted or bowed.

Accuracy of moulded parts means that components fit together easily. This reduces manufacturing cost considerably.

Advantages of plastics

Self-coloured. One of the advantages of using plastics to manufacture products is that it can be self-coloured. By including pigments with the powders or granules in the hopper of the moulding equipment parts can be produced in the desired colour.

Textures. Textures can be added to polymers by applying the texture to the surface of the mould. This is directly transfered to the polymer because of the way the softened material is forced into every part of the mould. This processes does increase the cost of the mould.

Self-finishing. Plastics are also known as self-finishing materials. This means that the quality of the mould must be very high to ensure that any trimming is kept to a minimum.

Q4U2Do. (E)

11. What is the main difference between Themoplastics and Thermosetting plastics?

12. Describe the imperfections which can occur in products made using the injection moulding process.

13. Describe some of the advantages of using plastics rather than other materials.

Woods

Wood can be divided into natural and man-made timbers. Natural timbers are further subdivided into hardwoods and softwoods. Man-made timbers include plywood, MDF and blockboards. Hardwoods come from broad leaf trees, which they shed in autumn. Softwoods come from coniferous trees which have thin neddle like leaves which they keep all year round.

Seasoning

Once a tree has been cut down it is cut into planks.
These planks contain a lot of water which needs to be dried out before the timber can be used.
This can be done quickly in a special kiln or by leaving the timber stacked in the open air for several years.



Hardwoods

The terms 'hardwood' and 'softwood' are biological classifications and are not simply based on the physical properties of the timber. Hardwoods come from trees which carry their seeds in the form of fruit. Softwoods come from confierous (cone-bearing) trees. Hardwoods are generally hard but some are soft such, as willow and balsa wood. Hardwoods are slow-growing, taking many decades to reach maturity. They are more expensive than softwoods.

Softwoods

Softwoods come from coniferous trees, which reach maturity in around 30 years. This allows them to be replaced at a far faster rate than hardwoods. This is better for the environment and also reduces the cost. Softwoods tend to be used much more than hardwoods.

Timber Defects

- Dry rot is a fungus that can occur in damp, unventilated situations. The wood becomes dry and powdery.
- Wet rot is caused by wet and damp conditions. The timber becomes weak and spongy.
- Wood needs protecting against insect attack such as woodworm and lyctus beetle.
- Splits will weaken the structure of the timber. They can also spoil the appearance of the wood.
- Wood may shrink and warp even after it has been seasoned.
- Knots weaken the wood and can cause problems when using hand and machine tools.

Manufactured Boards



Sterling Board

Chipboard

Exterior Plywood

Hardboard

Medium Density Fibreboard

Laminboard

Blockboard

Battenboard

Birch Ply

Ply Sheathing

Materials

Advantages of Manufactured Boards

- Available in large sheets of uniform thickness.
- Not affected by humidity.
- Can be used with veneers.
- Do not have a grain structure.
- More easily worked than natural timbers.
- Can be easily joined with knock-down fittings.

Q4U2Do. (F)

14. List the defects that timber can suffer from and explain their causes/ effects.

15 What advantages do manufactured boards have over solid wood?

Finishing processes for woods

Unprotected wood expands because it can absorb water - especially in outdoor applications. This causes the resins that bind the cells together to break down, making the material very weak. Bacteria and fungi can also attack wood.
Woods do not have the same natural protection against the environment as metals, and are prone to decay over a period of time. In general hardwoods have a greater resistance to the environment than softwoods due to the closer structure of their grain. They therefore last longer. Teak contains oils that help repel rainwater and so protect the material even outdoors.

Paints/varnishes

Paints can be used on woods, just as they can on metals, but first the material must be cleaned and any knots treated to prevent resin leaking. The surface of the wood must be sealed with a primer, which helps to key in the next layer of paint and prevents subsequent layers being absorbed by the wood. As with metals, an undercoat can be used followed by a topcoat. To obtain a high quality finish, it is necessary to rub the surface down with fine glasspaper or wire wool in between layers of paint.

