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WOOD WORKING

Michael Leadbeatter
–
Bruce Leadbeatter
John Keable
Tony Clarke

Fourth Edition

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ABOUT THIS BOOK

This fourth edition of the well-established *Woodworking* textbook has been comprehensively updated to reflect current practices and tools. The resulting text balances recent technological advances with the finer traditions of woodworking. Those traditional practices are retained from previous editions to maintain the integrity of timber craft and its history.

The text covers Stages 4 and 5 (Years 7–10) of the Industrial Technology (Timber) syllabus. However, *Woodworking* is also an ideal resource for Stage 6 students studying Industrial Technology (Timber). Information is presented in a logical sequence so the depth of study can be adjusted to suit the level and stage of individual students.

This fourth edition also covers Work Health and Safety and its importance for students. Timber resource management and the impact of technology on society and the environment are also examined.

Updated diagrams and a fresh approach to layout – including many safety tips, hints and facts – cater for all student levels.

This book is equally useful for amateur and professional craftspeople working with wood and allied materials, offering scope for the execution of many creative ideas. The print edition is complemented by a teacher website featuring teaching programs, weblinks and a selection of new project sheets.

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ABOUT THE AUTHOR

With a career spanning almost 40 years as an educator, Michael Leadbeatter taught woodwork as part of Industrial Arts in NSW Secondary Schools before accepting the senior role as a lecturer at Sydney Teachers' College and later Sydney University.

He returned to the secondary school system as Dean of Technological and Applied Studies at Sydney's Trinity Grammar School, where he earned a reputation for guiding and mentoring students' woodworking and design skills. He was a member of the NSW Board of Studies Board Curriculum Committee as an advisor on Industrial Technology and Design and Technology syllabus development.

AUTHOR ACKNOWLEDGEMENTS

A special thanks must go to my wife Kerrie for her understanding during the long hours spent revising this book. I would also like to acknowledge my father Bruce Leadbeatter, who co-authored the original book with John Keable. Bruce and John were outstanding craftsmen and educators who saw the need for a comprehensive woodworking book for both teachers and students, which has allowed *Woodworking* to become the definitive reference text on woodworking for schools since its introduction. I would also like to thank Ian Monaghan for his assistance in updating the language level of the text to make it less formal and easier to read and understand.

ABOUT THE COVER IMAGE

Since graduating from the Australian National University in 1999, Gary Galego has been designing and making furniture from his Sydney workshop. In 2003 his LEVE chair was exhibited at the Milan Furniture Fair and then produced by Australian manufacturer Woodmark International. He then designed various pieces of furniture for Beclau, and the Ivy chair for Galloway Design Collective. Launched in 2010, the Ivy chair was specified for partial use within Sydney International Airport and State Library of NSW; it is still distributed by the nationwide retailer Stylecraft today. Meanwhile, Gary commissioned for architects and interior designers; a highlight was refurbishing the NSW Governor's residence within NSW Government House in 2014. Gary believes good design `should reflect the thoughts and ideas of a designer working at a given point in time. It should represent ideas of functionality and sustainability and bring to the fore the visual process of making. Wood as a material encompasses all these attributes, and working with it acts as a conduit between these ideals and solving design problems.'

CHAPTER 1

Good workshop practice

In the practice of any craft, skill or sport, success depends largely on the amount of thought, time and organisation put into it. This is also true of woodworking. Safety should always be considered before any workshop practice is undertaken.

Therefore, the following chapter outlines good workshop practice guidelines to help you achieve success, with a particular emphasis on safety. Each guideline has been tested and proven by practical experience in the workshop.

Key terms

hazard a cause of danger or harm; a risk, particularly to safety

health the general wellbeing of people in the workplace

plant machinery or equipment used in the workplace

repealed withdrawn or revoked officially, such as a piece of government legislation that is overturned so it is no longer law

safety awareness/prevention of, and removal/reduction of potential hazards during practical activities

substance the material, or matter, of which something is made

toxicological of a poisonous nature or effect

workplace where events take place, such as a school workshop, a cabinet manufacturing factory or a hardware retail outlet

Work health and safety

Work health and safety (WHS) applies to everyone in the **workplace**, regardless of whether you are working somewhere full-time, temporarily or simply visiting the premises. You have a responsibility to ensure your own safety as well as that of the people around you to the best of your ability.

Health refers to the general wellbeing of those in the workplace and it includes aspects such as the effects of the atmosphere (breathing), lighting (eyes), workplace temperature and humidity (thermal comfort), noise (ears) and exposure to the harmful rays of the sun (skin). Some of these health issues may be long term, such as lung cancer, skin cancer and loss of hearing.

Safety relates to awareness of and removal or reduction of apparent hazards during practical activities. A **hazard** is an area, object or health risk within a workplace. Successfully removing hazards provides a safer working environment with accident risks kept to a minimum. If a risk assessment is made, and subsequent controls are observed, the hazard is removed or considerably reduced.

A hazard is not necessarily *permanently* present; for example, it may be created when a machine malfunctions or something breaks. In a workshop situation, a student should stop the machine, switch it off and report the problem to a teacher.

SAFETY

For safety to prevail, people must be aware, have a responsible attitude and take responsibility for their actions by observing duty of care requirements governed by the WHS regulations.

Work Health and Safety Regulation 2011

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The purpose of the *Work Health and Safety Regulation 2011* is to ensure the health, safety and welfare of persons at work. It effectively **repealed** the original Act of 1983. The Act requires employers to consult with workers on matters affecting their health, safety and welfare. This is typically achieved via the actions of WHS committees or WHS representatives.

Minor or even serious accidents can be reduced if sensible precautions are taken, risks avoided and, when required, help is provided or training given. For example, if you are not sure how to operate a machine, do not guess – ask your teacher. When concentrating on using a particular tool do not allow yourself to be distracted by others. See the list of safety points later in this chapter for more information.

SafeWork NSW

SafeWork NSW

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SafeWork NSW is the workplace health and safety regulator. They offer advice on improving work health and safety, investigate workplace incidents and enforce work health and safety laws in NSW. SafeWork NSW also has a regulatory role in licensing and certifying certain activities and hazardous equipment.

Risk assessment

Managing risks of plant in the workshop code of practice

A risk assessment involves considering what *could* happen if someone is exposed to a hazard, combined with the likelihood of it happening.

A risk assessment can help you determine:

- the severity of a risk
- whether existing control measures are effective
- what action you should take to control the risk
- how urgently the action needs to be taken.

A risk assessment is unnecessary if you already know the risk and how to control it.

To assess the risk associated with **plant** hazards you have identified, you should consider the following:

- What is the potential impact of the hazard?
- How severe could an injury or illness be? For example, could it cause lacerations or amputations?
- What is the worst possible harm the plant hazard may cause?
- How likely is the hazard to cause harm?

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Controlling risks

The ways of controlling risks associated with plant are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of risk control. The WHS regulations require duty holders to work through this hierarchy to choose the control that most effectively eliminates, or where that is not reasonably practicable, minimises the risk. Specific controls are required under the WHS regulations for certain types of plant, such as industrial robots.

Chemical safety

Any **substance** that can be purchased is required by law to have a safety data sheet (SDS) available for it. This information may be written on the container, in an attached leaflet, on the internet (the URL should be on the container) or by request from the supplier. The SDS presents four types of information.

1. *Identification* informs you what chemical you are handling.
2. *Health hazard information* describes how it may adversely affect your health.
3. *Precautions for use* details what care must be taken when using it.
4. *Safe-handling information* describes how to safely handle the chemical without a hazardous situation arising.

This information is necessary in order to reduce the risk of the substance becoming a hazard.

Planning safe practices

Dressing for safety is discussed first in the following section to emphasise the importance of not stepping into the workplace without already wearing the appropriate safety gear. Workplace safety often begins before you enter the workplace.

Dress for safety

You must protect yourself in the workplace against many potential hazards, such as dust, noise, fumes, airborne particles/objects, and so on. Methods of protection against potential hazards include the following: adequate ventilation, mechanical dust extraction, sensible lighting, thermal comfort, waste bins and guards on moving machinery parts.

When workplace hazards have been eliminated or controlled, the final protection is to use personal protective equipment (PPE). It is recommended that you supply your own PPE to guard against communicable diseases.

Table 1.1 contains the most commonly used types of PPE. Ensure you know how to use PPE equipment correctly and efficiently.

Table 1.1 PPE examples from top to bottom

Body part protected	Personal protective equipment
Skin	• Gloves • Barrier cream • Broad-brimmed hat • Sunscreen
Head	• Safety helmet • Cap • Hat • Hair band • Hairnet
Eyes	• Safety spectacles • Goggles • Face shield
Ears	• Ear muffs • Earplugs
Body	• Apron • Overalls (loose clothing is dangerous in practical areas; only schools require this – it is not legislative)
Respiratory system	• Disposable masks • Filtered masks • Self-contained respirators with hoods
Feet	• Safety shoes • Fully enclosed strong leather shoes (no thongs or open-weave shoes)

SAFETY

As a guide, if you can put your hair into your mouth, then it is long enough to get caught in machinery. It should be secured.

Aim for good workshop layout

Placement of benches, machines and storage should be arranged for maximum convenience and safety, and best use of light and ventilation. Maintain your workshop regularly by ensuring equipment is clean and in good working order. Machine safety zones should be marked appropriately on the floor around all machines.

Allow time to plan your work

Allow time for methodically planning, designing and setting out your project. This includes all the individual steps you will take to carry out your project. You will also gather all the materials you will need, such as adhesives and cramps for a gluing project.

Beware of solvents

Solvents typically used for thinning wood-finishing materials and for cleaning equipment are usually highly flammable and explosive. Due to their volatile nature, you should generally not expose them to wind in the open air. Use only in well-ventilated areas away from naked flames. Follow all instructions printed on the container.

Treat tools and equipment with respect

Your bench is 'home' to all your projects.

Do not drive nails directly into the bench. Wipe off anything you spill before it sets. Use bench hooks when sawing or chiselling on the bench. Lay tools and equipment in the middle of the bench, leaving a clear area to work in.

When tools are not in use, store them safely with their cutting edges protected from damage. Return tools and materials no longer required for a particular project to their proper storage places.

Keep edge tools sharp. Blunt tools require greater pressure and are more likely to cause injury to the user or damage to the project.

Take special precautions with power tools and machinery

- Check that the cord attached to all portable power tools is properly earthed. All connections must be made correctly by a qualified tradesperson.
- Check that all portable power tools have an up-to-date inspection tag attached to the cord.
- Always switch off the power before fitting an extension lead.
- Do not use power tools while standing on a wet floor.
- When using a circular saw, make certain the guard is properly fitted and adjusted.
- Make sure that stationary machines always have guards properly fitted over moving parts, such as blades, gears, pulleys and belts.
- Operators should be able to reach all switches easily without leaning over the machine.
- Always turn off the power when the machine is not in use, is being adjusted or is unattended.
- Bandsaws have thin, narrow blades that break easily. Do not use unnecessary force against the blade or twist it when cutting a curve. Keep the guides correctly adjusted.
- Be aware of any changes when the saw is running. Stop the machine immediately if any unusual noises or jarring occur. This may indicate a crack in the blade or joint that needs to be inspected immediately.

Pick up all scraps of wood off the floor

Scraps of wood are often the cause of trips and falls in workshops and around machinery. A disorganised or untidy workshop is both unpleasant and dangerous.

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Avoiding specific hazards

Material dangers

Some often-used timbers can have detrimental health effects. The dust from working these timbers can affect your sinuses and breathing (such as asthma), irritate your eyes, or produce skin conditions (such as eczema and dermatitis). Certain timbers, including western red cedar, oleander and copper-chrome-arsenic-treated timbers (CCA), are banned from schools because of possible severe health hazards.

Precautions when producing dust

- Keep dust to a minimum, especially when cleaning a bench.
- Ensure the dust extractor is switched on.
- Wear a dust mask, eye protection and protective clothing.
- Avoid using wood with known **toxicological** problems.
- Ensure all wounds are clean and well-covered before work starts.
- Wash hands when you are finished in the workshop.

WHS in the workshop for students

When you enter the workshop

- Store school bags away from benches and machines to avoid tripping accidents.
- Wear aprons for protection because loose clothing is dangerous.
- Always wear correct footwear in the workshop.
- Do not wear accessories if they pose a potential safety hazard; this includes bracelets, necklaces and loose earrings.
- Cover or tie back long hair to prevent it from becoming a hazard.
- Know your school's emergency procedures (ask your teacher if unsure). Basic first-aid and an ability to deal with an accident are useful skills to possess. Do you know what DRABC stands for?
- Teacher demonstrations and completed safety tests will reinforce the safe and proper use of tools, machines and equipment in the workshop.
- When in any doubt, ask the teacher.
- Read all cautionary and mandatory signs and posters in the workshop regarding potential hazards. Stay alert! (Figure 1.1)
- Do not use any power tools, machinery, sharp or dangerous tools while the teacher is absent from the workshop.
- Be aware of evacuation procedures: know the warning alarm sound; the exit route; the mustering point and roll procedures.
- Be familiar with extinguisher types and fire blankets and their use. Never play with extinguishers because lives could depend upon them one day.

When undertaking practical work

- Your teacher is the first line of inquiry and assistance.
- Always wear proper PPE to protect eyes from injury or irritation when operating machinery, power tools, hand tools and using toxic or hazardous fluids.
- Wear hearing protection when using noisy power tools and machinery.
- Wear cut resistant gloves when working with sharp tools or rough splintering objects.
- Wear disposable rubber gloves when handling potentially hazardous fluids.
- Use two people to carry long lengths of timber: one at each end and preferably with supervision.
- Keep the work environment (benches and floor) clear.
- Recycle whenever possible; not every offcut is rubbish.
- Dust and shavings are a respiratory and fire hazard; always brush gently into a dustpan or bin, use PPE (page 3), and ensure that the dust extractor unit is switched on.

Figure 1.1 Safety signs

- When moving with sharp tools, hold the tool at your side with your hand near the dangerous part/edge so you know where it is.
- Never use ladders without instruction and direct teacher supervision.
- Avoid lifting heavy loads without training; if in doubt, ask your teacher.
- Clean your hands at the end of a workshop lesson to remove glue, filler, lacquer, and so on.

When using electrical tools and machinery

- Safety areas around machinery should enclose just the operator and, possibly, the teacher (if required) at any one time.
- Neither distract nor try to assist other students who are using machinery, power tools or hand tools.
- Never operate a machine if the guards are missing or ill-fitting.
- Check that chuck-keys and spanners are removed before switching on machinery.
- Switch off electrical outlets before inserting or removing plugs.
- Switch off power tools before plugging into an electrical outlet.
- Remember, if in doubt, ask your teacher.
- Do not carry power tools by the electrical cord or pull on the cord to extract the plug.
- Always disconnect power tools and machinery before making adjustments.
- Machine stop buttons are always coloured red: know where they are.
- If something is not working correctly, immediately switch it off. Alert your teacher and do not allow anyone to use it.

Safe operating procedures – instruction and training

Work health and safety is an important and mandatory issue in schools, especially in workshop situations. Many schools use OnGuard® Safety Training Program, which is designed for safety instruction, training and testing, suitable for school workshop teachers and students studying a technology-based curriculum.

The modules in this program cover wood, metal, food, textiles, STEM, construction, hospitality and general workshop safety. The program includes:

- safe operating procedures, knowledge tests, work sheets and risk assessment for specific activities, tools, equipment, machines and power tools (Figure 1.2)
- OnGuard Just-In-Time Mobile Web: a new BYOD feature, permitting student access to training and teacher access to registers, utilising QR Codes and mobile device technologies
- a tracking feature that records all demonstrations, training, testing and competency assessment for every student
- a variety of posters and signage highlighting risks and hazards as well as operational information (Figure 1.3).

OnGuard Safety Training

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RISK ASSESSMENT WORKSHEET

STEP 1 **Who is involved?**	**STEP 2** **What does using the equipment involve?**	**STEP 3** **What are the hazards?**	**STEP 4** **Can the OHS risks be reduced?**	
What is the item of equipment or machine? Disc Sanding Machine **Who supervises the activity?** Workshop Trained Teacher **Who uses the equipment/ machine?** Year 7/8 9/10 11/12 Design & Technology Year 7/8/9/10 11/12 Industrial Technology Tech Teachers	The disc sander is suitable for sanding the end grain of long lengths of timber and smoothing flat surfaces, sides and edges of small timber pieces. The abrasive disc is made out of aluminium oxide compounds, which comes in different grades. The work piece is held in the hands of the operator. While pressing firmly down against the sander table, the operator slowly presses the work piece against the down side of the revolving sanding disc. It is important that the work piece is not lifted up off the table. The work piece should be slowly moved sideways while sanding.	**What injuries, illnesses or problems could occur?** • rotating disc – eye and finger injuries • movement of the workpiece • inhalation of fumes and dust particles • electrocution from power faults, faulty equipment or incorrect use • ejection of waste materials from sanding procedure • burns from hot materials or friction of disc	Can safer equipment or machine be used? **Yes/No** Name? Can the equipment or machine be modified and made safer? **Yes/No** How? Can use of equipment or machine be reduced? **Yes/No** How? Can PPE be used to improve safety? **Yes/No** How?	**What are our current control measures?** • Instruction • Testing • Teacher Permission to use • Supervision • Clearly defined safety zone • Inspection, testing and tagging of equipment • Dust extraction system • PPE such as spectacles and/ or dust mask, as indicated over page
	STEP 5 **What is the type of work environment?**	**STEP 6** **Have the instruction and training needs been addressed?**	**STEP 7** **What are the NSCA associated risk elements?**	**STEP 8** **When will the risk assessment be reviewed?**
What is the location of the activity? Wood Workshops	Noise X Air X Traffic X Hazardous Outdoors Heat Other:	Is a documented Safe Work Procedure available? **Yes/No** Do we have a documented training procedure? **Yes/No**	**Probability:** Unusual but Possible **Exposure:** Frequent **Consequences:** Minor	
What is the assessed Risk level?	Low Moderate Substantial High Very High		______ ______ ______ Assessor Position Date	

Figure 1.2 Risk assessment worksheet

➢ **Moderate risk of injury** if the correct procedures described for the activity are not employed in the prescribed manner

➢ **Teacher approval** is required. **General, but vigilant, teacher supervision** should be maintained.

➢ The operator must operate in the clearly defined **safety zone**

➢ **Appropriate PPE** is required to further reduce the risk of injury.

Risk of Injury is

MODERATE

Level

2

To operate this machine/equipment, you must have:

- Read and understood the Safe Working Procedure
- Completed the Safe Work Test with a 100% score
- Demonstrated competent and safe use

Figure 1.3 Assessed risk warning triangle

CHAPTER REVIEW QUESTIONS

1. Why is it important to maintain a clean workplace?
2. Perform an internet search for 'Chemwatch' and describe what it is and what it does.
3. In the three sections under the main heading 'WHS in the workshop for students' (pages 5–8), what point is so essential that it is mentioned three times?
4. From each of the following sections, 'When you enter the workshop', 'When undertaking practical work' and 'When using electrical tools and machinery' choose the three most important points that refer to students.
5. What do you think is the main purpose of the *Work Health and Safety Regulation 2011*?
6. Define a 'workplace hazard' and offer two examples relating to the workplace.
7. Briefly describe what SafeWork NSW is responsible for.
8. What is the purpose of assessing and controlling risk?
9. What is an SDS? What is its purpose?
10. Complete a risk assessment for the project you are working on.

CHAPTER

2

Design principles and processes

While woodworkers should possess a sound knowledge of wood and its associated products, and a basic proficiency with tools, it is also important to have an understanding of good design principles.

Designing is about creative problem solving to meet specific human needs. The need for design applies not only to elaborate and decorative pieces, but also to everyday items, such as cutlery and crockery, pots and pans, buttons, shoelaces, spades, rakes and buckets, as well as more complicated items, such as furniture, machines, cars, aeroplanes and buildings.

This chapter provides sufficient information and know-how to encourage the reader to create his or her own design solutions to suit particular needs and tastes.

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Key terms

aesthetics the science that deduces from nature and taste the rules and principles of beauty

analysing examining something critically to determine its essential elements or features

anthropometrics the study and measurement of the size and proportions of the human body

brief a concise statement clarifying the project task and defining the need or opportunity to be resolved

cross-sectional sizes when looking at the end of a piece of timber – its width and thickness

design process an activity that starts with the identification of a need or a problem through to the evaluation of the solution

dressed all round (DAR) a rough-sawn piece of timber that has been machine planed on all four faces

ergonomics the design of objects to take into account the bodily needs of a worker in the workplace (e.g. the shape of an office chair)

evaluation assess if the project has achieved what the brief intended

function how an item operates or fulfils its purpose

nominal the size of rough-sawn timber prior to DAR

parameters limits or guidelines that control a design

prescriptive a problem with many parameters (constraints) allowing less freedom in a design process

project sequencing the process of placing the stages of producing a design in a viable order

super foot a method of measurement used on exotic and rare timbers; its volume is 300 × 300 × 25 mm (1 foot × 1 foot × 1 inch)

time management organising one's time in the most efficient way possible

working drawings orthogonal drawings used for construction of a project

working rod (or measuring rod) a full size working drawing of a project where the sizes and joints can be marked

Design can be a relatively simple process or highly complex, depending upon the designer's knowledge and experience and the item being created. Designing a new model of car or aircraft would require extensive experience, specialist skills and a large team of people. However, a simpler process is involved if a student, new to design and woodwork, is given a relatively **prescriptive** design task requiring the minimum of research or experience, such as designing a food tray.

Applying a **design process** to satisfy a need is a more rewarding exercise than simply working to an existing plan. Modifying an existing design may be all that is required, but it can still be satisfying. This is often referred to as the partial or modified design process. To apply the design process to solve a problem or satisfy a need, you should consider the various factors of this process to achieve a result that will be both functional and beautiful.

Factors influencing design

The social life and customs of the time are always major influencing factors. For example, the highly decorated buildings and furniture of the 18th and 19th centuries reflect the elaborate tastes seen in the dress and manners of those times.

The novice woodworker, and sometimes the experienced craftsperson, tends to be more concerned with the 'nuts and bolts' of fabricating a piece of furniture than with its overall design. As a result, even expertly made pieces often lack the appeal of well-designed commercial products. One of the reasons for this is the lack of any recognisable style in the pieces produced. Therefore, you should seek out designs that have clearly recognisable styles. For example, you could make a comparison of the chair styles of some contemporary Australian furniture designers (Figure 2.1).

There are no hard and fast rules by which you can ensure that a design will be good. However, if certain essential concepts or ideas are absent, you can be sure a design will not be good. For convenience these concepts can be grouped under two categories.

1 **Function**: how the design will work or perform the job it was designed for.

Guell Stool by David Upfill-Brown. Jon Harris Photography

Phoebe Everill

Ross Annels: Bent bar stool (steam bent quandong and spotted gum)

Figure 2.1 Chair styles of some contemporary Australian furniture designers; **a** David Upfill-Brown, **b** Phoebe Everill, **c** Ross Annels

2 **Aesthetics**: the appeal and beauty of the finished product.

As you will see, these are closely interrelated.

Function and aesthetics

Design involves combining function and aesthetics in varying ratios. A design can have a high degree of functionality but very little aesthetic appeal. For example, a wooden mallet is designed to apply a striking force to a chisel and its appearance is not of high importance (Figure 2.2). In contrast, a wooden sculpture boasts design with dominant aesthetic properties, and is appreciated for these values (Figure 2.3). An example of the mix of the two aspects is a dining chair, which must seat the person comfortably at the table and look good with the rest of the furniture in the house.


iStockphoto.com/tmacphoto

Figure 2.2 A wooden mallet is designed for its function rather than its aesthetics


Grant Vaughan

Figure 2.3 A wood sculpture by Grant Vaughan boasts design with dominant aesthetic properties

The design process

The design process has a very important place in woodworking. To design we need to bring together all the factors: function, appearance, size, materials, construction, cost and safety. To illustrate that the design process is flexible and that some stages may

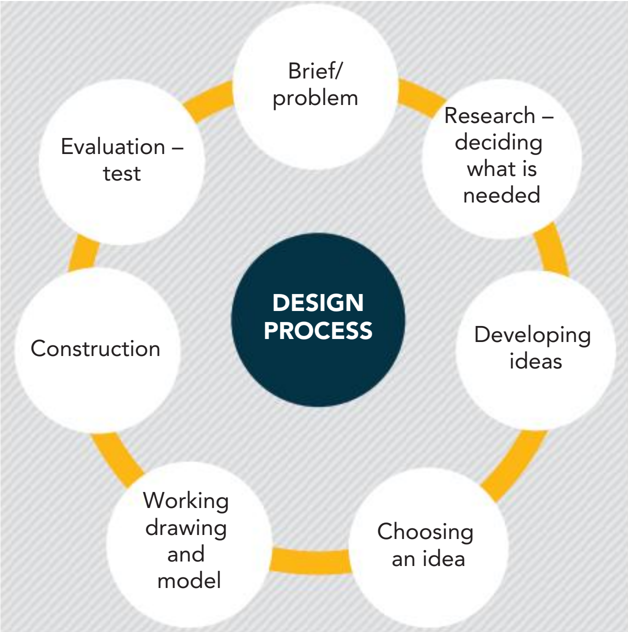

Figure 2.4 The design process

be repeated, it can be represented as a circular chart (Figure 2.4).

An easier method of representing the design process for beginners is in a fixed order, as shown below.

1. Brief (problem)
2. Research (decide what is needed)
3. Develop ideas
4. Choose an idea
5. Working drawing and model
6. Construction
7. Test (evaluation)

The brief or problem

The **brief** is a concise statement clarifying the project task and defining the need or problem to be resolved.

It is suggested that the designer breaks down the need or problem into parts to make it clearer to decide what is required to solve it. This often includes the **parameters**, or constraints that need be looked at because they may affect or restrict the design. These often include:

- time constraints (to complete the project)
- safety for the user (no sharp or weak parts)
- materials involved
- size (limited dimensions)
- budget (limited available finance).

Research (investigation)

Functional aspects

- *Fitness or suitability for purpose*. Is the item to be placed indoors or outdoors? Is the timber to be used appropriate to withstand the weather? Teak (oily), treated pine and Tallowwood (resists decay/insects) are fine for outdoor use; almost any timber is good for interior use.

HINT

An excellent reference for information like this is *Wood in Australia: types, properties and uses, second edition*, McGraw-Hill, ISBN 9780071014014.

The Australian Timber Database

Weblink

- *Cost factor*. A senior student may be tasked with selecting and paying for the timber they choose to use in their major project. There are several aspects to consider regarding this. These aspects are then prioritised and shortlisted. A spreadsheet may be made up of the shortlist, for comparison purposes. The following is an example of a prioritised shortlist:
  1. colour of the wood (heartwood and sapwood)
  2. availability
  3. cost
  4. method of conversion (for grain and matching)
  5. working characteristics (hard to plane, wavy grain, etc.)
  6. density
  7. available sizes (without joining)
  8. manufactured boards (backs, bases and large areas).
- **Ergonomics**. The difference between a well-designed piece of furniture and one that is useless is largely determined by how the furniture fits the human frame and how it has been adapted to the way people use it. Serious designers study the comparative dimensions of the human body to arrive at the initial scale and dimensions of a piece of furniture.
- **Anthropometrics**. Standardisation of certain body measurements helps designers know, with a high degree of accuracy, the parameters imposed by the human frame on their designs (Figure 2.5).

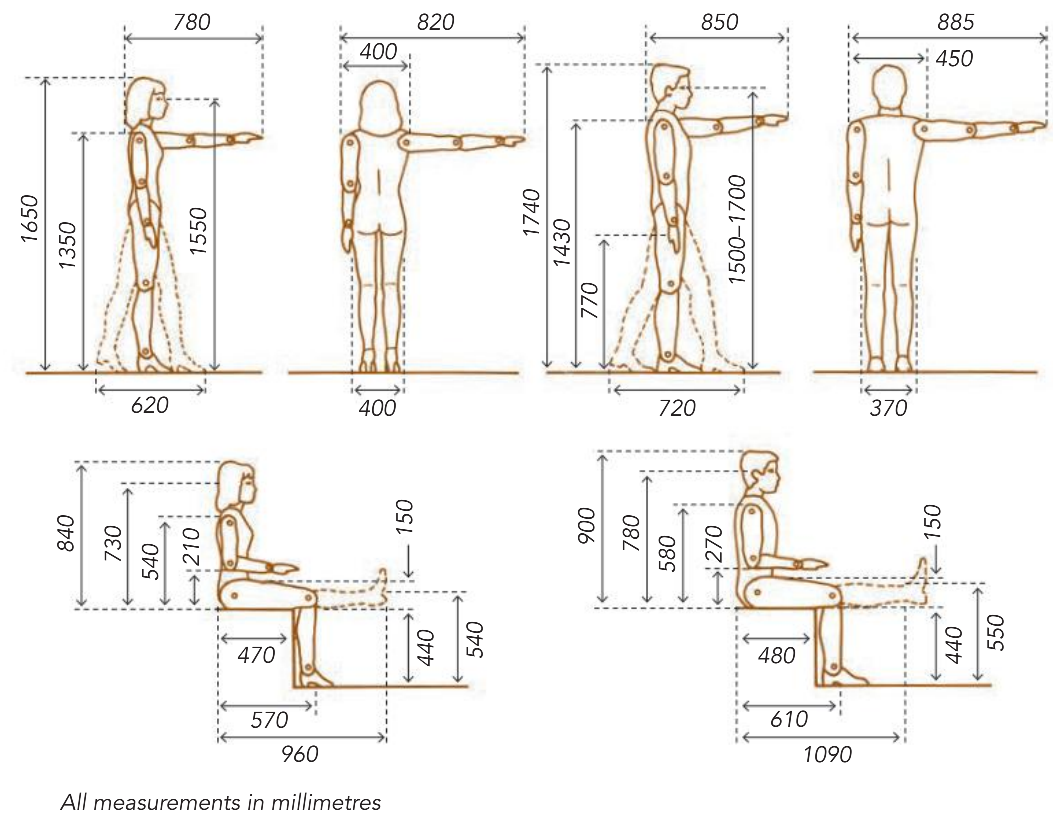

Figure 2.5 Diagrams indicating how average dimensions of men and women determine the dimensions of furniture

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It is important to realise that the 'average physical proportions' used in furniture design satisfy the majority of the population but do not necessarily satisfy people at the extreme ends of the size scale. Even though a designer tries to cater for at least 90 per cent of the population, the top and bottom 5 per cent may not always be taken into consideration. These limits are known as the 5th and 95th percentile (Figure 2.6). Therefore, the designer should further refine data to fit a particular case. For example, think of designing furniture for children – how do you make allowances for growth?

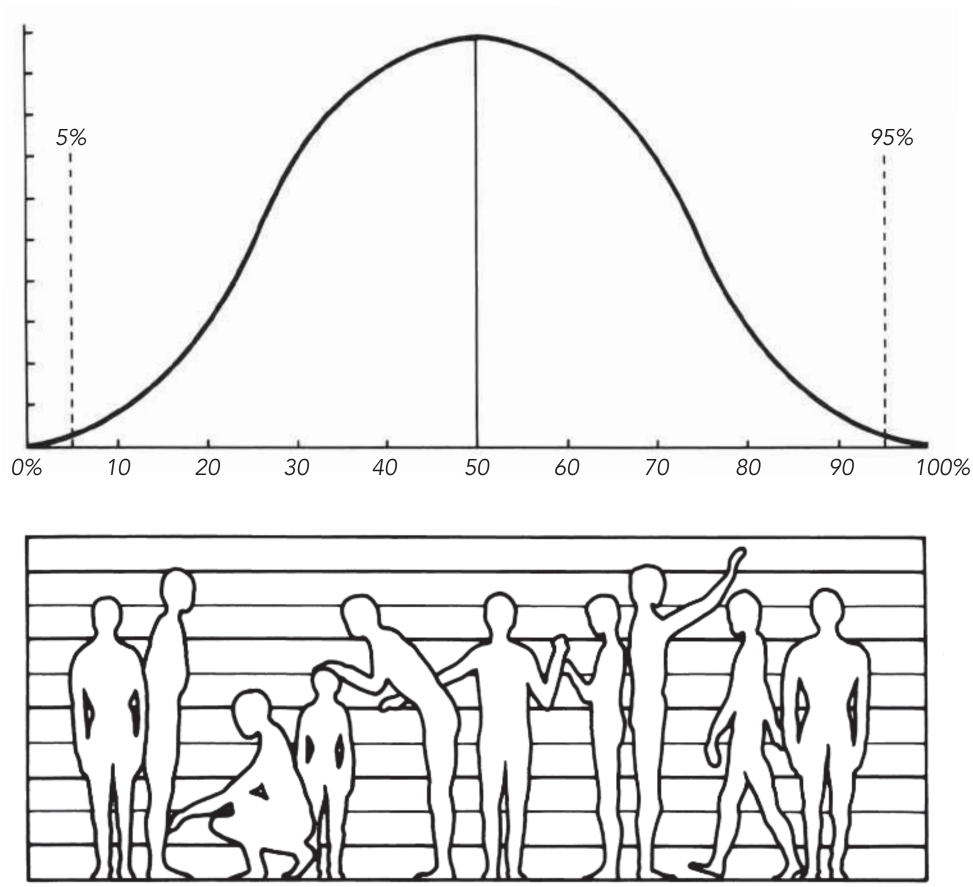

Figure 2.6 Graph showing distribution curve for given number of people in relation to height; some people are very tall and some are very small, but majority fall into the area either side of the middle or 'mean'

- *Safety*. A vital consideration in every design. For example, there should be no sharp parts (even an arris can be a danger), no chance of the item breaking easily, no small parts that could fall off and be swallowed by a child and no toxic finishes (lead paint is illegal).
- *Construction method*. For example, working out the choice of methods for joints, **analysing** and making valid choices (written).
- *Hardware*. Research the nails, screws, hinges, locks and so on to be used and make valid choices. Hardware is discussed in detail in Chapter 7.
- *Finish*. Choose an appropriate finish for protection. Finishes are discussed in detail in Chapter 12.

