

## Forces and stresses

All materials, structures and products have to withstand stress as certain forces are applied to them when they are in use. An applied force can be either static or dynamic. A static load, such as a book resting on a table top, does not move. A dynamic load, for example the same book dropped onto the table from a height, does move.

## Tension

Tension occurs when a pulling force is applied to either end of a material. The object becomes stretched as it tries to resist being pulled apart.



Tensile strength is the ability of a material to resist being pulled apart.

## Compression

Compression occurs when a pushing force is applied to either end of a material. The object becomes compressed as it tries to resist being squashed. For example, a spring in a suspension system or a clove of garlic in a garlic press being compressed.

Air in a balloon and spray deodorant in a can are also being held under compression. Holding liquids and gasses under compression is an economical way of storing them.

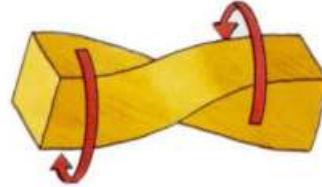
Compressive strength is the ability of a material to resist being compressed or squashed.



## Torsion

Torsion forces occur when a material is being twisted. The two ends of the material rotate in opposite directions creating a twist, like wringing out a wet towel.

Torsional strength is the ability of a material to resist being twisted out of shape.



## Bending

A bending force results in both tension and compression either side of its neutral axis. The pressure to make a material bend is applied at either end with an upwards or downward pressure.

Stiffness is the ability of a material to resist being bent out of shape.



## Key Questions

- Give 3 examples of materials under tension.
- In which direction do the forces travel when a material is under torsion?
- What 2 forces are acting when a material is being bent?
- What happens to a material if it is subjected to greater tensile forces than it can withstand?
- Give 3 examples of shear force.

## Shear

Shear force is a force that acts on an object in a direction perpendicular to its length. For example, wind pushing against a tree is a shear force. The object experiences shear stress, and may eventually snap or break.

Shear forces also occur when a material or a joint between materials is being pulled apart along different planes or lines. The two forces will travel in opposite directions from different planes or lines. Imagine fabric shears cutting cloth.



To strengthen or enhance a material you first need to consider the forces and stresses that it will be subjected to when in use. Remember to consider dynamic forces, if applicable, as well as static forces.

### Reinforcing

This is a way of strengthening a material or object by adding material to it to improve its ability to withstand force and stress.

### Webbing

Webbing is a strong fabric woven into strips from yarns, which are often made of synthetic fibres such as nylon or polyester, or very high-strength materials such as kevlar.

Webbing is used for belts of all kinds, including car seat belts, straps for securing loads on vehicles, climbing equipment, furniture manufacture and many other products.

It is very light, strong and flexible



### Stiffening

Some forms of reinforcement involve stiffening a material through manipulation. Materials can be laminated to improve strength. Interfacing may be used to stiffen fabric. Folding and bending techniques can be used to improve the mechanical and physical properties of a material.

### Laminating

Laminating involves bonding two or materials to improve a product's strength, stability, aesthetics and even its flexibility.

The frame of the classic Ikea POANG chair is made from layers of flexible plywood that are glued together and held under compression in a mould until the adhesive has set.

This creates a laminated wood frame that is solid and stable; it has added strength and yet has retained some of its flexibility.



### Fabric interfacing

Fabric interfacing is used in textile garments as an additional layer in specific areas where extra structure, shape or support is required.

Areas that are commonly interfaced include collars, cuffs and waistbands. Interfacing comes in different weight or thickness depending on the task required.

### Folding and bending

Material manipulated through reshaping can gain many physical advantages.

If you place a piece of paper across a gap it will not be able to hold much more than its own weight. However, if you put specific folds in the paper first, it will be able to hold a surprisingly heavy load.

The chair is a product that often acquires increased strength through intricate folding and bending. Below is Harry Thaler's Pressed chair, a single flat sheet of 2.5mm aluminium has been pressed using relief before being folded into its final form.

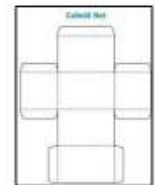


### Nets

A net is a flat 2D shape that can be folded and glued to form a 3D object. The drawing of the net shows cut-lines, score-lines and tabs.

Cut-lines are drawn solid and show where the material is cut from the sheet.

Score-lines are usually dotted and indicate where the product is folded.



### Key Questions

- How could you determine whether a material needs strengthening for the manufacture of a particular product, and the amount of strengthening that might be required?
- What are the advantages of a webbing strap over a strap made of rubber or leather?

## Carbon Footprint

Carbon is produced during the manufacturing of products. The amount of CO<sub>2</sub> emitted during a process is known as its carbon footprint.

