

Year 10 Design and Technology Knowledge Navigator Cycle 1

Production Techniques and Systems

CAD Computer Aided Design

Examples; 2D Design, Autodesk Inventor, Fusion 360, Photoshop, etc

Advantages

- Easy to change designs
- Designs are easily saved and sent
- Can be worked on by multiple people simultaneously
- Can be used for virtual testing
- Can produce high-quality designs

Disadvantages

- Complex and time-consuming to learn
 - Expensive to buy
- PCs can crash or be hacked – causing work to be lost
- Takes up PC memory

CAM Computer Aided Manufacture

Examples; 3D Printing, Laser Cutting, CNC Router, Automated Machines and Robotics, etc

Advantages

- Faster and more accurate than traditional tools
- Repetitive accuracy/ consistent outcomes
 - Machines can run 24/7

Disadvantages

- Expensive to buy the equipment, etc
- Training takes cost and time
- Need specialists to maintain and repair the machines
- Dependence on CAM can cause unemployment

Flexible Manufacturing Systems

This is where **automated machines** are adaptable and can produce different products if needed.

If a manufacture is making a product with machines that are just dedicated to specific tasks they have to be reprogrammed and re-tooled before changing to a new task. This is time consuming and expensive.

Examples include; CNC Machines, 3D Printers, Laser Cutters, Robotic arms, etc

Just-in-Time (JIT) Manufacture

This is where manufacturers only order materials, parts, etc when needed. The customer's order triggers the production process and the resources needed for that order are the only ones bought.

This can be used in any **scale of production** but is particularly useful for one-off production.

Advantages

- Saves on warehouse and storage costs
- Money is not tied-up in stock
 - Little/minimal waste
- Customer often pays in advance so money is secure before production

Disadvantages

- All production stops if a part/ material is missing
- Needs to have a fast, reliable and good quality supply chain to work properly
- Can be time-consuming

Lean Manufacturing

This is where waste and energy is kept to a minimum. This helps manufacturers save money and resources in production, as well as helping minimise the **environmental impact** of producing products.

Industry and Enterprise

Automation

This is when machines and robotics help make products or make them for you.

Often this is done by **CAD (Computer Aided Design)** and **CAM (Computer Aided Manufacture)**

This helps products be made quicker, with more accuracy. Reducing errors humans make to products.

However, these machines are expensive to buy, need specialist training to use and need constant maintenance to keep them working properly

Virtual Marketing

This is when websites, social media and email are used to promote and sell products. This has become very popular in recent years, with big social media apps being funded by advertisers

Companies can also pay search engines to push their company further to the top of the results page, so customers are more likely to click it.

Cooperatives

A Cooperative is an Enterprise that is run by members that are part of the workforce or customers.

This means the organisation is democratic and often supports the local community. They are set-up to protect the rights of their members and ensure the same rules apply to everyone

Enterprise

This is when an idea is developed into a business and produces a viable product.

Often, one of the biggest enterprises in in apps for smartphones

To make sure ideas are protected from being copied, a **Patent** can be applied for. This legally protects your idea on invention from being stolen.

Crowdfunding

This is where ideas are funded by large groups of ordinary people.

www.Kickstarter.com is a good example of this.

Fair Trade

This is an organisation that promotes fair pay, working conditions and better trade with farmers in developing countries

You can tell when something is Fairtrade as it will often have the symbol on the product or packaging. Common Fairtrade items include; bananas, cotton and chocolate.



People. Society and Culture

Market Pull and Technology Push

Technology Push is the development of new technology, materials and manufacturing methods to create new products or improve old ones.

Examples include; Smart Phones, Electricity, Mass Production, etc

Market pull is the demand from consumers for new products and improvements in old ones; this is often found via reviews, polls, surveys, etc

Examples include; Product **Aesthetics**, making products easier to use, etc

Cultures, Faith and Belief

Different groups of people have different interests and have to be catered for.

Different countries and cultures also react to products differently.

E.g. In India McDonalds don't sell beef burgers as it has a large Hindu population, and cows are seen as sacred – in contrast the UK sells its most amount of fish and chips on a Friday as it is a Christian tradition to not eat meat on that day.