Aesthetic aspects

- *Harmony and unity*. Woodworkers have many factors working to their advantage in producing harmony in wooden pieces. A cabinet made entirely of one species of timber will naturally have continuity and harmony. The rule is that in any design, no part should look odd or misplaced and that styles should blend in the finished item. For example, lack of unity and harmony can often be seen in structural additions to buildings, where the new part has been added in a style or with materials not in keeping with the original.

- *Variety and contrast*. Different materials, textures, colours, sizes, ornamentation and decoration, and shapes provide variety and contrast. These are the qualities that offer life and interest to a design. In furniture, variety may be achieved through changes in timber grain direction, contrasting materials, curved shapes, and the colours, textures and patterns of upholstery fabrics.
- *Rhythm*. Rhythm offers the essence of movement to a design. This may be achieved through the arrangement or repetition of decorative features, or through the smooth flow from one part to another, such as the curve in the arm of a chair, a table leg or in a mirror frame.
- *Symmetry*. The result achieved when parts of a design are equally spaced about a centre, such as a clock face, or when similar equal parts face each other from either side of a dividing line.
- *Composition*. The thoughtful blending of design components. It is the key to aesthetically successful and pleasing design.
- *Finish*. Choose the right finish for looks, such as a glossy finish to enhance the grain. Finishes are discussed in detail in Chapter 12.
- *Colour and grain flow of timber*. Always choose the best grain for exposed areas, such as drawer fronts and surfaces, to show them to best advantage (mark and allocate these parts first). The colour might be important if the piece is to blend with other, existing furniture. Try to centralise, rather than offset, any grain features.
- *Proportion*. The length:width:height ratio has to not only accommodate the contents of the piece (such as a Blu-ray player and stereo unit) but also should be visually appealing in terms of aesthetics. If possible, it should also match the style of existing furniture. The golden mean or golden section is a rectangular shape – with origins around 500 BCE (Pythagoras' lifetime) – that is a design presence in nature's shapes and was found to be a geometric ratio of 1:1.618 (see Figure 2.7). This ratio is still used today in many forms of architecture and art because of its excellent aesthetic qualities.
- *Decoration*. This includes a variety of forms, such as carving, pyrography, fretwork, arris treatment, handles and inlay work. The options are extensive but should be sketched on paper first to ensure that the best use is made in the end result.

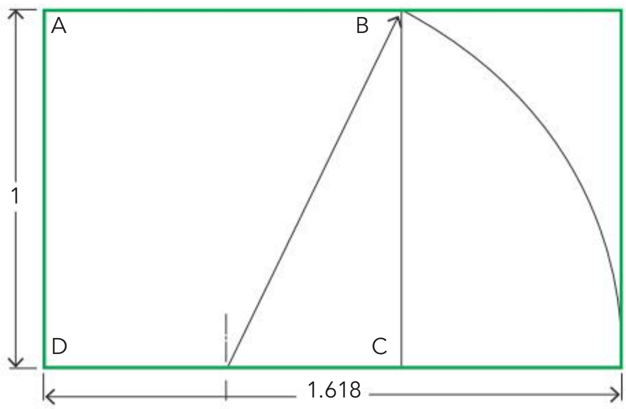

Figure 2.7 The Greek golden mean, or golden section, is based on a rectangle with ratio of width to length equal to 1:1.618 or approximately 5:8

Ideas and final choice

When all the research is completed, various sketches of possible solutions should be drawn up, discussed and considered. When a final decision has been reached, highlight the outline of the chosen design so it stands out from others.

The project as a whole should be broken down into smaller sections to make it more manageable. For example, if you are designing a drawer (see Chapter 7), it is important to work out what it might be used for; the contents may demand particular dimensions. Next, choose the joints to suit the drawer's use and sketch them, adding the dimensions. Now, decide on a method of fitting the base, runners and stops. With all the necessary information available, a set of **working drawings** should be completed.

CHECK YOURSELF

1. Give reasons for adding 10 per cent to the length of each cross-sectional size of a timber order.
2. Provide an example of a highly complex design project and provide reasons to justify why you think it is complex.
3. Name and describe the two aspects of design.
4. What is the purpose of a brief during the design process?

Working drawings

These may uncover a problem needing a little design refinement (alteration). Before starting the project, a fully dimensioned scale drawing or a full-size drawing may be done on paper or on a strip of timber or plywood; in this case, it is called a **working rod** (or **measuring rod**). Details of this type of drawing are included under the 'Orthogonals' heading in Chapter 3 (page 25).

Pictorial drawings

Pictorial drawings are discussed in Chapter 3.

Material list

Material lists, also known as cutting lists, are discussed in Chapter 3.

Ordering

When you order timber, the retailer or local timber merchant will not be interested in a list stating, for example, six pieces of 350 × 120 × 19 mm timber. They will want the total length of a particular cross-section, including an additional allowance for cutting, problems, splits and knots. You may have a few different **cross-sectional sizes** so you will need to be organised.

Timber is sold by the linear metre (lm), in 300 mm increments. Traditionally, the minimum length is 900 mm (0.9 m) and the maximum 4.2 m, with 300 mm being the widest board available.

FACT

Although some retail outlets have increased the minimum saleable length, they have still retained the 300 mm increments – a link to the imperial 'foot'. The maximum width of 300 mm is getting scarcer as trees are being harvested earlier and, therefore, lack the necessary diameter.

A timber order must contain the following:

1. the material required
2. the **nominal** cross-sectional size (width and thickness)
3. the number of pieces and their specific lengths (including the 10 per cent extra). Other lines are added to the order, with similar information if a different cross-section of timber is required.

The order would be set out as shown in Figure 2.9.

HINT

Warning: 'nominal' is the width and thickness of the timber as it comes 'rough-sawn' from the sawmill (see Figure 2.8). These sizes are 18, 25, 38, 50, 75 and 100 mm for thicknesses and 50, 75, 100, 150, 200, 250 and 300 mm for widths. The timber is then dressed all round (DAR), which means it is put through a thicknessing machine that takes 3 mm off every side and edge (also known as the 'finished' size). Although this saves time by normally giving you a clean, accurate surface, the downside is that the overall width and thickness of the timber have been reduced by 6 mm and this must be taken into account when placing your order (see Fig. 2.9). You will pay for nominal-sized timber but receive DAR-sized timber (i.e. you pay for the DAR shavings). This does not affect length in any way.

CHECK YOURSELF

1. What is the purpose of a pictorial drawing in the design process? Name an alternative.
2. Suggest another word that could replace 'investigation' in the design process.
3. Under what circumstance would you use freehand sketching in the design process?
4. List six aspects that require investigation in most designs.
5. Apart from designing a product, discuss and provide examples of two areas to which design may be applied.
6. Why is it important to the design process to know how a piece of wood is converted and what its working characteristics are?
7. Define 'generic' as it applies to design.
8. Justify why you would analyse three possible joints that might be used for a certain design.
9. List the steps necessary before working drawings can be produced.

Figure 2.8 Examples of rough-sawn timber (note the blade marks from the saw mill) and DAR (dressed all round) timber – a smaller width and thickness after this process

Costing

Timber is costed using different methods depending on the situation. Sawmills (wholesaler) handle such a high volume of timber, they cost it by the cubic metre. Local timber stores (retailer) typically sell **DAR** timber at varying linear metre prices for each cross-sectional size they stock. For specialist exotic and rare timber sellers, costing has traditionally been by the **super foot**. A super foot is 1 foot × 1 foot × 1 inch, which equates to 300 mm × 300 mm × 25 mm. Therefore, this method works on volume as opposed to linear metres.

Costing is calculated individually per cross-sectional size. These subtotals can then be added, followed by GST.

Material	Cross-sectional size	Lengths of pieces	Totals for cross-section including 10% extra
Pacific maple	150 x 25 nominal	1/3.3 m; 3/2.7 m	- total 11.4 lm
Radiata pine	50 x 50 nominal	1/0.9 m	- total 0.9 lm
	Sized as rough sawn	Number of pieces	Linear metres

Figure 2.9 Order for Pacific maple and radiata pine

A costing for the above order would be set out as shown in Figure 2.10.

Material	Cross-sectional size	Cost per linear metre	Cost x length	Sub-total
Pacific maple	150 x 25	@ $5.46/lm	$5.46 x 11.4 m	= $62.24
Radiata pine	50 x 50	@ $2.12/lm	$2.12 x 0.9 m	= $ 1.91
			Total	= $64.15
			Plus GST 10%	= $ 6.42
			Grand total	= $70.57

Figure 2.10 Costing of the order in Figure 2.9

Production

Once the working drawings have been completed, producing the item is not just about applying techniques and using tools or equipment safely.

Project sequencing is an important part of a successful construction or production process and should generally follow this order:

- selection of the proper timber (i.e. grain and features), marking out lengths and labelling parts (leave 5 mm space between for cutting and sanding)
- cutting and sanding to length
- marking for joints and shaping
- cutting joints, and drilling and shaping – including turning
- applying any aesthetic decoration
- sanding to an almost-finished state
- gluing and assembly, with checks completed for square and diagonals
- final sanding
- staining, if necessary, and applying a finishing layer
- upholstering and affixing hardware
- waxing, if necessary, and performing final functional checks.

Time management is an essential aspect of completing a project within the allocated timeframe. Senior students are expected to plan ahead by first looking at the available time for the project then drawing up a pre-timeline plan that covers the complete design process from the brief through research, analysis, decision-making, drawing, production to evaluation. This pre-timeline plan is essential because it can be checked against the project's progress to see if the student is behind schedule, on target or ahead of time. The student can then take appropriate action to meet the timeframe.

Working co-operatively is a necessary attribute in any good workshop because it promotes a safer working environment if people are aware of and looking out for each other. If the responsibility for cleaning up, replacing tools, gathering raw materials and storing projects safely is shared equally, this leads to efficient working practices. Certain projects are sometimes shared between several students. Sometimes a whole class is involved in a group design or problem. It always becomes obvious who makes the most effort and has the most input in projects such as these.

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Table 2.1 An example time plan for a project (Gantt chart)

Industrial technology: time plan								
Term dates	***Week 1–2***	***Week 3–4***	***Week 5–6***	***Week 7–8***	***Week 9–10***	***Week 11–12***	***Week 13–14***	***Week 15–16***
Research/ideas								
Working drawing /model								
Working rod								
Preparation of timber								
Joint construction								
Sanding/assembly								
Finish								
Evaluation								

Evaluation

Evaluation is a time for analysis and reflection. Re-read the original brief (statement of intent) and critically examine the end product to assess if it has achieved what the brief intended. Listed below are some of the questions that should be asked during evaluation.

- Does the item function as intended?
- Is it safe and well-made?
- Will it handle the environment in which it will be used?
- Does it appear aesthetically presentable?
- If you had your time over, would you change anything; for example, would it be a different size, more stable, use a heavier timber or be a lighter colour?
- Are the anthropometrics and ergonomics acceptable?
- Was the overall cost within budget?
- Was it all worthwhile?

All these considerations should be addressed in a final typewritten report to complete the folio and the design project.

Evaluation is an ongoing process that is carried out at each stage of the process, not just at completion.

CHAPTER REVIEW QUESTIONS

1 List three products where aesthetic appeal is the most important part of the design.

2 List three products where function is the most important part of the design.

3 Distinguish between ergonomics and anthropometrics.

4 How does the golden mean relate to proportion of a design?

5 Define a 'cutting list'.

6 Clearly describe what 'cross-sectional size' means.

7 Provide another word for 'rough-sawn' timber.

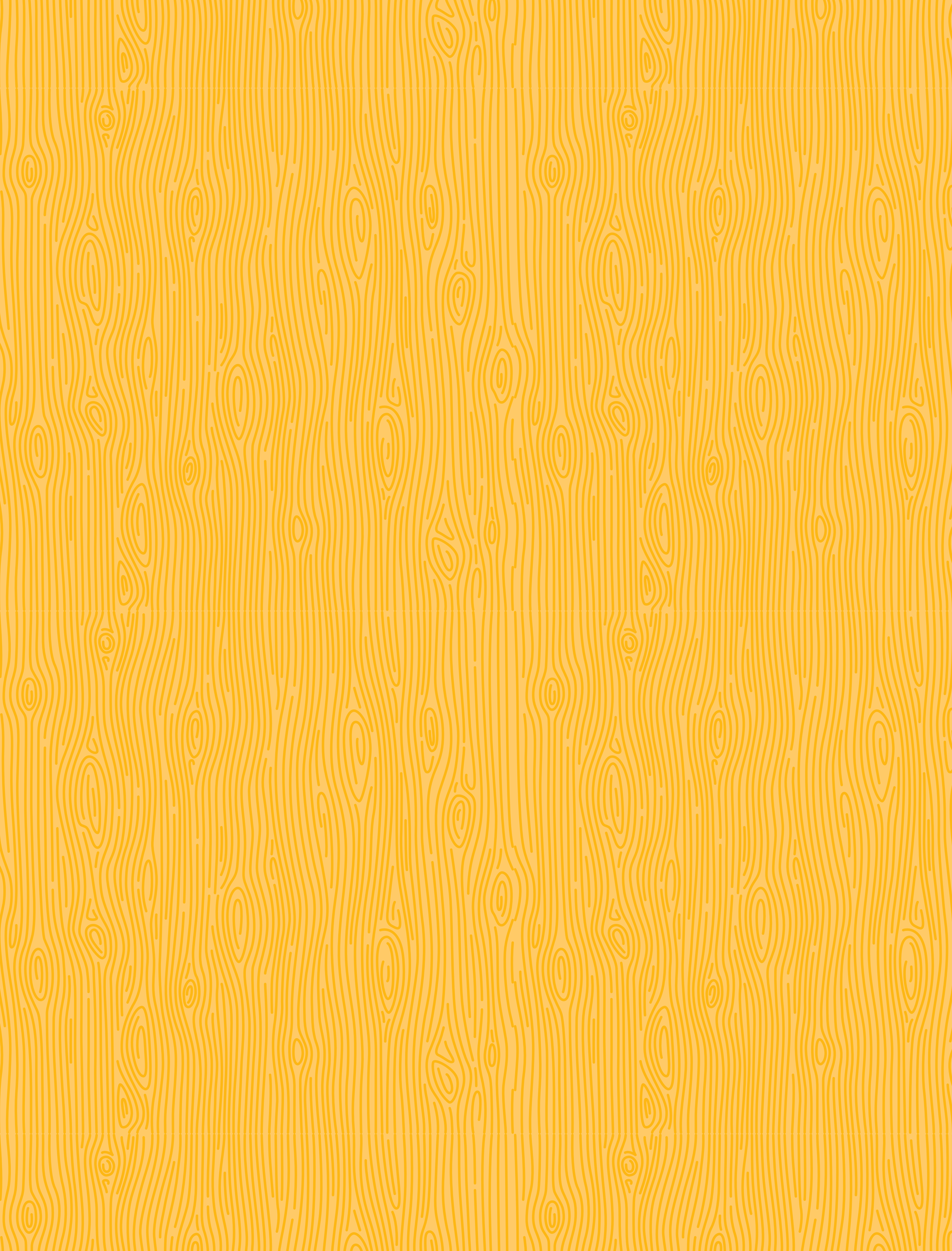
8 What is a 'super foot'? When might you encounter this term in woodworking?

9 What is the use of a working rod in furniture production?

10 Expand on the need for 'project sequencing'.

11 Explain what 'time management' is.

12 Give a brief explanation of why evaluation is an essential practice in the design and construction of a project.



CHAPTER 3

Communication techniques

Communication is the essential human act of passing on information. From drumbeats and smoke signals through to today's newspapers, radio, TV and electronic media, communication tools have been evolving. Communication is essential in woodwork and design. In this context, its role is many-faceted. While you listen to instructions and watch demonstrations from your teacher, you must also be able to read plans for project building information. When designing you need to research, sketch, make decisions, draw plans, complete the project, write a report, evaluate and present the report.

Traditionally, the method of communicating designs was by hand through sketching and drawing. With the introduction of user-friendly computer software, such as computer-aided drafting (CAD) packages, computers have taken up a much larger role in design development.

This chapter describes these techniques along with an emphasis on communication through drawing.

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Key terms

architectural referring to the art or science of buildings

axes plural of axis

axis an imaginary line of symmetry representing the centre of an object

the cloud online internet file storage

copy and paste computing term for copying information and placing it elsewhere

cursive writing in flowing strokes with joined letters

drag 'n' drop computing term for highlighting information and dragging it to release it in another position

eye level at the same level as the eyes

isometric drawing a scaled drawing with one vertical axis and two axes at 30° to the horizontal

material lists also known as cutting lists, are translated from a drawing or drawings of a project, extracting all the necessary detail to cut the parts out to exact sizes

oblique drawing a scaled drawing with one vertical axis, one horizontal axis (basically a front view) and the other axis projecting 45° to the left or right

orthogonal drawing a way of representing a three-dimensional object in two dimensions, used in working drawings

perspective a pictorial drawing where the object seems to converge together at some point in the distance

proofread re-read a completed passage to check for mistakes in spelling, grammar and content

scale in drawing, the process of reducing or increasing the sizes of an article by a set ratio in order to maintain proportion

search engine a means of looking for information on the internet, such as Google or Bing

vanishing point (VP) the point at which parallel lines receding from an observer converge to a point (e.g. as with a long straight road)

Drawing

In Australia, the methods and rules for laying out various views of a project, constructing your drawing and providing different dimensional points are known as *Australian Standards* (AS 1100). Therefore, it is important to learn and apply these methods and rules. The more frequently used methods are discussed below.

Sketching

Sketching is a skill improved through practice. As a freehand method (rules are not necessary) it is used to start a design project, although there are other uses for sketching. You will initially be given a brief, which you may think about, research and discuss. You may wish to put some ideas down on paper as inspiration strikes (before you forget them). Sketching is the ideal way to do this using a sharp pencil, an eraser and some A4 or rectangular grid paper. Your name should be clearly marked on the paper.

Figure 3.1 shows some freehand sketching and workings for a large die to be used as a pencil holder and paperweight. Which of the dimensional sketches gives the most information when looking at the overall design? There are occasions when a flat view is better, as in working out the positions of the dots. The rough working should be retained in case a recheck or alteration is required. Keep sketches neat and tidy, make them large enough to read the details and use printing rather than **cursive** writing. Always keep all sketches for your report; they are essential to show your design application.

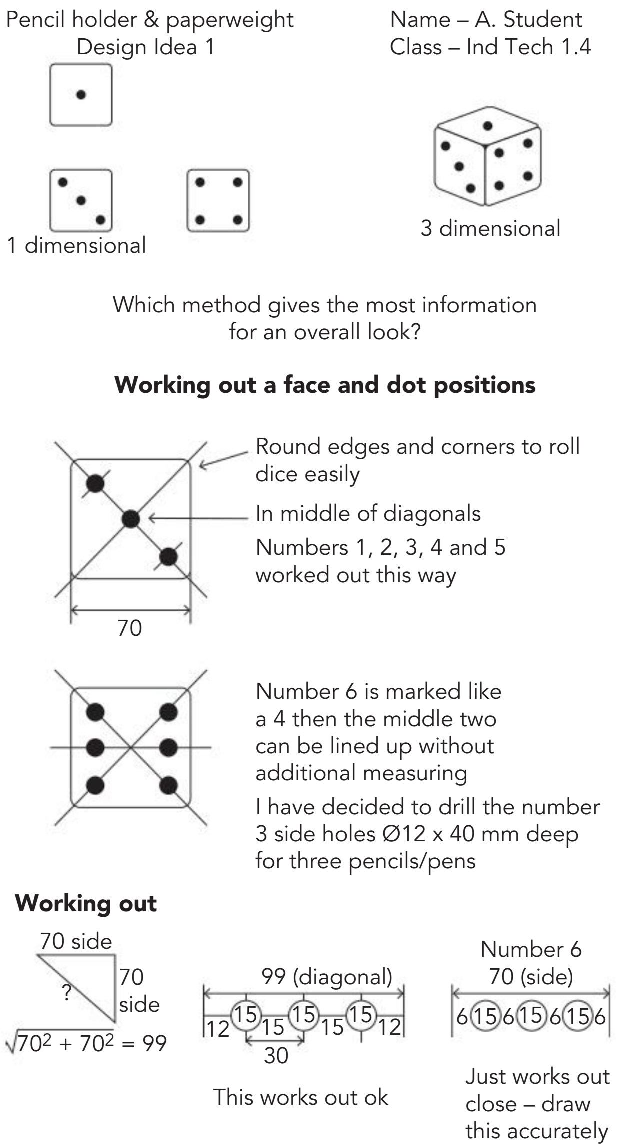

Figure 3.1 Example of a sketch page

Orthogonal drawing

Orthogonal drawings or working drawings (also referred to as workshop or cabinet drawings) (Figure 3.3b) are used by a production team/individual to construct a project. They consist of systematically arranged views of the faces of an object, such as a front, top and side view. However, more views may be used to show additional details when necessary (Figure 3.4).

A working drawing (which may be a freehand pictorial sketch, a fully dimensioned scale drawing (Figure 3.4) or a full-size drawing) is made. The full-size drawing may be done on paper or on a strip of timber or plywood; in the latter case, it is called a working rod (Figure 3.2). The advantage of a full-size drawing or working rod is that the sizes of members and joints can be marked or taken off directly, thus lessening the possibility of error in measurement. A working rod is particularly suited to projects containing multiple parts, such as stools or tables, or where a number of pieces of furniture of the same design are required. The rod should be large enough to take full-size horizontal and vertical sections. Both sides of the board may be used. The edges of the timber should be straight and parallel so that a pencil and rule can be used as a thumb gauge to draw parallel lines and a try square can be used to square lines at 90° to the edges. It is also normal practice to include a materials list on the rod and to show overall dimensions; that is, length, width and height.

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Material list						
	Member	#	L	W	T	Material
A	Leg	4	350	90	20	Maple
B	Side rail	2	350	65	18	Maple
C	End rail	2	250	65	18	Maple
D	Handle	2	300	30	30	Maple
E	Corner block	4	90	60	60	Maple
F	Seat	1	400	250	12	Particle board
G	Foam	1	400	250	30	Foam

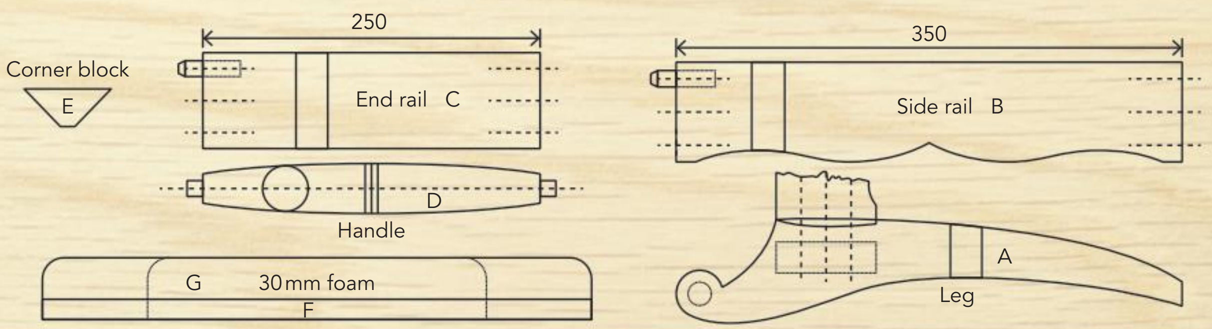

Figure 3.2 An example of a working rod for a small stool. Notice the inclusion of the material list, joint detail and cross-sectional shapes.

TRY THIS

Make a sketch of some alternative designs for a pencil holder. Select your best design and make a working drawing with a cutting list.

Tip: you will need to research:

- the size of the pencils and how many you wish to store so you can work out the overall size of the pencil holder
- the timber available to you to use for construction
- what type of joints you will use
- the style that will influence the shape of the holder.

HINT

Rotate your pencil after drawing one or two lines; it will not wear flat and will remain sharper for a longer period.

Equipment for orthogonal drawing (by hand)

Minimum requirements include a drawing board, a 'T' square, a 45° triangle, a soft eraser, a 300 mm rule (preferably plastic), a pair of compasses and a pencil.

The hardness of the pencil should match the level of pressure the student applies to it. For example, a heavier hand should use a 2H grade; a lighter hand, an HB. Take care to maintain a sharp pencil.

Always angle the pencil in the direction it is moving to give it a smoother line and guard against the tip digging in.

Scales

Drawings need to be accurate and drawn to **scale**. For example, if you were drawing a car, it obviously would not fit on a sheet of paper, so you would reduce the drawing size to around one-tenth of its actual size. A desk tidy may be drawn life size, while a mobile phone would probably need to be shown at twice its normal size (Table 3.1).

Every drawing must include its scale clearly printed so the reader knows how big the object will be when it is completed.

On a scale drawing every part must be equally reduced or equally enlarged, but all dimensions are shown actual size, usually in millimetres (Figure 3.4). The same scale is not always used for all drawings on one sheet: for clarity, details may be drawn to a larger scale with the scale generally indicated on the drawing.

Table 3.1 Deciding what scale to use for a drawing

Item	Size drawn as	Scale as shown on drawings (left side shows the actual drawing and right side the real life size ratio)
Cabinet drawing	One-tenth life size	Scale 1:10
Pencil box	Life size	Scale 1:1
Small wooden dice drawing	Twice life size	Scale 2:1 Note: other way round

Choosing a scale

The common reduction ratios are: 1:2, 1:2.5, 1:5 and 1:10. They all easily divide into 10, which makes it easier to convert real-life measurements when drawing. Imagine deciding on a one-seventh reduction and trying to work out the measurements.

The next scaled down sizes are: 1:20, 1:25, 1:50, 1:100 (guided by multiplying by 10). Life size is always 1:1 and drawing larger is 2:1, 5:1, 10:1.

Setting out views

If your eyes were positioned right over the top of the box in Figure 3.3a you would see the view shown on the top glass. The same would apply if you were to look directly at the front or side of the box.

Now imagine that you could hinge the top of the box up and the side of the box out (note the green hinges in the drawing). The drawing would then show the front view of the box with the top view directly above it and the side view directly to the right of the front view. This is exactly how you would set it out and draw it on paper (Figure 3.3b).

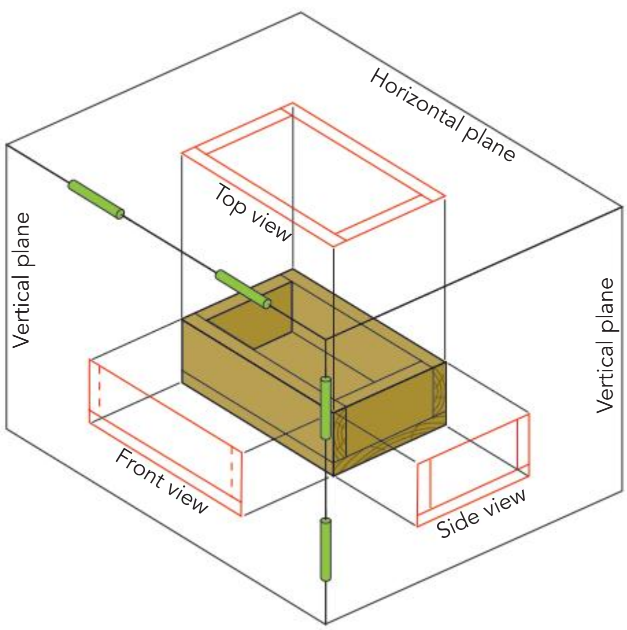

Figure 3.3a Setting out by viewing the object through a glass box

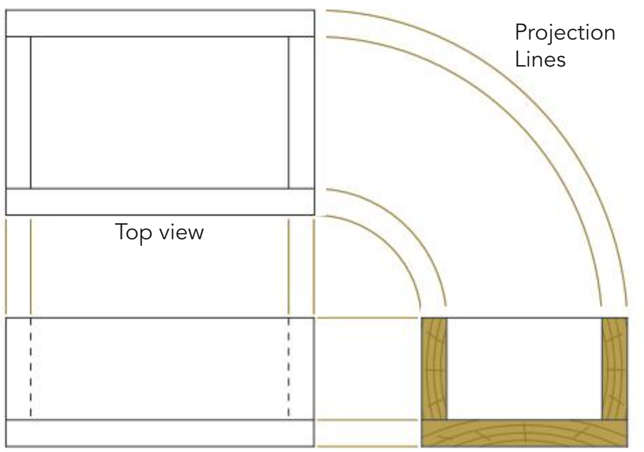

Figure 3.3b Three separate views are usually necessary in orthogonal drawings

> **FACT**
>
> In Australia we use the AS1100 drawing standard, which states that we are to use third-angle projection for orthogonal drawings. All orthogonal drawings need a top view, front view and side view. Only one side view is necessary, either left or right if each view is the same; however, if each side view has different detail they must both be drawn (Figure 3.4).

The next decision is the scale you will use, then laying out the three views (if you need three – drawing a tube would only need two) and spreading them evenly over the paper. It saves time setting out the views in this manner, because once the front view is completed, lines can be projected upwards for the

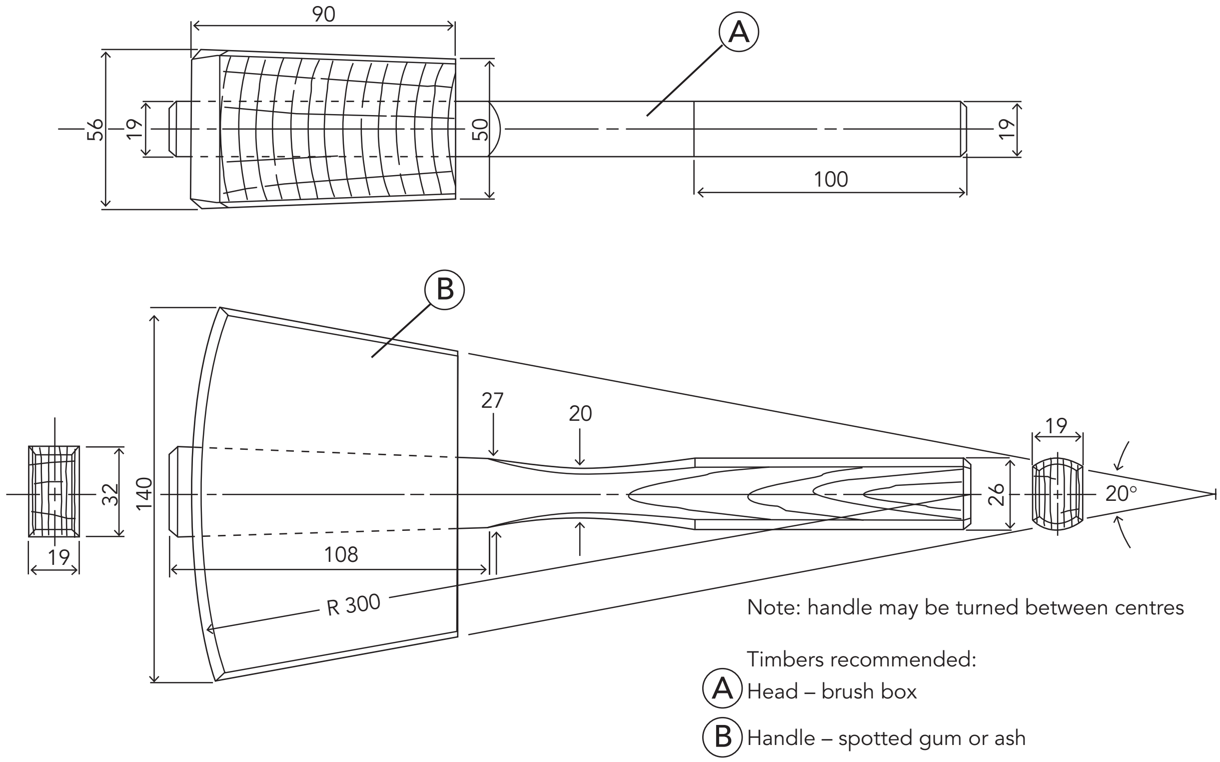

Figure 3.4 An orthogonal drawing of a mallet showing the necessity for a left and right side view

top view and outwards for the side view. Note that a single view does not provide enough information to construct an item. Every drawing page should contain the following information: the scale used (e.g. 1:10) and all dimensions in millimetres positioned neatly away from the actual drawing itself.

Dimensioning

- Orthogonal drawings must include all the necessary measurements so that the object can be created from the information supplied.
- The main drawing should be easily viewed and uncluttered, with dimensions clear of the drawing whenever possible.
- Avoid repeating the same measurement in another view; it is unnecessary.
- Regardless of the scale used, always use the full-sized measurements on the drawing.
- All dimensions should be orientated so they may be read from the bottom right-hand corner of the paper without turning the sheet.

