**Hand Tools**

It's not all fancy high-tech stuff in this section. You need to know about hand tools too.

**Saws are the Main Cutting Tools**

1. Different saws have teeth designed for cutting different materials. Tenon saws and rip saws are used on wood. Hack saws are used for cutting metals and plastics. Coping saws can be used on either wood or plastic, and are mainly for cutting curves.
2. Saws have to be kept sharp, either by sharpening (e.g., tenon saw) or replacing the blade (e.g., coping saw).

**Planes and Files are Used for Shaping and Smoothing**

1. This is a bench plane:
   - Files have hundreds of small teeth to cut away at a material.
   - Different cuts of file make them suitable for different processes: rough cuts are for removal of material, fine cuts are for finishing (final smoothing).
   - Most files are meant for metals and plastics, but there are special ones with very coarse teeth called cabinet rasps for use on wood.

**Drills Make Holes (no kidding...)**

1. Hand drills, braces, and Bradaws are hand tools for making holes. There are also machine drills and hand-held power drills. All drills rotate the drill bit clockwise and press it against the material.
2. Twist bits are used for drilling small holes into wood, metals and plastics.
3. Flat bits are used on wood and plastic to drill large flat-bottomed holes.
4. Countersink bits make holes for screw heads to sit in.
5. Different bits are suitable for different materials. Spade bits and auger bits are used on wood. High speed steel (HSS) twist bits are used on metals and plastics.

**Chisels are Used for Shaping Woods and Metals**

1. Chisels are used to cut away and shape materials.
2. Wood chisels (bevel-edged, firmer and mortise chisels) are used on wood and are hit with a mallet.
3. Cold chisels are used on metals and are hit with a hammer.
4. Bougers are chisels with grooves in them — they're used for sculpting.

**Learn about tools — you know the drill...**

Before removing material always mark out what's to be removed and then double-check your marking out. It's a bit tricky to stick stuff back on if you've cut it off by mistake.

**Machine Tools**

Machine Tools do the same jobs as manual tools — but a lot quicker and more accurately.

**Machine Tools are Quick and Accurate**

1. These are usually stationary and are often bolted to the workbench or the floor.
2. They can be used for processing large quantities of material accurately and quickly.
3. Most machines used for wood are attached to a dust extractor.
4. Safety glasses should be used and clothing buckled in to avoid catching in machines.

**There are some Ace Machines for Cutting and Drilling**

Whether you have these tools in your D&T workshop or not, you still need to know that they exist and what you'd use them for.

- The circular saw or saw bench has a round blade and is used to cut wood and man-made wooden materials like plywood to size. It makes straight cuts only.
- The band saw has a blade in a long flexible loop and is normally used to cut wood, but special blades can be bought for use on plastics and softer metals. The blades come in different widths and can be used for straight or curved cuts.
- A planer and thicknesser (either separate or both in a single machine) are used for flattening the surface of pieces of wood and for reducing their thickness to a specified measurement.
- A pillar drill or pedestal drill is used with HSS twist bits, or other types of suitable bit (see page 10), to make round holes. They can be used on all kinds of materials, depending on the bit used.

**Lathes** come in two types — wood lathes and engineers' lathes (for working metal). A piece of material is held and rotated by the lathe, while the turning tool or cutting bit is pressed onto the material to cut it. Lathes are used to produce round objects.

All this information is giving me a saw head...

Machines are cool, don't you reckon — especially compared with doing it by hand. Personally, I'm hopeless at sawing — never get it in a straight line and generally cut myself. Not fun. But give me a saw bench and I'm your... um... person. Lovely neat edges and no missing fingers. Smashing.
Machine and Power Tools

Just wait till you see these Sanders and Grinders

Aah... these little beauties...

1) A **sanding disc** spins a disc of abrasive paper which the material's pushed against.
2) It's used for **fine grinding** to a line.
3) Different types of abrasive are available for use on wood, metal, and plastics.

1) A **bench grinder** contains abrasive wheels of different grades (coarse to smooth).
2) It's used to **remove metal** for shaping or finishing purposes, as well as for sharpening edged tools such as chisels.