Case Study: £5 note

Hindu, Sikh and some other faith-based communities may choose to follow a vegetarian diet, and this is part of their culture. In addition to not eating meat, many followers of these faiths, as well as vegans and vegetarians, take every opportunity to avoid using animal products in their day-to-day lives.

The revelation in 2016 that the new polymer Bank of England £5 note contained tallow, an animal fat-based substance, upset a number of communities. There was a prompt call for the Bank of England to find an alternative way to produce the note and in the first two days of an official petition well over 100,000 signatures were received.

Shortly after the Bank of England admitted that the new polymer £5 note contained the animal by-product, some establishments refused to take the notes as a method of payment. One café owner was repulsed by the idea that the note contained tallow and believed that her customers supported her view. They received no complaints.



The Bank of England say they currently have no plans to change the manufacturing process.

Fashion and Trends

Fashion and Trends will change quickly, and you can see major differences in fashions over decades.

Designers have to make sure their products meet the fashion and trends of the area they are designing and selling the product to.

The change of products over time is called **Product Evolution**. This is caused by Market Pull, Technology Push and Fashion and Trends.



Some products are seen as **timeless**. These products are called **Iconic Designs**. These products are timeless because they were innovative, set a bench mark for following products, changed their industry and are often copied. Examples include; iPod, iPhone, Angle-Poise Lamp, Swiss Army Knife, Converse Shoes, Levi's Jeans, Classic Mini Cooper



Inclusive vs. Exclusive Design

Inclusive Design: The aim to create a product that as many people as possible can use

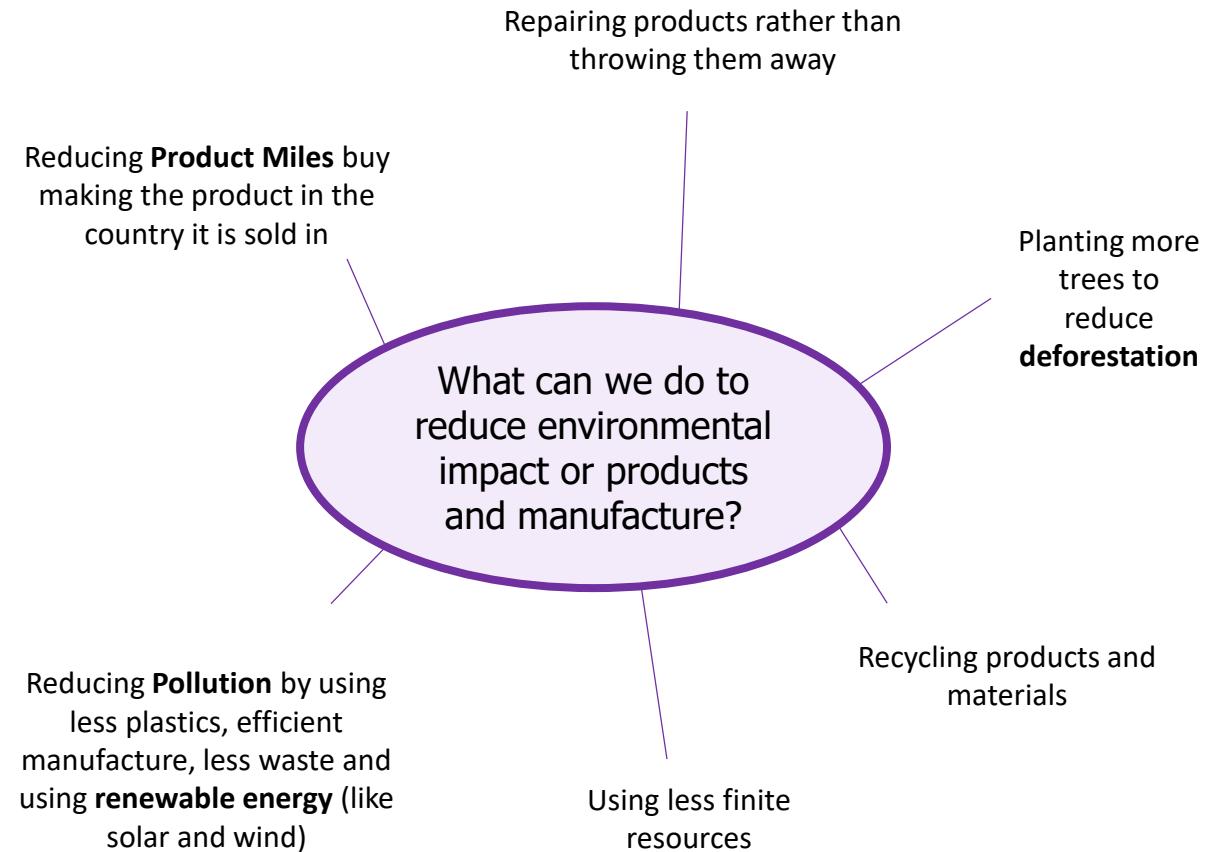
Examples include; Cars, Doorframes, Adjustable Products, etc