Traditionally oil-based paints have been used on woods. These are hardwearing, non-porous and are available in a range of colours. These paints can be used inside or out and are used for coating window and door frames.

Polyurethane paints are extremely hardwearing, tough and scratch-resistant.

If the natural grain of the wood is required, then sealing can be achieved by the use of transparent polyurethane varnishes. For products that are used outside, such as patio tables and chairs, yacht varnish can be used. This is not affected by sunlight or the expansion and contraction of the timber in the same way that polyurethane varnish is.

Due to environmanetal concerns water based alternatives have been developed which have similar properties.

Wood preservatives

The three main groups are:

- tar-oil derivatives (creosote);
- water-soluble preservatives;
- organic solvent preservatives.

All of these can be applied by brushing, dipping or spraying, or by pressure treating.

Creosote has been traditionally used for the preservation of a range of timber products. The main disadvantage with this method is that creosote will destroy any plants it makes contact with and is generally damaging to the environment. This has led to it being banned for use. Alternative water-based solvents are now available in a variety of colours. As they are water-based, they have to be maintained more regularly.

Increasingly, timbers can be obtained that have been tannelised. This involves the impregnation of the timber with a solution of copper sulphate which helps prevent water from being absorbed. Tannelised wood is pressure treated in large chambers. Water is first removed by drying, followed by filling the chamber with the preservative. Pressure is slowly increased until the desired amount of preservative has been injected into the timber. The wood is then steam dried before removing it from the chamber.

The main advantage of pressure treating timber is that it can be applied to uncut timber before manufacture of the finished product. Timber products treated in this way will last up to fifty years.

Q4U2Do. (G)

16. Describe the different surface finishes that can be applied to woods.

17. What is tannelising and why is it done?

Composite Materials

Composites are now being widely used as replacements for metals and plastics. Two of the main types are fibre-reinforced composites and sandwich beam constructions. Fibre-based composites consists of strong fibres such as glass, carbon or kevlar embedded in a metal or plastics matrix. Sandwich beam constructions consist of a lightweight core material sandwiched between thin-skin materials.

Fibre-based Composites

Fibre-based composites are made up of layers of fibre embedded in a matrix material. Each layer is called a lamina and a number of layers makes up a laminate. Common fibres are glass fibres, carbon fibres and kevlar. They all have good tensile properties and their use in the composite improves the stiffness and strength of the material. The matrix material can be either a thermoplastic or thermosetting plastic or a metal such as aluminium or titanium.

Sandwich Constructions

Sandwich constructions usually consist of a lightweight core material such as paper or aluminium honeycomb sandwiched between two tough outer skins. The skins are bonded to the core material by a strong adhesive. This construction is used in many aircraft structures and in house doors. These structures are lightweight as well as being strong.

Modern and Smart Materials

Modern Materials are those that have been developed by scientists in laboratores rather than occuring naturally.
Smart Materials are materials whose properties can change due to changes in pressure, force or temperature or in response to some other input. They are often used for sensors. Piezoelectric sensors produce an output voltage when squeezed. Typical uses are burglar alarm pressure sensors.

Shape memory alloys are able to change their shape in response to changes in temperature. An example is in glasshouse window openers. Here the material responds to changes in temperature and is as part of the ventilation mechanism.

Thermochromic pigments can be added to plastics so that they change colour in response to heat. An example of this can be found in table-wear for babies where the colour of the product changes to indicate that the food is too hot.

Other smart materials include biodegradeable plastics such as PLA. These are made from renewable raw materials such as wheat starch. They have the ability to disolve over time which makes them suitable for things like plastic bags and nappies.

Q4U2Do. (H)

18. Find out as much as you can about the follwoing Modern Materials-

Graphene

Metal foam

LCD

Teflon

Corn starch polymers

Kevlar

Teflon.