Calculating a carbon footprint is a way of estimating greenhouse gas emissions caused by a product, process, person, event or organisation.

## Ecological Footprint

An ecological footprint measures the impact of a person's life on the natural environment by quantifying the amount of the earth's natural resources they use.

## Social Footprint

A social footprint is a measure of the impact that a company's social policies have on its employees, partners or subcontractors and on society as a whole. Companies have an obligation to protect the environment by reducing their ecological footprint wherever possible, but they also have a duty to consider the effect that company policies have on all those affected. For example:

- Is there a flexible hours policy for parents who need to pick up children from school?
- Is the health and safety of all employees a primary concern?
- Does the company contribute anything to the local community?
- Are employees being paid a fair wage?
- Are there appropriate training schemes for employees?

## Deforestation

The devastation caused to many of the planet's forests is caused by the need to provide timber for housing, infrastructure, cooking and warmth. The term slash and burn describes a technique of converting virgin forest into farmland. The trees are felled and then set alight.

## Mining

Mining is essential in order to gather the primary materials, minerals and metals required to supply our manufacturing needs. There are 2 types of mining; surface mining and underground mining. Both methods have negative effects on the landscape and the environment.

## Drilling

Some resources such as gas, oil and shale gas are best harvested through drilling. A borehole is drilled into the earth's crust to reach pockets of a resource.

## Farming

A huge proportion of the earth's surface is used as farmland. Farming creates about 15% of the world's greenhouse gas emissions. Increasingly large areas are being farmed to grow plants that are used to make modern materials and biofuels.

## Harvesting raw materials

When raw materials are harvested from the earth, it is inevitable that some disruption will occur. The damage on the environment, very much depends on the mineral being extracted or plant material being harvested and the methods being used in harvesting it.

## Product miles

A product is normally a collection of materials and parts. Each element may have taken a very different journey on its way to being part of a product. By adding up all the miles that individual parts have travelled and considering the weight of each component, you can work out the CO<sub>2</sub> emissions that have been produced in transportation alone to obtain the materials for the product. There is a growing movement among British consumers to buy local and British products whenever possible.

## Oceanic pollution

One of the major issues with a society based around manufacturing and consumerism is the amount of waste that is produced.

Many oceans currently collect huge floating rubbish dumps, which continue to grow and devastate wildlife. Plastic is the main problem, as it does not degrade for such a long time. Many sea creature and birds ingest plastic pieces.

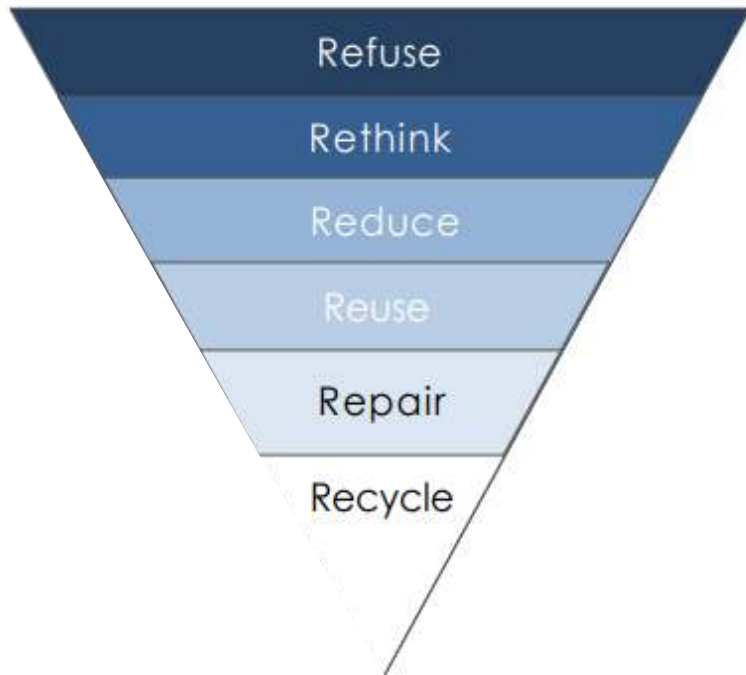


## Atmospheric pollution

The ever-increasing rise in population and the increased wealth of many countries means that there is a growing need for food, transportation, housing, new products and energy. Each of which create emissions which results in atmospheric pollution. The Paris agreement, which was signed by 174 countries and European Union in April 2016 under the UN framework.

## Year 11 Knowledge organiser— The Six Rs

Responsible designers and manufacturers have to create products that are as sustainable as possible. This reduces the burden on the earth's natural resources.



### Reduce

Reduction is often the result of having rethought a design or action. Materials and energy are saved due to efficient manufacturing practices and the use of clever design, incorporating sustainable materials.