Exclusive Design: The aim to create a product for a particular group and their needs

Examples include; Car seats for babies, Wheelchairs, Stair Lifts

Sustainability and the Environment

The 6Rs	Meaning
Reuse	To use a product again either for the same purpose or a different one
Reduce	To have less of material/packaging/pollution when making products by making them more efficient
Recycle	Breaking down and forming the material into another product
Refuse	Customers not buying or supporting products that make an environmental impact
Rethink	Designers and customer rethinking their decisions when making and buying products.
Repair	Fixing a product rather than throwing it away. Extending its life rather than using more resources to make another Often products are Designed for Maintenance so can easily be repaired. E.g. Using screws so even non-specialists can take a product apart, or using components that can easily be replaced like fuses or batteries



Life Cycle Assessment



This is when a designer looks at the environmental impact a product makes over its life time and how it could be reduced. Including:

- Impact of materials
- Impact of processes
- Product Miles (how far a product has to travel to get from factory to consumer)
- Impact while in use
- Impact when disposed of (6Rs)

Sustainability is maintaining our planet and its resources and making a minimal negative impact

Finite Resources <i>Will run out of eventually</i>	Infinite Resources <i>Can be re-grown and re-bred. Will not run out of</i>
Plastics	Paper
Metals	Boards
Polymers (Textiles)	Natural Timbers
	Cotton
	Leather

Planned Obsolescence	This is where products “die” after a certain amount of time. E.g. Disposable cups, Phones, Lightbulbs, Printer Ink, etc This can have a big environmental impact as customers are throwing away lots of products, and resources are being used to create new ones.
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Energy Generation and Storage

Non-Renewable Energy Sources	This is when certain sources of energy will run out eventually
Fossil Fuels	<ul style="list-style-type: none"> • Coal, Oil and Gas • Burned to create steam, turned in turbines to create electricity. • Burning creates CO₂ which adds to Global Warming
Nuclear Power	<ul style="list-style-type: none"> • Nuclear Fission controls the reactor (that creates the electricity). This requires Uranium which is non-renewable • Accidents and waste can severely damage the environment and cause radiation poisoning • Radiation poisoning can be fatal and cause physical deformations • Nuclear waste has to be disposed of properly and is hazardous for thousands of years.

Renewable Energy Sources	This is when certain sources of energy will not run out.
Solar	<ul style="list-style-type: none"> • Solar panels are used to collect light and convert it into electricity • There is no waste and a consistent supply • However, the panels are not effective at night or in countries where there isn't a lot of sunlight
Wind	<ul style="list-style-type: none"> • Turbines harness wind energy • Not effective on non-windy days • Some people don't like turbines as they are noisy, and not attractive to look at
Hydro-Electrical	<ul style="list-style-type: none"> • This harnesses energy from water held behind a dam • Has to be created by flooding land – damaging wildlife habitats • Tidal energy comes from using energy from waves
Biomass	<ul style="list-style-type: none"> • This is fuel from natural sources e.g. crops, scrap woods and animal waste • Growing biomass crops produces oxygen and uses up CO₂ • However, is a very expensive method