19. Find out as much as you can about the following smart materias-
Thermochromic film

Photochromic film

Shape memory alloys

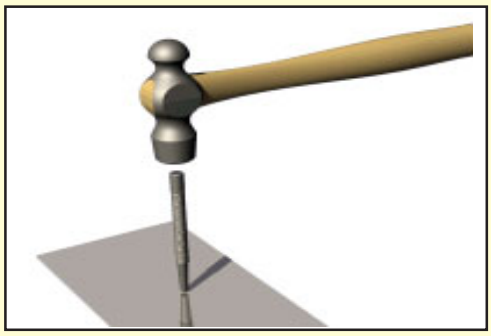
Material Testing

Workshop testing

Workshop testing of materials can be carried out for;

- Hardness
- Ductility and malleablility
- Tensile strength
- Toughness

Hardness testing



- Test 1- hold the material to be tested in a vice and run a file over it. If the metal cuts easily it is soft if it does not it is hard.
- Test 2- Use a dot punch to create an indent in the material. The larger the dot produced the softer the material.

In both tests it is important to apply the same amount of effort to each sample when the tests are carried out.

Ductility testing

The ductility of a material can be tested by placing a piec of material in a vice and the attempting to bend it. The greater the angle of bend which can be achieved prior to the sample cracking the greater its ductility.

Toughness testing

The toughness of a material can be guaged by holding it in a vice and then stiking it with a hammer. The more force the material is able to withstand the tougher it is.

Tensile testing

A very basic test for the tensile strength of a material can be carried out in the workshops by clamping one end of a length of material in a vice and then applying a load to the other end. If the material resists bending it indicates that it has good tensile strength. *(This is based on the principle that in order to bend the top of the beam is being stretched and the bottom of the beam is being squashed. Can you think why this test may not be very reliable?)*

Industrial Testing

The workshop tests we have just looked at may be sufficient to help you choose the correct materials for your project work but they would not be accurate enough for industrial purposes. Instead a range of more scientific tests are used.

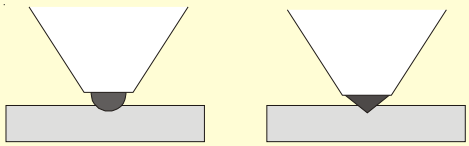
Hardness tests

There are three basic methods for testing for hardness;

- The Brinell test
- The Vickers test
- The Rockwell test.

All of the tests involve making an indentation in the material. In the Brinell test a hardened steel ball is pressed into the surface using a suitable load whereas in the Vickers tet a diamond pyramid is used. In both tests the indentation is measured using a powerful microscope and according to the size of the mark a hardness value is calculated.

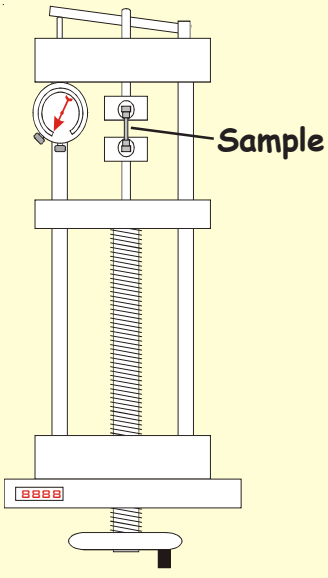
In the Rockwell test the depth of the indentation is used to calculate the hardness which is indicated by a dial on the machine - without the need for a microscope.