There are five types of lines common to orthographic drawing:

1. *Construction lines* are very faint lines used when setting out the drawing. You should be able to see the line as your guide, but the person sitting behind you should not. These lines are so faint that there is no need to erase them later.
2. *Outlines* are a continuous thick line (0.5 mm thick) used for visible outlines of objects.
3. *Dimension*, *projection* and *leader lines*: are all thinner continuous lines (0.35 mm) that assist in 'reading' the drawing. They are normally kept outside the actual drawing itself. Dimension lines have a narrow arrowhead at each end that touch projection lines and illustrate exactly where measurements start and end. Projection lines are parallel lines that project from the drawing (not quite touching the drawing) at the two points being measured. Leader lines are links from printed information to the drawing, usually with an arrowhead touching the specific part of the drawing.
4. *Hidden detail lines* are used for outline detail that cannot be seen because it is behind something else in a particular view. It is a line of dashes (0.35 mm).
5. *Centre lines* are a thin series of dashes (0.35 mm thick), alternating long and short, that represent the middle line of an object like a side view of a hole or tube. When looking into a hole use horizontal and vertical centre lines crossing in the middle, which are then used to dimension a location on the drawing.

Lettering and numbering

When using A4, A3 and A2 (normal school use) paper, always print using upper case. The recommended minimum height for letter sizes are:

- 5 mm high for titles and drawing numbers (up to 7 mm)
- 3.5 mm high for sub-titles, headings view and heading descriptions (up to 5 mm)
- 2.5 mm high for general notes, material lists, dimensions, etc (up to 3.5 mm).

Material lists

Material lists, also known as cutting lists, are translated from a drawing or drawings of a project, extracting all the necessary detail to cut the parts out to exact sizes (Figure 3.2). If you are unable to complete a cutting list, it means you have left some information off the drawing or you are not reading it correctly. There is an obvious connection between a cutting list, an orthographic drawing and an ability to read the drawing.

What information is required in a cutting list?

- Column 1 – You need something to link a part in the drawing with an item in the cutting list. A number or a letter is ideal for identification; a letter prevents any confusion with amounts and measurements. Note how it is illustrated on the drawing (Figure 3.12b).
- Column 2 – Give the part a name.
- Column 3 – How many of that part are there? (i.e. there may be four legs of a table)
- Column 4 – Exact length of the part (always along the grain with solid timber).
- Column 5 – Exact width of the part.
- Column 6 – Exact thickness of the part. (This is the smallest measurement of the three.)
- Column 7 – What material (or choice of materials) is the part made from?

Check the information in the cutting list against the drawing to see if it is correct and that you understand what is required.

TRY THIS

Produce a sketch page showing the design development for a selected project, and then produce an orthogonal drawing and cutting list for the same project.

Pictorial drawing

When designing a product, you can have all the sizes worked out but you still need to visualise what the finished article will look like and its proportions before committing to either buying or cutting the wood. There are two methods of visualisation that give a better impression than the three separate orthographic views.

Cameron Fawcet

Figure 3.5 A model of a coffee table by Cameron Fawcet, see CAD drawings in Figure 3.12a and b

One method is to create a small **scaled** model, the other is to draw a three-dimensional scaled picture from your measurements (Figure 3.12a). There are several methods of achieving this; the three most common are discussed below.

Two points are worth noting. This is meant to resemble a picture of the actual object; therefore, no hidden detail is shown. Dimensions are generally not shown.

Isometric drawing

An **isometric drawing** is a scaled drawing with one vertical **axis** and two **axes** at 30° to the horizontal, one projecting to the left and the other to the right. A 30/60 triangle is required to produce isometric drawings.

The front corner of the object provides a starting point. A decision on whether you want the longest side (if there is one) to project back to the left or the right follows. This information is necessary so you can work a point from which to start the drawing. When you have a starting point, use the T-square and triangle to draw faint construction lines at 30° to the left and right and a vertical line from the same starting point. You now have what looks like the corner of a wall. From here you use your scaled measurements and create the vertical and 30° lines, building up the isometric picture (Figure 3.6).

HINT

There are no horizontal lines in isometric pictorials.

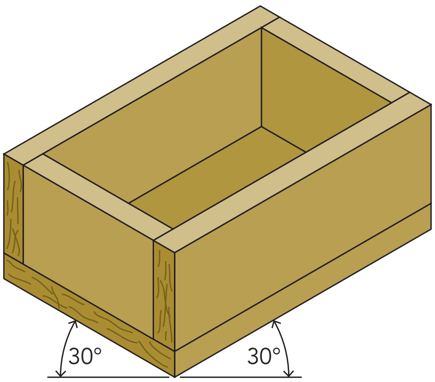

Figure 3.6 An isometric drawing

TRY THIS

Draw an isomentric drawing of a bench hook.

Tip: use the overall dimensions of the bench hook to draw a box first, then draw in the shapes.

Oblique drawing

An **oblique drawing** is a scaled drawing with one vertical axis, one horizontal axis (basically a front view) and the other axis projecting to the left or right at 45°. The lines projecting back at 45° produce an unnaturally long-looking side so, to prevent this, all the lines projecting at 45° are drawn at half their scaled length. A 45° triangle is used to produce these pictorials.

Start by deciding whether to project back to the left or the right, then work out a starting point and draw a front view (remember – no hidden detail). Now, using the 45° triangle, project the lines back (remember – half lengths) from every corner on the front view. Lastly, bring up the verticals to complete the drawing (Figure 3.7).

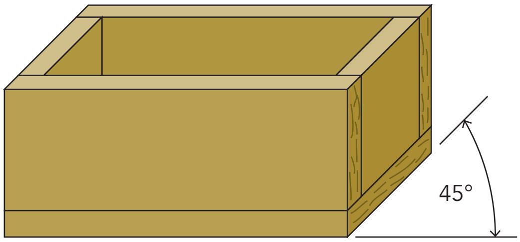

Figure 3.7 An oblique drawing

TRY THIS

Draw an oblique drawing of a bench hook.

Tip: draw the side with the most detail first then project back at 45°.

Perspective

When you look down a long straight road you will notice that the edges of the road, the roof line of the houses and the tops of fences all seem to converge together at a point in the distance. This is the effect known as **perspective** and is often used in the field of **architectural** or industrial design where the subject matter is large. There are three variations of perspective drawing: one-point, two-point and three-point perspective.

One-point perspective

A typical example of one-point perspective is the road mentioned above, which has parallel horizontal and vertical axes, and an axis that is projecting away and converging to a **vanishing point (VP)**.

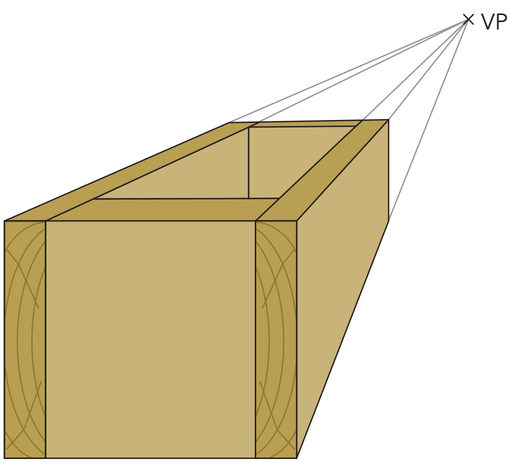

Figure 3.8 Single point perspective drawing

TRY THIS

It is relatively simple to draw a room in one-point perspective.

1. First, stand in a room with your back against the middle of a wall, now look at the wall to ceiling lines projecting away from you, they appear to be converging.
2. To draw this, get a sheet of A4 paper and construct the diagonals (where they cross is the VP and will be your **eye level**).
3. Next draw a horizontal line 50 mm down from the top of the page, across from one diagonal to the other, drop vertical lines and construct a rectangle with the other corners at the lower diagonals. This will be your back wall.
4. On the bottom right corner of the back wall draw a rectangle that will be an end of a kitchen unit (20 mm wide by 30 mm high). With a rule lined up through the VP and the three corners of the rectangle, in turn, draw faint lines towards you. These are the surface and front of a cabinet.
5. Decide how long you want the cabinet and draw the vertical and horizontal lines that are the end of the cabinet. Repeat for the left side and you will see the room taking shape. The more items you add, the better it looks. Just remember horizontal and vertical lines, and the other axis going back to the VP (Figure 3.9).

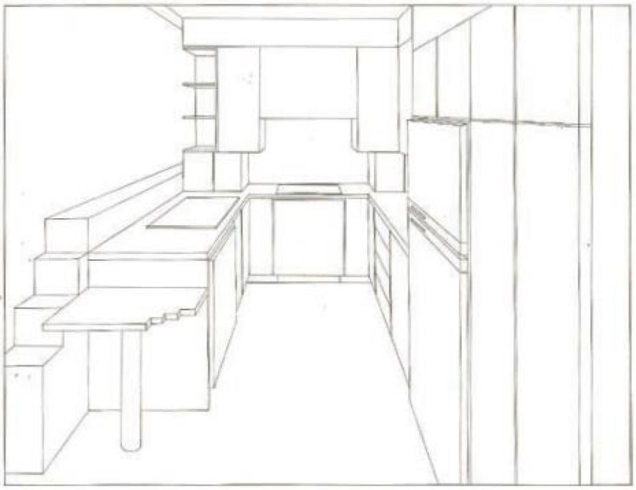

Figure 3.9 A kitchen drawn in one-point perspective

Two-point perspective

This method uses two vanishing points on the same horizontal plane (at eye level) and one vertical axis of parallel lines. The two VPs are normally set on the left and right – possibly even off the paper. This effect is like standing in the middle of a crossroad looking at a corner with one long road going away to the left and the other to the right, both going to their own VP. By altering the height of the VPs (eye level) the effect of looking down upon, or up at, the object can be achieved (Figure 3.10).

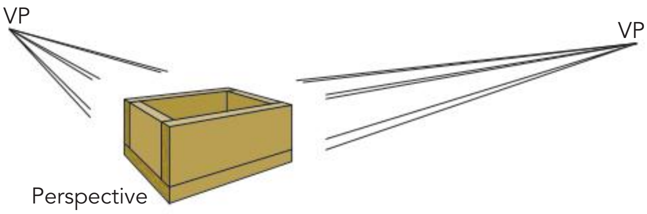

Figure 3.10 A two-point perspective drawing

CHECK YOURSELF

1. Describe two methods of producing orthographic drawings.
2. What is another name for a working drawing?
3. Describe a working rod.
4. Define the term ‘pictorial drawing’.
5. Name and describe three methods of pictorial drawing.
6. What are pictorial drawings useful for in the design process?

Computer software and technologies

The evolution of computers has spawned a range of software packages to record and store, manipulate and display information. It can be displayed as print matter that is stored in a folder either on the computer or in **the cloud**, viewed on screen with text and graphics on the internet, as a movie on YouTube or heard as a narration. Information can be passed on via email or file sharing programs, posted on CD, stored on a memory stick or DVD or simply printed.

The internet

The internet offers a huge database for research. You can direct your search for subject-specific information using a **search engine**, such as Google or Bing. The internet can also be used to discuss topics through forums and clubs on related subjects or problems, order products and services as well as email work home. Advances in wireless laptops and networks are making connecting simpler while providing choices in data transfer speeds. Using the cloud to store your information allows you to access this data on many devices and from anywhere the internet is available.

Word processing

Probably the most used piece of computer software, word processing, is one of the most useful tools, allowing you to record information, construct folios, write reports, prepare homework, undertake basic drawing and create tables. Optical character recognition (OCR) programs allow you to scan a page of text which then gets converted to a file that allows you to manipulate it using a word processor. Similarly, there are voice recognition programs that allow you to talk to the computer, which then converts speech to text. The reverse is also possible; text can be converted and read to you.

What is word processing? There are three stages to word processing:

1. *Creating* is basically typing, without worrying unduly about grammatical errors.
2. *Editing* is when you spell and grammar check (can be automatic), **drag 'n' drop** or **copy and paste** information, and **proofread**.
3. *Formatting* is improving the layout through the use of justification, bold, italics, underline, tabs, bullets, headers/footers, borders, shading, line spacing and importing pictures, which makes the text more readable and more visually presentable.

Computer graphics

By including photographs, illustrations and drawings you can add interest and information to your work as well as improve the presentation of assignments and folios. It is relatively simple to create computer graphics by using a scanner, or downloading pictures from the internet or a digital camera.

Digital cameras typically include software for adjusting light and contrast, producing special effects, such as sepia and monochrome colouring, and joining (stitching) pictures together to create a panorama.

The use of graphics is essential in web page construction.

Presentations

Presentations can involve text, speech, or music and graphics, and can be made to run automatically (or manually) with pre-set time delays for people to read, listen, watch and learn.

Databases

Databases store, manipulate and extract specific information and are very useful for quickly sorting through large amounts of data. For example, the Yellow Pages or White Pages (online or in a book) are typical large databases regularly used for research purposes.

It may be useful to create a database of people and contact details, or products that companies provide, including models, location, delivery charges and delays, available discounts and prices. This will allow you to choose the cheapest product, the nearest store and so on, very quickly.

Spreadsheets

Spreadsheets are ideal for creating cutting lists, recording expenses (and quickly costing out a project), making lists, making charts and graphs in your reports for finance and time plans.

Coffee table materials costs								
Letter	Part	Amount	Length	Width	Thickness	Total	Price	Total cost
A	Top	1	1200	1200	33	$1.44m^2$	$\$150/m^2$	$216.00
B	Long leg	4	630	95	30	2520	$26/m	$65.52
C	Support leg	4	290	95	30	1160	$26/m	$30.16
D	Base leg	4	510	95	30	2040	$26/m	$53.04
							Total	$364.72

Figure 3.11a An example spreadsheet used to calculate the costs of timber for a coffee table

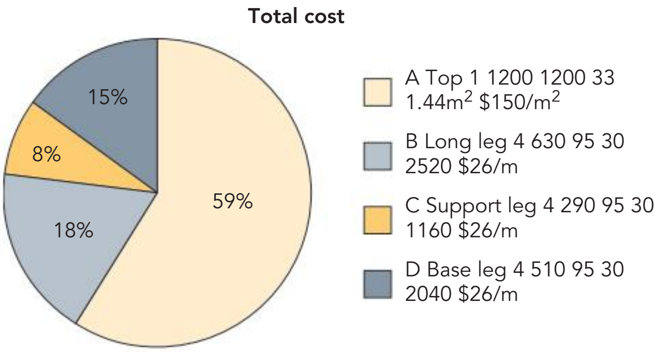

Figure 3.11b A pie chart showing the percentage costs of timber for a coffee table.

Computer aided design and drafting

Computer aided design and drafting (CADD) is a clean and fast method of drawing engineering orthogonals to scale, adding dimensions, making alterations and printing the end result using dedicated machines. It is also possible to make pictorials, which are able to be rotated, tilted, enlarged, reduced and altered. Software programs are becoming more user friendly and more versatile in their application. CADD drawing has become an important part of the designing and manufacturing industry. Many kitchen and joinery companies use CADD to help the customer visualise the final design by producing a solid model drawing of the design (Figure 3.12a). The CADD drawing can be used to make an orthogonal working drawing with a cutting list (Figure 3.12b) that a computer numerical controlled (CNC) machine can use to accurately cut out the components for the kitchen. This is known as CAD/CAM (CAM stands for computer aided manufacturing).

You will benefit by knowing about and using as many of these forms of communication as possible.

Figure 3.12a An example of a solid modelled CADD drawing of a coffee table

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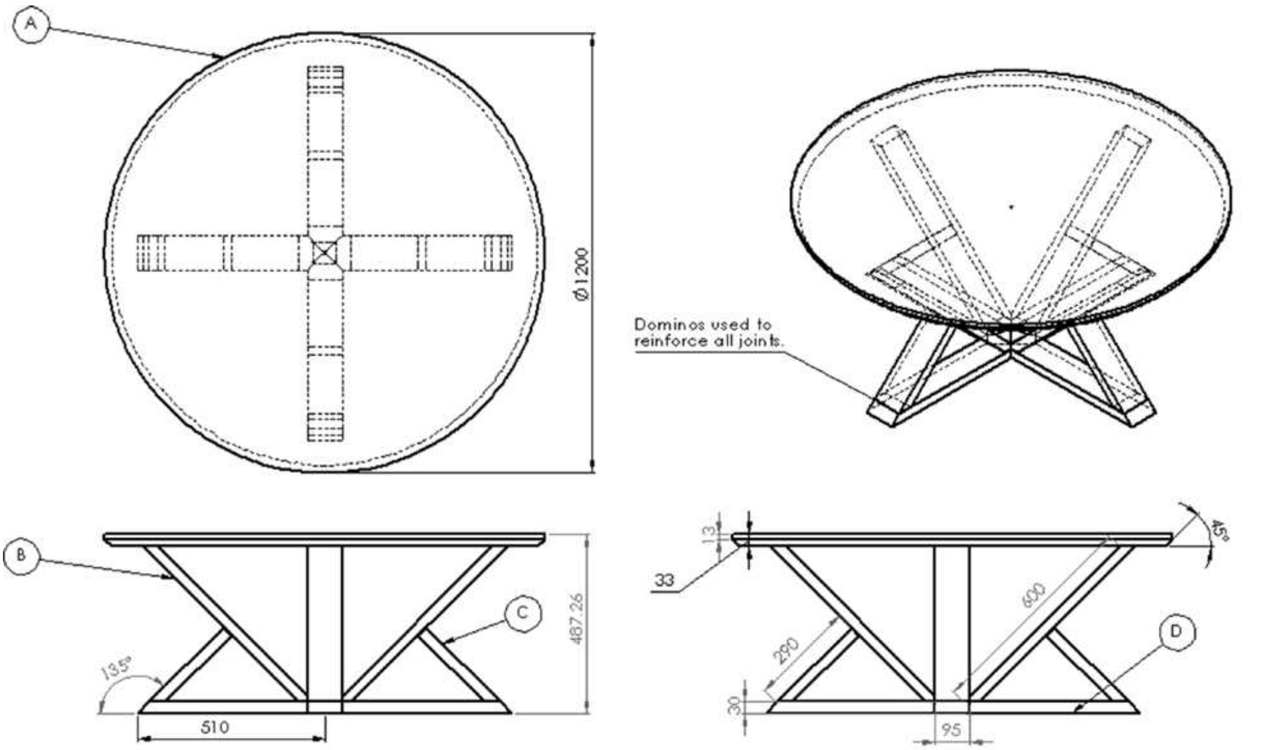
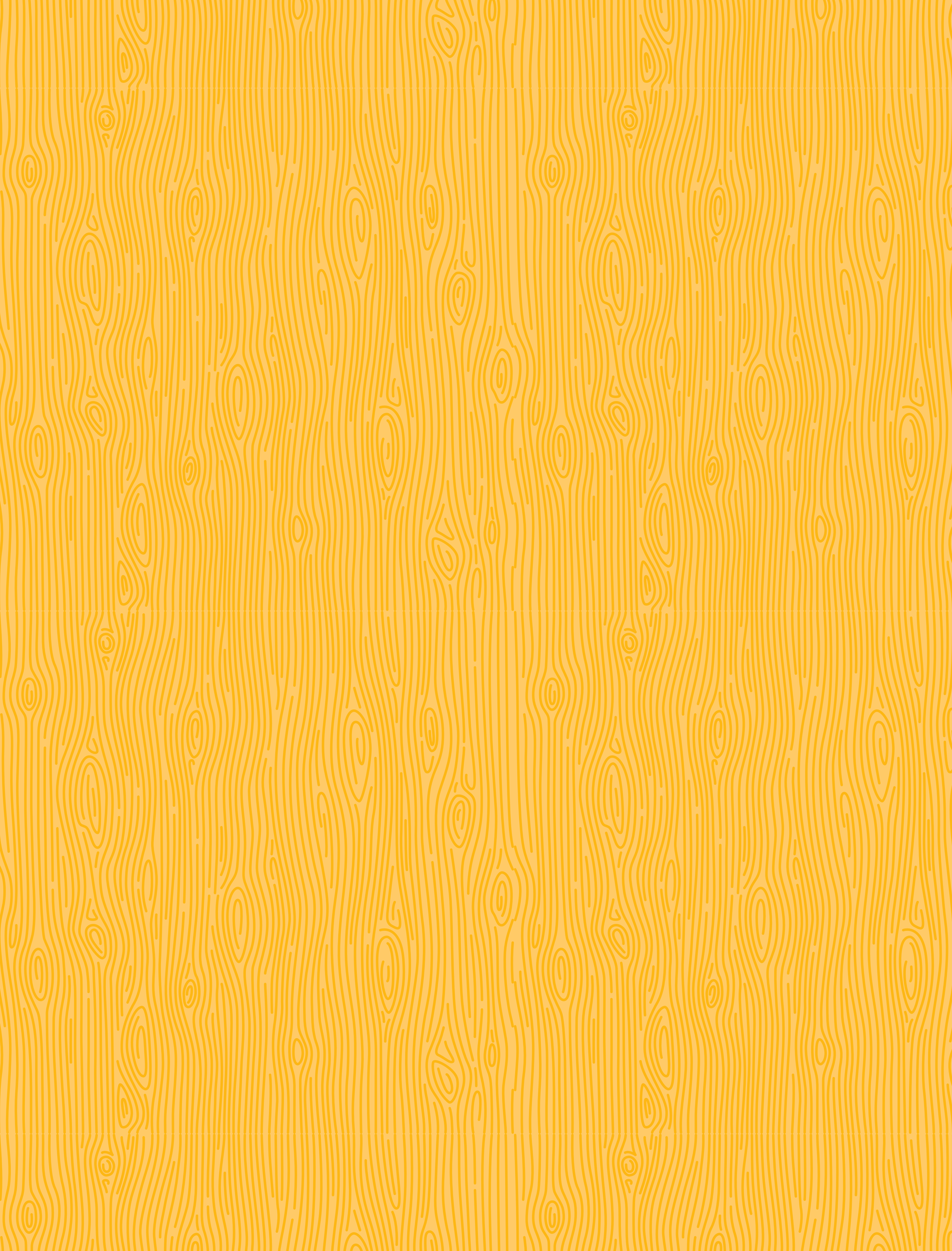


Cutting List		Coffee Table		All dimensions in mm	Scale 1:10	Third angle projectopn
Letter	Part name	Amount	Length	Width	Thickness	Material
A	Top	1	1200	1200	33	Rosewood veneered particle board
B	Long leg	4	630	95	30	Rosewood
C	Support leg	4	290	95	30	Rosewood
D	Base leg	4	510	95	30	Rosewood

Figure 3.12b A cabinet drawing of a coffee table created using CADD

CHAPTER REVIEW QUESTIONS

1. What can you use a spreadsheet to represent in a project report?
2. What is an effective computerised method of producing an evaluation to go in a report?
3. Explain what 'formatting' is.
4. What software could you use to present a report on a finished design?
5. Research and explain 'resolution' as it applies to digital photography.
6. Create a cutting list using a computer.
7. List three advantages of using CAD over manual drawing methods.
8. What does CNC stand for?
9. List the keyboard 'short cuts' for copy and paste.
10. Explain what 'the cloud' is and how it is used.



CHAPTER

4

Timber properties and uses

Wood has been an indispensable resource to humans since the dawn of time. Besides providing the raw material for many of the world's largest industries, including buildings, furniture, rubber, paper and food (fruit and nuts), trees also provide life-sustaining oxygen as a by-product of photosynthesis.

Key terms

aesthetics how our brains interpret something to be beautiful or ugly, is the object pleasing to our senses, mainly sight and hearing (but can include smell and taste)

air seasoning a method of seasoning timber that relies on natural drying in the open air

back sawing a method of converting timber (tangential cut) that produces boards whose faces are, in general, tangential to the growth rings

burls or burrs wart-like growths on the side of a tree, which can be turned as a bowl or sliced as a veneer

checking splits that can appear in the surface of timber during the drying process

conversion the action of cutting up logs into rectangular pieces of timber for the retail market

cup a piece of timber that bends across its grain due to shrinkage; normally in tangential cut timber

deciduous trees or shrubs that shed its leaves annually (usually in autumn)

end grain the exposed view of a piece of wood that has been cut across the grain

equilibrium moisture content (EMC) the moisture content at which wood is neither gaining nor losing moisture; however, this changes with relative humidity and temperature

figure another name for the grain pattern in a piece of timber

flitches slabs of timber cut from a sawn tree trunk from which finished boards are cut. Flitches are typically <100 mm thick and <150 mm wide

grain the arrangement or pattern of wood fibres in a piece of timber

green timber unseasoned timber that still contains its natural moisture

hardwood wood cut from broad-leafed deciduous trees with the botanical name *Angiospermae*

heartwood the hard central wood of the trunk of a tree that consists of mature timber

kiln seasoning seasoning with the use of an oven to speed up the drying time (unlike air drying)

latewood the wood growth that occurs late in the yearly cycle; generally has slower growth with a denser structure

live sawing a method of converting timber that is the simplest and quickest way to saw a log resulting in the central planks being radial cut (quarter-sawn) and the two outer areas of the converted log being tangential cut (back-sawn)

photosynthesis the process by which green plants create energy from carbon dioxide and water using light as an energy source

quarter sawn a method of converting timber (radial cut) that produces boards whose faces are generally parallel to the medullary rays and at right angles to the growth rings and has less tendency to cup

regenerate to be formed or regrow again

resawn sawing flitches into smaller pieces

sapwood (or xylem) the newer timber that is formed outside the heartwood; more attractive to borers

seasoning drying timber to reduce its moisture content

silviculture the deliberate cultivation of forests; forestry

softwood wood cut from fir and pine trees (needle-bearing evergreen trees with the botanical name *Gymnospermae*)

spring the curvature of the edge of a piece of timber, with the face remaining flat.

springwood (earlywood) the wood growth that occurs early in the yearly cycle; generally has faster growth with a less dense structure

sustainable yield producing at least as much of a resource as is being used

twist or 'wind' is a spiral warp along the length of a piece of timber

waney edge a piece of timber that has its edge missing showing the bark or sapwood

warping the broad term that is used to describe any distortion from the straight cut that may occur during or after seasoning (e.g. bow, spring, cup or twist)

FACT

The Amazon rainforest represents more than half of the planet's rainforests and has been described as 'the lungs of the world', but it has been mercilessly logged and cleared, by first felling and then burning the tree cover. The major destroyer is the cattle industry, but much of the forest is slashed and burnt by small subsistence farmers for the cultivation of soy, palm and other crops, often using chemical fertilisers. By 1995, 70 per cent of former forest in the Amazon had been converted to cattle production. At the peak of deforestation, almost a hectare of rainforest was disappearing every second (50 000 hectares per day).

As the rainforest species disappear, so do many possible cures for life-threatening diseases. While 25 per cent of Western pharmaceuticals are derived from rainforest ingredients, less than 1 per cent of the potential of tropical trees and plants has been investigated by scientists. Search the internet for 'Amazon rainforest' to learn more.

Amazon rainforest

Weblink

Deforestation

Weblink

In terms of their global resource, trees are being used faster than the rate of regrowth, and because they are the basic material of industry, woodworkers and hobbyists, it is essential that the resource is used wisely. Therefore, you should have an understanding of the growth and structure of timber, how it is cut, how it is prepared for use and how it behaves when used.

Physical features of timber

From the plant classification 'exogens', wood grows by the constant addition of new outside layers of the trunk and branches. It is made up of minute, tubelike cells packed closely together and joined end to end or overlapping obliquely. The cells include cellulose and lignin, a complicated organic material, which is a combination of carbon, hydrogen and oxygen. Inside the cells is a watery composition of starches, sugars, minerals, gums and resins. As the cells age, lignin is deposited in and between the cell walls, making the walls more rigid and the wood more durable.

How trees grow

Trees make food through a process known as **photosynthesis**, which is the formation of sugar from carbon dioxide and water in the presence of sunlight. This process only takes place where there is chlorophyll – the green colouring matter in leaves.

Water and minerals in solution are absorbed from the soil by the fine hairs on the roots and transported by the sapwood, which is immediately beneath the cambium layer and bark, to the leaves. Here, a large proportion of the water evaporates, leaving the minerals and some water behind. This process is called 'transpiration'. Carbon, a basic element in all plants, is obtained from carbon dioxide (CO_2) in the air. Entering through minute apertures called 'stomata' on the underside of the leaves, the CO_2 is broken down by chlorophyll, with the aid of sunlight. The carbon combines with the water from the roots, while oxygen is returned to the air.

The tree's food, which is manufactured in the leaves, is transported down the inner layers of the bark cells (phloem), thus providing the living cambium cells with materials for the formation of new wood and bark. On its way down, some of the food material also reaches the living wood cells immediately inside the cambium layer by means of special cells called 'medullary rays' or 'ray parenchyma', which are produced for this purpose (and also for food storage). A ring-barked tree will eventually die because the food from the leaves cannot pass down through the inner layers of the bark to the roots. In addition, if the sapwood is severed, the tree will generally die more quickly.

A tree grows both in height and in girth (or diameter).

Growth in height is due to the division and growth of numerous special cells at the extreme tips of the trunk and branches. These special cells are thin-walled and do not, in themselves, produce woody tissue. A short way back from the growing tip the inner cells form the pith or medulla, while the outside cells form the cambium layer. Once the wood is formed, it does not grow in length or height.

Growth in girth is brought about by the division and growth of the thin-walled cells of the cambium layer, which are very thin and invisible to the naked

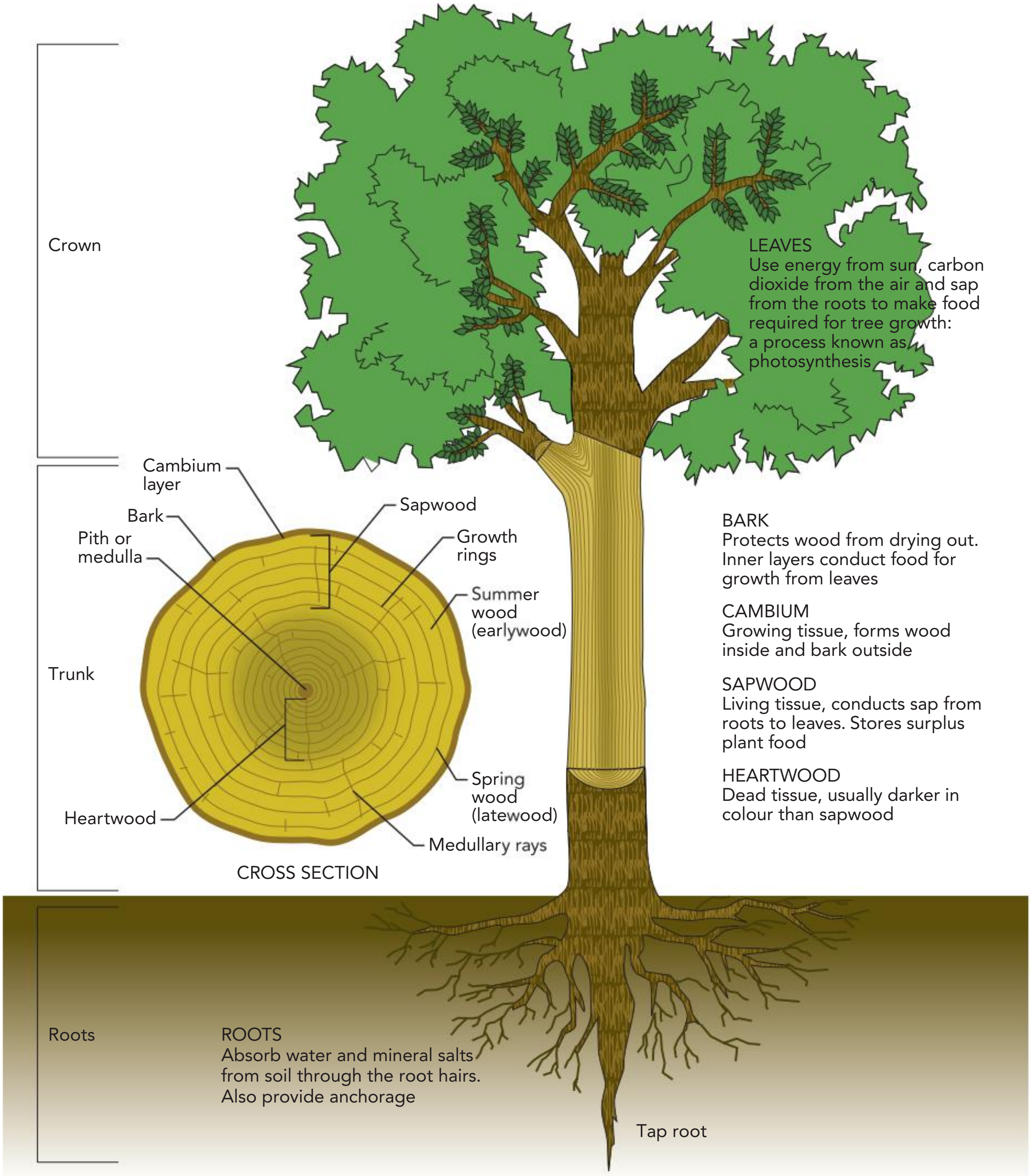


Figure 4.1 Structure of a tree

eye. This layer lies just beneath the bark. These special cells divide, forming the inner, living portion of the bark and the new woody tissue of the sapwood, which later matures into heartwood. Neither the sapwood cells laid down on the inside of the cambium layer, nor the bark cells laid down on the outside of the cambium layer, influence growth in height.

Visible evidence of growth

If a nail was driven into the stem of the tree at a measured height you would notice that as growth continues (whether it is 10 cm or 1 m in a year), the nail would remain at the same height and would be gradually covered.

Parts of a tree

The pith (or medulla) is the heart or centre of a tree and stores food in the young tree. It is usually quite soft, darker in colour and often rots out, referred to as 'piping'.