Storing Energy

Pneumatics: This is the production of energy using compressed gas or air. E.g. Pistons in an engine

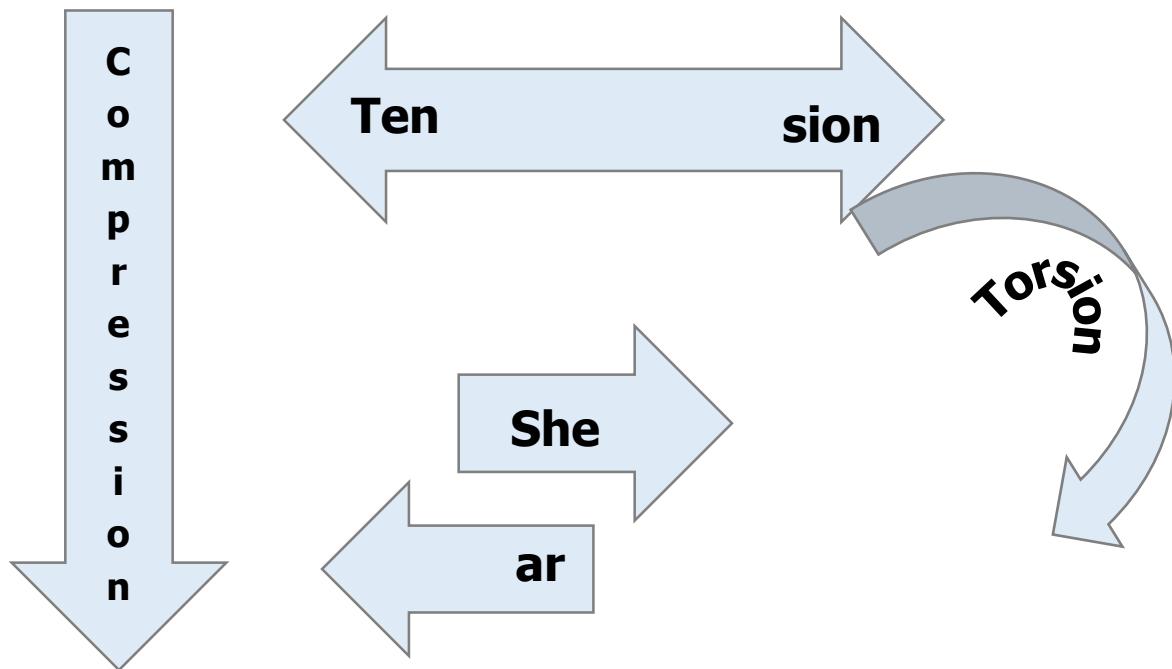
Hydraulics: Like a Pneumatic system, but uses water or oil under pressure. E.g. Wheelchair lifts

Kinetic: Energy that is generated by movement. This is stored by items like springs in a "clickable" pen or balloons,

Batteries: Electrical power can be stored in batteries. Rechargeable batteries are becoming increasingly popular.