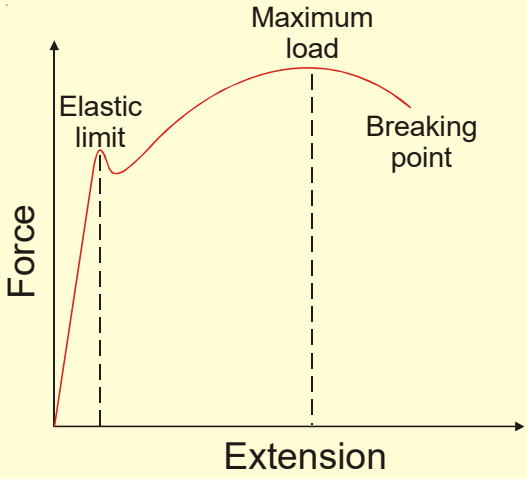


Brinell Test Vickers Test

Tensile Testing

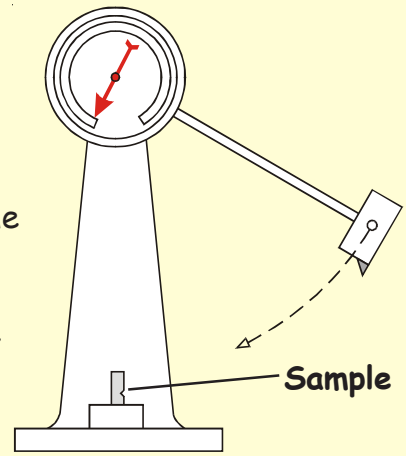
To test the tensile strenght of materials a standard sample of material is clamped in the jaws of a 'tensometer' and a tesnile load is applied using either a motor or handle. The elongation and size of load are displayed on dials. The results can be plotted on a graph like the one below.





Impact testing (Toughness)

The main method of impact testing is the Izod test. The test involves a standardised material sample being struck by a falling 'hammer'. A dial on the machine indicates the amount of energy that is absorbed by the material.



Materials

Q4U2Do. (I)

20. Use the Focus on Materials software to fill in the missing properties for the materials on the following tables.

Hardwoods

Name	Oak (European)
Origin	According to country of origin.
Hardwood	
Hardness	
Weight	
Strength	
Durability	
Suitable for exterior work	
Tendency to move	
Suitability for turning	
Ability to be steam bent	
Ease of planing/cutting	
Finishes well	

Name	Beech (European)
Origin	Central Europe, UK
Hardwood	
Hardness	
Weight	
Strength	
Durability	
Suitable for exterior work	
Tendency to move	
Suitability for turning	
Ability to be steam bent	
Ease of planing/cutting	
Finishes well	

Softwoods

Name	Western Red Cedar
Other name	British Columbia Red C...
Origin	Canada, USA, UK
Softwood	
Hardness	
Weight	
Strength	
Durability	
Suitable for exterior work	
Tendency to move	
Suitability for turning	
Ability to be steam bent	
Ease of planing/cutting	
Finishes well	

Name	Scots Pine
Other name	Red Deal, Redwood
Origin	Russia, Scandinavia, UK
Softwood	
Hardness	
Weight	
Durability	
Tendency to move	
Suitability for turning	
Ability to be steam bent	
Ease of planing/cutting	
Finishes well	

Materials

Thermoplastics

Name	ABS
chemical name	Acrylonitrile Butadi...
Thermoplastic	
Stiffness	
Conductor of electricity	
Available in opaque colors	
Available as transparent	
Impact resistant	
Resistant to chemicals	
Flammable	
Can be welded	
Can be glued	
Can be calendered	
Can be rotational moulded	
Can be injection moulded	
Can be blow moulded	
Can be extruded	
Can be vacuum formed	
Can be strip bent	

Name	Polypropylene
other name	PP
chemical name	Polypropene
Thermoplastic	
Stiffness	
Conductor of electricity	
Available in opaque colors	
Impact resistant	
Resistant to chemicals	
Flammable	
Can be welded	
Can be rotational moulded	
Can be injection moulded	
Can be blow moulded	
Can be extruded	
Can be vacuum formed	
Can be strip bent	

Thermosetting plastics

Name	Polyester Resin
other name	PR
Thermosetting	
Hardness	
Stiffness	
Conductor of electricity	
Available in opaque colors	
Available as transparent	
Resistant to chemicals	
Resistant to UV light	
Resistant to heat	

Name	Urea Formaldehyde
other name	UF
chemical name	Urea Methanal
Thermosetting	
Hardness	
Stiffness	
Conductor of electricity	
Available in opaque colors	
Resistant to heat	
Can be compression moulded	