Power Tools are Hand-held Motorised Tools

1) A **jigsaw** has interchangeable blades and variable speeds.
2) You can make straight or curved cuts in all materials, but it's quite slow. (See page 53 for more on jigs.)

1) You can get a hand-held version of the circular saw (see page 11).
2) In this case the wood is held stationary and the saw is moved along it, using adjustable fences for guidance.
3) It's good for making straight cuts very quickly in wood.

1) A **planer** is used like a bench plane to remove shavings of wood. It's used either to reduce the material to the required size, or for rough shaping.
2) The advantage of a power planer is that it takes much less effort and is much faster — but it's not as **accurate** as a bench plane.

Don't let this page grind you down...

It goes without saying, but don't be an idiot with power tools. Waving a circular saw around might seem amusing at the time but you'll probably regret it if you accidentally cut someone's head off.

Deforming

Deforming means changing the shape of a material.

Laminating is Gluing Thin Strips of Wood Together

1) Thin strips of wood (usually 2-6 mm thick) are glued together, like plywood.
2) This 'sandwich' is held in a **jig**, which keeps it in the shape of the finished product whilst the glue dries.
3) Items produced this way include chair and table legs, roof beams, and rocking chair runners.

Most Metals need to be Heated before Bending

1) Some thin pieces of metal can be bent cold on a **jig** or **former**.
2) Thicker or harder metals have to be heated or annealed first (see p. 25) and allowed to cool.
3) This makes them soft enough to bend easily, but the annealing process might have to be repeated as bending makes them go hard again ('work hardening').

Sheet Metals can be Folded...

1) This is a method of shaping **sheet metals** such as aluminium and tin plate.
2) The outline of the product, e.g. a box, is marked out and cut from a **flat** sheet of metal.
3) The sides are then bent or folded up using **folding jigs**, **formers** and **mallets**.
4) The corners are then **joined** using rivets, soldering, brazing, etc.

...and so can Plastics...

1) **Line bending** is ideal for use with **acrylic sheets** — e.g. for making picture frames and pencil holders, etc.
2) It can be done manually or with a **line bender** or **strip heater**.

Iron and Steel are Forged

1) Metal, especially **iron** and **steel**, can be heated in a **forge**. A forge is a fire with air blown into the middle of it to produce a very hot flame.
2) When the metal's hot enough to have softened sufficiently, it's taken out and hammered into shape on an **anvil**.

Dave said he'd deform my nose if I kept seeing his girlfriend...

If you're making something out of metal, you might find that you end up using iron or steel. Now, iron and steel can be forged. But if I were you, I'd use the real stuff. It's probably better.
Deforming

Most of these processes involve heat — so take necessary safety precautions (see p45).

Press Moulding is Used to Shape Thermosets

1) A 'slug' of thermosetting plastic powder is put into a 'female' mould.
2) A former is pressed onto it and pushes the plastic into the mould.
3) Very high temperatures and pressures liquify the powder, and the plastic is set into a permanent shape.

In Vacuum Forming, Air is Sucked from Round the Mould

1) A sheet of thermoplastic is heated until it goes soft.
2) A pattern (or male mould) is put onto the vacuum bed. The bed is then lifted close to the heated plastic.
3) The air is sucked out from under the plastic. Atmospheric pressure forces the plastic onto the pattern mould.

NOTE: The sides of the pattern must be slightly tapered and the corners rounded to allow the finished product to release from the mould.

Blow Moulding Uses Air

1) A sheet of thermoplastic is clamped to the bed of the former and is heated until soft.
2) Air is blown under it, which forces the plastic up through a large hole in the bed.
3) This forms a bubble or dome, and is used to make dome-shaped products.

Pop Idol moulding is used to make Darius, Gareth, Will... yuk...

It's not that hard to remember this stuff — press moulding uses pressure, vacuum forming works by creating a vacuum and blow moulding works by blowing air into the plastic. Once you've got that, you need to learn the diagram for each, and an example of what you could make that way.