Mechanical Systems

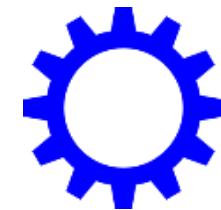
Forces



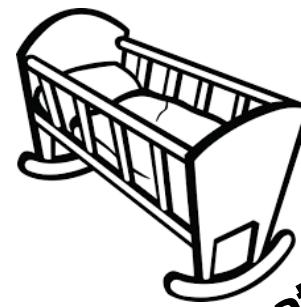
Motion



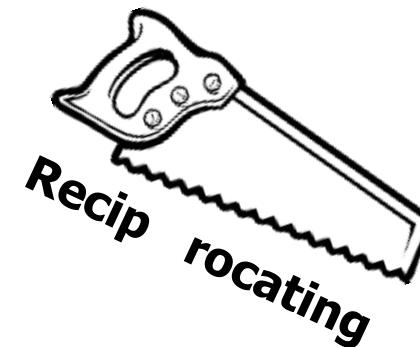
Linear



Rotation

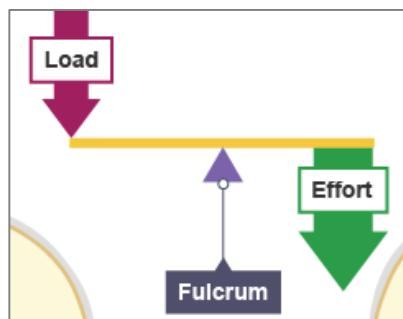


Oscillating

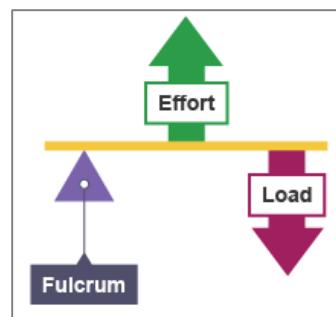


Reciprocating

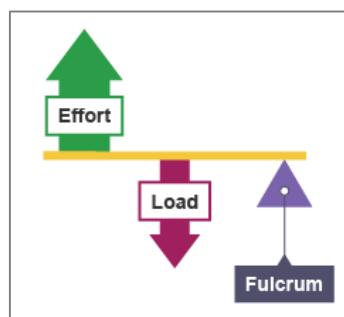
Levers



1st Class Lever:
Fulcrum in the centre
E.g. Scissors



2nd Class Lever:
Load in the centre
E.g. wheelbarrow



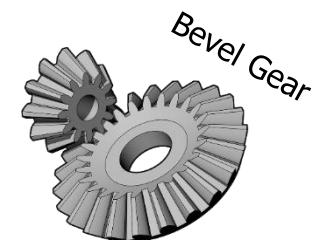
3rd Class Lever:
Force in the centre
E.g. Lifting a dumbbell

Gears and Pulleys



A Pulley is a grooved wheel, that has a belt running through it

This uses rotary motion and is often used to help with heavy loads, and transfer force from a motor to a tool in machines like drills, etc



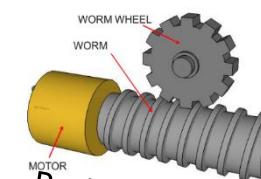
Bevel Gear

Gears have teeth that mesh together with each other (like teeth on a zip)

They mainly focus on rotary motion on tools and machinery e.g. car steering and pillar drills



Spur Gear



Rack and Pinion



Worm and Wheel

Modern and Smart Materials

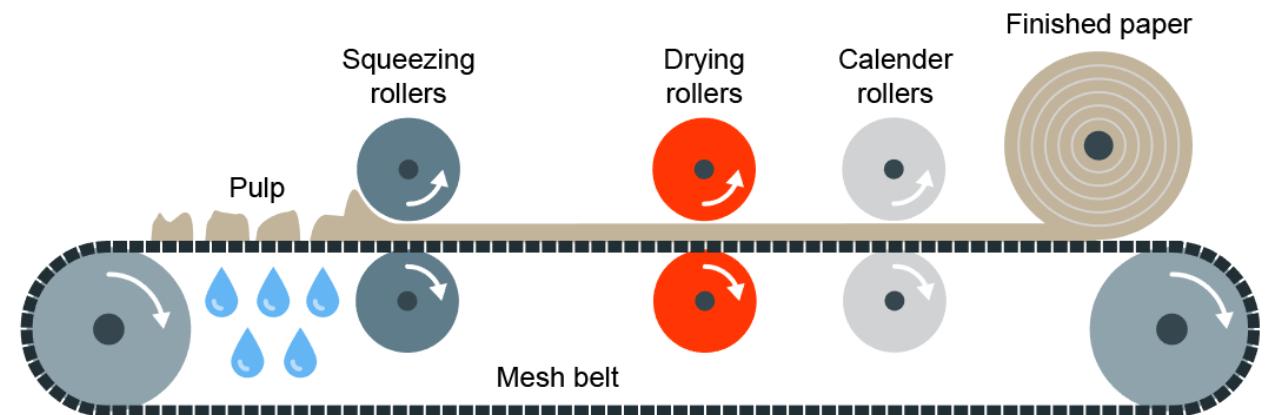
Modern Materials are materials that have been developed recently		
Material	Key info	Examples
Corn-starch Polymers	These are plant-based polymers that are a replacement for plastics that are biodegradable but cannot be recycled.	Plastic bottles, tubs, food containers, etc
Flexible MDF	Made in the same way as normal MDF but with grooves cut into the surface so it is flexible. Flexiply is the same but for Plywood. These can easily be shaped into curves	Modern furniture, interior walls and room dividers
Titanium	High strength to weight ratio. Doesn't corrode or rust. Suitable for medical use as its hypo-allergenic	Prosthetics, medical applications, sports cars, etc
Kevlar	A woven polymer with a high strength to weight ratio.	Bullet-proof vests, tyres, helmets, etc