Materials

Ferrous Metals

Name	Stainless Steel
Composition	Fe, C, 18%Cr, Ni, Mn
Melting point	
Hardness	
Tough	
Weight	
Strength	
Malleable	
Ductile	
Conductor of heat and electricity	
Resistant to wear	
Resistant to corrosion	
Can be soldered	
Can be brazed	
Can be welded	
Can be cast	
Can be rolled	
Can be forged	
Can be machined/cut	
Can be spun	
Can be bent	
Can be pressed	
Polishes well	
Can be extruded	

Name	Mild Steel
Composition	Fe, 0.15%-0.35%C
Melting point	
Weight	
Malleable	
Ductile	
Conductor of heat and electricity	
Resistant to corrosion	
Can be soldered	
Can be brazed	
Can be welded	
Can be rolled	
Can be forged	
Can be machined/cut	
Can be bent	
Can be pressed	

Materials

Non-Ferrous Metals

Name	Copper
Composition	Pure metal
Melting point	
Hardness	
Tough	
Weight	
Malleable	
Ductile	
Conductor of heat and electricity	
Resistant to wear	
Resistant to corrosion	
Can be soldered	
Can be brazed	
Can be welded	
Can be cast	
Can be rolled	
Can be forged	
Can be machined/cut	
Can be spun	
Can be bent	
Can be pressed	
Polishes well	
Can be extruded	

Name	Aluminium
Composition	Pure metal
Melting point	
Hardness	
Weight	
Strength	
Malleable	
Ductile	
Conductor of heat and electricity	
Resistant to wear	
Resistant to corrosion	
Can be welded	
Can be cast	
Can be rolled	
Can be forged	
Can be machined/cut	
Can be spun	
Can be bent	
Can be pressed	
Polishes well	
Can be extruded	

Materials

AQA General Certificate of Secondary Education

Design and Technology: Product Design

Unit 1 Written Paper

To help you prepare for the written exam

Q. 1 Which one of the following is a biodegradable material? [1 mark]
A Acrylic
B Nylon
C Polythene
D Silk

Q. 2 Which one of the following statements is true? [1 mark]
A Carbon fibre is a natural material used in model making
B Low carbon steel is a non-ferrous metal used in damp environments
C Medium Desisty Fibreboard is a man-made material used in the manufacture of flat pack furniture.
D Nylon is a conductive material used in electronics

Q. 3 A tough material is commonly described as: [1 mark]
A A material that can withstand repeated impacts
B A material that is hard to scratch
C A material that is possible to stretch into a different shape
D A material that takes a long time to decompose

Q. 4 Identify the correct definition of a composite material. [1 mark]
A A combination of two or more different materials
B A material that changes its properties when exposed to sunlight
C A naturally occurring renewable material
D A polymer material that can be injection moulded

Q. 5 Which of the following timbers is a naturally occurring hardwood? [1 mark]
A Larch
B Oak
C Pine
D Spruce

Q. 6 Which one of the following is a softwood? [1 mark]
A Beech
B Mahogany
C Oak
D Spruce

Q. 7 Which of the following timbers is a softwood? [1 mark]
A Ash
B Beech
C Mahogany
D Pine

Materials

Q. 8 Which of the following metals should not be used outdoors without a protective coating of a different material? [1 mark]

A Aluminium alloy
B Copper
C Low carbon steel
D Zinc

Q. 9 Which of the following textile based materials comes from a sustainable source? [1 mark]

A Denim
B Elastane
C Kevlar
D Polyester

Q. 10 Which of the following is a thermosetting polymer? [1 mark]

A Acrylic (PMMA)
B High Density Polythene (HDPE)
C Polyester resin (PR)
D Polypropylene (PP)

Q. 11 Which one of the following statements is true? [1 mark]

A Balsa is a natural material used in model making
B Medium Density Fibreboard is a man-made material commonly used for outdoor furniture
C Silk is a man-made material used in the textiles industry
D Urea formaldehyde is a natural material used tomanufacture electrical sockets