Reforming

Reforming is where metals or plastics are liquified, usually by heat and pressure, and then shaped in some form of mould. How absolutely amazing. This stuff really keeps me on the edge of my seat.

Die Casting is Used to Mould Metals and Thermoplastics

1) Die casting is a process used to mould metals and thermoplastics.
2) The material is melted and poured into a mould which is in the shape of the product.
3) Some plastic resins can be cold-poured into moulds (without heating). They harden or set through a chemical reaction.

Injection Moulding Uses Pressure to Mould Plastics

1) This is similar to casting, but the molten material is forced into a closed mould under pressure.
2) The plastic is often melted using built-in heaters.
3) This is an industrial process which is usually automatic and continuous.

Extrusion Produces Long, Continuous Strips

1) Used for some metals and thermoplastics, this process is very similar to injection moulding.
2) The material is melted and forced under pressure through a die.
3) It produces long, continuous strips of the moulding, such as plastic-covered wire, and plastic and aluminium edgings.

Don't eat this book — because this page is all mould-y...

Reforming processes are usually industrial processes for mass production, and are not usually economically viable for small quantities of products. Like my life-size model of Eamonn Holmes.
Assembly and Finishing

This is the putting together of components to build the final product.

Assembly — Putting the Product Together

1) **If permanent joining methods are to be used, it’s vital to double-check the fit of the parts before final assembly.** The project could be ruined if you can no longer get access to carry out other processes you might have forgotten.

2) Sometimes it is easier to **clean up** (e.g., with glasspaper) and apply a **finish** (e.g., paint) **before** final assembly, because **access** to inside areas for finishing is easier.

3) **When gluing, soldering, brazing, or welding it’s vital to get the joint areas clean and free from dirt and oil, etc.**

4) **It’s important not to touch** areas to be joined after cleaning as **fingerprints** can leave enough grease on the surface to stop the joint from working.

5) **When gluing, make sure you’ve tried the parts together first in a “dry run”.** This avoids getting halfway through gluing and finding that a part won’t go on properly.

6) **Gluing up (and often soldering, brazing and welding) needs clamps to hold the work securely whilst joining.** Removing clamps too early can **break** the joint. Some glues require the joint to be clamped for 12 hours or more.

Finishing — Making it Look Pretty

Finishing is the final process in the making of any product. It makes the product look good and protects it from moisture and dirt.

1) **Before finishes are applied it is important to remove any visible tool marks and blemishes with files, emery cloth, glasspaper, etc.**

2) If paint of any type is to be applied, the surface must first be **cleaned** to remove grease and dust.

3) Different paints are produced for different **materials** and for use in different situations. It’s important to select the correct type — otherwise it might not stick to the material and it could even damage it. You’ve got to be especially careful when painting particular **plastics**.

4) **Deburr** paint is generally applied to metal. It’s applied on and looks great because it gives a very smooth finish. However, it’s expensive as spraying means that much of the paint doesn’t end up on the product.

Fabricating — Screws and Bolts

Fabricating is the joining of pieces using the most **appropriate** method. Different methods are used for different materials and in different situations.

Screws and Bolts are Used with Woods, Metals and Plastics

1) **There are different types of screws for use with wood, metals, and plastics.**

2) **Wood screws** often require ‘pilot’ and ‘clearance’ holes to be drilled before the screw is inserted. As the screw is turned by a **screwdriver**, the thread (the twisty bit around the outside of the screw) pulls it into the wood. Different types of **head** are available for different jobs, e.g., round, countersunk, slotted and cross-heads.

3) **Self-tapping** screws have **hardened threads** and are designed to cut their own threaded holes in hard materials such as **metal** and **hard plastics**.

4) **Machine screws** have a straight **shank** and are used with **washers** and **nuts**. Heads vary (round, pan, countersunk, etc.). Some are tightened with a **screwdriver** (cross and slotted types), and some with an **Allen key** (socket head).

5) **Bolts** are similar to machine screws but have a **square** or **hexagonal** head and are tightened with **spanners**.