Much like the plumbing pipework of a tree, the **sapwood (or xylem)**, keeps the leaves supplied with water from the roots. This living 'pipeline', not only supplies water to the leafy extremities, but stores moisture in accordance with the seasons. However, by the time they become competent to conduct water, all xylem tracheids and vessels have lost their cytoplasm and the cells are, therefore, functionally dead. All wood in a tree is first formed as sapwood. Very leafy trees featuring vigorous rates will have a larger sapwood volume. Rapid growth trees in the open have thicker sapwood for their size than trees of the same species growing in dense, shaded forests. Sometimes trees (of species that do form heartwood) grown in the open may grow to considerable size, 30 cm (12 in) or more in diameter, before any heartwood begins to form, such as in second-growth hickory, or open-grown pines.

Other living cells form the medullary rays (or ray parenchyma), whose purpose is to store plant food, mainly in the form of starch. Sapwood has three main functions in the living tree: support, conduction and food storage.

The **heartwood** is the fully matured wood that surrounds the pith (Figure 4.2). The term heartwood derives solely from its position and not from any vital importance to the tree. In fact, a tree can thrive with its heart completely decayed. It is frequently darker in colour than the sapwood due to the deposits of tannin, resins and gums in the dead cells. These also act as 'antiseptics' against decay and fungi attack. Heartwood contains very little starchy food; therefore, it is not as susceptible to insect or fungi attack as sapwood.

Tony Clarke

Figure 4.2 A board through the centre of a radiata pine tree showing the pith

However, sapwood cells are more open and can be treated more readily with penetrating preservative fluids, which makes sapwood as durable as, or even more durable than, heartwood. In some cases, sapwood may be a superior material. For example, sapwood from Canadian ash is selected for the manufacture of laminated tennis racquet frames because it is slightly lighter and less brittle than heartwood. Heartwood has practically no other function in the growing tree than that of structural support.

The cambium is entirely responsible for the tree's growth in girth through the development of growth rings. These concentric rings of alternating light and dark wood tissues are visible in the cross-section of most trees and are sometimes called 'annual rings'. However, some trees, particularly in the tropics, have more than one period of growth and, consequently, form more than one ring each year. Many other tropical and subtropical trees, in which growth is more or less regular throughout the year, produce no visible growth rings, while trees grown in areas with greater climatic variation feature more pronounced rings. These rings are true annual rings and provide a means of determining the age of the tree. The cambium is most active in woody plants, where it lies between the bark and wood of the stem. In spring, the cambium forms a layer of light-coloured, thin-walled cells commonly called **springwood**. Smaller, darker-coloured cells with thicker walls are formed later in the year, and are called **summerwood**. However, this term is misleading because summerwood may be formed in autumn, so the terms *earlywood* and **latewood** are now widely accepted as more accurate.

Rays (or ray parenchyma) are specialised cells in the xylem that grow radially from the pith or intermediate growth rings to the cambium layer. Their function is to store sap food and convey it to the inner living parts of the tree. They also serve to bind the growth rings together.

The bark (or cortex) varies considerably in thickness and appearance between species, but always contains some dead, corky material, which protects the tender, living inner bark (phloem). The phloem carries the plant food from the leaves to the cambium layer.

The structure of wood

According to its botanical features, wood is classed as either **hardwood** (pored wood) or **softwood** (non-pored wood). Hardwood trees have leaves, are generally **deciduous** and have covered seeds, such as gum nuts. Softwood trees usually have needle-like foliage, and

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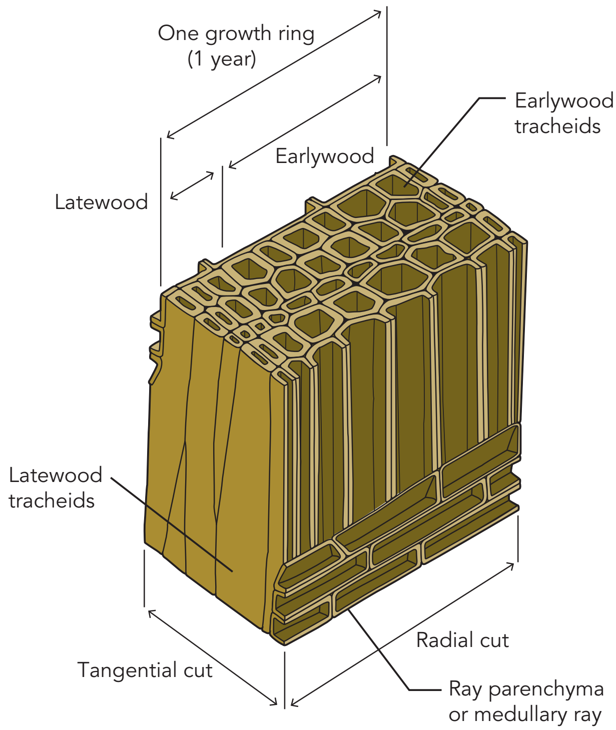

Figure 4.3a Cell structure of softwood

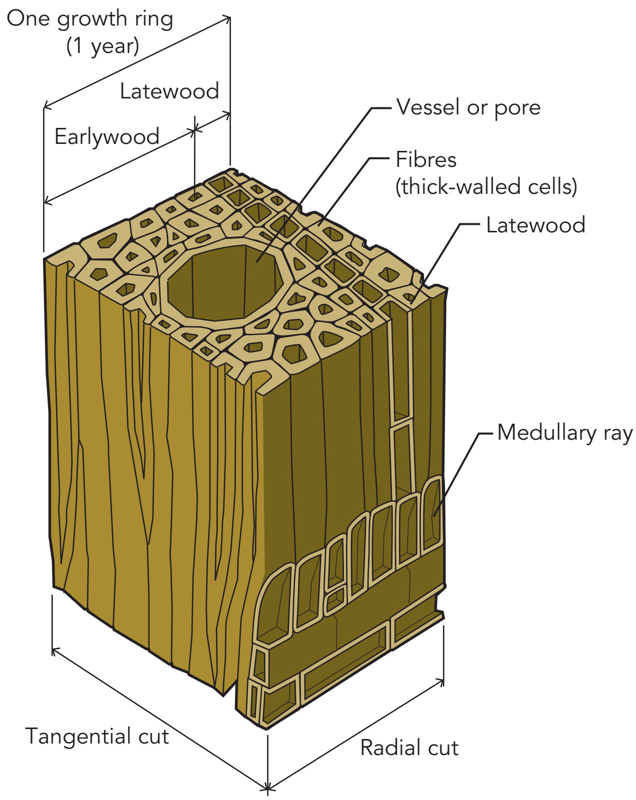

Figure 4.3d Cell structure of hardwood

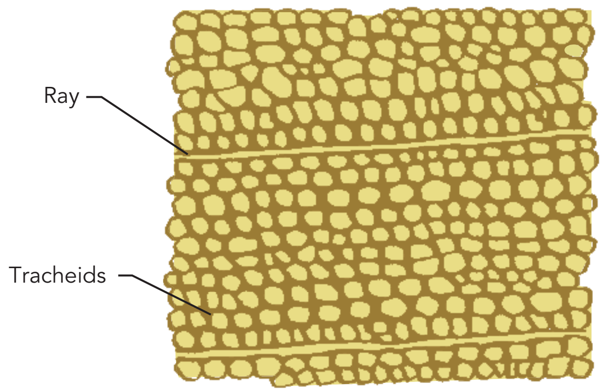

Figure 4.3b Cross-section of softwood

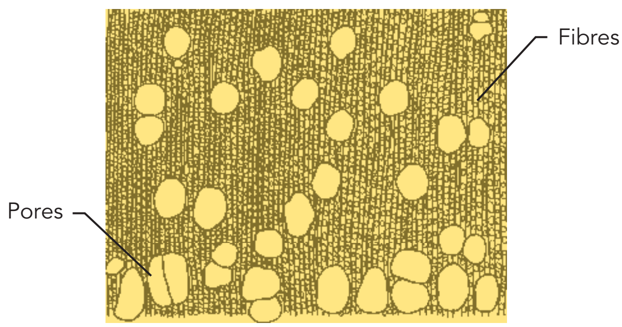

Figure 4.3e Cross-section of hardwood

Tony Clarke

Figure 4.3c A typical pine forest (softwood)

Tony Clarke

Figure 4.3f Eucalypt trees (hardwood)

are generally from the pine or conifer family with uncovered seeds that fall from the pine cone as it opens. Hardwoods do not necessarily have harder wood than softwoods; balsa wood, which is the lightest and softest commercial wood in the world (used in model airplane construction), is a hardwood. As far as the woodworker is concerned, the main difference between softwood and hardwood is in the cell structure.

Chemistry of wood

Wood's chemical make-up is not as simple as many think. Carbon makes up about half of its content in weight, with oxygen almost as plentiful, hydrogen about 5 per cent, nitrogen 1 per cent, followed by a raft of elements in tiny quantities, such as calcium, potassium, sodium, magnesium, iron, and manganese. Smaller quantities of sulphur, chlorine, silicon and phosphorous are also present.

Softwood

Softwoods or non-pored woods feature a simpler, more uniform cell structure. The majority of the wood is made up of long, very thin cells called 'tracheids', which carry the water and mineral salts from the roots and leaves. Connection between the cells is by 'pits', minute holes in adjacent cell walls. Rays, which are very small when compared with those in some hardwoods, radiate from the centre of the tree and at right angles to the tracheids, and store food and carry food materials from the phloem inwards to the living cells in the wood. All non-pored woods come from coniferous or pine trees (e.g. Oregon pine, radiata pine, hoop pine and cypress pine). See Figures 4.3a–c.

Hardwood

Hardwoods or pored woods are characterised by large, tubelike vessels or pores. These consist of short stubby cells varying considerably in size and joined together to provide, when newly formed, a continuous means of conducting solutions from the roots to the leaves. The vessels frequently occur in groups and have pits in the side walls to allow the passage of solutions. The pores in some hardwoods, such as pacific maple, are visible to the naked eye, while a magnifying glass is necessary to see those in coachwood. Smaller, thick-walled cells (called 'fibres') act simply as mechanical support for the tree, while the medullary rays have the same function as the rays in softwoods. Some of the more important hardwoods include eucalypts, blackwood, maple, oak, walnut, ash, beech, willow, red cedar, mahogany, basswood and hickory. See Figures 4.3d–f.

CHECK YOURSELF

1. What are the two ways a tree grows in size?
2. What is summer wood and latewood?
3. What is the purpose of the cambium layer of a tree?
4. What is the difference between softwood and hardwood?

Properties of wood

While trees can be classified as pored or non-pored woods, nature has provided many different species of timber each bearing unique properties and characteristics. These are governed by the type and arrangement of cells and the variety of sugars, starches, resins, gums, oils, tannins, silica and colouring matter.

Density

Density depends on the size of the cells, the thickness of the cell walls and the amount of lignin, gums and resins present. Density is usually quoted as 'light', 'medium', or 'heavy' and in kilograms per cubic metre (kg/m^3) for timber dried to 12 per cent moisture content.

Hardness and softness

Hardness and softness are closely related to density because they vary according to the size of the cell, the thickness of the wall and chemical inclusions. Remember that balsa, classed as a hardwood (pored wood), has a density of only around 112 kg/m^3 so that it is, in fact, very light and soft.

Durability

Durability depends largely upon moisture content and the presence in the cells and cell walls of chemicals that are resistant to insect and fungus attack. Usually sapwood contains less resin and gum and more plant food than heartwood; therefore, it is usually less durable. A durable timber is not necessarily hard or tough; for example, Californian redwood is one of the most durable timbers in the world.

Strength

Strength is directly related to the type of cell structure, size of cells, thickness of walls, amount of lignin and direction of growth. Strength does not necessarily follow weight: Oregon pine has one of the highest strength-to-weight ratios for building timbers yet it is soft, light and easy to work with.

Figure

Figure is the overall pattern or design produced on the longitudinal surface of the wood and is due to variations in texture, **grain** and colour (Figure 4.4).

Andrew Saber

Figure 4.4 A variety of timbers have been used in this marquetry box

Texture

The size and arrangement of the cells is referred to as texture, often classified as 'fine', 'medium' or 'coarse', 'uneven' or 'uniform'. The differentiation between coarse and fine texture applies mainly to hardwoods and is made on the dimensions of the vessels and the width and abundance of rays. For example, silky oaks, which have large vessels or pores and broad rays, are said to be of coarse texture, while timbers such as coachwood, have small vessels and narrow rays, are fine-textured.

Forests NSW, www.dpi.nsw.gov.au/forests. CC BY 4.0.

Figure 4.5a A top view of rippled grain

Grain

Referred to as 'cross', 'spiral', 'wavy' and so on, grain refers to the direction of the fibres and associated wood elements in relation to the axis of the tree (Figures 4.5a–d).

Forests NSW, www.dpi.nsw.gov.au/forests. CC BY 4.0.

Figure 4.5b A side view of rippled grain

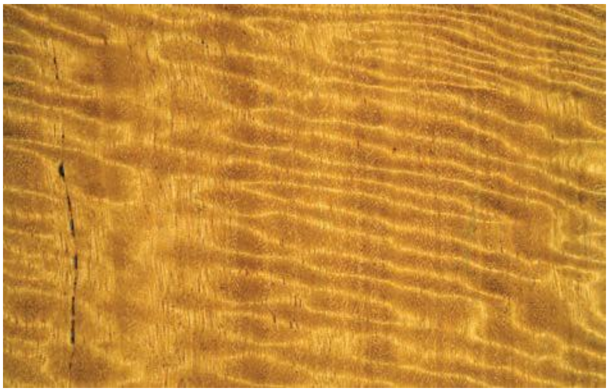

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Figure 4.5c Wavy grain (blackbutt)

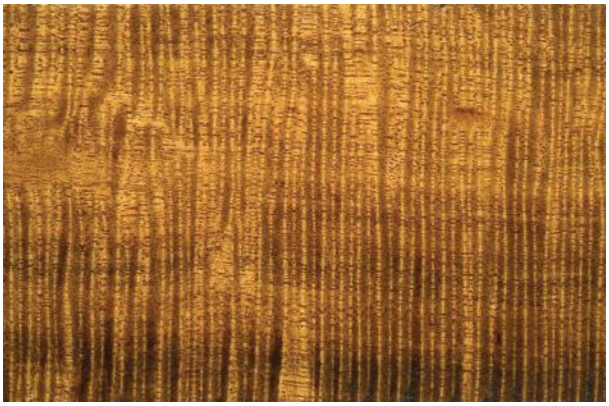

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Figure 4.5d Fiddleback figure in ash eucalypt

Timber conversion

After a tree has been selected and marked, and the undergrowth has been cleared, if necessary, the logger fells the tree. Two cuts are generally made using a chainsaw, a mobile circular saw, a two-man crosscut saw or an axe. The direction of fall is controlled by the undercut.

Prior to felling trees, loggers identify hazards in the felling area, such as widow makers, snags, spears, hang-ups, spring poles, blowdowns, and unstable ground, and either eliminate or avoid them.

After felling, the limbs and crown are cut off and the trunk is cut into manageable logs. These are then loaded onto timber jinkers for transport to the sawmill.

At harvesting time (approximately 25–35 years) in softwood pine plantations, where trees are of a uniform size and evenly spaced, a one-man operated tree harvester grips and cuts the tree off near ground level, turns the trunk 90° to horizontal, strips all the branches, docks the log to a computer-set optimum length and stacks the log on a truck ready for transportation.

Methods of conversion

The **conversion** of timber involves cutting the logs into marketable or commercial sizes. Typically, in Australian hardwood mills logs are 'broken down' with twin circular saws or a log bandsaw into **flitches**. The flitches are then **resawn** into marketable sizes on a smaller circular saw. The flitches are also docked to set lengths while waney sections and splits are cut out (Figure 4.9g).

Live sawing

The **live sawing** method results in the central planks being radial cut (quarter-sawn) and the two outer areas of the converted log being tangential cut (back-sawn). This gives an increased choice of grain pattern (Figure 4.6a).

The main problem with live sawing is the difficulty of cutting out faults, such as piping (hollowed-out pith area), internal gum pockets, and checks or shakes.

Back sawing

Back sawing (tangential cut) produces boards whose faces are, in general, tangential to the growth rings (Figure 4.6b). This is a highly flexible method well suited to securing high-grade timber from varied and faulty logs; it allows for sawing around faulty parts with little waste.

Timbers, such as red cedar, Oregon, radiata pine and alpine ash, which possess distinct growth rings, are usually back sawn, because this exposes the most decorative figure. Timber for ceiling and floor joists, bearers, and axe and hammer handles are generally back sawn, because there is more strength in the direction of the growth rings. Back-sawn boards shrink mostly in width and tend to **cup** or warp away from the heart of the tree.

Quarter sawing

Quarter sawing (radial cut) produces boards whose faces are generally parallel to the medullary rays and at right angles to the growth rings (Figure 4.6c). The log requires even more frequent turning than in back sawing and more timber is lost through waste, but the recovery rate is still good because quarter-sawn timber seasons very evenly.

Timbers with distinct ray figure, such as silky oak, sycamore and, to a lesser degree, maple, reveal a very decorative figure called 'silver grain' when they are **quarter sawn**. Timbers with interlocked grain, such as Queensland maple and walnut, show a valuable decorative 'stripe' or 'ribbon' figure (Figure 4.7). For this reason, most valuable cabinet timbers that have prominent rays and/or interlocked grain are fully quarter sawn (that is, sawn within 10° of the rays). The seasoning process is slower for quarter-sawn timber than for back-sawn timber, but quarter-sawn boards retain their shape and do not cup or check to

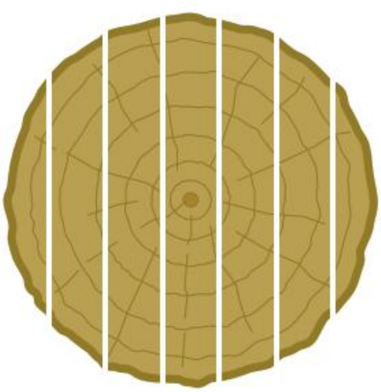

Figure 4.6a Live sawing

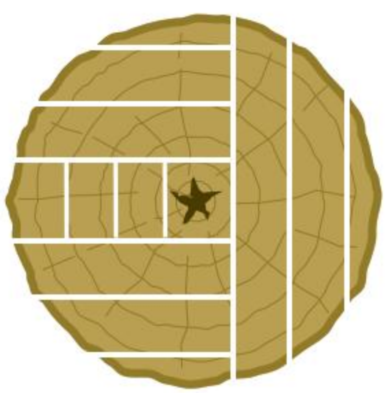

Figure 4.6b Back sawing

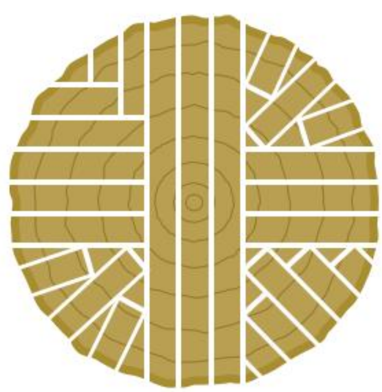

Figure 4.6c Quarter-sawing

any extent. The edge grain that is revealed produces an even-wearing surface. Timber for architraves, mouldings and flooring boards is usually quarter sawn (Figure 4.8).

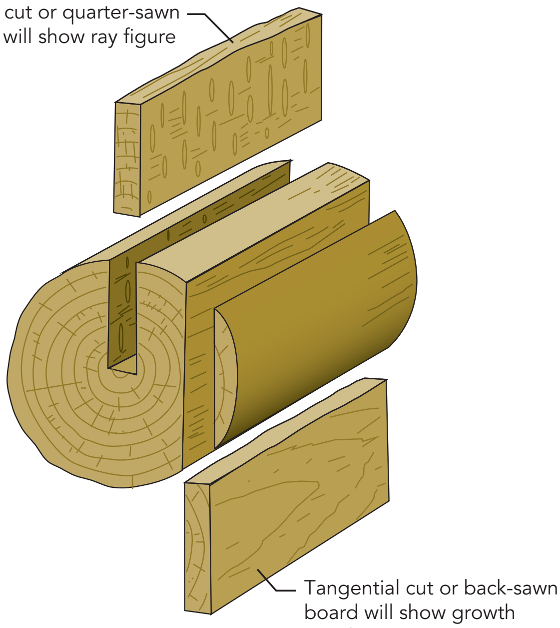

Figure 4.7 Grain effect on quarter-sawn and back-sawn boards

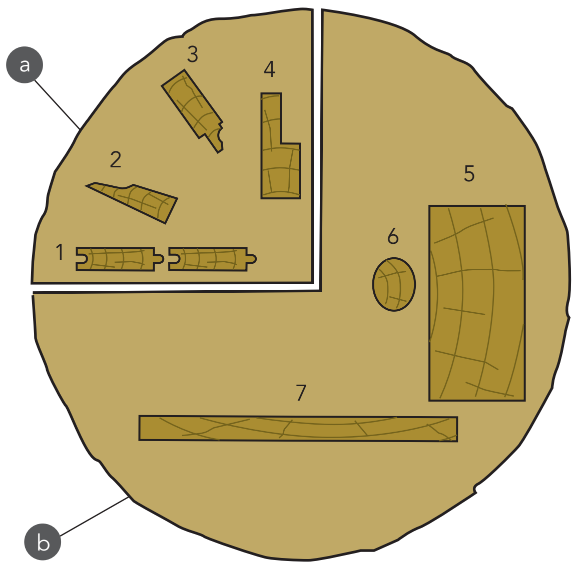

Figure 4.8 Typical uses for quarter-sawn and back-sawn timber: **a** Quarter sawing for pieces to retain shape – 1 flooring boards for wear and less shrinkage, 2 mouldings and architraves, 3 window sashes, 4 door frames; **b** Back sawing for strength and growth ring figure – 5 beams, girders, joists, etc., 6 hammer and tool handles, 7 shelving and table tops, heartside up

Timber classifications

Timbers are classified according to their sizes:

- Logs: trunks with the branches cut off
- Baulks or flitchs: <100 mm thick and <150 mm wide
- Planks or sheeting: 40–100 mm thick and <150 mm wide
- Scantlings: sawn to dimensions up to 150 × 100 mm
- Boards: pieces 10–40 mm thick and <75 mm wide
- Battens: pieces 20–40 mm thick and 25–75 mm wide
- Strips: >20 mm thick and up to 75 mm wide.

Timber floorboard production

Tony Clarke

Figure 4.9a Felled logs being delivered and unloaded from the truck

Tony Clarke

Figure 4.9b Docked logs ready on an in-feed deck

Tony Clarke

Figure 4.9c Log loaded on an in-feed deck for the first cut in half, using one blade of the twin edger blades

Tony Clarke

Figure 4.9f Sharpened blades ready to be changed at the end of the day (Note the safety hard hat!)

Tony Clarke

Figure 4.9d Half log cutting flitch, using both twin edger blades

Tony Clarke

Figure 4.9g Cutting out waney edge and splits, then docking to lengths

Tony Clarke

Figure 4.9e The finished green flitches

Tony Clarke

Figure 4.9h All offcuts ready to be used for pallet construction or to be chipped, sorted and sold to nurseries. (Note the safety signs and equipment.)

Tony Clarke

Figure 4.9i Timber placed in kiln for seasoning. Note the yellow paint that identifies the species and the date produced

Tony Clarke

Figure 4.9j A four-blade cutter on a four header to DAR timber

Tony Clarke

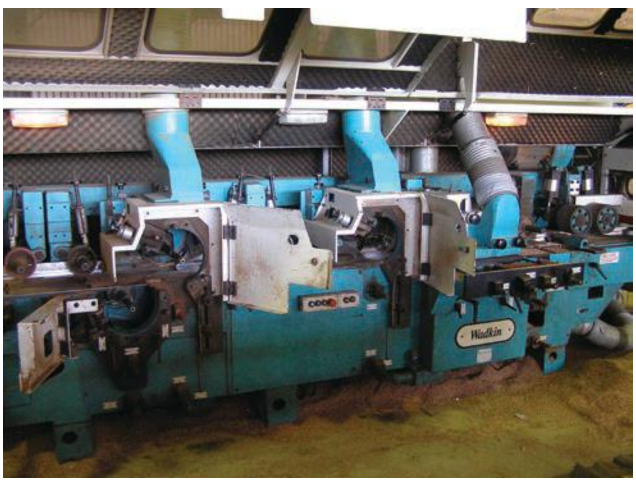

Figure 4.9k A six header: two rough face cuts, two smooth face cuts, and a pair of matched side cutters (tongue-and-groove)

Tony Clarke

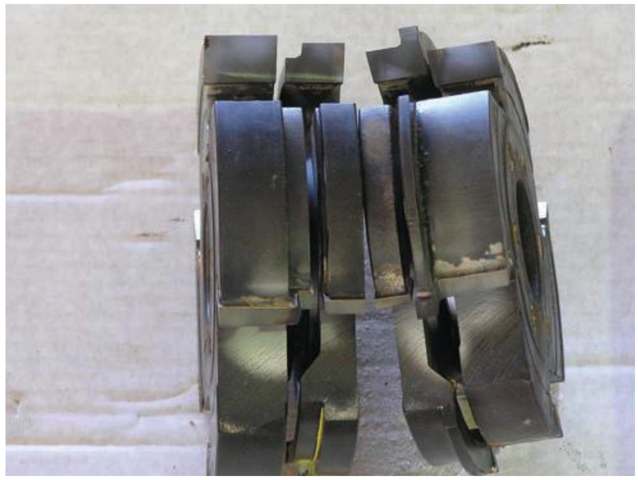

Figure 4.9l A pair of shaped tongue-and-groove side cutters for floor boards

Seasoning timber

Green, or unseasoned timber, contains a large amount of water. **Seasoning** is simply the drying out of most of the water from the cell cavities and cell walls, in order to:

- reduce shrinkage, **warping** and **checking** to a minimum
- reduce weight, with a consequent reduction in freight charges
- reduce likelihood of attack by wood-boring insects
- prevent blue stain and attack by other moulds, such as decay fungi
- increase the strength of the wood
- improve bonding properties so that adhesives, paints and finishes will adhere better and last longer
- make the timber lighter and easier to work.

The aim in seasoning is not to dry the water completely from the wood, which, under normal conditions of use, always contains some moisture. For example, under Sydney conditions a seasoned hardwood floor for a room 5 m × 5 m will contain about 55 L of water. The weight of water present is expressed as a percentage of the weight of the oven-dried wood, and this percentage is referred to as its 'moisture content' (Figure 4.10).

The moisture content of freshly sawn timber often exceeds the weight of the wood itself. For example, in green radiata pine moisture content is frequently greater than 200 per cent. The ideal moisture content for seasoned timber varies with the relative humidity and temperature of the air. To keep shrinkage and

Figure 4.10 Modern moisture meter. Note the two prongs that are placed against the wood to obtain a readout

swelling (movement) to a minimum, timber should be seasoned to the **equilibrium moisture content (EMC)** of the locality where it is to be used. In Sydney, this is around 12 per cent.

Shrinkage takes place during the process of seasoning.

There are two stages in the seasoning of **green timber** because the sap exists in two forms: as 'free moisture' in the cell cavities (Figure 4.11a) and as 'combined moisture' within the cell walls. In the first stage, the wood cells give up their free moisture (Figure 4.11b), the combined moisture in the cell walls remaining until the cell cavity is empty. This condition is referred to as the 'fibre saturation point', at which the moisture content is typically around 30 per cent. Shrinkage occurs when the cell walls start to give up their combined moisture, and continues until seasoning is complete (Figure 4.11c).

Despite their apparent contrast, wood and water happily co-exist. This is the function of a hygroscopic substance – the ability to take in or give off moisture in the form of vapour. Water within wood exerts pressure in the form of vapour, with that pressure determined by the size of the water-filled capillaries. If water vapour pressure in the ambient space is lower than vapour pressure within wood, desorption takes place. The largest-sized capillaries full of water empty first, and as vapour pressure within the wood falls, water is contained successively in smaller capillaries. A stage is eventually reached when vapour pressure within the wood equals vapour pressure in the ambient space above the wood, and further release of moisture through the surface ceases. As humidity changes (such as in periods of rain or drought), so too does the moisture content of the wood; unless it is totally sealed from the atmosphere, which is just one of the reasons for lacquering, waxing or oiling a project.

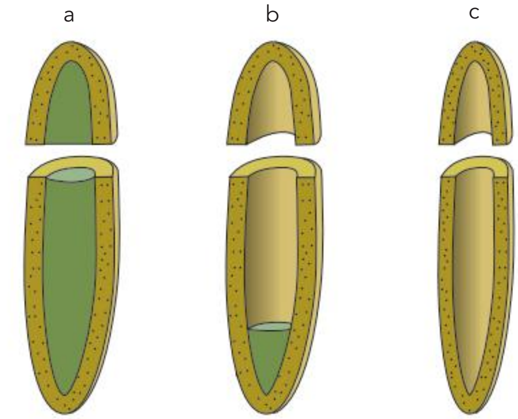

Figure 4.11 Stages in seasoning of timber (cells)

Very little shrinkage takes place along the grain because the cells do not shrink to any extent in their length. Similarly, the rays, which are long, thin cells running at right angles to the growth rings, restrict radial shrinkage. Most shrinkage, therefore, takes place in the direction of the growth rings. This is called tangential shrinkage, and is usually about double that of radial shrinkage and about 100 times greater than longitudinal shrinkage (Figure 4.12).

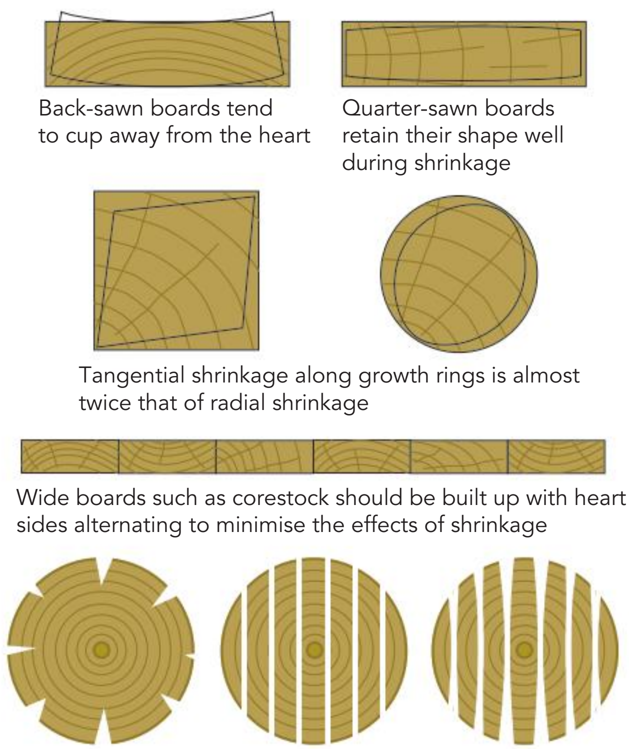

Figure 4.12 Effects of shrinkage

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Seasoning methods

Air seasoning

Air seasoning, or the natural drying method, requires the timber to be stored in stacks in the open, so that it dries slowly, in natural weather conditions. The secret to efficient **air seasoning** is air circulation. To achieve this the stack is laid on bearers to keep it clear of the ground, and strips of dry wood, usually about 20 mm thick and 25–40 mm wide, are placed exactly one above the other between the layers of boards. Any strips not in vertical alignment will cause distortion in the boards. The strips in each layer should be spaced at 500–1000 mm intervals, immediately above the cross-bearers of the foundations. The boards should be placed along the stack so that there is a space of 25–50 mm between their edges to allow the vertical passage of air. Stacks should be protected from the effects of sun and weather. The ends of the boards are usually sealed with a thick coat of paint to stop the **end grain** from drying out too quickly. As a general rule, air seasoning takes approximately six months for every 25 mm of timber thickness, but the time varies according to several factors, such as species of timber, size of boards, season and climatic conditions, location, and method of stacking (Figure 4.13).

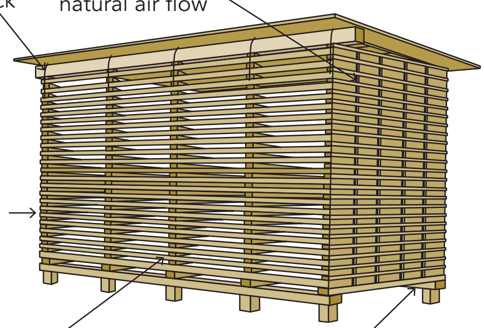

Figure 4.13 Air seasoning

Kiln seasoning

The seasoning time for wood can be reduced considerably through the use of a specialist kiln. This method can be used to accurately control the moisture content of the wood. Kiln seasoning, or the artificial drying method, requires the stacking of timber in a similar manner to that for air seasoning. Wood is placed on special trucks and wheeled into oven-like rooms called 'kilns' where heat and humidity is carefully controlled. The timber is dried using air circulated by fans over steam-heated coils. Steam inlets supply moisture to control the humidity (Figure 4.14).

Care must be exercised in the early stages to ensure that the free moisture in the cell cavities is not drawn off too rapidly, resulting in serious degradation in the form of 'collapse' (Figure 4.15). Collapse is a flattening of softwood cell structure, causing distortion, severe shrinkage and a large loss in overall strength. **Kiln seasoning** is particularly suited to softwoods because they are not prone to collapse and the entire seasoning process may be completed in the kilns. However, with hardwoods it is more economical to air dry to fibre saturation point (about 30 per cent moisture content) and then kiln dry to EMC, this keeps degradation to a minimum.