Smart Materials are materials that change and react to the stimuli		
Material	Key info	Examples
Thermochromic Pigments	Change colour in reaction to heat	Kettles, baby bottles, etc
Photochromic Pigments	Change colour in reaction to light	Colour changing glasses, windows, etc
Shape Memory Alloy	Returns to its original shape, in reaction to heat	Braces and glasses
Polymorph	Granules that once exposed to hot water, become a modelling material (like a dough or clay)	Modelling and repairs

Papers and Boards

Papers and Boards come from trees. The Stock forms for papers are: rolls, sheets, A4, A3, etc		
Material	Key info	Uses/ Examples
Cartridge Paper	Thick white paper, completely opaque and more expensive than photocopy paper	Sketching, ink drawings
Layout Paper	Light, semi-translucent, good for blending inks and artist markers	Sketching, drawing and some tracing
Corrugated Cardboard	Strong but light. Rigid triangles of card sandwiched between a top and bottom layer.	Outer packaging, food packaging
Duplex Board	Light card with white outside layers. Waxy coating can be added	Cheap packaging. If waxy coating is applied, can be used for food
Foil-lined Board	White card coated with a thin aluminium layer. Foil is great for insulation and water resistance	Takeaway containers
Solid White Board	High-quality white card with a smooth finish. Stiff and holds colours well	Greetings cards, packaging and advertising

Primary Processing of Papers and Boards



Paper is made by first making pulp. Pulp is a mix of tree fibres and water. This is cooked and bleached white, and adding any other additives. The pulp is then drained and goes through **Calendering** where the pulp is drained and goes through rollers to convert it to its stock forms

Metals, Alloys and Plastics

Metals

Metals come from ores in the ground. **Stock forms** are sheets, bars and rods

Ferrous Metals contain iron and are magnetic and rust		
Material	Key info	Examples
Low Carbon Steel	Tough and ductile and easily machined and welded	Construction, screws, cars
High Carbon Steel	Hard and wears well	Tools, blades and knives
Cast Iron	Hard but brittle. Easily cast but hard to machine	Pots, pans, vices

Non-Ferrous Metals do not contain iron, aren't magnetic and don't rust		
Material	Key info	Examples
Aluminium	Light, high strength to weight ratio and ductile	Pots, pans, cars, cans
Copper	Ductile, malleable and good conductor	Plumbing supplies and cables
Tin	Soft, malleable and good conductor	Used as a protective coating

Alloys

Alloys are mixtures of 2 or more metals to get the best of their properties		
Material	Key info	Examples
Brass	Malleable and easy to cast	Musical instruments, plumbing
Stainless Steel	Doesn't rust, hard and smooth	Cutlery, medical tools, etc

Plastics

Plastics come from crude oil. **Stock forms** are sheets, powders, granules and rods

Thermoplastics can be reheated and reshaped and infinite amount of times		
Material	Key info	Examples
PET	Easily blow moulded , food safe and easily recycled	Bottles, packaging, etc
PVC	Flexible, tough, easily extruded	Pipes, tape, hard hats
HIPS	Flexible, lightweight, food safe and easily vacuum formed	Containers and yoghurt pots
Acrylic	Tough, brittle, easily scratched	Car lights, baths, displays/ signs