6) **Screws and bolts are usually made from steel, brass or stainless steel, and are “self-finished” or plated with zinc, brass, chrome, or black japan (a black varnish).**

Threading is Often Used to Make Joints More Secure

1) **Threading is a method of fastening machine screws and bolts directly into a metal or plastic component without using nuts.**

2) A hole is drilled and a set of **taps** used to cut a **female** thread in the hole. The screw is inserted into it and tightened until it stops.

3) A round **rod** can be made to fit a threaded hole by cutting a **male** thread onto the outside of the rod. Male threads are cut either with a **split die** or on a **lathe**. This allows components to be joined **directly** without the use of **bolts** or **screws**.

Assembly — where all the teachers and kids are really bored...

Before starting assembly of your project **stop and think** — have you completed all the other necessary processes to the required standard first? And, can you put it off till another day?

If you don’t learn this page you’ll be scr... um... scuppered...

Remember, screws are much like people in some ways — they have different shaped heads. But in other ways they’re very different — for example, I’ve never seen anyone with a countersunk head.
Fabricating — Nails, Rivets and Adhesives

Nails and rivets and threads — the fun never stops with Resistant Materials. Ah, no, I tell a lie — the fun always stops with Resistant Materials. Much better — that first one didn't sound right at all.

Nails are Used for Joining Bits of Wood Together

1) These are similar in use to woodscrews but have a **straight shank** with no thread.
2) They're inserted with a hammer and can be punched below the surface with a **nail punch** to hide the head.
3) Nails are **only** used in **wood** and wooden **products**, e.g. plywood. They're much **quicker** to use than screws, but the joint they make is nowhere near as **strong**.
4) Nails are mostly made from **steel**, but special ones can be made from other metals, e.g. **brass** for use in **boat building**. Like screws, they come with a **variety** of **head** and **shank** shapes for different uses.

Rivets are Mainly Used for Joining Sheet Metal

1) A rivet is a **metal peg** with a **head** on one end. Rivets are used mostly for joining pieces of metal.
2) A hole is drilled through both pieces of metal and the rivet is inserted with a **‘set’** (hammer-like tool). The head is held against the metal whilst the other end is flattened and shaped into another head with a **hammer**.
3) ‘Pop’ (or ‘blind’) rivets are now very common. They can be used where there is only access to **one side** of the material (hence ‘blind’ rivet). It's a **fast** and **easy** method of joining sheet metal.

**How Pop Rivets Work**

1. The metal pin is inserted through a hole in the centre of the pop rivet.
2. Both rivet and pin are placed in the hole in the material.
3. The pin is pulled tight with riveting pliers and snapped off.
4. This causes the end to expand and form a head on the other side.

You Need to Choose the Right Adhesive for the Job

1) There are many different **types** of adhesive for use with different **materials** and for different jobs, e.g. PVA and **animal glue** (for wood), contact adhesive and **epoxy resin** (for lots of materials).
2) Adhesives will only work properly if the **right one** is chosen for the job, and if the surfaces to be joined are thoroughly **cleaned**.
3) Some plastics can't be glued as they're too **smooth**, and have a **gummy** texture which stops the glue from 'keying in'.
4) Adhesives are often used to **reinforce** other methods of fabrication, e.g. joints in wood.

That page was riveting...

When deciding which method of fabrication to use on a product, think carefully about which is more important — **speed** of assembly or **strength**. It's often a trade-off between the two.

Fabricating — Joints

Wood can be joined together in several ways — either by the traditional method of cutting joints and nailing and gluing together, or by using special fittings which can be taken apart again.

Some Joints are More Permanent than Others

1) There are dozens of different joints, e.g. dovetail, mortise & tenon, housing, halving and mitred, for use in different situations. It's important to use the right joint in the right place.
2) Joints are often **glued** to make them **secure** and **permanent**.
3) **Marking out** and cutting joints takes a lot of skill. **Accuracy** is vital if the joint is to fit and hold together (as well as look good).