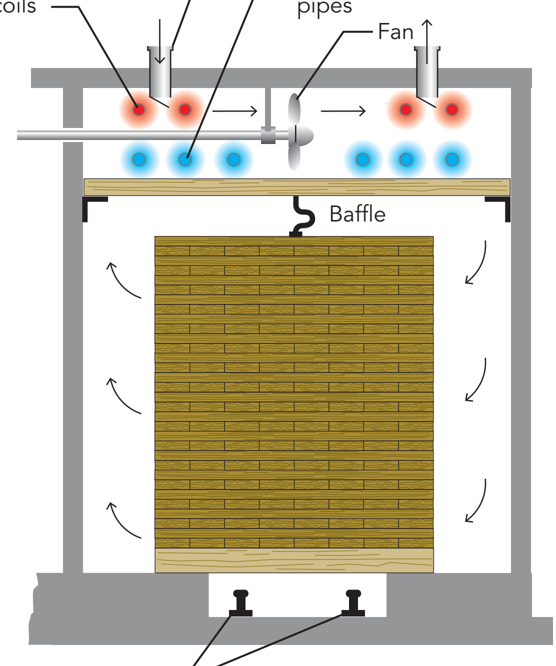

Figure 4.14 A compartment kiln

Figure 4.15 Collapse during drying

Depending on the species and the other factors mentioned previously, 25 mm thick green timber takes between 1–3 weeks to kiln dry, compared with 3–9 months for air drying.

There are two types of kilns in general use: compartment kilns and progressive kilns. The majority of kilns used in Australia are the compartment type, which lends itself to an economical arrangement for combined air and kiln seasoning. These kilns offer greater control over the drying process for individual stacks. This is important where a number of different species are to be seasoned at the same time. Ceiling fans induce air from the outside and drive it over heating pipes, down the side and through the stack, where it is returned to the fans over a second set of heating coils. A steam spray line and exhaust and inlet air vents in the ceiling control humidity.

A progressive kiln represents an assembly line. Truckloads of timber are moved progressively along the kiln so that the green stock added at the cool moist end and is gradually dried as it slowly moves along, until it emerges at the hot dry end ready for use. Progressive kilns lack the flexibility of compartment kilns and are suitable only when a continuous supply of timber of the same kind and thickness is available. Some progressive kilns combine the advantages of both types by dividing the tunnel into several compartments and controlling heat, moisture and air circulation in each. However, they generally are not popular, because many technical problems are involved in their control, especially in Australia where so many species of timber exist.

The advantages of kiln seasoning include a considerable reduction in the time required for seasoning, destruction of insects and fungi, reduction of moisture content to a desired level, and a measure of control to minimise the causes of seasoning defects.

Combined seasoning

Combined seasoning utilises the advantages of both air seasoning and kiln seasoning. It helps to overcome the main disadvantages of kiln seasoning; namely, distortion and checking due to rapid removal of the free moisture from the outer wood cell cavities. The timber is first air seasoned for about three months until the free moisture in the cell cavities has dried out and is then kiln dried for 3–7 days to remove the combined moisture from the cell walls. The final moisture content can be regulated so that the timber can be used either indoors or outside.

Other forms of seasoning

Other forms of seasoning include:

- Solar: a combination of air and kiln seasoning.
- Microwave: microwave energy is directed at the timber, driving out the excess moisture.
- Chemical: this is a specialist technique, involving submerging the 'green' wood in a hydroscopic chemical for 24 hours. The chemical slows down the rate of water loss, helping to reduce damage, such as warping, during the air-drying stage.

Storage of seasoned timber

In retail and domestic situations, the storage of timber should be undertaken so that scantlings, boards, battens and strips of timber remain straight and are not subjected to insect attack, moulds or fungi.

Timber needs to be stored in an airy environment that is not too dry nor too damp. Timber should be stacked horizontally; vertical storage will cause timber to bend under its own weight. Support should be provided for timber along its length, as frequently as possible, and preferably on a flat surface. Due to dampness, avoid storing timber on the floor; this leads to mould, fungi and insect attack.

CHECK YOURSELF

1. What are the three main methods of conversion of timber?
2. What method of conversion is the most stable and best suited for furniture making?
3. What are two methods of seasoning timber?
4. What does EMC stand for?

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Defects in timber

A defect in wood may be defined as any irregularity that affects its normal strength, durability, appearance or value for use.

Natural defects

Knots are caused as limbs (branches) form on the tree. There is an obvious change in grain direction, which often presents seasoning and working problems. There are two types of knots – live and dead.

Live knots occur when the trunk (bole) grows to a larger diameter with age and gradually grows over a live limb. When converted to boards, the limb shows as a live knot (Figure 4.16a).

Live knots generally weaken the timber and spoil its appearance, but in some timbers, such as cypress pine, these knots remain sound and tight and are not classed as defects; in fact, they can be used to enhance **aesthetics** on otherwise plain timber.

A dead knot is produced when a branch is removed and ceases to grow. As the trunk grows its diameter increases, eventually covering the limb completely, including its bark. When this timber is converted to boards it shows the knot, including its bark, which may become loose and fall out (Figure 4.16b).

Burls or burrs are tree growths in which the grain has grown in a deformed manner. Commonly found in the form of a rounded outgrowth on a tree trunk or branch that is filled with small knots from dormant buds (Figure 4.17a). They are believed to be caused by an injury, such as a bump from a falling limb, or by insect attack. Turned bowls and veneers cut from burls are highly prized because the wavy or uneven fibre alignment usually presents an attractive figure (Figure 4.17b).

Gum veins and pockets may occur naturally or be caused by tree injuries. Timber is weakened and disfigured by their presence (Figure 4.18).

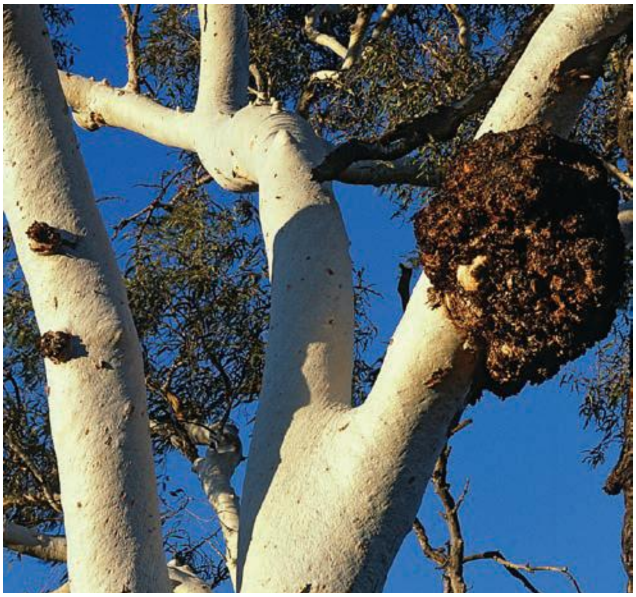
Brittle heart and heart rot are common defects found near the pith or medulla of the tree. The wood is pulpy, affected by decay, or of such a brittle nature that it is structurally weak.

Shakes are caused by separation of the adjoining layers of wood either from the centre of the tree along the medullary rays or between the growth rings. Shakes arise in the standing timber or during felling, not during the seasoning process. However, they usually extend as the timber dries, following the split lines originally established. Heart shakes, which occur at the central region of the tree, are believed to be caused by swaying or growth stresses.

Tony Clarke

Figure 4.16a Live knots. Note that because of the position of these knots, the board is structurally weak

Figure 4.16b A dead knot showing bark



Grant Dixon Photography

Figure 4.17a Burls on a tree

VeneerSupplies.com

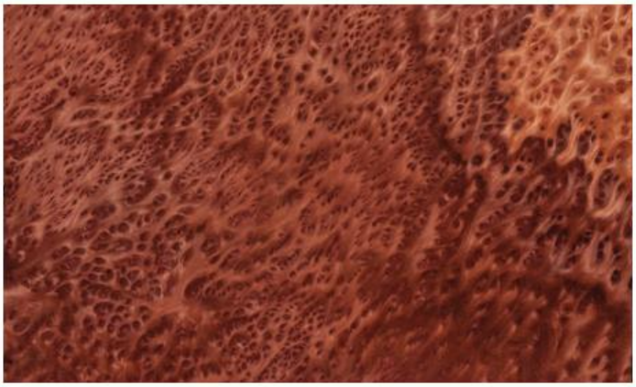


Figure 4.17b An example of redwood burl veneer

Gene Anderson-Conklin

Figure 4.18 An example of a pitch or gum pocket in timber

Grain direction is classed as a defect only if it weakens the timber or makes it too difficult to work. Although there are many variations of cross-grain, such as spiral, diagonal, wavy, interlocked and curly, only the first two are generally classed as defects. When the fibre alignment runs at an angle to the axis of a piece of timber, the timber is said to be cross-grained. Interlocked grain is caused by the fibres of the adjacent layers of wood being spirally inclined in opposite directions. This produces a distinctive figure called 'ribbon grain' or 'fiddleback' (see the section on grain within the section 'Properties of wood', pages 42–3). This is sometimes difficult to plane or sand. Queensland maple and walnut can show interlocked grain; however, it is not classed as a defect unless it weakens the timber.

Seasoning and handling defects

Checks or splits are ruptures in wood along the grain. They are usually caused by seasoning that is too rapid or imbalanced resulting in uneven shrinkage. There are two types of seasoning checks: end checks and surface checks. Once they develop they remain as a permanent weakness in the timber, even though they may appear to have closed up.

Collapse results if the cell structure is flattened by excessive or uneven drying. Usually evidenced by severe and irregular shrinkage, in most cases it may be reconditioned by steaming.

Case hardening is a condition in which the outer layers of timber become abnormally hard as a result of drying that has occurred too rapidly. Uneven stressing results and unless reconditioning is carried out, the timber will be prone to cupping and warping.

Compression wood is indicated by the presence of eccentric growth rings. Compared with normal wood it is heavier, weaker and exhibits unusually high and irregular shrinkage along the grain.

Warping is the broad term that is used to describe any distortion from the true plane that may occur during or after seasoning, such as bow, spring, cup or twist (Figure 4.19). 'Bow' may be described as the longitudinal curvature of the wide face of a board caused by uneven shrinkage during seasoning. **Spring** is the curvature of the edge of a piece of timber, with the face remaining flat. 'Cup' is a simple warp across the face of the timber and is commonly associated with back-sawn wood. The curvature, which is caused by uneven shrinkage, is generally away from the heart and can be minimised by careful stacking and seasoning. **Twist** or *wind* is a spiral warp along the length of a piece of timber and may be caused by sloping grain or poor stacking when drying.

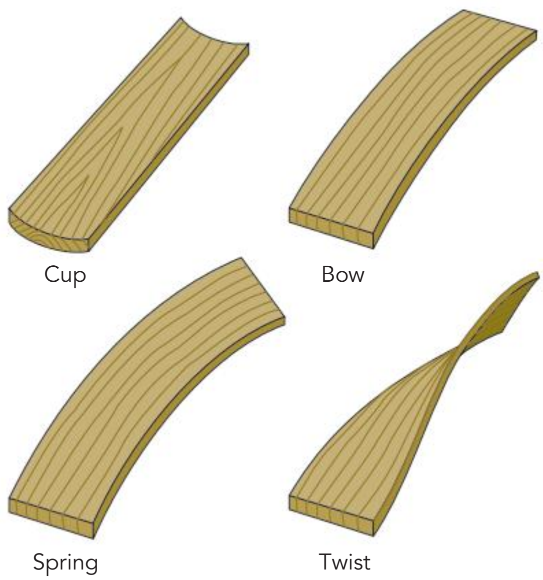


Figure 4.19 Types of warping

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Figure 4.20 Waney edge

Waney edge is the absence of the wood on the edge or corner, showing the bark or sapwood (Figure 4.20).

Defects due to fungi

The terms *dry rot* and *wet rot* relate to the decay of timber. They are a little misleading because they both require a certain moisture content. They are versions of the partial disintegration of wood due to wood-destroying fungi – a primitive form of plant life that lives on the wood and devours it as food. These microscopic organisms require food, warmth, moisture and air to exist. If any of these factors is absent, or can be maintained in a condition that is unfavourable to the growth of the fungi, decay will not occur. If all are present, conditions conducive to decay exist.

Dry rot is caused by a fungus that can exist in apparently dry conditions, like those found under badly ventilated buildings. Despite its *dry* reference, the fungus draws moisture from damp timber via long, threadlike strands that reach down to the soil. Dry rot spreads by using these threads or by means of spores so minute that they can be carried in the air. This fungus cannot exist in well-ventilated areas.

Live trees and logs lying on moist ground are the common residences for wet rot. It is also present at the bottom of fence-posts and poles below ground level. The best preventative is to keep the wood dry, or by impregnating it with a preservative, such as creosote oil.

Wood-staining fungi cause a bluish discolouration in some timbers, notably pines, but this does not impair the structural strength of the wood. This type of fungi requires a timber moisture content of approximately 20 per cent to exist. If caught in the early stages the discolouration can be treated with a weak oxalic acid solution.

Defects due to insect attack

Public enemy numbers one and two when it comes to damage of trees, logs, freshly sawn timber and even wood that has been well seasoned, are borers and termites.

Borers

The furniture beetle (*Anobium*) is the most common member of the borer group and is found worldwide. It mainly infests the sapwood of softwoods (conifers), although damage to the heartwood is not uncommon. Attacks in native eucalypts are rare.

Larvae (grubs) may feed and tunnel in the timber for years before entering pupal or resting stage near the timber surface. The newly developed adult beetle emerges a few weeks later, then bores an escape tunnel to the surface (Table 4.1, row a).

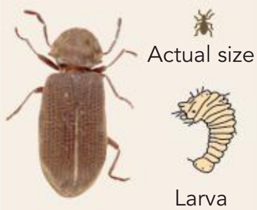
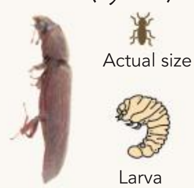
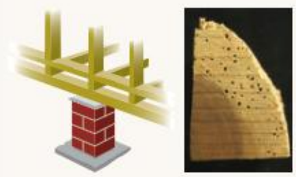
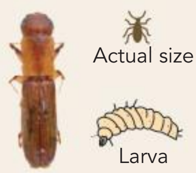
Furniture beetle infestations are usually noticed in old timber (from 7–40 years), partly because of the insects' comparatively long life cycle (2–6 years) and also because it is possible for several generations to emerge before attack is discovered.

Powder post or *Lyctus* beetles are borers often found attacking the sapwood of select hardwoods. The larvae damage the timber by feeding on the starch in the sapwood. The heartwood (truewood) escapes these attacks because it contains no starch. Timber containing susceptible sapwood is usually attacked within 12 months after milling, and the infestation continues until all of the food (starch) has been eaten.

Lyctus beetle eggs are laid in the vessels or pores of the wood; and therefore, cannot attack softwoods (non-pored woods) or hardwoods with minute pores. The complete life cycle may be as short as 4–5 months with a single emergence a year (Table 4.1, row b).

Pin-hole borers (*Ambrosia*) attack green timber. The adult beetles infest almost all species of trees, and frequently tunnel deeply into the wood of weakened trees, freshly felled logs, and even milled timber that is high in moisture content. Their tunnels or holes are typically long and straight across the grain, such that a pin may be inserted a considerable depth. Fungi are introduced into the tunnel by the beetle, and the young larvae feed on the ambrosial fungus. The fungus is dependent upon a generous moisture supply and cannot grow in dry wood. Therefore, the pin-hole borer does not damage seasoned timber.

Table 4.1 Timber-boring insects

Types of borers	Timber attacked	When attacks occur	Shape and size of holes	Prevention and treatment
a Furniture beetle (*Anobium*) 	Sapwood mainly, usually of softwoods	Seasoned timber		Pressure impregnation of sapwood and heartwood with preservative chemicals. Surface spraying or brushing with contact insecticides. Fumigation with methyl bromide if found in furniture. Heat will also kill insects.
b Powder post beetle (*Lyctus*) 	Sapwood only of various timbers, usually hardwoods	Partly or wholly seasoned timber		Immunisation of sapwood with suitable chemicals or removal of susceptible sapwood. Fumigation or kiln drying will kill Lyctus, but will not prevent fresh attack.
c Pin-hole borer (*Ambrosia*) 	Any timber that has been freshly felled	Unseasoned timber only		Debark logs and spray with insecticide immediately after felling. Momentary dip and diffusion method may be used for boards prior to seasoning.

The wood surrounding the borer holes is generally discoloured by the fungi; and although pin-hole damage does not generally weaken wood structure, it does affect appearance and can lower its market value (Table 4.1, row c).

Termites

Termites are often called white ants. While they are not really ants, they destroy large quantities of timber in Australia, attacking poles, posts, sleepers

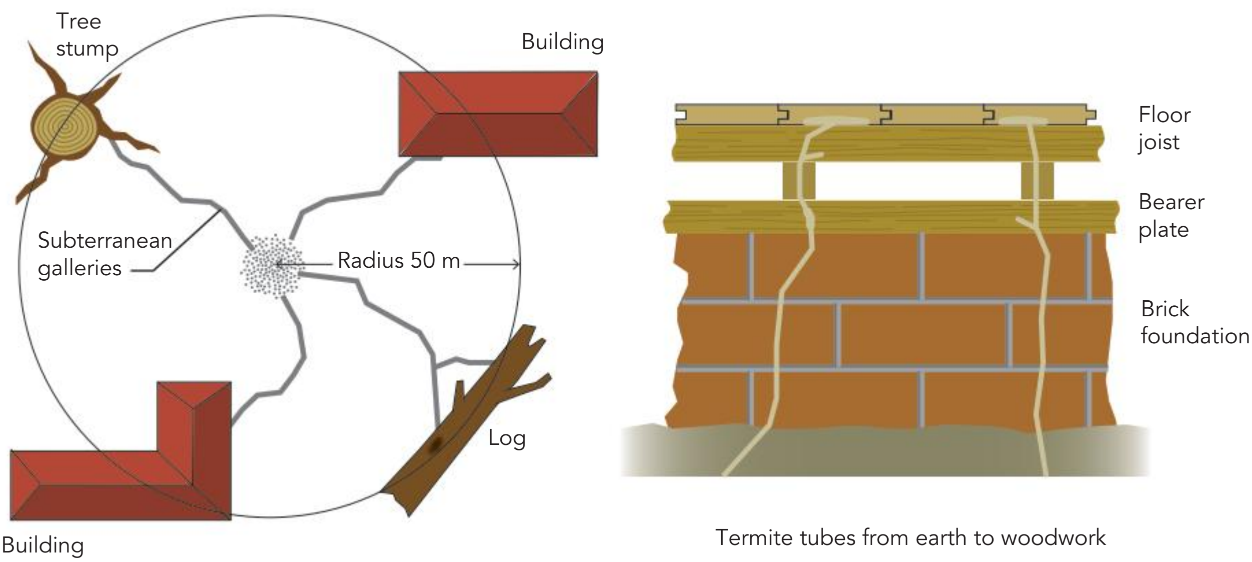


Figure 4.21 Typical termite nest and earthen tubes

and wooden structures of all kinds. They live in colonies, and individuals cannot exist without communications with the colony. In some species the nest is a series of galleries in timber; others build a mound-shaped nest above the ground; yet others construct a subterranean nest. Practically all of the termite damage to seasoned timber is caused by the subterranean species, and timber in contact with soil is most at risk (Figure 4.21).

The damage produced by termites is often difficult to detect in a structure, because they prefer to seek out dark and badly ventilated areas. The signs of their presence include the termite galleries leading from the ground. Often the damage is not discovered until timber has been almost completely hollowed out. Once found, the damage is easy to recognise; the termites work inside the boards, along the grain, eating out large galleries or runways. These destructive networks are often lined with disintegrated wood and clay mixture, and the shell of timber left is often decayed (Figures 4.22a and b).

Prevention and control

Termite species capable of serious damage need contact with the ground or access to a continuous source of moisture. Therefore, prevention of damage calls for making it difficult for termites to make a concealed entry into a structure from the surrounding soil, and measures to eliminate dampness within the building:

- *Physical barriers*. Preferably, foundations should be constructed from a solid, inorganic material, such as brick, steel or concrete slab, so that termite tunnels may be visible on them. All foundation walls and piers should be fitted with termite shields made from durable material, such as crushed stone, steel capping or stainless steel mesh.

Shutterstock.com/sirirak kaewgorn

Figure 4.22a Wood partly destroyed by termites

iStockphoto.com/bruceman

Figure 4.22b Termite damage in housing

- *Soil treatment.* Liquid treatments using a pesticide called a 'termiticide' create a barrier around a house so that termites cannot pass. Long-life chemicals are no longer registered for this use; therefore, modern chemicals must be re-applied to maintain protection.

  There are two basic kinds of liquid pesticides used on termites: repellents and non-repellents. Repellents try to create a chemical barrier which termites cannot pass. The chemicals repel termites, and they will not cross the barrier to get into your home.

  Non-repellents just kill the termites when they cross the barrier.
- *Ventilation.* Adequate underfloor ventilation reduces the presence of moist, sheltered areas sought by termites.
- *Drainage.* Adequate drainage avoids water collection areas under structures.
- *Use of treated timber.* Naturally durable timbers, such as cypress pine, or timbers that have been impregnated with suitable preservatives reduce the options for termite infestations.

The building Code of Australia (BCA) requires all new building work to conform to Australian Standard AS3660.1-2000 Termite management.

The life cycle of termites

Every termite colony is founded by a king and queen. The queen produces a vast number of eggs that give rise to the various castes of termites; workers, soldiers and reproductive alates (winged types). The workers of this pest species are small, wingless, white-bodied, blind insects with well-developed jaws

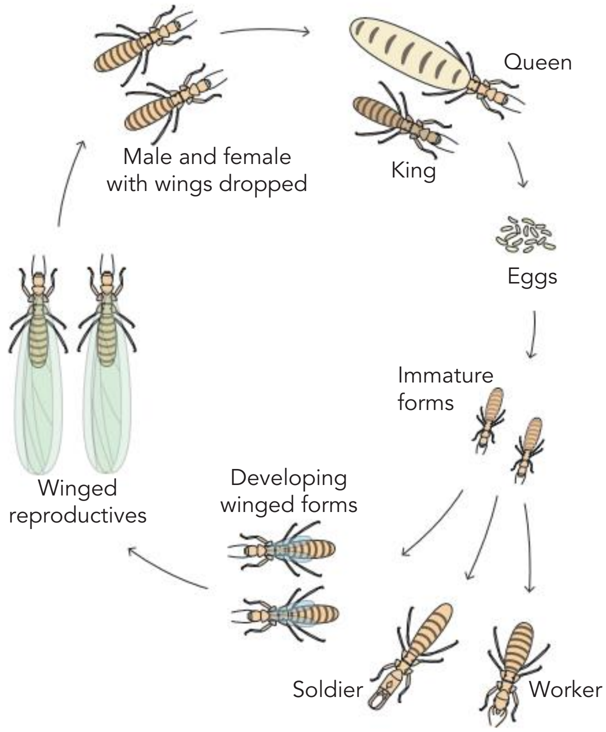


Figure 4.23 Termite life cycle

for gnawing wood. The workers are responsible for building the nest, collecting food, and the feed and care of the rest of the colony.

The soldiers, whose function it is to protect the nest from invaders, are also blind, but are armed with longer jaws than the workers. The male and female reproducers are provided with wings, which enable them to fly from the nest to start new colonies (Figure 4.23).

Two peculiar habits of the termites enable us to control their activities:

1. They groom or clean each other by removing particles of dust and moisture.
2. They eat their own dead.

Poison powders and insecticides introduced into termite galleries are thus transferred from one termite to another until the whole colony is dead.

Wood preservation

Wood preservation is the treatment of timber to increase its durability and service life. The principal agents causing deterioration or destruction of wood are fungi, insects, fire and weather. Excluding this quartet of destroyers prolongs life, evidenced by the good condition of wooden furniture unearthed from very dry, sealed tombs dated to the times of the Pharaohs.

Some timbers, such as Californian redwood, naturally contain chemicals that are toxic or repellent to fungi and insects. Choose either naturally durable or correctly preserved timbers where decay or insect attack is likely to occur.

Timber may be preserved in two broad ways.

1. By the provision of physical barriers against attack through sound construction and maintenance methods.
2. By treatment with chemical preservatives.

Physical barriers

The evolution of building techniques using durable timbers, concrete, brick or stone foundations with correctly fitted termite shields and sub-floor ventilation has resulted in a large reduction in the need for chemical preservatives.

A continuous film of paint affords good protection against fungal and insect attack and also helps to control the ‘working of wood’ (shrinkage or swelling caused by variations in moisture content).

Chemical preservatives

Preservation is recommended if conditions are conducive to fungus or insect attack. Sound construction using durable timbers, and normal maintenance, should ensure a satisfactory life without preservatives.

Timber may be coated or impregnated with preservatives, and their effectiveness depends on the degree of penetration achieved. Although the heartwood of most species is non-permeable, and can only be treated by special means, generally the sapwood of all timbers, hardwood or softwood, can be impregnated. This enables the safe use of susceptible sapwood and normally ‘non-durable’ timbers for construction.

Preservatives should be applied before infestation has begun. Unless the wood is fully impregnated, decay can proceed in the part not reached by the preservative; therefore, timber should be further treated after completion of all sawing, boring and other operations likely to expose untreated areas.

Types of preservatives

Oil types

Creosote, a common and efficient preservative, is used for treating fence posts, poles, sleepers, structural timber, etc. Besides being an effective fungicide, it is toxic to insects and marine borers. It has satisfactory penetration and lasting qualities, but because of its dark colour and oily nature it renders the timber surface unsuitable for painting or varnishing.

Copper chrome arsenic salt (CCA salt) is a water-soluble preservative that becomes *fixed* in the wood. This mixture can be applied through sap-replacement of green timber or vacuum pressure impregnation.

From March 2006 the Australian Pesticides and Veterinary Medicines Authority (APVMA) has implemented a number of restrictions on CCA because of its potential carcinogenic properties. CCA is not to be used to treat timber where regular human contact is likely, such as picnic tables, handrails, decking and playground equipment. However, CCA has not been restricted in industrial, agricultural and marine applications.

Copper and zinc naphthenates, which are almost insoluble in water but easily soluble in kerosene and many other organic solvents, are highly toxic to fungi, borers and termites, and, to a lesser degree, marine borers. The naphthenates are suitable for treating plywoods and timbers used in boat building. Copper naphthenates leave a green stain and are only suited for painted surfaces, while the zinc naphthenates, though less toxic, are non-staining and may be used where a clear finish is desired. Naphthenates are generally available from large hardware stores.

Water-borne types

These types consist of chemicals, either unfixed or fixed salts, dissolved in water. The chemicals, provided in powder form, are usually odourless and non-staining; when dry, the treated wood may be painted.

Various boron compounds, such as borax and boric acid, are used to protect susceptible timbers from attack by Lyctus and Anobium. These salts offer a clean, paintable surface without discolouration. Boron compounds should not be used on timbers or plywoods exposed to conditions that could cause the salts to leach out. They are better suited to interior or painted work.

Methods of applying preservatives

Vacuum pressure treatment

The most effective and reliable form of preservative is pressure-impregnation of wood and plywood. This factory treatment, carried out by specialist firms, must be specified when ordering materials. Plywood can be treated with preservatives to a concentration up to 8 kg/m^3 and still be satisfactorily glued in assembly. This treatment does, in fact, aid painting. CCA salts and creosote are pressure-impregnated into plywood or timber in specially designed chambers. The CCA treatment is permanent and imparts a green colouring to the material, which has excellent resistance to fungal attack.

Hot and cold bath process

The timber is soaked in heated preservatives for a few hours, then allowed to cool. The heat in the tank expands the air in the wood and a certain amount is expelled, so that during the cooling process a partial vacuum is formed and the preservative is virtually sucked into the wood under pressure. Good penetration is achieved, particularly in the sapwood of hardwoods.

Dipping

In this process, the wood is dipped in a tank or bath for a period varying from a few seconds to a maximum of three minutes. Sodium 'penta' borax is used as a preservative in a stain dip. Satisfactory preservative penetration in veneers and solid timber is obtained by using the momentary dip and block-stacking process, sometimes referred to as the 'dip-diffusion process'.

CCA fixed preservatives are generally accepted as the most effective waterborne preservatives available. Aqueous solutions in 2–6 per cent concentrations are generally used in pressure plants and for dip treatment of veneers, where carefully controlled loadings can be maintained. These salts are non-leaching and non-staining, so that when dry, treated wood is blemish-free and may be painted or varnished.

Proprietary preservatives, such as Boliden K33, Celcure AP and Tenalith C and CA, consist primarily of copper chrome arsenates.

Fire retardants

Some timbers boast degrees of natural resistance to fire. Large sections or laminated beams, in particular, usually char on the outside and then burn very slowly because the charcoal shields the wood from oxygen. Plywood and timber may be impregnated with fire-retardant chemicals, such as ammonium sulphate and ammonium phosphates, and further protection can be afforded by applying special fire-retardant paints. These chemicals and paints protect the wood by melting at a temperature below the combustion point of wood and forming a glaze over the surface, or by giving off non-flammable gases that blanket the combustion.

Brush and spray application

This may be the simplest method, but it is usually the least effective because only a light surface penetration is achieved. Specialists in timber preservation have a wide range of solvent-based preservatives available, which are designed to meet specific requirements. Follow the preservative manufacturers' recommendations regarding brush or spray application, paying special attention to any cracks and end grain areas. Preservatives do not readily penetrate the core stock of plywoods and, for this reason, they should not be applied until components are cut to size. Further cutting or drilling also exposes untreated surfaces, where decay could start if conditions are conducive.

CHECK YOURSELF

1. List two examples of natural defects in timber.
2. Name one seasoning defect.
3. List two methods of preventing white ant attack on a house.
4. What causes dry rot in timber?
5. What risk is associated with working with treated pine timber?

HINT

As in any specialised field, it is wise to discuss any specific preservation problems with experts. Organisations, such as the Division of Wood Technology, the Plywood Association of Australia and the Timber Development Association, will be glad to provide additional information when requested.

Commercial uses of timber

Timber characteristics

There are various timber characteristics that dictate diverse use. The guidelines that make timber especially suitable for structural, joinery and cabinetwork are:

- good strength-to-weight ratio
- adaptability for a variety of uses
- ease of working and joining with glues and mechanical fasteners
- pleasing appearance (aesthetics).

The following disadvantages also need to be considered:

- susceptible to attack by insects and fungi
- prone to variations in quality, when compared with metal, due to the effects of grain direction, knots, shrinkage and moisture content
- susceptible to the weather, necessitating the application of a preservative.

Used structurally, timber is subject to the same stresses as steel, but resists them in a different way. This is why joints, struts and braces in timber must be designed to resist compression stresses, while in steel they must resist tension stresses.

Forestry

Considerable concern has been expressed for some years now regarding the increasing rate at which timber is being used. Some countries have made positive moves to reduce the rate of disappearing forests by practising **sustainable yield** through **silviculture**. Silviculture is a managed plantation

Figure 4.24 Forestry Australia's facts

system controlling the establishment, growth, composition and quality of forest vegetation, the conservation of water resources, recreational areas and wildlife habitats, and the level of livestock grazing.

The practice of sustainable yield involves trying to grow at least as much wood as is being used in the timber industry by plantation work, natural regrowth and disciplined harvesting. Unfortunately, as yet, this is not being met on a global scale.

World forests

Almost half of the world's original forest cover has been lost since the last ice age, with most of this loss occurring since the 1960s. Study the map in Figure 4.25 and you will see that, setting aside the large desert areas and the regions near the North and South Poles where no forests exist, there are two natural belts of timber: softwoods (conifers) extending across the northern part from the Arctic Circle down to about the 50th latitude and hardwoods covering the tropical areas. Although the Northern Hemisphere contains the natural pine belt, pines are plantation cultivated in all parts of the world, just as Australian eucalypts are cultivated in other countries.

A report from the United Nations Food and Agriculture Organisation (FAO) indicates that forests

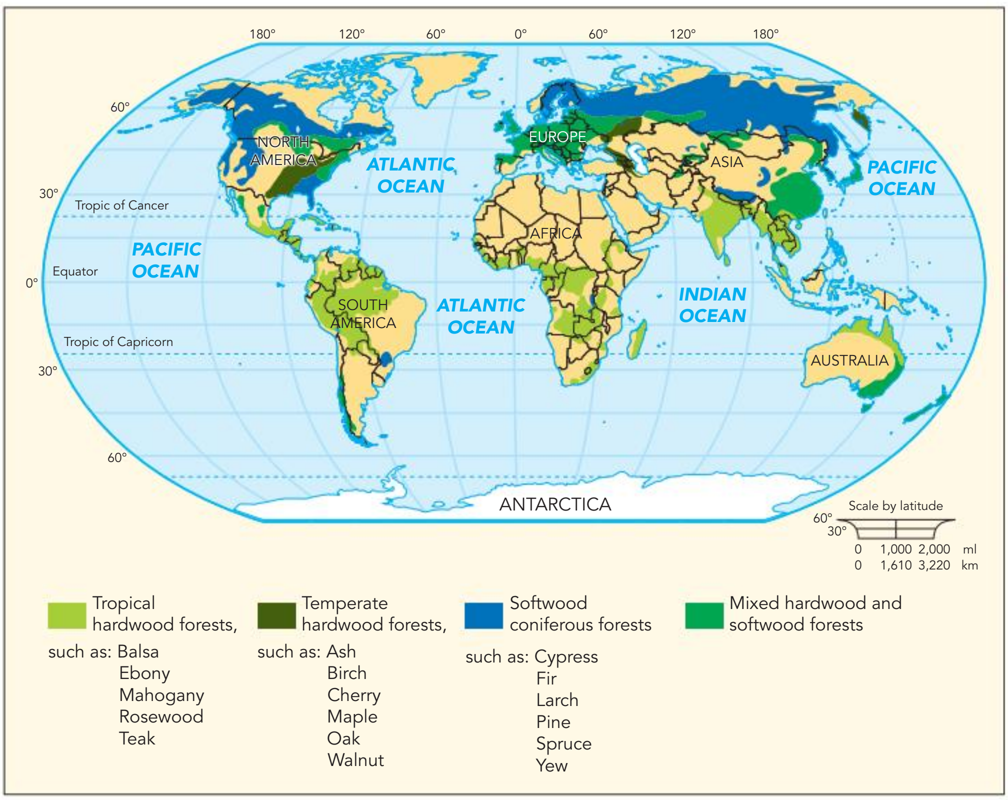


Figure 4.25 Distribution of the world's softwood and hardwood forests

were reduced by 3 per cent in 1990–2015 to a total of 3999 million hectares, which represents 31 per cent of the globe's land mass. This represents a drop in the rate of deforestation. Rainfall, temperature and soil conditions are the factors affecting not only the distribution of forest areas throughout the world, but also the variations that occur in the timber produced by the same species in different regions. For example, English oak, American oak and Japanese oak are all members of the Quercus family, but they differ from each other in density, colour, weight and texture.