Thermosets once heated and set cannot be reshaped		
Material	Key info	Examples
Melamine Formaldehyde	Food safe, hygienic, hard and brittle	Kitchenware and work surfaces
Urea Formaldehyde	Good insulator, hard and brittle	Electrical casings, buttons and handles
Polyester Resin	Strong, heat resistant, can be transparent	Coatings, casings

Primary Processing of Metals and Alloys

Metals are mined from the earth and then go through an extraction process. Extraction happens by putting the ore in a blast furnace. The metal is then separated from the waste material.

Primary Processing of Plastics

Crude oil is extracted from the earth and then processes into different types of fuels, etc. This is called **Fractional Distillation**. A process called **Cracking** then converts the large hydrocarbon molecules into plastics.

Woods and Boards

Natural Timbers

Softwoods are generally cheaper than hardwoods as they are more available, since they grow quicker.

But because man-made boards are manufactured they are cheaper than timbers. Man-made boards also come in a better variety of sizes since they don't depend on tree growth.

Stock forms for both include; sheets, dowel, planks, etc

Hardwoods come from Deciduous Trees . These trees lose leaves in winter and grow fruit and flowers in spring		
Material	Key info	Examples
Ash	Flexible, tough and shock resistant	Sports equipment Tool Handles
Beech	Fine finish, tough and durable	Toys, furniture and veneers
Mahogany	Easily worked, durable, high quality finish	High-end furniture
Balsa	Very soft and spongy. Light	Modelling
Oak	Tough, durable and hard	Flooring, furniture and veneers

Softwoods come from Coniferous Trees . These have thin, needle-like leaves and grow all year round. Often have pine cones and sometimes nuts and seeds		
Material	Key info	Examples
Larch	Durable, tough, good water resistance and finishes well	Furniture, flooring and used outdoors
Pine	Light, easy to work with but can split	Cheap furniture, construction and decking
Spruce	Easy to work with, high stiffness but can decay quickly	Furniture, musical instruments and construction

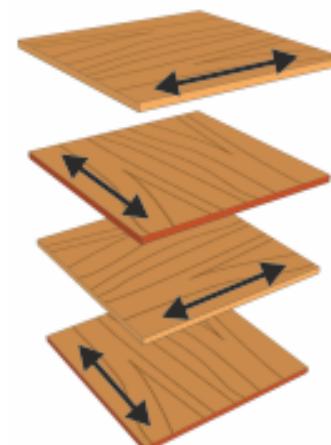
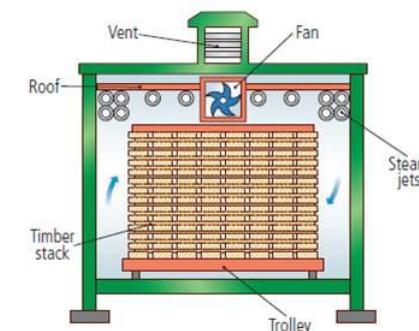
Man-Made Boards

Manufactured boards are made from wood chips/dust/ layers and glue.		
Material	Key info	Examples
Chipboard	Prone to chipping but good compressive strength. Not-water resistant	Flooring, low-end furniture, flat-pack
MDF	Rigid and stable. Easy to finish. Absorbs liquid easily	Flat-pack furniture and kitchen units
Plywood	Very stable. Exterior veneer can be used from more expensive woods	Shelving, furniture, toys

Primary Processing of Papers and Boards

Trees are cut then converted into planks by cut using saws
It is then seasoned to reduce the moisture in the wood. This is done by either:

- Air-drying** – Planks are stacked and air allowed to circulate; causing evaporation
- Kiln-drying** – Where planks are put into a kiln and dried rapidly. This process is more costly than air-drying



Manufactured boards can be either be made by lamination or compression

Lamination – Layers of woods and adhesive are layered and compressed together. Usually with a more expensive wooden veneer on the top

Compression – Wood is shredded, heated and compressed with adhesive under extreme pressure