**BUTT JOINT**

Pretty **feasible** but very **quick** and **simple**. Often used for joints in **cheap pine furniture**.

**MITRED JOINT**

Mortised joints are similar to butt joints but prettier and trickier to cut. Often used in **picture frames**.

**DOWEL JOINT**

Dowel joints use a **wooden** or plastic peg, called a **dowel**, which fits into aligned holes to reinforce the joint. Often used in **factory-made furniture**.

**MORTISE AND TENON**

Mortise and tenon joints (cut with a tenon saw and mortise chisel) are **strong** and **fancy**. Often used in **tables and chairs**.

**LAP JOINT**

Lap joints have a larger surface area for giving them butt joints, so they're a bit stronger. Used in some **drawers** and **boxes**.

**HALVING JOINT**

Halving joints are fairly **strong** — again, due to the larger surface area for giving. Sometimes used in **frame construction**.

**HOUSING JOINT**

Housing joints are often used in **shelving units** as they provide a good surface area for gluing, and the shelf is supported all the way along its depth.

**DOVETAIL JOINT**

Dovetail joints are very **strong** and look **attractive**. They're often used in **drawer construction**. They're the **best** to make. Unless you have a dovetail tool (see p53).

Knock-Down Fittings are Non-Permanent Joints

1) These are **blocks**, **brackets** (plastic or metal) and other fittings which enable furniture to be assembled and taken apart again easily.
2) They are used instead of traditional joints, and are very **fast** to use, but are nowhere near as **strong** as glued joints.
3) Most types are assembled with **screwdrivers** or **Allen keys**.
4) They are usually used for cheap **‘flat-pack’** furniture.

Butt joint... **Nope**, nothing funny about that...

So, just to wrap up... which joint you use depends on:

- a) whether you're a traditionalist,
- b) how much time you've got,
- c) how good you are at woodwork,
- d) whether you want to take the thing apart again,
- e) how strong you want the joint to be.
Fabricating — Joining Metals

It's the page you've been waiting for — it's all about welding and stuff. Splendid.

**Soldering, Brazing & Welding are for Joining Metal**

These are methods of joining metal by the use of varying amounts of heat.

1) **Soldering** is a relatively low temperature process. Solder, made from tin and lead, is melted onto the components to be joined, sticking them together when it cools and solidifies. A *soldering iron* or *blow torch* can be used for this process.

2) **Brazing** is a higher temperature process which uses *brass spelter* as the joining material. It's much stronger than soldering. Either a *gas brazing torch*, a *blow torch*, or a brazing attachment for an *electric-arc welder* is used to heat the joint.

3) **Welding** uses a very high temperature from an *oxyacetylene torch*, an *electric-arc welder* or a *TIG welder* to actually melt the edges of the joint so that they flow together. Thinner metal or slight gaps are filled with metal from a *welding rod*. This is by far the strongest method of joining metal.

**The Joint Needs to be Carefully Prepared**

For all three of the above processes careful preparation of the joint is vital:

1) Joints have to be well-fitting with minimal gaps.
2) They must also be very clean and free from grease. Fingerprints on the surface can stop solder or brass spelter from "taking".
3) "Flux" has to be used when soldering and brazing and on some metals when welding. This stops the air oxidising the surface of the metal whilst heating it, as this too would stop the joint from taking.

Marty has to get to 88 mph to make the flux capacitor work...

Extra care needs to be taken with heat processes. And make sure you use the safety and protective clothing and equipment provided. And don’t try and solder your hand to your face. It’ll hurt.

---

Computerised Production

Almost everything is designed on computer now — washing machines, hoovers, cars, planes, houses, cameras, computers. It’s much easier and quicker than doing it all on paper.

**CAD — Computer-Aided Design**

1) Computer Aided Design involves designing products on a computer, rather than the traditional methods on paper.
2) Software ranges from 2-D engineering *drawing* programs to 3-D frame and solid *modelling* packages.
3) CAD allows designers to model and *compare* designs *cheaply* and relatively *easily*. Also, many problems can be ironed out before the production of prototypes.
4) In 3-D programs, finished products can be *viewed* from all angles, and *scales of components* can be worked out in relation to each other.
5) Finished drawings can be printed off on large format *inkjet printers* or *plotters*, or can be distributed *electronically* and instantly to production teams at factories across the world.