> **FACT**
>
> HMS Victory, best known as Lord Nelson's flagship at the 1805 Battle of Trafalgar, was built using an estimated 5000 mature English oak trees. There were 27 ships like it making up the Royal Navy fleet; even more in the French-Spanish alliance.

The majority of Australia's more than one million hectares of softwood plantations consist of radiata pine. About 70 per cent of the softwood timber we consume in Australia is domestically grown. Radiata pine takes approximately 25–35 years to mature; and therefore, provide a return on investment. Only two other softwoods, cypress pine and hoop pine, are of commercial importance.

Australia has more than 980 000 hectares of hardwoods in plantations so far – much of which is lower value and used for wood fibre and paper production. Eucalypts (hardwoods) are predominant; New South Wales has about 240 different species, of which only about 20, chiefly blackbutt, are exploited to any extent.

Forestry: what is it?

There are five main aspects summing up the use of forest lands. They are central to the science and art of forestry management:

1. *Maximum yield of timber products*. Research by bodies, such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), results in the creation of more efficient methods for achieving maximum yield from timber products (i.e. reafforestation).
2. *Conservation of water resources*. Watersheds in Australia are within the tree line, and because removal of forests from catchment slopes causes silting of creeks and dams, forest management plays a vital role.
3. *Preservation of outdoor recreation areas*. The rapid increase in urban populations means that certain forest areas must also service recreational use by the general public.
4. *Provision of a secure habitat for wildlife*. Most wild creatures live in the forests so they must be allowed unhindered use of areas, or face extinction.
5. *Controlled grazing for domestic livestock*. Grazing within forest lands is approved in order to meet the demand for animal feeding; however, a balance must be reached so that livestock is not in direct competition with wildlife for food. It has been stated that grazing contributes to the bushfire hazard by accelerating erosion; and therefore, decreasing water catchment.

Conservation

Europe's first plan to regenerate forest lands dates back to 1750. In Australia, New South Wales led the charge to control timber cutting in 1839, but it was not until the early 1900s, following the establishment of the Forestry Commission to control and manage the state's timber forests and reserves, that the first attempt was made to practise forestry as we now know it. Since then, planting programs have established new hardwood forests and, more notably, considerable areas of softwoods (conifers). By 1973, 100 000 hectares of pine had been planted in New South Wales, and planting was expected to continue at the rate of 6000 hectares annually. According to the NSW Department of Primary Industries there were about 251 500 hectares of radiata pine plantations in New South Wales in 2005. Preservation of suitable trees in existing forests, so that they may develop to advantage, is achieved by three operations: thinning, pruning and protection from fire.

Thinning

Within nature, a forest thins itself; the more vigorous trees outgrow the weakest and the slow growers, which are more prone to insect and fungal attack. By using planned thinning, foresters ensure the preservation to maturity of useful species with good shape and size. In pine plantations, thinning is large scale. By initially planting trees closer together, this process promotes straight stems, branch shedding

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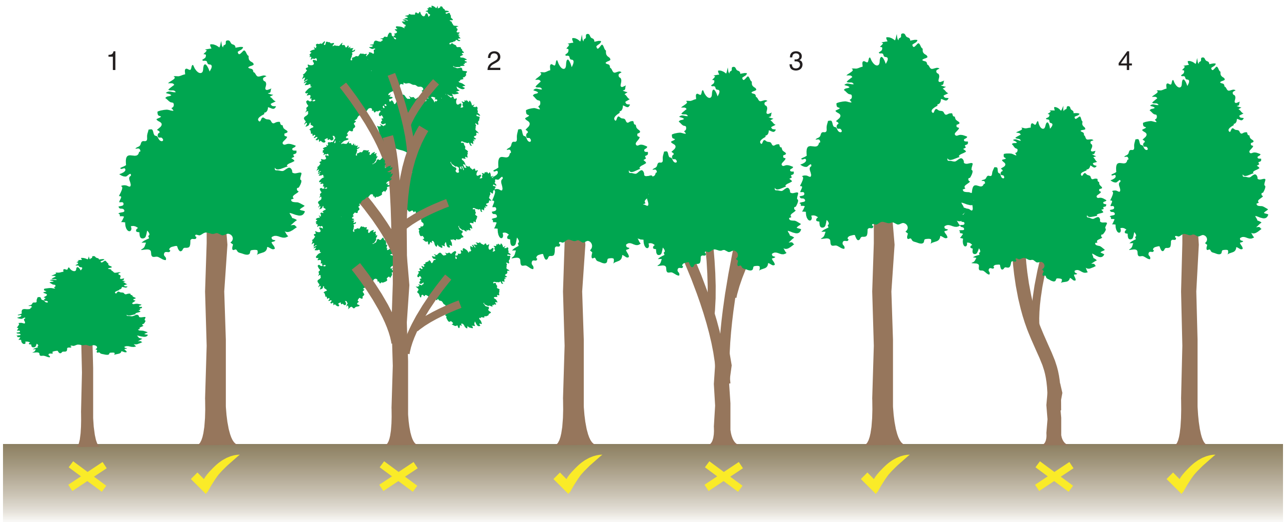

Figure 4.26 Thinning managed forests

and encourages upward growth towards the light. Thinning removes the trees with poor growth, large branches, forks and bent trunks. This leaves only the best quality trees (Figure 4.26).

Trees are planted at intervals of 2.5 m in rows 3 m apart, which translates to about 1300 trees per hectare. By the end of 12 years, the number remaining after thinning is about 500 per hectare. Thinning is conducted around five-year intervals, until at 35–40 years there are around 150 per hectare left standing. Thinnings are achieved using chainsaws or poison treatments. Smaller thinnings can be chipped for mulch and larger ones are used for fuel and posts, or pulped. The total yield from a hectare of such a pine forest is about 166 m^3.

Pruning

As a tree grows, the lower branches play a less active part in the life process and eventually die and are shed. In eucalypts this happens at an early stage and the stubs of fallen branches heal quickly, producing long, clean trunks with few knots. In pines and most other trees whose foliage requires less light than that of eucalypts, the lower branches remain for much longer. When they do die and fall, loose knots are formed in the trunk, spoiling the timber quality. The aim of pruning is to prevent such knots by removing the lower branches while still living. Subsequent growth on the pruned section will then be knot-free. The usual practice is to prune all trees around eight years of age, when the height is usually about nine metres. Then, at 13 years, trees that are selected to remain for the final felling are pruned five metres from the ground.

The advantages of pruning are fourfold.

1 It improves the shape of the tree and its log.
2 It produces clean timber, free from knots and defects.
3 It aids in fire-proofing because the removal of lower branches reduces fuel for ground fires.
4 It improves access to all parts of the forest for logging and other activities.

Protection from fire

Controlled fires are used to clear a site for planting, preparing seed beds, burning off dense undergrowth prior to logging and exterminating plagues of insects. Uncontrolled fires bring the risk of loss of life and property as well as destruction of recreational areas and natural food of birds and animals; however, they also have serious implications for forest management.

Mature trees may be burnt or, if not killed, severely damaged. Scorching of the crown (the top branches and leaves, which play a vital role in maintaining the tree's food supply) will retard development; destruction of bark leaves a tree prone to attack by termites or fungus; defects such as gum veins may be caused, spoiling the timber's appearance. Fire may lower the commercial value of a forest area by destroying useful species, such as blackbutt, which grow only from seed, and allowing less desirable species that propagate by lignotubers to grow again. By destroying humus (the mulched material formed from dead leaves and other organic matter, which supplies important chemical elements to the soil), fire may change the nature of the soil to such a degree that it either will not support tree life or will produce only inferior quality timber.

Fire-control measures are concerned with the three main factors that cause fires; namely, fuel material that will burn (dry grass and undergrowth, fallen bark, leaves and sticks), oxygen (present in the air) and heat (flames, sparks, lightning) to cause ignition. Fire trails criss-crossing the forest are vital for fire control, providing access roads for vehicles, people and equipment. Fire prevention is the best remedy and is being aided in Australia by the enforcement of penalties for lighting fires in the open and by research into the causes of fire. It is estimated that lightning is responsible for only 1 per cent of bushfires in Australia. The remainder are caused by carelessness with camping and picnic fires, or during burning-off and clearing operations.

Reafforestation

Forests **regenerate** naturally as trees shed seeds and form lignotubers. Species seed at different ages (some eucalypts at 4–5 years, Monterey pine at 10 years) and spread their seeds over a distance equal to their height. A lignotuber is a woody mass formed by some trees in the first shoot of seedlings, carrying food reserves and dormant buds. As the tree grows, the lignotubers bury into the ground, remaining dormant until the tree is felled or destroyed, when, subject to the right conditions, they form new growth. Most eucalypt forests play host to about 1250 lignotubers per hectare.

Deliberate cultivation of forests, known as silviculture, involves replanting or reseeding with due regard to the site and the method of cutting existing timber. Clear felling and selection are the two operational systems.

Clear felling

Clear felling involves four different methods. New plantations are established by clear felling and planting.

When the whole of the usable crop is felled at one time, the site is cleared and the new crop planted. Simplicity is the main advantage, ensuring planting of the required species, and, since the seedlings are usually one or two years old, this allows the correct spacing of trees. Disadvantages include cost, risk of soil erosion caused by wholesale clearing, the necessity of first growing nursery trees to shelter seedlings (if they are of a frost-sensitive type), and the fact that failure of the crop, or destruction by fire or vermin, means total area replanting.

Another method of clear felling avoids seed trees of desirable species so the area can regenerate after other trees have been removed. The advantage is no reliance upon pre-grown seedlings, and if any young trees die, the seed trees replenish the stock. Disadvantages include that regeneration may be uneven, depending on the seeding cycle, and that seed trees are very exposed and may deteriorate or be damaged by wind.

A variation is called strip felling, in which the seed trees are left in strips. This provides more effective seed distribution and more shelter which leaves young trees less exposed to the elements.

Under the fourth method, the 'sheltered system', the old crop is felled in gradual stages, allowing small trees to develop and the new crop to establish itself before all the old trees have been felled.

Selection

Selection operates similarly to the sheltered system of clear felling in that the largest trees are felled as they mature, leaving the smaller ones to develop.

The 'individual' system, which operates well in Switzerland, where trees of all sizes grow side by side and removal of a single tree has no effect, is not practical in Australia.

The 'group' system, as the name implies, sees groups of trees felled (in areas up to half a hectare) rather than single trees. This system is often used in eucalypt forests, where gaps, formed mainly through the loss of trees by fire, have been filled with much younger self-sown trees. Removing the older trees enables the young ones to develop more effectively.

Selection systems are useful where species sensitive to exposure are grown, but logging costs are high owing to the small yield of trees for felling, with the total unpredictable and variable. The cutting cycle is usually about 10 years, which means that one-tenth of the area is cut every year. Contrast this with clear felling systems, in which the cutting cycle is from 30–60 years.

Forest products as commercial raw materials

Besides supplying the needs of structural and general woodworking use, forest products produce the raw material used in many manufacturing processes (Figure 4.27).

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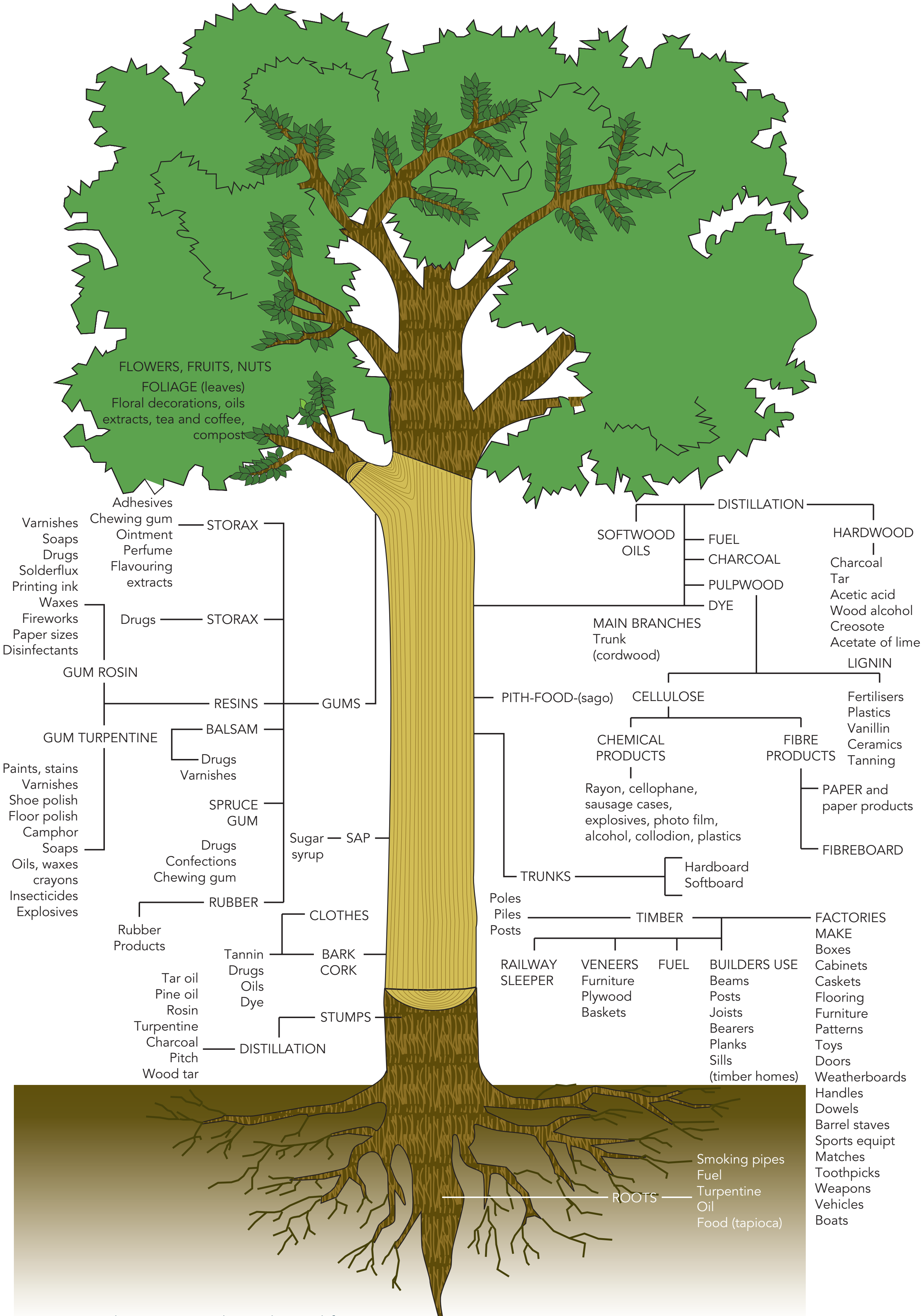

Figure 4.27 The many products derived from a tree.

Sawdust utilisation

This is an important factor in overcoming a major cause of waste in timber conversion, with sawdust accounting for up to 20 per cent of a log. Problems with its use include transport, separation of species, colour grading, resin content and particle size; however, further research may produce marketable solutions to these problems. Although attempts to produce sawdust-based boards have not been fully developed, sawdust is used commercially for fuel, bedding litter for cattle, packing, insulation, stuffing and food preservatives. It is also used to manufacture linoleum, plastics, explosives and abrasives, and as a composition ingredient in concrete, cast clay products, stucco and plaster.

Paper pulp

The paper and pulp industry uses more than 40 per cent of the industrial wood traded globally, according to the World Wildlife Fund. Australia is a relatively small industry player, but Australians are recognised as consuming 230 kg of paper products per person every year, comparable with the United States, while Western Europe's per capita usage is 179 kg, Latin America 79 kg, Asia 41 kg and Africa 8 kg. Australians are consuming too much paper with very little consideration about where that paper is sourced from and how it is made.

With a history spanning 2000 years, making paper is still basically the same process: logs are cut into chips, which are ground and pulped with water and chemicals to make the fibres bind. The pulp is bleached, then formed into a mat and compressed between rollers.

Chemicals and other materials are produced from wood by distillation and allied processes. Creosote, methanol, acetone and tar are distilled, leaving charcoal as a by-product. Other products include wood alcohol for making synthetic rubber and explosives, tannin for the leather industry, and resin and turpentine tapped from living trees as well as produced from wood waste.

Specific uses for special timbers

Based on their particular qualities, different timbers aid in special applications.

Cypress pine contains guagol and callitral, which make it resistant to decay and a resinous substance that makes it termite-resistant. Therefore, it has a special value as scantling, flooring, weatherboards and lining for house construction, as well as fence posts and vineyard trellises.

Lignum vitae, while not a structural or cabinet timber, boasts a density and hardness that makes it particularly suitable for bearings for artillery weapons, stern tube bearings in ships, pulley sheaves, gear wheels, mallet heads and tool parts. There is a marked difference in colour between the dark brown heartwood and the yellow sapwood.

Teak, seen in furniture and veneer, has long been used for joinery and decking on ships and boats. Natural oils withstand water immersion and make for a long life, while there is little shrinkage or twisting. It is also highly resistant to fire and termites.

Spotted gum, a useful structural timber, has high shock-resistance and good bending qualities, making it ideal for ships' ribs and planks, for vehicle bodybuilding and bent work. It is the best available Australian timber for tool handles.

Turpentine, a structural timber, is resistant to the Teredo worm, a marine borer, and is used for building wharves, where the bark is often left on, because it is believed that the oleoresin present in the inner bark repels the Teredo. Turpentine is the least flammable of all Australian timbers.

The working characteristics of commonly used cabinet timbers

- *Radiata pine*. The most economical softwood timber on the market. It is easy to work (plane or chisel) except for knots and it nails satisfactorily. Its high resin content can make it hard to glue and it clogs up abrasive paper easily. Back-sawn pieces can cup easily but have attractive grain figure. Can take a very good finish; will darken with age and exposure to light.
- *Meranti, Phillippine mahogany and luaun (all from the Shorea family)*. Among the cheapest and most readily available of the hardwoods. Works well, apart from the lighter coloured varieties that tend to collapse when chiselling across the grain. There is a tendency for these timbers to split along the grain, so be aware. Relatively straight grained and

knot free, these timbers can take a good finish; however, some examples have a furry surface and require the grain to be lifted and re-sanded.

The following tables dissect hardwoods and softwoods, Australian and imported. Note, some are getting quite scarce and are now protected.

Table 4.2 Australian hardwoods

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Ash, silver North-east Queensland, north NSW	Almost white 670 kg/m^3	Fairly close texture, straight grain, sometimes with interlocked, wavy, fiddleback and ribbonlike figure	Easy to work; glues and stains and finishes well; good seasoning timber, does not warp or twist; bends well	Veneers, plywood, panelling, interior decoration, flooring, lining, joinery, tennis racquets, cricket stumps, baseball bats, boat ribs, sail slats, oars and sculls
Blackbutt Coastal NSW, southern Queensland	Pale brown 880–1030 kg/m^3	Usually straight grain; moderately close texture, often with small gum veins	Hard, strong and durable	General building construction, scantlings, floorings, sleepers, posts, poles, shipbuilding, fencing and paving blocks
Blackwood Mainly Tasmania, but also other states except WA	Reddish brown 640 kg/m^3	Straight grain, moderately open texture; fissile	Strong and tough; excellent for steam bending; sapwood susceptible to Lyctus borer attack	Furniture and cabinet work, shop and office fittings, panelling, billiard tables, parquetry flooring, inlays and aeroplane members
Bean, black North NSW, Queensland	Dark walnut with pale sapwood 770 kg/m^3	Rather open texture; alternating light and dark zones	Durable; high electrical resistance; does not glue well; liable to cause dermatitis	Panelling, cabinet work, shop and office fittings and wood carving
Box, brush Eastern coast from Port Stephens, NSW to Bowen, Queensland	Pale to reddish brown 910 kg/m^3	Close texture, often slightly interlocked grain	Hard and tough; somewhat liable to warp and twist in seasoning; excellent wearing qualities; durable, resistant to termites	Bridge and wharf decking, paving blocks, coach and carriage work, mauls and mallets, woodworking, plain high-class floors, general building purposes, wedges and shipbuilding yards
Cedar, red Coastal NSW and Queensland, Pacific Islands	Light to deep red 420 kg/m^3	Open texture	Soft, aromatic, light, easy to work; very durable when exposed to weather	Cabinet work and joinery, racing skiffs, patternmaking, sheathing, interior panelling, show cases, carving, shop and office fittings, veneers and plywood

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Coachwood or scented satinwood NSW coast and ranges	Pinkish colour; darkens on exposure 620 kg/m^3	Close texture, rather tough; often prettily figured	Somewhat leathery to work; readily polished	Rotary-cut veneers and plywood, veneer and corestock
Gum, spotted Coast of NSW and Queensland	Pale colour 950 kg/m^3	Moderately open texture; grain often interlocked; fine concentric lines of soft tissue	Strong, tough; broad sapwood particularly subject to destruction by powder post borer	All classes of building construction; shipbuilding; heavy oars; axe, pick and hammer handles
Ironbark Coast and dividing range in NSW and Queensland	Deep red 990–1120 kg/m^3	Close texture, usually with interlocked grain	Hard, strong and durable; ranks high in ironbark group	Heavy construction work of all kinds, sleepers, poles, posts, bridge and wharf building and paving blocks
Jarrah South-west WA	Reddish 880 kg/m^3	Straight grain, moderately close texture	Durable and fire-resistant	Used in WA for general building purposes, flooring, rusticated weatherboards, shipbuilding, wood paving, posts, sleepers, panelling, cabinet work, carving; used in NSW for high-class parquetry flooring, rusticated weatherboards and chamfered fencing
Maple, Queensland North Queensland tablelands	Pinkish 580 kg/m^3	Moderately close texture	Readily seasoned; can be easily fumed; excellent cabinet wood	High-class furniture, interior joinery, mouldings, panelling, shop and office fittings, boat building, rifle stocks and window sashes
Oak, northern silky North Queensland rainforests	Brownish pink 550 kg/m^3	Rather open texture, prominent medullary rays	Moderately soft; excellent for steam bending; sapwood wide and highly susceptible to borer attack	Cabinet work, plywood, shop and office fittings, interior joinery, mouldings, panelling, turnery and car hood bows

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Sassafras Hunter River, NSW to Mary Valley district, Queensland	Yellow to yellowish brown 610–720 kg/m^3	Close texture, straight grain	Not durable exposed to weather; sapwood highly susceptible to attack by powder post borer	Cabinet work, interior joinery and fittings, small tool handles, turnery and plywood
Stringybark South-east Australia and Tasmania	Pale colour 740 kg/m^3	Rather open texture, usually straight grain	Strong, easily worked; sapwood highly susceptible to attack by powder post borer	General building purposes, furniture and cabinet work, interior joinery and fittings, shingles, palings, cases, wood pulp and paper pulp
Tallowwood NSW central coast to Fraser Island, Queensland	Greyish yellow 980 kg/m^3	Fairly close texture, greasy nature	Gard, heavy, strong and very durable; sapwood liable to powder post borer attack	Floorings, general building, weatherboards, window sills, paving blocks, decking, sleepers, poles, posts, bridge and heavy construction work and works exposed to weather
Turpentine NSW and Queensland coast	Reddish brown 930 kg/m^3	Close texture, usually straight grain	Hard; difficult to season, being liable to warp and twist; most resistant to attack by marine borers; specifically fire-resistant	Saltwater piles, wood paving, sleepers, bridge and wharf decking, flooring, scantlings and ship planking
Walnut, Queensland North Queensland rainforests	Varies from yellowish or reddish brown to dark chocolate 700 kg/m^3	Moderately close texture, frequently with rich figure	Contains silica, making it difficult to work with hand and machine tools; slices well to make attractive veneer; highly electrical resistant	Shop and office fittings, all classes of ornamental turnery, veneers; highly prized for decorative furniture and panelling

Table 4.3 Australian softwoods

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Pine, cypress Australian interior	Pale yellow to brown 660 kg/m^3	Close texture, pleasant smelling	Rather hard, subject to numerous firm knots, often possessing beautiful figure for turnery; slices, but does not peel well; durable in ground and famous for termite resistant properties	All kinds of building purposes, scantlings, flooring, panelling, lining, weatherboards and concrete formwork
Pine, hoop North NSW and Queensland	Pale yellow to almost white 480–640 kg/m^3	Even texture, no pronounced growth rings	Not durable in wet situations; subject to blue stain in sapwood due to fungal attack	Interior joinery, shelving, plywood, flooring, lining, ceilings, mouldings, masts, booms and spars, light oars, planking for light boats, cabinet work,and brush and broom stocks
Pine, radiata or Monterey pine NSW and SA	White to creamy yellow 510 kg/m^3	Straight grain, frequent knots, fine texture; distinct growth ring figure	Strong and takes preservatives well	All kinds of building purposes, mouldings, flooring, lining, weatherboards, joinery, corestock and plywood manufacture

Table 4.4 Imported hardwoods

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Hickory Eastern North America	Sapwood white, truewood reddish brown 800 kg/m^3	Straight grain; fine and uniform texture; distinct fine growth rings	Strong, tough, shock resistant, elastic; not durable, subject to insect attack	World's foremost timber for tool handles, vehicle parts, agricultural tools, poles, shafts, spokes, ladder rungs and gymnastic bars

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Jelutong Malaysia, Indonesia	White or pale yellow 400–500 kg/m^3	Rather fine, even texture; fairly straight grain; sapwood and heart not clearly defined	Soft and light; contains latex deposits, making it unsuitable for face work; saws easily and planes to good finish; not durable in exposed positions; sapwood susceptible to Lyctus borer	Patternmaking, drawing boards, plane tables, carving, matchboxes, ceiling battens, interior joinery; sap used in manufacture of chewing gum
Maple, Pacific (red meranti group) Malaysia, Indonesia, Philippines, Thailand	Light pink to red 400–720 kg/m^3	Interlocking grain	Moderate weight, reasonably easy to work	Furniture, shop and interior fittings, joinery and cabinet-making
Meranti, red or Borneo cedar Malaya, North Borneo, Philippines	Pale pink to purple-brown; darkens on exposure 450–720 kg/m^3	Coarse texture; grain usually interlocked, but even	Saws and machines readily; gives good finish; durable in dry situations, but not in contact with ground; attack by pin-hole borer common in green timber	Furniture, shop and interior fittings, joinery, flooring, rotary-cut veneer and ship decking
Nyatoh Malaya, Borneo and Philippines	Reddish brown, slightly lighter sapwood 510–930 kg/m^3	Moderately fine to coarse texture; straight grain with occasional interlocking	Moderately soft to hard and strong; not durable in exposed areas or in contact with ground; seasons well with little degrade; works to a fine finish; holds nails well and takes a good polish	Sideboards, wardrobes, drawers, shelving, cigar boxes, patternmaking, general building purposes and ship planking
Ramin Sarawak, Borneo	Light yellow 640 kg/m^3	Straight grain, sometimes slightly interlocked; fine and uniform texture; has distinct odour when unseasoned	Works well; requires very sharp tools, interlocked areas require most sanding; stains and polishes well; may require boring for nails and screws; not durable, susceptible to surface checking	General joinery and fittings; a good furniture wood

Table 4.5 Imported softwoods

Name and distribution	Colour and density	Grain and texture	Qualities	Uses
Cedar, western red North America, British Columbia, Vancouver Island	Dull, pinkish red to deep brown 350 kg/m^3	Straight grain; thin sapwood	Seasons readily; takes paint and stains well; good gluing properties; very durable	All interior joinery, doors, rusticated weatherboards, shingles, laths, patternmaking, veneer, corestocks and many exterior applications
Oregon or Douglas fir North America	Pale yellow to reddish brown 420–640 kg/m^3	Straight grain, comparatively free from knots and resin; thin sapwood	Strong, of moderate weight, fairly durable, easily worked and seasons readily; rarely attacked by borer, but highly susceptible to termites, not suitable for damp situations	All building purposes, ladders, plywood, masts and spars, oars and interior joinery
Pine, klinki Upper Ramu and Huon Gulf areas of New Guinea	Straw-coloured 450 kg/m^3	Straight grain and uniform structure	Soft to cut and easy to work; gives smooth finish; not durable in wet situations; subject to blue stain in sapwood due to fungal attack	Interior building purposes, flooring, lining, joinery, mouldings, battens, furniture, cabinet work, plywood and veneers, turnery and patternmaking
Pine, Parana Brazil	Various shades of brown; sapwood yellowish 480–640 kg/m^3	Straight grain, uniform texture	Easy to work; holds paint well; sapwood not liable to attack from powder post borer	Interior joinery, shelving, plywood, flooring, lining, ceilings, moulding, masts, booms and spars, light oars, planking for light boats, cabinet work, and brush and broom stocks
Redwood or Sequoia California	Dark reddish 390–500 kg/m^3	Straight grain	Soft, easily worked; great durability in weather, highly resistant to fire, borers and termites	All interior joinery, doors, rusticated weatherboards, shingles, laths, patternmaking, veneer, corestock and many exterior applications

Something to think about: old-growth forests, silviculture, self-sustainability, logging and ecosystems

Before we delve more deeply into this section it is important to define a few concepts, such as old-growth forests and ecosystems. An old-growth forest is an ecologically mature forest where the effects of disturbances are negligible. An ecosystem is a community of plants and animals and their environment, functioning as a unit.

Below are facts and statements that are associated with various aspects related to the timber industry, such as logging, wood chipping, deforestation, environmental degradation and conservation concerns. It is important to bear in mind that there are two sides to an argument; exaggerations are sometimes made to emphasise a point and wording is altered so that it becomes ambiguous. Read these statements, research the topic on the internet or at the websites provided, discuss them and become more informed about this very important issue.

Wilderness Society

Weblink

According to the Wilderness Society, over the next few years 10.8 km of new roads are planned within pristine old-growth forests in the Upper Florentine area of Tasmania. Forestry Tasmania has admitted that up to 90 per cent of the timber extracted from the area will end up as woodchips and low value products. A recent report by The Wilderness Society highlights the fact that the majority of Tasmania's old-growth woodchips are exported to Japan. Research the impact of this forestry.

The proportion of Australia's native forests formally protected in public nature conservation reserves has increased from 11 per cent (17.6 million hectares) in 1998, to 17 per cent (21.5 million hectares) in 2013. Is this enough protection? Research and comment. (Source: Australian Government Department of Agriculture and Water Resources).

RIRDC

Weblink

A study by the Federal Government Rural Industries Research and Development Corporation (RIRDC), and funded under the Joint Venture Agroforestry Program (JVAP), aimed to identify ways to enhance the conservation value of exotic softwood radiata pine (*Pinus radiata*) plantations in south-eastern Australia. The work was focused in the Tumut region of southern New South Wales (NSW). This publication outlines the design of a study that has begun to address key issues of plantation design and management in the Tumut region. Summarise some of the principles that can be embraced to increase the conservation value of both existing plantation landscapes and new areas targeted for future plantation expansion.

The transformation of Tasmania's former Triabunna woodchip mill site includes creation of a new hub for designers and innovators.

Operating under the banner of Spring Bay Mill Innovations, it utilises the latest in solid-wood bending technology, part of the plan to transform cheap plantation timber into quality furniture.

Mill site owner Graeme Wood, the founder of Wotif.com, released plans for the development, which also includes a lodge, botanic gardens, culinary school, marina and an education centre. Research other innovative timber industry breakthroughs.

Ecotourism

Weblink

The United Nations (UN) General Assembly has approved the adoption of 2017 as the International Year of Sustainable Tourism for Development. Discuss the role of ecotourism and its impacts upon the timber industry.

25 innovative woodworking tools

Weblink

Wood Magazine's editors recently published their list of 25 of the most innovative woodworking tools of the past quarter-century. Discuss some of the list inclusions.

Plantation 2020

Weblink

Softwood can be harvested as early as 25–35 years for investment returns; hardwoods take about 80 years to become harvestable. This represents a long-term investment and means there is a need to plant on a large, rotational scale for a continual return.

As an interesting exercise, compare and contrast old-growth logging and sustainable silviculture.

Does Australia still export and/or import wood in any form?

9780170411516

CHAPTER REVIEW QUESTIONS

1 Calculate the total cubic metres of two pieces of timber, each measuring 5000 × 150 × 40 mm.

2 Sketch the changes to wood cells from a freshly cut tree to fully seasoned timber. Fully label all diagrams.

3 Describe two methods of seasoning timber.

4 Sketch and fully label a diagram of the end of a stack of air drying timber.

5 Give the full name of an Australian plantation softwood.

6 State the function of each of the following parts of a tree: cambium layer, roots, leaves, bark and medullary rays.

7 Why does a tree die when it is ring barked?

8 Draw and label a sketch showing how a knot is formed on a growing tree.

9 State the name of one timber that gets its figure from medullary rays. Sketch how this timber is milled from a log.

10 Neatly sketch a log showing the annual rings, medullary rays, bark, cambium layer and pith. Lightly shade the heartwood area.