Q. 12 What is the definition of a smart material? [1 mark]

A A material that can hold data
B A material that can withstand excessive force
C A material that reacts to changes in the environment
D A material that shrinks when heated

Q. 13 Choose one of the material categories listed- Metal based materials, Paper and boards, Polymers, Textile based materials, Timber based materials. State your chosen material category and state its source or origin. [1 mark]

Q. 14 Name one process used to convert your chosen material category into a workable form. [1 mark]

Q. 15 Describe two ways that materials and/or products are strengthened or reinforced. Give examples in your answer. [2 x 2 marks]

Q. 16 Give two properties of manufactured boards. [2 marks]

Q. 17 State two properties of natural fibres that make them suitable for clothing. [2 marks]

Q. 18 Explain how Kevlar fibres are processed and arranged to give this material its unique properties. [2 marks]

Q. 19 Circle one of the following and give two reasons why its characteristics or physical properties are suitable for its intended use. [2 marks]

Polypropylene -for a school stacking chair
Foam core board -for a display board
Brass -for a trumpet
Pine - for a bedroom wardrobe
Silk -for use in a men's tie
Printed Circuit Board (PCB) -for use in a hand held game

Q. 20 Materials frequently need to be surface treated or have a finishing technique applied. Name two different surface treatments or finishes applied to materials. Explain why materials may need a surface treatment or finish applied. [2 marks]

Q. 21 Circle one of the following and give two reasons why its characteristics or physical properties are suitable for its intended use. Polypropylene - for a school stacking chair, Foam core board - for a display board, Brass - for a trumpet, Pine - for a bedroom wardrobe, Silk - for use in a men's tie, Printed Circuit Board (PCB) - for use in a hand held game [2 marks]

Q. 22 Explain why materials may need a surface treatment or finish applied. [3 marks]

Q. 23 Materials can have their properties modified for specific purposes. Select one material category below. Circle your choice. Explain how and why it needs to be modified. Give an example in your answer. Timbers, Metals, Papers and boards, Textiles, Polymers [3 marks]

Q. 24 Explain why surface finishes are applied to materials and fabrics for aesthetic reasons. Give examples in your answer. [3 marks]

Q. 25 Explain why surface finishes are applied to materials and fabrics for functional reasons. Give examples in your answer. [3 marks]

Q. 26 Describe how aesthetics influence the selection and choice of materials and components in manufactured products. Give an example in your answer. [3 marks]

Q. 27 Different products use different materials and components to make them fit for purpose. Consider the items below. Complete the table below by matching the main material or component to the product. You may only use each product once. [3 marks]

Food container	Beech
Jumper	Bevel gear
PCB	Foil lined board
Child's toy train	Glass reinforced polymer
Hand whisk	Polyester

Q. 28 Using notes and/or sketches describe the process you have named above. [4 marks]

Q. 29 The following are examples of different stock forms. Acrylic rod, Corrugated cardboard, Aluminium sheet, Wool yarn, Medium Density Fibreboard (MDF). Choose one of the stock forms. Name one of the primary sources it is made from. Use notes and/or sketches to explain the process of changing it from primary source to stock form. [5 marks]

Exam Advice

You are very likely to get a question about materials and finishing processes. You should be familiar with at least two examples of each of the following - thermoplastics, thermosetts, ferrous metals, non-ferrous metals, hardwoods, softwoods, composites and smart materials.

You are also likely to be asked to design some packaging so make sure you are familiar with suitable materials.

You are **not** likely to be asked about material testing at GCSE level - this is more likely to be tested at AS / A2 Level.

List of CGP Revision questions:

B1 Properties of Materials
B2 Paper, Board and Timber
B3 Metals, Alloys and Polymers
B4 Textiles
B5 Textiles and Manufactured Boards
B8 Development in New Materials
C1 Selecting Materials
C6 Production of Materials
C7 More on Production of Materials
D1 Uses of Wood Metals and Polymers
D7 Treatments and finishes