**CAM — Computer-Aided Manufacture**

1) Computer-Aided Manufacture is usually linked with CAD.
2) Components and products are *made on machines*, such as *milling machines*, which are controlled and operated by computers rather than by people.
3) Products are designed with CAD software and *control data is downloaded* from the computer to the *control unit* of the machine.

**Machines used in CAM are Computer Numerically Controlled — CNC**

1) The machines used in the CAM process are Computer Numerically Controlled.
2) This means the CAD/CAM program works out the necessary movements of the *tool head* and sends the data to the machine in the form of numbers. The machine’s *onboard processor* interprets the numbers and controls the movement of the tool head.
3) Machines which can be controlled in this way include *lathes*, *milling machines* and *drilling machines*.

<table>
<thead>
<tr>
<th><strong>ADVANTAGES</strong></th>
<th><strong>DISADVANTAGES</strong></th>
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<tbody>
<tr>
<td>1) Less cost due to less need for separate specialised machine tools for each product.</td>
<td>1) High initial cost of the machines.</td>
</tr>
<tr>
<td>2) Less chance of human error.</td>
<td>2) High cost of training programmers and operators.</td>
</tr>
<tr>
<td>3) The product can easily and quickly be changed without expensive retooling.</td>
<td>3) Fast special purpose machines are cheaper than CNC machines for large-scale production runs.</td>
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My sister’s pants were manufactured by a computer — they’re CAMknickers...

End of section. Now you should know all you have to about tools and processes. But if you don’t, go back over the section again and really try and ram it into your head. Then have a doughnut.
Revision Summary for Section Two

Well here we are again... at the end of a section and at the start of a Revision Summary. What could be better. What a beautiful place to be. Sit back and relax. Look forward to answering thirty-one questions all about 'tools and processes'. Bet you can't wait. I know how much fun I had when I was writing them. There I was, about to go out with my mates, when I realised I hadn't done these questions. "What a wonderful place the world is," I thought, "and how lucky I am to be able to stay in and write questions about Resistant Materials instead of going out with my friends."

1) Define the terms 'deforming', 'reforming', 'fabricating', 'assembling' and 'finishing' in the context of resistant materials.
2) Name four different types of hand saw. What is each one used for?
3) Name three different types of drill bit. Say what each one is used for.
   a) Describe a saw bench, and say what it is used for.
   b) What is the name of the hand-held version of a saw bench?
   c) What is the main difference between the way you use the two saws?
5) Describe how a band saw works.
6) Name two uses of a bench grinder.
7) Which power tool would you use to cut along a curved line?
8) Describe the process of laminating.
9) What is 'work hardening'.
10) What is a forge?
11) Describe the process of press moulding.
12) Draw a series of diagrams to illustrate vacuum forming.
13) How does blow moulding work, and what shape is produced in this process?
14) Explain the difference between casting and injection moulding.
15) What shapes are produced by extrusion? Describe the process.
16) Name three things you must do before permanently assembling a product (using solder).
17) Give one advantage and one disadvantage of using cellulose paint.
18) Name the three main types of screw. How do they differ, and what are they used for?
19) Explain the difference between a bolt and a machine screw.
20) Name the tool used to cut a female thread.
21) Describe two different ways of cutting a male thread.
22) Give one advantage and one disadvantage of using nails rather than woodscrews.
23) Why can some plastics not be glued?
24) How does a pop rivet work?
25) Name four types of wood joint.
26) What is the main disadvantage of using dovetail joints?
27) What are 'knock-down' fittings?
28) Describe the main differences between soldering, brazing and welding.
29) Why do you need to use flux when soldering and brazing? What does it do?
30) What do the abbreviations CAD, CAM and CNC stand for?
31) Give three advantages and three disadvantages of CNC over specialist machines.

Section Two — Tools and Processes