11 Why are galvanised iron caps placed under the bearers when a structure is being built?

12 Identify each of the following timbers as either Australian or imported and hardwood or softwood: meranti, jarrah, Oregon, coachwood, spotted gum, cypress pine, silver ash, ramin and western red cedar.

13 Sketch tangential sawn and radial sawn pine planks and indicate the effect of shrinkage on the end view. Draw on the flat main surface of the plank the grain lines you would expect to see.

14 What class of timber makes up the bulk of Australian forests? Name two important varieties of this timber.

CHAPTER

5

Working with timber

Timber varies greatly between different species; even timber from the same tree is never exactly the same. After timber goes through the process of conversion and seasoning it needs to be carefully selected for its intended purpose. Colour, grain pattern, texture, density, hardness and durability all need to be considered. Timber needs to be worked to an exact size that is both straight and square; otherwise, the end product will be poor.

This chapter looks at proven methods of preparing and working with timber that ensure a quality product at the end.

9780170411516

Key terms

arris where two surfaces meet at a sharp edge to form a sharp corner

bevel an angle, less than 90°, produced over a complete face of a material (e.g. wood); the ground angle of a cutting tool

carving in the round shapes are carved on all sides, figures may be abstract, stylised, or natural

chamfer a 45° angle produced on an arris

density the mass per unit of volume. It depends on the size of the cells, the thickness of the cell walls and the amount of lignin, gums and resins present. Density is typically quoted as 'light', 'medium', or 'heavy' and in kilograms per cubic metre (kg/m^3)

dressed timber that has been planed to size

face edge an edge that is accurately planed to 90°, used for marking out

face side a side from which all other measurement can be taken (datum surface)

former a shaped mould used to hold layers of glued material in place until the glue dries

grain the layout of wood fibres in a piece of timber

grooves (or hollows) a recess cut along the length of timber with the grain

inlay imbedding pieces of material into a surface to create decorations or patterns

intarsia a form of inlaying similar to marquetry that uses varied shapes, sizes, and types of wood fitted together to create a picture, a bit like a puzzle

kerfing the process of cutting several slots, at specific points, in material to weaken it, allowing it to be bent and formed

laminated wood relatively thin pieces of timber that can be glued together to form a stronger and thicker component (may be shaped)

marquetry the process of applying pieces of veneer to a surface to form decorative patterns, designs or pictures

moulding a decorative contour or outline given to architraves, skirting boards, cornices, etc

parquetry decorative patterns and geometric shapes produced using blocks of timber glued to a backing material

pyrography the art of decorating wood with burn marks, historically added using a hot poker

relief carving creating a three-dimensional effect in carving by removing the background

scratch stock an 'L-shaped' piece of timber that holds a shaped metal blade, which is scraped along a timber edge to form a shape

shooting a method of planing the end grain of timber

splay an edge created at any angle except 45°

square a right angle; 90°

steam bending the process of steaming susceptible timbers and permanently bending them, such as Thonet's bentwood chair

texture the size and arrangement of wood cells is referred to as texture, often classified as 'fine', 'medium' or 'coarse', 'uneven' or 'uniform'

true accurate or correct

trench a recess cut across the grain of timber

veneer a thin piece or sheet of wood that is typically used for decorative purposes by gluing over an inferior board

Preparation of timber

The nature of wood

By its very nature, wood is unique! Like human fingerprints or DNA, each piece of timber is different. Even when cut from the same tree, various cuts of wood display subtle differences. Identifying diverse species and being able to tell how each chosen piece will behave when worked is a big part of the fascination of woodworking. This unique nature demands study before beginning a project.

Density, colour, smell, **grain** and **texture** are variants noticeable at first touch or sight. Is it hard or soft? Is it light or dark coloured? Will it be easy to plane? Is it a prime candidate for splitting when nailed?

As for recognising species, some look so alike that they can be identified only by special tests; however, common commercial timbers (such as Oregon, radiata pine, cypress pine, meranti, spotted gum, tallowwood and coachwood) can easily be recognised by their colour, grain, texture and in some cases their smell. This is covered in greater detail in Chapter 2.

Timber consists of a number of tightly packed, microscopic tube-like cells, much like a bundle of drinking straws, but invisible to the naked eye. These cells, commonly referred to as *fibres*, form what we term *grain*. Their arrangement, size and spacing determine the texture. Just as woven fabrics may be coarse or fine textured (Figure 5.1), so too may timber have a fine or coarse, even or uneven texture (Figure 5.2). Think of the differences between materials such as silk and hessian.

Each piece of timber presents its unique pattern of cell formation, in which the fibres lie or project in a certain direction. This raises two important points on working a project:

1 Working across the fibres tends to break them apart.

Figure 5.1 **a** Fine-textured denim fabric contrasted with **b** coarse-textured jute

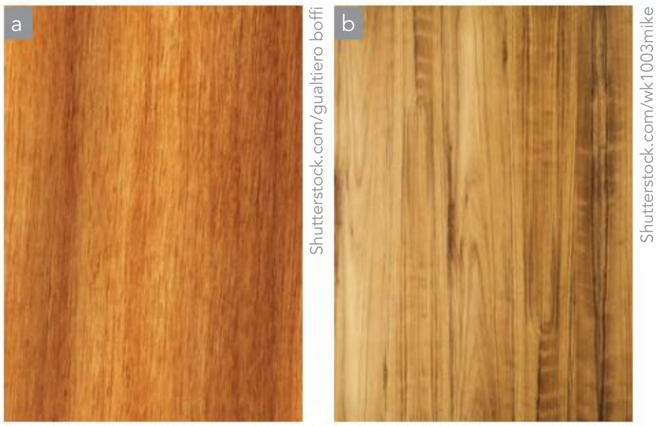

Figure 5.2 Examples of **a** fine and **b** coarse wood

2 Working against the direction in which they lie causes the fibres to lift and tear.

TRY THIS

To demonstrate the first point, wind a metre or so of string closely and tightly around a small piece of wood and fasten each end (Figure 5.3). The loops of string represent the grain fibres in a piece of timber. With a saw, make a few strokes across the string, this will demonstrate effects of working across the grain, then do the same along the string. Note that across the string the saw teeth bite in, pushing the fibres apart, while along the string the saw causes little disturbance.

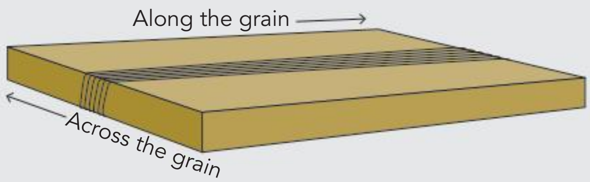

Figure 5.3 String wound around a piece of wood representing grain fibres

An example of the second point becomes clear if you compare working timber with stroking a cat's fur. The fur fibres lie from head to tail, and if you stroke in that direction the fur remains smooth; however, if you stroke from tail to head, the fibres are lifted and the fur is ruffled. Similarly, timber planed or chiselled in the direction of the grain cuts smoothly, but working against the *set* of the fibres it will cause it to tear and produce a rough surface (Figure 5.4). This is the most important lesson to be learnt: when working a piece of wood, you must always follow the grain direction (Figures 5.5 and 5.6).

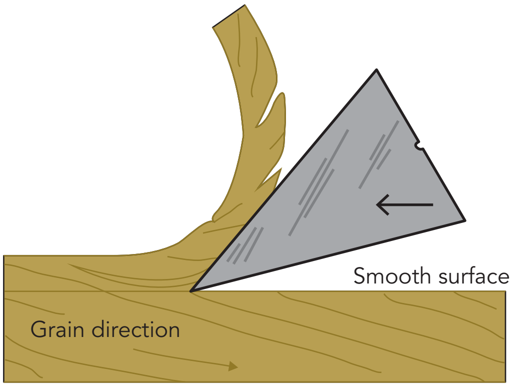

Figure 5.4a Effect of cutting with grain

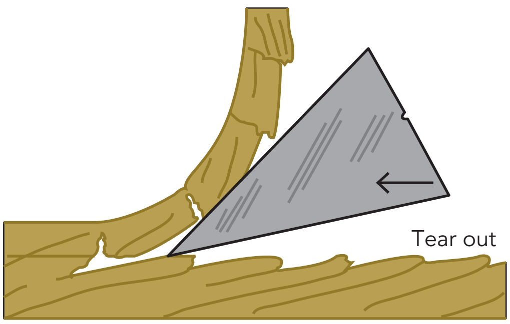

Figure 5.4b Effect of cutting against grain

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Figure 5.4c A smooth shaving taken when planed with the grain

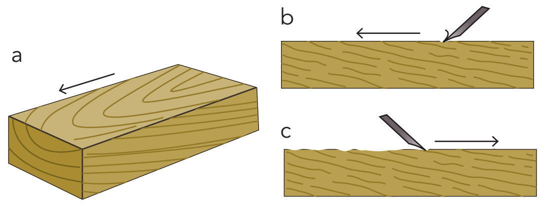

Figure 5.5 Grain never runs exactly parallel to a side or an edge of timber: In **a** and **b**, a cutting edge moving in the direction of the arrows is working 'with the grain' and will cut smoothly; in **c**, the edge is working 'against the grain' and will tear protruding fibre ends upwards, producing a rough surface

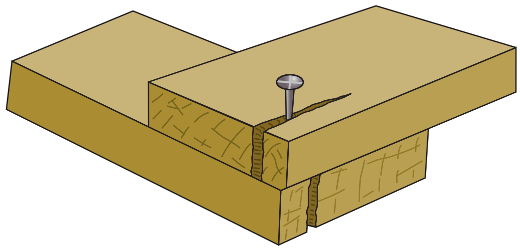

Figure 5.6 Consideration of grain behaviour is important in all woodworking operations; note how nailing too near a corner causes the timber to split

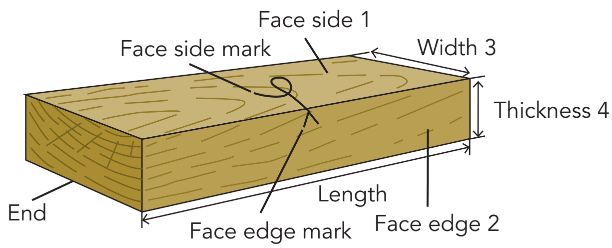

Figure 5.7 Terms used to denote parts of a piece of wood: numbers indicate correct sequence of operations in preparation

Preparation

Timber sourced directly from the saw is inaccurate in dimensions, rough to the touch and not easily finished with paint or similar materials. For most work, timber needs to be planed or **dressed** to size so that surfaces are made true and **square**; without twist or wind. This process is called 'preparation of timber' and precedes the 'setting out' or marking of necessary lengths and joints for your project.

Look at Figure 5.7 and learn the terms used to denote the various parts of a piece of wood. Note particularly that length is always measured along the grain and hence may be less than the width or thickness. This is in contrast with other materials, such as paper or metal, for which the greatest measurement is always taken as the length.

First select the best surfaces to be the **face side** and the **face edge**. Look for attractive grain appearance and freedom from cracks, knots and other blemishes (Figure 5.8). The face side and face edge should have the same grain direction if the timber is to be made into a frame or if the corner where they meet is to be worked or shaped. Preparation follows the sequence of steps as indicated by numbers in Figure 5.7.

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Figure 5.8 Grain changes direction around a knot

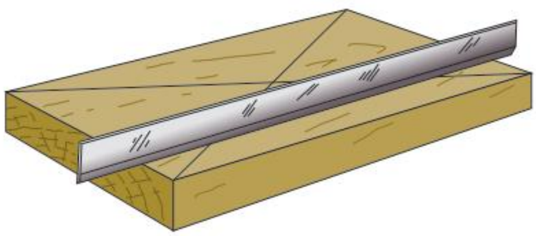

Figure 5.9 Testing face side for flatness and straightness with a straightedge. The sequence of steps is indicated by the numbers in Figure 5.7.

HINT

To help remember the sequence of steps in the preparation of timber the acronym FEWTEL is used to represent: Face, Edge, Width, Thickness, End and Length.

Face

Plane face side. Use a straightedge to test for flatness across and straightness along the length (Figure 5.9). Test for twist, or wind, with winding sticks (Figure 5.10). Correct any inaccuracies. When the surface is **true** apply the face side mark with its tail touching the face edge (Figure 5.11).

Edge

Plane face edge. Test for squareness from the face side with a try square (Figure 5.11), and for straightness along the length with a straightedge (Figure 5.12). Correct inaccuracies. When the surface is true apply the face edge mark V, with its point meeting the tail of the face side mark (Figure 5.13).

Width

Gauge width. Gauge from the face edge, on both sides using a marking gauge (Figure 5.14). Plane accurately to the gauge lines.

Thickness

Gauge thickness. Gauge from the face side on both edges using a marking gauge. Wide timber may also be gauged on the ends (Figure 5.15). Plane accurately to the gauge lines.

End

Square one end using the disc sander or planing the end grain (**shooting**). Take care when planing the end grain not to slit the timber on the edges. This is best done by either planing in half way from each side or clamping a scrap piece of timber on each end (Figure 5.16).

Length

Cut to desired length.

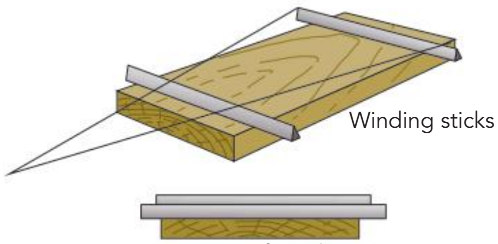

Figure 5.10 Testing face side for twist or wind with winding sticks

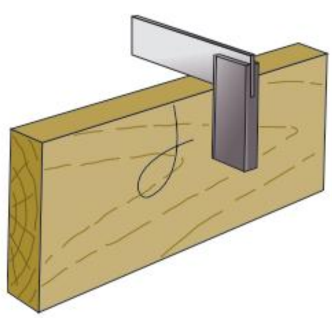

Figure 5.11 Testing face edge for squareness with a try square; note face side mark

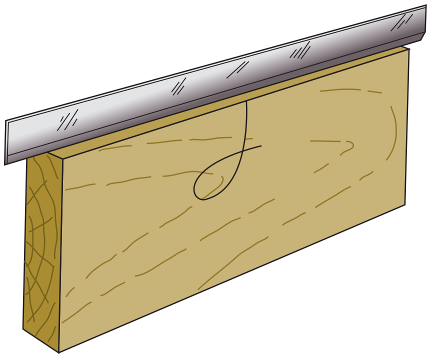

Figure 5.12 Testing face edge for straightness with a straightedge

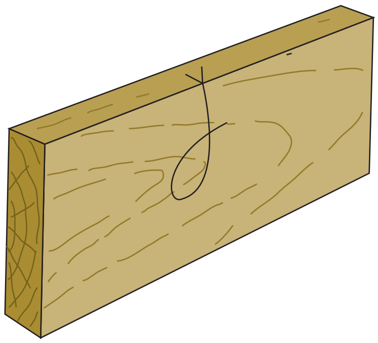

Figure 5.13 Face side and face edge dressed and marked

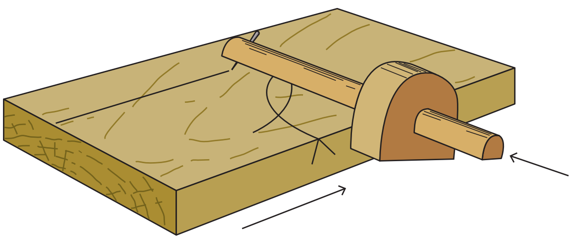

Figure 5.14 Gauging to width; arrows indicate direction of pressure on gauge

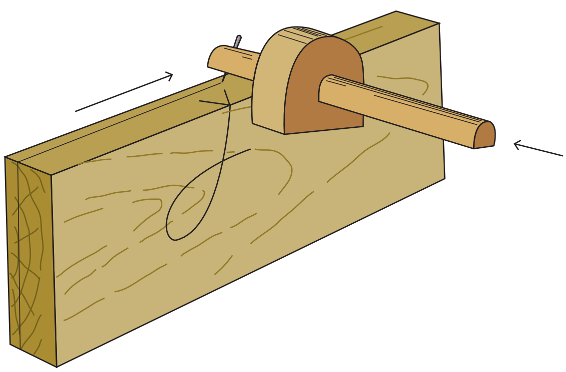

Figure 5.15 Gauging to thickness; arrows indicate direction of pressure on gauge

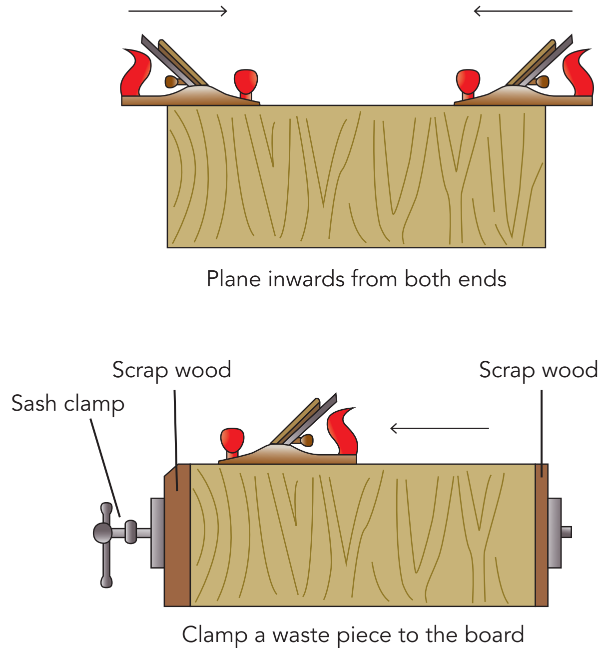

Figure 5.16 Plane end grain (shooting) inwards from both ends or clamp a piece of waste to the board

Function of face and edge marks

Face and edge marks are used so that:

- the side and edge selected can be quickly and easily seen
- parts can be arranged in pairs when necessary (Figure 5.17)
- setting out can be done from the one side or edge
- the members of a frame can be arranged correctly, with face edges inwards and face sides all on one side of the work (Figure 5.18).

Always make the marks clearly at or near the centre of each piece of timber, joining them on the corner where side and edge meet.

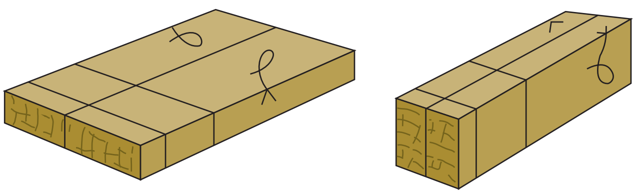

Figure 5.17 Members of frame arranged in pairs for setting out

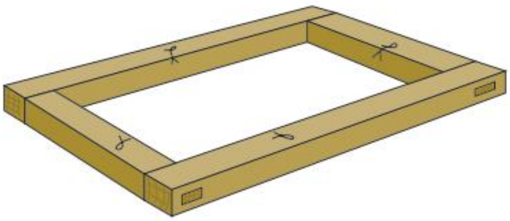

Figure 5.18 Frame assembly, showing position of face marks

It is essential to prepare all of the pieces required for your project, including marking length, before proceeding to setting out. Except in the case of dovetail and mitre joints, cutting accurately to length is left until after the joint has been made and the glue has set. This leaves the waste on the ends protecting the corners as long as possible.

Preparation of machine-dressed timber

Timber that has been planed by machine can often be used without further dressing other than final cleaning off with abrasive paper. However, hand planing will be necessary if the wood has been carelessly dressed (Figure 5.19), is oversize, damaged, or has swelled, bent, warped or twisted. A planing machine not entirely free from vibration produces a wavy surface, which may have imperfections not obvious until the work is coated with paint or polish. If a fine finish is intended, the wood must be dressed carefully by hand.

It cannot be emphasised too strongly that for work involving any framing or joining, timber must be straight, square, out of wind and dressed accurately to size. Good timber will equal a good project.

Shawnda Horn

Figure 5.19 Example of badly dressed machine-planed timber

Shaping timber

Edge treatments

Planing a side and adjacent edge of a piece of timber produces a sharp corner, called an **arris**. Typically, an arris is removed because:

- any liquid finish applied to the wood will run together on the sharp corner, forming a 'fatty' edge
- the sharp edge is easily damaged and, in hardwoods and timbers such as Oregon, tends to splinter.

Removal of the arris is the simplest form of edge treatment and is done with the stroke of a plane or abrasive. Do not take off so much as to spoil the clean line of the edge or to round the corner. Exceptions to this rule include parts such as the legs and top rails of chairs, which are slightly rounded for the sake of comfort and to reduce wear on clothes. Note that arrises are not taken off frame members, particularly stiles, until after they have been glued together, because removal of the arris near the shoulder will make the joint appear open.

CHECK YOURSELF

1. Why does rough sawn timber need to be dressed?
2. List four steps in the preparation of timber.
3. What is the purpose of face side and face edge marks when preparing timber for a project?
4. Describe how you plane the end grain of a timber board without causing it to split.

Arris treatments

These are many different types of arris treatments, such as **chamfers**, **splays**, **bevels**, **mouldings**, **grooves** and hollows. An arris may be treated to remove sharpness or for decorative purposes.

Chamfers may be continuous or stopped (Figure 5.20a). Small or large, they are always 45° and can be produced by simply being sanded, marked with a pencil gauge and planed, or by using a spokeshave or router.

Splays are created at any angle other than 45°. They are rarely stopped; are pencil gauged and typically planed (Figure 5.20b).

Bevels remove a complete face rather than just an arris. They may be any angle. They can be produced by marking then planing, or cut with a bandsaw, table saw or circular saw.

Mouldings are a decorative contour or outline given to architraves, skirting boards, cornices, etc. Smaller mouldings are attached for decoration around jewellery box lids or storage chest panels. Classic shapes include beads, half-rounds, quads, ovolos, coves, boledictions and ogees. These shapes are produced using routers or specialist machinery (Figure 5.20c).

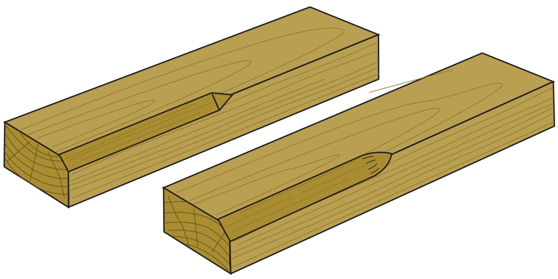

Figure 5.20a Stopped chamfers with straight and curved stop ends

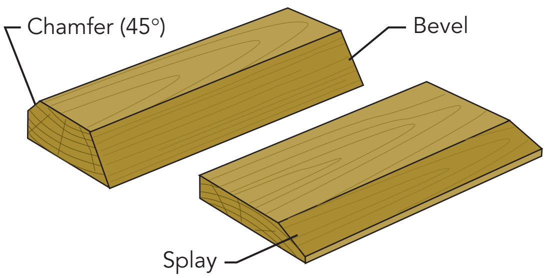

Figure 5.20b Chamfer, splay and bevel

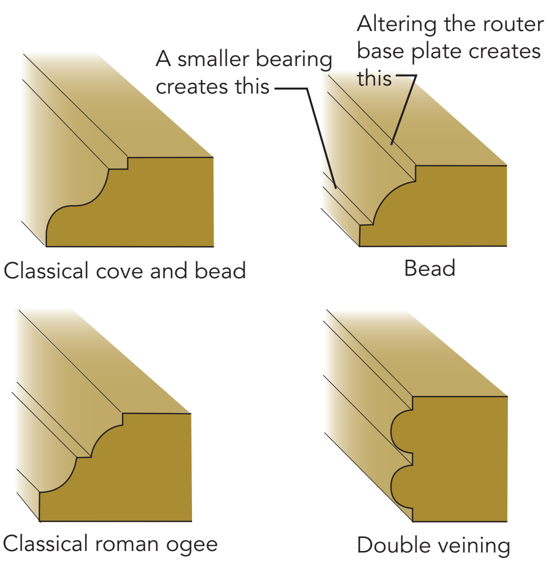

Figure 5.20c Moulding types

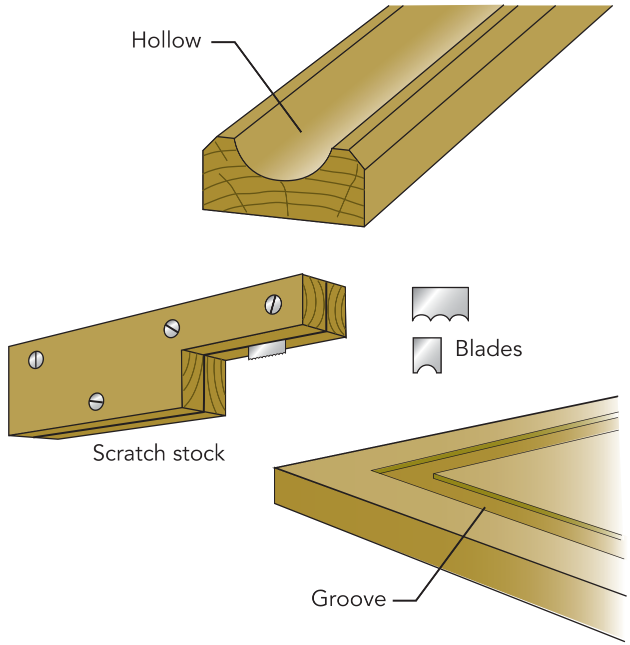

Figure 5.20d Hollow and groove made with scratch stock

Hollows and grooves are channels cut in the direction of the grain. They are used to break up a flat surface and enhance an otherwise plain panel or door.

A **trench** is cut across the grain. Trenches can be produced with a router or by using **scratch stock** (Figure 5.20d).

Laminating and bending timber

Curved shapes in wood are created by either cutting the curve from solid timber, moulding the shape in **laminated wood**, bending a piece of solid wood by **kerfing** or by **steam bending**.

Cutting a curved piece from solid stock produces a lot of waste material and is typically weak due to short-end grain.

Laminated wood involves a number of layers of parallel-grained timber, thin enough to be bent, that are glued together face to face then formed and clamped in or around a mould. Note that gluing timber edge to edge is not classified as laminating but as widening.

Laminated wood is used where the grain runs parallel to the length of the timber, such as in the frames of older-style tennis and squash racquets. Laminated wood is also commonly found in structural beams and arches, skateboards, snow and water skis, boat frames and hulls, piano key lids and guitars. For some specialised work, industry produces *improved wood* by impregnating wood laminates with plastic to increase density, toughness and workability. Some products made from improved wood include aircraft propellers, golf club heads and knife handles. Laminated wood is stronger than solid timber because defects, such as knots and splits, are localised to individual layers, reducing their weakening effect. On a strength-to-weight ratio basis, laminated wood is considerably stronger than steel.

Hardwoods and softwoods are both suitable for laminating, though hardwoods will generally bend better. The timber should be straight-grained, preferably free from knots and other defects, and have a uniform thickness. Oily timbers, such as teak, should be cross-sanded to aid glue adhesion.

Collection: Powerhouse Museum, Sydney. Photo: PHM

Figure 5.21 'Peanut' chair, laminated craftwood, designed by Marc Newson, made by Eckhard Reissig, Sydney, 1988

Figure 5.22 Two-part mould for laminating veneers

Glues used for laminating must allow enough working time for positioning and clamping before setting.

There are two types of moulds used in laminating: a two-part mould (Figure 5.22) or a single non-flexing form. Vacuum moulding is sometimes used to press the project to the form.

Kerfing involves making a series of partial cuts in solid timber. This weakens the timber enough to allow the weakened part to be bent around a **former**. The required curve can only be produced after you have experimented with the thickness of each cut, its depth and the amount of cuts needed. A single kerfed piece of wood is fine when only the outsides are seen. Two kerfed pieces may be glued back to back if necessary (Figure 5.23).

Steam bending is the use of steam on certain timbers (those that are susceptible to the softening effect) to achieve permanent bends in the working of projects. Suitable timbers for this are ash, beech, birch, elm, hickory, oak, walnut and yew.

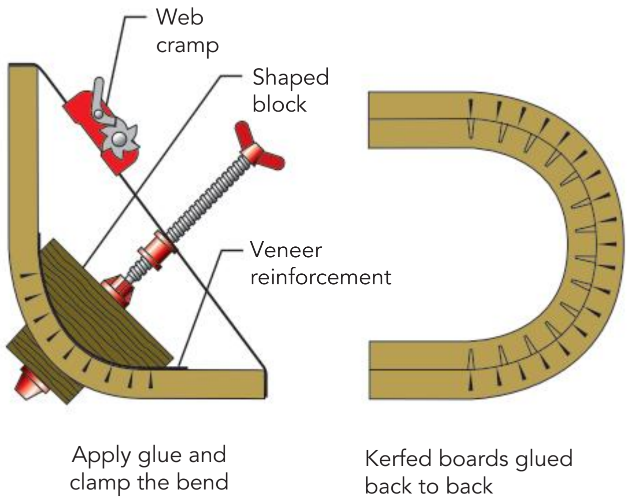

Figure 5.23 Kerfing: single and back to back

Probably the most well-known use of this treatment is the *Bentwood chair* by Thonet, which is created using steam bent beech timber. This design is almost 150 years old and has barely changed in appearance compared with those made today (Figure 5.24).

Steam bending involves heating strips of timber in a tube-like container, which has an attached supply of steam from a boiler at one end and an exit for pressure build-up at the other. Soaking time for 25 mm thick timber is approximately one hour. As the strips of timber are removed (with thick gloves) they must be quickly placed around a former before they cool. Generally, a stainless steel strap is placed around the outer section of the strip to hold it clamped until it dries and adopts its new shape (Figure 5.25). Note: There is always a small amount of springback, which must be allowed for when designing the former.

Figure 5.24 Thonet's steam bent beech chair

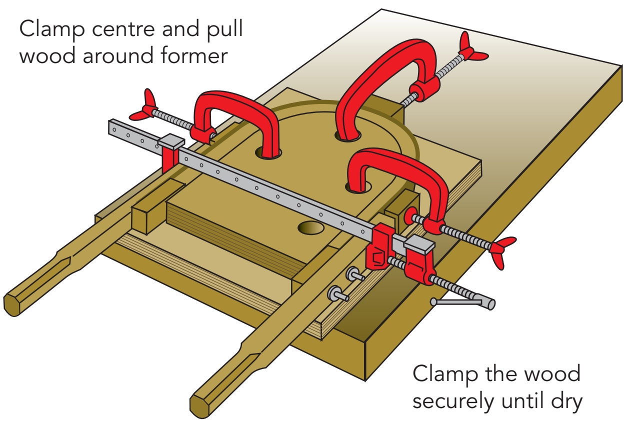

Figure 5.25 Steamed item, bent and clamped to dry

Veneering timber

The **veneer** process involves decorating the surface of timber by gluing thin sheet wood (veneers) to a backing or core. Veneers allow effects to be created that are not possible in solid wood. An important point to consider is the increasing scarcity of finely figured timbers. Cutting them into veneers means that the supply goes much further.

Veneers can be produced in three ways: rotary peeled, sliced or sawn.

Rotary peeled veneers

An appropriate log is cut to length, soaked to soften it, then mounted on a large lathe. As the log is rotated, a long blade is pushed against it, moving in a little with every turn so as to maintain an even and continuous sheet of veneer (like a pencil sharpener) (Figure 5.26). This is tangential cutting and produces an interesting wavy grained effect. The veneer is then cut to size and dried (similar to the plywood manufacturing process). For a slightly different grain effect, the log can be offset in the lathe; this produces repetitive waves and lines.

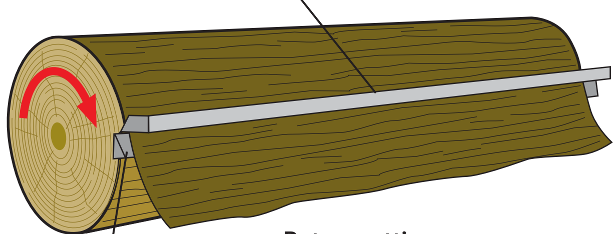

Figure 5.26 Rotary peeling

Sliced veneers

Logs are selectively cut into flitches then, depending on their grain figure, sliced tangentially (back cut) or radially (quarter cut). The flitch is mounted on a moving frame that reciprocates passing a blade (similar to a bacon slicer) to produce similar veneer *leaves* (Figure 5.27). Because each leaf is similar, when they are dry they are numbered and bundled together in multiples of four up to 32, which allows for quartering. Depending on how the flitch is sliced, the following grain effects can be produced: medullary ray figure, fiddleback, flame, ribbon and birds eye.

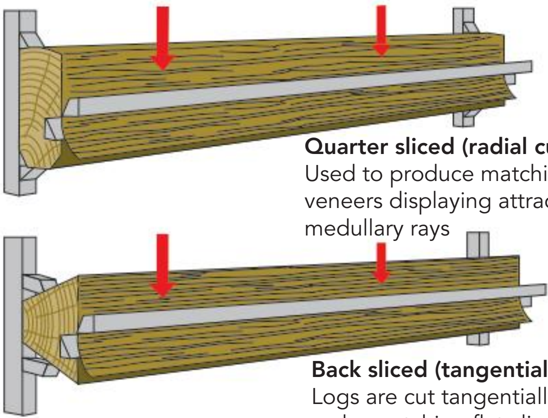

Figure 5.27 Slicing veneers – quarter and tangentially cut

Sawn veneers

Less common since the introduction of slicing machines in the 18th century, even though the blades are thin, this type of veneer produces more waste due to the kerf of the saw. Nowadays, sawn veneers are only used for timbers that are difficult to slice (such as some burls, crotches, stumps and roots) or when thicker veneers of up to 3 mm are required (Figure 5.28).