- Modern materials are lighter and stronger than traditional one have contributed to miniaturisation.
- In schools and hotels, fitting motion sensitive lighting and smart heating systems can significantly reduce energy usage.

### Rethink

Consumers have a growing number of choices to make about where and on what they spend their income.

Greener and more sustainable options are not always the cheapest or the best, but making informed decisions and rethinking one's spending power can play a huge part in conserving resources. A growing number of passengers refuse to travel by air due to the massive carbon footprint that it creates. Taking different forms of transport to get to their destination has differing levels of impact.

### Reuse

Reusing products multiple times for the same purpose is also known as primary recycling. Reusing a product in a different way from the one it was designed for is known as secondary recycling.

It is becoming popular for furniture and other household items to be 'upcycled' with a coat of paint and some minor repairs or adaptations, extending their useful life by many years.

The hierarchy of sustainability places the strategies that are best for the planet above those that have a greater negative impact on the environment. By systematically working through them for each element of a proposed product or purchase, the best possible option will eventually be chosen. This will potentially save resources, reduce energy consumption and minimise CO<sub>2</sub> emissions.

### Refuse

Is the proposed product, part, purchase or even journey required? Asking the question 'Is it really necessary?' can play a major role in reducing demand on materials. Simply not using something save 100% of what you have chosen not to use. Examples include using your own carrier bag instead of getting a new disposable one, walking or cycling to school instead of being driven.

### Key Questions

- What journeys or new products have you undertaken or purchased this week that were not absolutely necessary.
- Rank the 6Rs in order of best to worst. Explain why you have chosen the best and the worst.
- Name 3 products which are routinely replaced rather than repaired.
- Explain each of the 6Rs in your own words, give examples for each R.

### Repair

Being able to repair a product when it is broken or worn is a way of extending its life and delaying the purchase of a new one.

Repairing is a positive option over replacements as it means that only some parts of the produce are replaced. A number of products can often be bought reconditioned rather than new, and these are usually a cheaper and more sustainable option.

### Recycle

Tertiary recycling, although a very important stage, is lower down the hierarchy of preferred options because most materials that are recycled this way tend to be of lower quality than the original material. It takes a lot of energy to recycle materials - although not as much as creating new ones.

All councils in Britain operate recycling centres and will recycle nearly all household waste.

More complex items are sent to specialist centres for processing.

## Quantity of products required

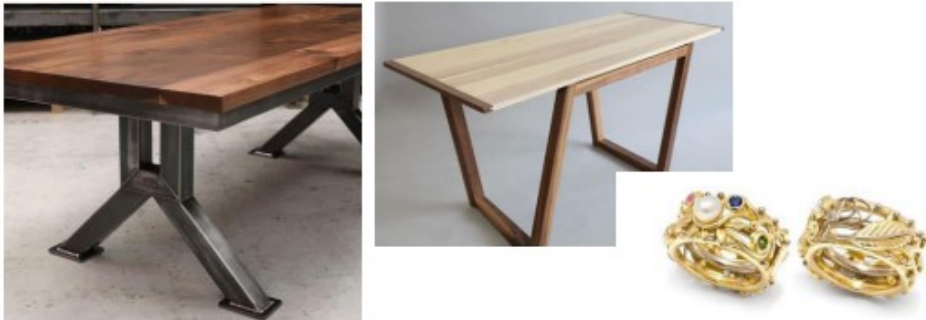
The number of products being made determines the level of production required. There are no definitive quantities that make an item suitable for one type of production rather than another, but there are a few principles that make selecting the appropriate production method easier to understand. The four scales of production are one-off, batch, mass and continuous production.

## Key Questions

- Give 3 examples of products made by each scale of production.
- Explain what is meant by lead time.

## One-off

Bespoke items that are designed for, or commissioned by, individual clients are classed as one-off products. They might be made to perform a specific task and cannot be bought off the shelf. One-off production is very labour intensive and products are frequently handmade by a specialist.



## Batch

This method of production is used when a certain number of identical products are required. This is known as a batch, as they will all have been produced together. One batch could contain a large or small number of products. Batch production still uses some highly skilled labour. However, as some of the tasks are more repetitive, small production lines and semi-skilled workers may be employed.



## Mass

Mass-produced products tend to be items that are in constant use and where the design does not change significantly. Drinks and food containers, electronic products such as mobile phones and even large assemblies product such as cars and motorbikes are typical examples. Usually a dedicated production line that does not need to change is set up for the manufacturing of these products.



## Continuous

Continuous production is very similar to mass production although the products tend to be made to create stock or standard material forms before final processing or assembling elsewhere. The factory will operate up to 24 hours a day and 7 days a week. Staff are mainly low-skilled and operate the factory shifts.