Tabletops, wardrobe doors, door and wall panels, and sideboard tops and ends all offer a surface that is large enough to veneer; and therefore, display aesthetic patterning. Various effects that can be created by using sequential sliced veneer leaves, include book matching, quartering, diamond, herringbone and segmenting (Figure 5.31a).

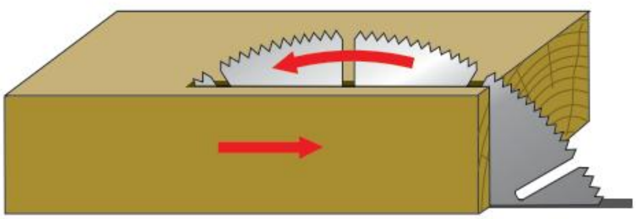

Figure 5.28 Sawing veneers

Marquetry

Modern **marquetry** is the process of applying pieces of veneer to a surface to form decorative patterns, designs or pictures. A good marquetry design makes use of the natural colour and figure of the wood to depict materials, tones and textures (Figure 5.33). Simplicity of design is an important consideration because it is difficult to achieve gradual shading from one area to another, so plan the picture using solid colours to represent various hues.

Inlay

Inlays for decorative contrast were originally narrow, straight or curved strips of wood, bone, ivory, brass, silver, precious stones, mother-of-pearl or tortoiseshell set into the timber's surface. More elaborate floral and pictorial designs or scroll patterns developed into an art form, which is believed to have spread through Europe along the Silk Road trading route from Persia and India. This art form reached its peak in the 17th and 18th centuries. Typical examples of inlay include a simple *stringing* line of one narrow strip of wood around a lid, herringbone edge *banding* (many designs, patterns and widths are available) and centre inlay motifs (Figure 5.29).

Mr Gene Treanor

Figure 5.29 Fiddleback Victorian ash jewellery box showing the outer lid and its inlay that consists of ebony, satinwood and andaman padauk timbers

Intarsia

Intarsia is a form of inlaying that is similar to marquetry that uses various shapes, sizes, and types of wood that are fitted together to create a picture, a bit like a puzzle. Intarsia uses a selection of different types of wood, using the selected timber's figure and colour (but can involve the use of stains and dyes) to make a pattern. After selecting the specific woods to be used within the pattern, each piece is then individually cut, shaped, and finished.

Courtesy of Fantastic Woodworking, www.fantasticwoodworking.com

Figure 5.30 An example of intarsia, depicting an Aboriginal elder

Parquetry

Like marquetry, **parquetry** covers the whole surface of the work; however, parquetry is always geometrical in design. Its main use now is in flooring (Figure 5.31b). Accurately machined tongued and grooved timber pieces up to 300 × 75 × 12 mm are laid over an existing or sub floor in a variety of patterns. Parquetry floors are hardwearing as well as decorative, and worn sections are relatively easy to replace.

Cutting and laying veneer, marquetry or parquetry

Cutting veneers, especially fine or curved shapes across the grain, requires practice and patience. Veneer cutting knives (preferably with a ground edge on one side only) offer a vertically cut edge that will butt up to the next piece more accurately. For straight lines, always use a safety rule. As joins are made, tape along the edges with a water-based paper adhesive tape to easily identify the join. Note: masking tape may be difficult to remove after being clamped.

HINT

If the veneers are dry they may split easily; spraying with a light mist of water normally helps prevent this.

Using a laser cutter

The introduction of laser cutters to cut veneers has made a difficult process far easier. Complex shapes can be easily and accurately cut from a variety of veneers and glued back together in a marquetry pattern. The design needs to be drawn on a computer in a vector format (typically, dwg or dxf). Once the computer drawing is complete, multiples can be easily cut and arranged back to form the marquetry design.

CHECK YOURSELF

1. What is the difference between a splay and a bevel?
2. List three methods of bending timber.
3. Contrast and compare marquetry and parquetry.
4. What is the best way to cut veneers from difficult to cut timber?
5. What method of cutting veneer allows for book matching the pattern?

Jamie Meldrum

Figure 5.31a Close up of the marquetry table top where the veneers were cut using a laser cutter

The best core or base to use is a non-flexing, manufactured board because it has very little expansion or contraction due to moisture change. Note: when gluing onto MDF or particle board both sides of the board must be veneered to prevent warping. Ensure there is no dust or grit on the joining materials and have clamps, clean white paper, a *caul* (basically a solid top to clamp over the drying veneers), glue and a small rubber roller available to work with. PVA glue is ample for simple and small marquetry designs; however, for a complex design, where more time is needed to lay up the job, an epoxy resin or urea formaldehyde glue with a slow setting hardener will allow you more working time. For more information on adhesives refer to Chapter 7.

Jamie Meldrum

Figure 5.31b A marquetry table top; note the parquetry flooring

Stacy Marantos

Figure 5.32 Ornate bamboo designed marquetry room divider

Andrew Saber

Figure 5.33 Marquetry box using contrasting timbers to form a pattern

When laying veneers, use a roller for applying an even, thin smear of glue on both surfaces (this will slightly expand the veneers, helping to hide any gaps). Then, position the veneers and add a layer of clean paper to prevent staining and excess glue sticking to the caul. Clamp to keep the veneers under pressure until they dry.

When dry, gently peel back and remove the tape, taking care not to tear out any small veneer pieces.

Inlay bandings

Strips range in width between 2–50 mm and are generally about 1 mm thick.

The method of working is as follows:

1. Grooves in which the bands will be glued are marked parallel to and an equal distance from the edges of the work with a cutting gauge (ground edge of blade facing inwards). If a marking or mortise gauge is used, the conical spurs, which make a V-shaped mark, must be sharpened with a fine file so that the outside edges of the grooves will be cut square to the face of the work (Figure 5.34). Gauge marks must not run beyond the required dimensions of the groove.
2. Waste is cut out with a chisel used ground side down and the groove is cleaned out with a scratch stock (Figure 5.20d). Bands, mitred at the corners, should be an accurate press fit and flush with the surface or the thickness of a fine shaving above. If the fit is too tight, take a fine shaving off the edge of the banding in preference to widening the groove. If the inlay is below the surface, the whole surface of the work will need to be planed down level with it: if only the area near the inlay is planed, this will show when the work is polished.

3 Glue the bands in the grooves, pressing carefully into place by hand. If necessary, tap or rub lightly with a hammer to force out air bubbles. Wipe off surplus glue with a wet cloth. If the inlay tends to lift, glue a piece of paper over the whole area and leave to set.
4 When the glue has set, tear off the paper and chisel away any lumps of surplus glue before cleaning off with a cabinet scraper.

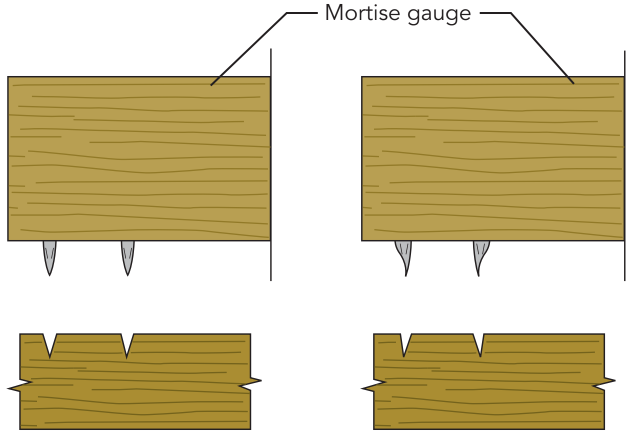

Figure 5.34 Spurs of mortise gauge filed to cut vertical shoulders on inlay grooves

Centre inlays

Inlays may be made up of squares, diamonds, rectangles and curved shapes, and are often used as centrepieces. These are glued into a recess then cleaned off and finished the same as for strip inlays. Attractive designs are created by using timbers of various grains and contrasting colours – either natural or stained. Popular central motifs may be purchased premade and ready to insert.

1 Place the inlay in position, matching the grain direction with that of the work, and mark around it with a sharp pencil. Use a sharp chisel or knife to cut about 1 mm inside the mark.
2 Chisel out waste to the required depth then carefully trim to the marked line, testing frequently for fit. Work as far as possible with the grain. A chisel ground and sharpened to a V point is useful for cleaning out acute angles.
3 Glue the inlay into the recess, clean off and finish same as for a strip inlay.

Carving

Ever since humans discovered that pieces of wood could be shaped for functional reasons (such as weapons and cooking implements) or decorative purposes (such as artefacts and sacred items), this ancient art has continued to develop and is still popular today. There are a large assortment of specialised chisels, gouges and timbers available, and the possibilities are only limited by the carver's imagination. Carved works are typically expensive due to the time and skill levels required.

The main forms of carving are relief carving and carving in the round.

Relief carving

Relief is meant to be viewed from one side only and is normally applied to a board or panel. Therefore, it is a relatively thin work piece. The depth to which the background is cut away determines whether the result is classified as a low or high **relief carving** (Figure 5.35).

Grant Vaughan

Figure 5.35 A relief carved mirror by Grant Vaughan

Carving in the round

As the term **carving in the round** implies, shapes are carved complete, not as applied ornament or part of a panel. Figures may be abstract, stylised, or natural. Like high-relief carving, the work demands a flair for modelling and for selecting timber that will lend itself to the required visual effect.

Figure 5.36 Example of in the round carving. Emotional expressions by Maricha Oxley

Shutterstock.com/Alexandru Niku

Figure 5.37 Pyrography adds detail to carvings and is ideal for decorating items.

Pyrography

Pyrography is the art of decorating wood with burn marks, historically with a hot poker. Also known as pokerwork. These days most schools have a pyrographic burner, some of which resemble soldering irons. Pyrography is ideal for decorating items, such as spice racks, with pictures and writing, or adding detail to carvings. It is also useful for burning a monogram of your initials into the back or base of projects (add the year in which it was made).

Practice first on a piece of scrap wood to improve your skills. Draw the design onto the project to ensure it is correctly positioned and fits the space. There are plenty of books on lettering to help in this regard. Keep the heat as low as possible to maintain neat line-work rather than burning 'blobs' as soon as the element touches the wood. Best results are achieved by having your hand resting on something to steady it rather than supporting it in mid-air. You will also find different effects are created if you move the element sideways rather than backwards. Avoid pushing the element as it will tend to dig in to the wood surface.

CHAPTER REVIEW QUESTIONS

1 Why is the direction of the grain important?

2 Define 'with the grain'.

3 Define 'against the grain'.

4 Make a pictorial drawing of a small piece of wood about 100 × 50 × 25 mm and indicate on it: length, width, thickness, face side mark, face edge mark, endgrain and across the grain.

5 Briefly set out the steps in preparing a piece of timber.

6 Identify the testing tools used.

7 Explain what 'winding' is.

8 Explain what 'square' means when applied in the preparation of timber.

9 Why is it important for timber to be prepared straight and square?

10 When does machine-dressed timber need to be redressed?

11 Why is a kerf-bent board visually suitable on the side of a shop counter?

12 Sketch and explain rotary peeling of veneers.

13 Provide an example of parquetry found in homes.

14 Distinguish between intarsia and marquetry.

15 What is pyrography and when would you use it?

CHAPTER

6

Manufactured timber products

Not all trees are suitable for producing solid timber, nor can all parts of those trees be utilised for this purpose. Moreover, human advances into the world's forests over thousands of years have seriously depleted the supply of many species of trees. Re-forestation (replanting with forest trees) is only part of the answer to this problem, because timber-producing trees take many years to reach maturity.

We have had to find ways to reconstitute, into a usable form, trees, and parts of trees, that would otherwise go as waste. Development and introduction of wood products has ushered in great change in woodworking techniques and in the variety of work that can be achieved. A log may constitute 40 per cent of the tree when used to recover solid wood (the remainder used for other products). However, that same log, when used for composite products, uses 80–90 per cent of the tree. Plywood is the most common of these composite products, along with particle board, hardboard and medium density fibreboard (MDF). The manufacture and usage of these and other products is described and illustrated below.

Key terms

carcase the main body of a woodworking project (e.g. a cabinet)

coreboard (or blockboard) a plywood with a solid timber core, mainly used in furniture construction, for table tops and cupboard doors

corestock timber in the middle of coreboard, generally pine

cross-banding where the grain of the veneer is at right angles to the grain of the adjacent wood

glulam a structural engineered wood product consisting of a number of layers of timber glued together

hardboard (also known as masonite) an engineered board made from compressed and treated wood pulp, from hardwood chips

Laminated veneer lumber (LVL) an engineered wood that is similar to plywood but has no cross banding; each layer has the grain running in the same direction

medium density fibre board (MDF) an engineered wood product typically made by breaking down softwood into fibres which are mixed with wax and glue and pressed into a board

offcuts the timber that is left after a required part is cut from it

oriented strand board (OSB) a type of engineered wood similar to particle board, made by gluing layers of wood strands (flakes) in specific orientations under pressure

panelling square or rectangular pieces of wood that fit together to cover a wall or ceiling

particle board an engineered wood product manufactured from gluing wood chips together

patternmaking making accurate shapes which are used as moulds from which to cast items

plywood three or more thin sheets of wood or veneer plies glued together with the grain at right angles in adjacent layers

tensile strength the maximum ability of a material to be stretched prior to failure (breaking)

urea formaldehyde a thermosetting resin used in adhesives, finishes, particle board, MDF, and moulded objects

Plywood

The manufacture of **plywood** involves gluing three or more thin sheets of wood or veneer plies together with the grain at right angles in adjacent layers. Although some two-ply is made, especially for bending, plywood typically has an odd number of layers, varying from 3–21. To impart strength and stability, prevent splitting, and ensure that the two outer plies are running in the same direction (to appear as solid wood), the odd-numbered layers are generally laid with the grain along the length of the sheet, while even-numbered layers have the grain running across. The **cross-banding** veneers may differ in thickness from the others and the desired thickness of the finished sheet determines the thickness of the veneers or plies.

The manufacture of plywood results in far less cutting waste, from the log or flitches selected, compared to milling of solid planks (Figure 6.1).

Since its introduction and production just over a century ago, plywood has greatly improved in quality and appearance and is now highly regarded as a construction and facing material.

Where moisture is a concern, or in a marine environment, waterproof plywood (bonded with phenolic glues) is essential. It is also well suited to exterior construction and concrete formwork.

There are prefinished sheets for **panelling**; and plywood faced or reinforced ply with aluminium for insulating purposes (Figure 6.2).

As the name suggests, **coreboard** (or blockboard), is a plywood with a solid timber core, mainly used in furniture construction, for table tops and cupboard doors. Generally, only available in 1830 × 915 × 20.7 mm sheets, the core is made by edge jointing and gluing together narrow boards or strips of softwood, such as pine, with heart sides alternating to minimise twist or warp. The core is then dressed and cross-banded on each side to further stabilise the panel. After drying, the panel is resurfaced and the face veneers are glued on with the grain running in the same direction as the **corestock**.

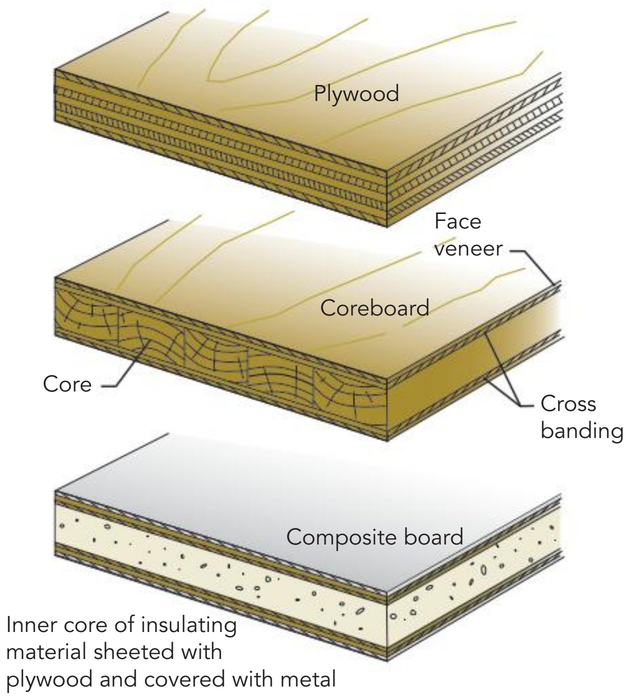

Figure 6.2 Three common types of plywood

Advantages

- Strength and uniformity. Solid wood is 20 times stronger along the grain than across its grain. Plywood over 10 mm thick is almost equal in strength in both directions.
- Virtually no shrinkage. Any shrinkage is miniscule because plywoods alternate grain direction in adjacent layers, wood movement is restricted.

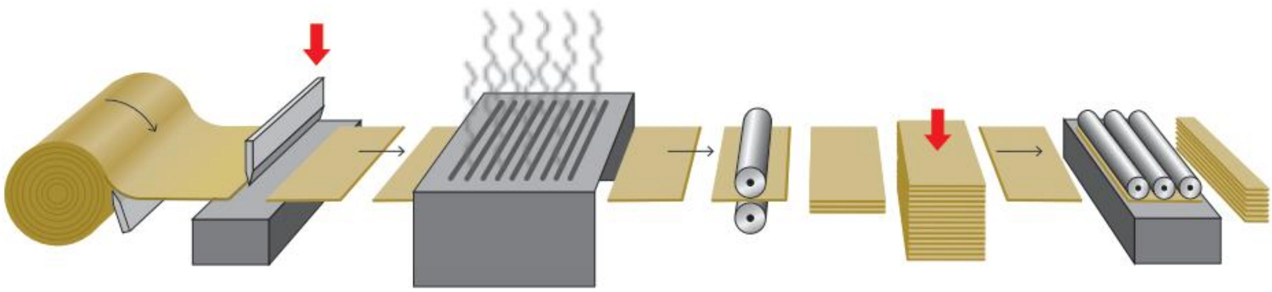

Figure 6.1 Typical steps in the manufacture of plywood

- Large sizes are available: the size of the sheet is not restricted by the size of the tree, but by the size of the manufacturing press. For example, 2.4 m × 1.2 m is typical, with choices of thicknesses from 3–25 mm.
- More economical use of expensive timbers: cheaper timbers can be used for the core so that exotic veneers are saved for the face.
- Matching panels easily obtained.
- Plywood can be formed or bent for curved surfaces.
- Fewer splitting problems, so that nailing and screwing near edges and ends is possible.

Disadvantages

- Exposed edges need sealing or covering.
- Due to the thin outside ply and cross-banding, plywood is not as easy to work by hand.
- Edges are difficult to work across the outer grain direction and are prone to splinter.

Sizes

Although 2400 × 1200 mm is the most common size, sheets are available in sizes up to 3100 × 1850 mm. Thickness usually range from 3–19 mm. However, both thinner and thicker plywoods can be specially ordered.

Working techniques

Thin sheets require support when being sawn and a fine-toothed blade works best. If sawing across outside plies, take care to avoid tearing of the under-ply: cutting with a marking knife or chisel first makes for a cleaner cut. Planing of faces is difficult; sanding is preferable. Care is necessary when planing edges because some end grain must be planed. Solid core types need special care when planing the end grain of the core. For external use, waterproof plywood is a must, glued with better-quality veneer, and the face and edges must be sealed with paint or a clear finish to prevent checking, particularly at ends. Use the type of plywood best suited for the job.

Uses

Plywood and coreboard are one of the most commonly used construction materials. Typically used for wall cladding, partitions, doors, concrete forming, beams and trusses; in boat building for frames, decks, planking, covering boat hulls and for interior fittings. The furniture industry uses a wide range of thicknesses, timbers and finishes for **carcase** construction, doors, panels, linings, backs, drawer bottoms and shelves.

Methods of cutting veneers (plies) are covered in Chapter 5.

Particle board

Manufactured under various tradenames, such as 'Pyneboard', 'Panelboard', 'Wehlboard', 'Chipboard' and 'Flakeboard', **particle board** is generally from pine forest thinnings and trimmings.

Debarked thinnings, chemically treated to prevent mould growth, are cut and milled into coarse and fine flakes, which are then dried and sprayed with **urea formaldehyde** glue before being formed into a mattress with coarse flakes sandwiched between outer layers of fine ones. Mattresses are pressed simultaneously between electrically or hot-water heated platens to produce strong, grainless sheets. Sheets are sanded true and to accurate, even thicknesses, then cut to size-on a multiple saw. Sheets are available in sizes up to 4880 × 1830 mm and thicknesses from 4–33 mm (Figure 6.3).

Advantages

- Large, accurate thickness sheet sizes are available.
- Much more stable than solid wood. It is practically inert (subject to little expansion and contraction) and retains its shape well.
- Forms an excellent base for covering with veneer or plastic laminates because of its stability.
- Uniform in strength due to lack of grain direction.
- Easily worked with hand or machine tools.
- Suitable for carcase construction without framing.
- Accepts paint and other finishes.
- Cheaper than plywood or coreboard of comparable size and thickness.

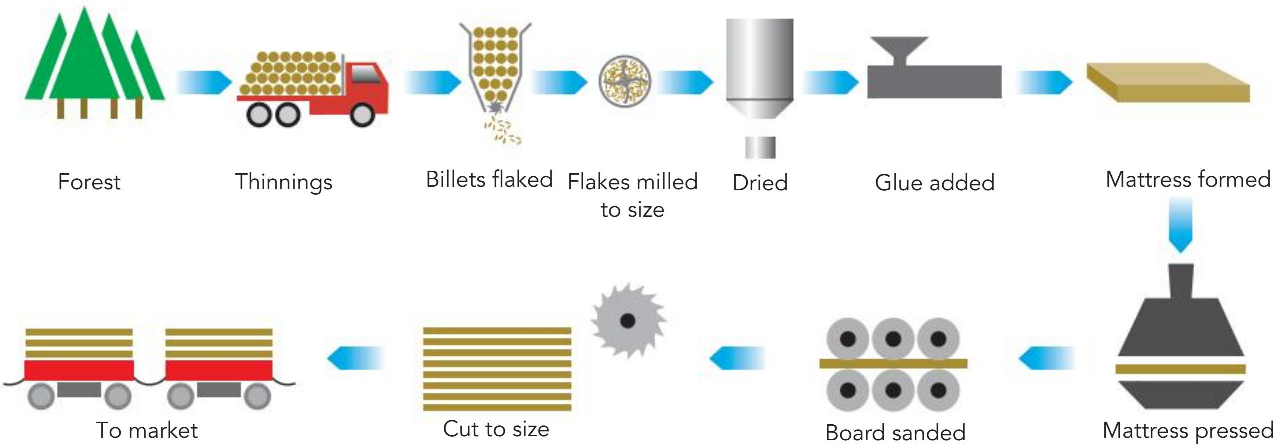

Figure 6.3 Typical steps in the manufacture of particle-board

Disadvantages

- Edges require special treatment because of the porous structure (Figure 6.4).
- Prone to breaking away on corners; care is needed when screwing or nailing near edges.
- More absorbent than most timbers and can swell up when wet.
- Dust created when cutting can be an irritant.
- Tends to blunt saw blades and other cutting edges quickly.

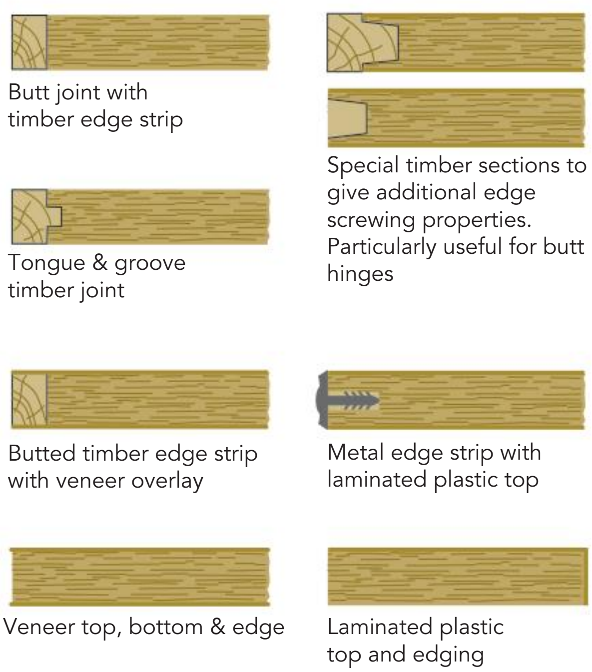

Figure 6.4 Typical edge treatments used on particle board

SAFETY

Cutting or sawing particle board produces fine sawdust that may be a health hazard; use appropriate PPE when working it.

Working techniques

All hand and power woodworking tools may be used. Edge tools must be kept sharp. When sawing to size, support the sheet because it is liable to break near the end of the cut. Use a fine-toothed blade.

The board may be glued edge to edge to increase width or utilise **offcuts**. Butt, trench and rebated joints are the best types of construction joints. For drawer fronts and similar work, rebate and butt joints are preferable to dovetails. Apply adhesive to both faces; edges require two coats because of absorption (Figure 6.5).

When using screws, bore the necessary shank and core holes for the full length of the screw. Screws with a full-length thread are recommended. Do not keep turning the screw once it has taken the full pressure because it may tear away fibres, thus losing strength. Sheets should be stacked flat in a dry place. Veneered sheets should be stored with veneered face down and covered for protection against reflected heat.

Uses

Particle board is often used as a base or inner core for veneers and plastic laminates. Plain and veneered versions are used extensively by the furniture industry for carcases, tops, drawer parts and shelves. It is also used in shop fittings and shelving, built-in furniture, partitions, feature walls and flooring.

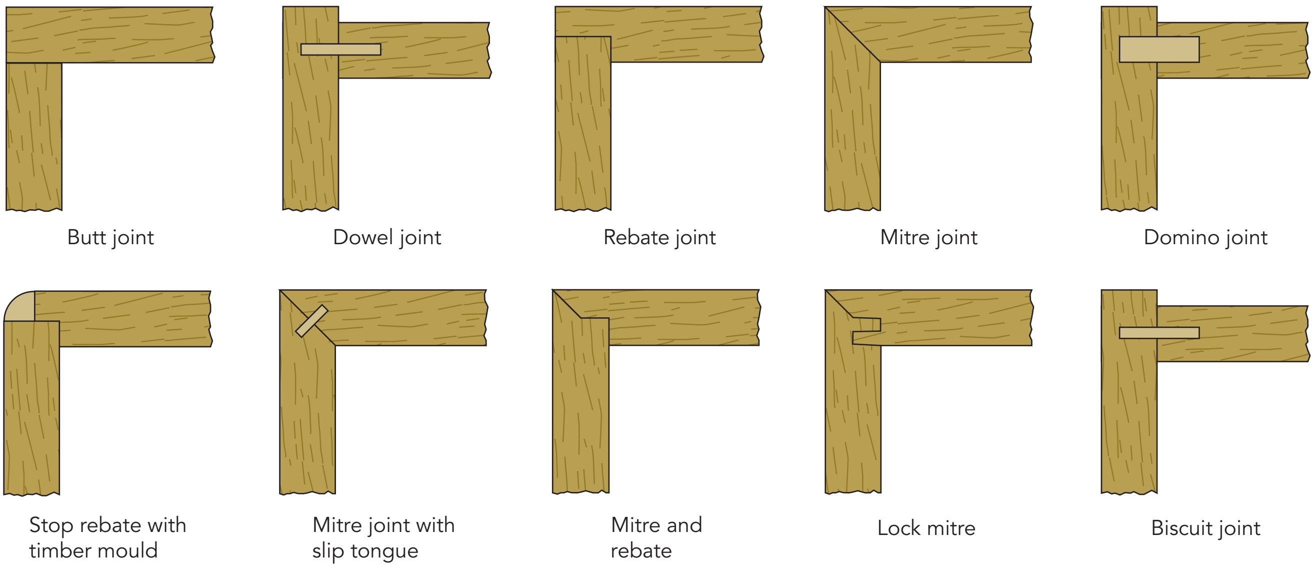

Figure 6.5 Examples of corner joints for particle board

Types

There are three types of particle board. All have similar methods of manufacturing, but are distinguished by different resin additions that modify their properties to meet specific applications and the environments in which they are intended.

Interior

Interior particle board is manufactured using urea formaldehyde as a bonding resin. It is essential that it has no contact with water. Used as a basic cabinet board when laminated with veneer or plastic laminate for cabinets, furniture, interior partitions and feature walls.

Flooring

One of the largest uses of particle board in recent years is in flooring. Particle board flooring is highly moisture-resistant. A phenol or tannin formaldehyde is used in the surface layers and a melamine or urea formaldehyde is used as a bonding resin. It may also be treated with fungicide and germicide. It is possible to purchase termite-resistant board as well.

High-moisture-resistant

High-moisture-resistant (HMR) particle board uses a melamine or urea formaldehyde resin, plus a blue dye in the core resin to distinguish it from the other types of particle board. Wax emulsion is included in the resin to repel water. This board is used extensively in the kitchen building industry as a core for plastic laminate coated boards and as structural wall bracing in timber-framed houses.

Hardboard

For decades, 'Masonite' was the name attached to **hardboard**. It is produced from hardwood chips, mainly eucalypt, pulped with water, spread as a 'mattress' on a travelling wire mesh screen, and compressed in high-pressure hydraulic presses at about 204°C to form a tough, dense, grainless sheet. After treatment in humidifying ovens, the board leaves the factory with a moisture content between 5–8 per cent (Figure 6.6).

Advantages

- Available in a wide range of sizes from 1220 × 915 mm to 5490 × 1370 mm, and in thicknesses 3–9.5 mm.
- Has no grain direction and can be nailed or screwed close to an edge.
- Available in a variety of prefinished colours and textures; also, pre-primed for painting.
- Can be formed to curved shapes.
- Available tempered, offering greater hardness and weather resistance.
- Can be worked with all power or hand tools.

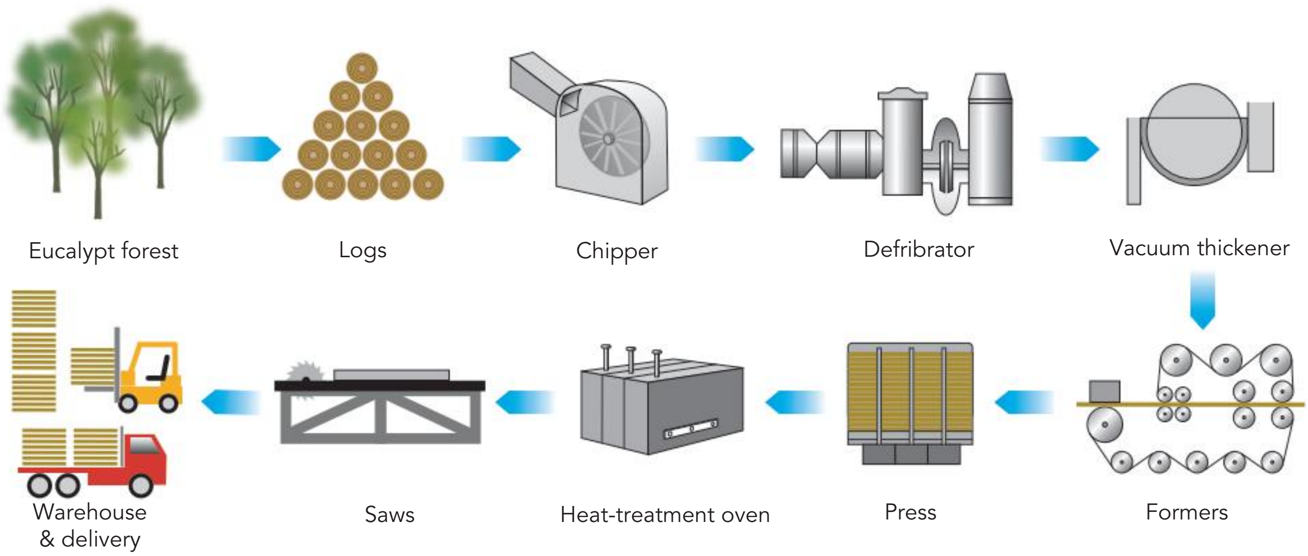

Figure 6.6 Typical steps in the manufacture of hardboard

Weathertex, Timber cladding made perfect, naturally! www.weathertex.com.au

Figure 6.7 Varieties of Weathertex hardboard, from left to right: Primelok 200 Smooth, Primelok Classic Woodsman and Primelok Ruff Sawn

Disadvantages

- Standard type is more absorbent than timber.
- Requires a frame for construction work.
- Is affected by atmospheric conditions, such as humidity, dryness or heat.
- Punctures and breaks more readily than the same thickness of plywood.

Working techniques

To stabilise moisture content, sheets should be moistened on the back and stacked flat for at least 24 hours before use. Use a sharp, fine-toothed blade for cutting and support the sheet near the cut. Butted edges should be covered or V jointed. Carcase construction requires a frame or corner members.

Uses

Hardboard is used extensively as a lining and facing material in building construction and furniture making. Standard sheets have a plain, smooth face. A variety of patterned and textured surfaces are available, such as printed timber graining, moulded slab effects, tile-patterned boards, and panels with punched perforations forming a design. Pre-primed sheets are a labour-saving addition to the range, and tempered board is designed for exterior use and other applications demanding moisture resistance (Figure 6.7).

Hardboard is typically used for wall and ceiling linings, partitions, facings for acoustical insulation panels, furniture backs, and drawer bottoms. Pegboard hardboard is ideal for tool and equipment racks and display boards. Standard board is used as a smooth base for linoleum and vinyl floor tiles.

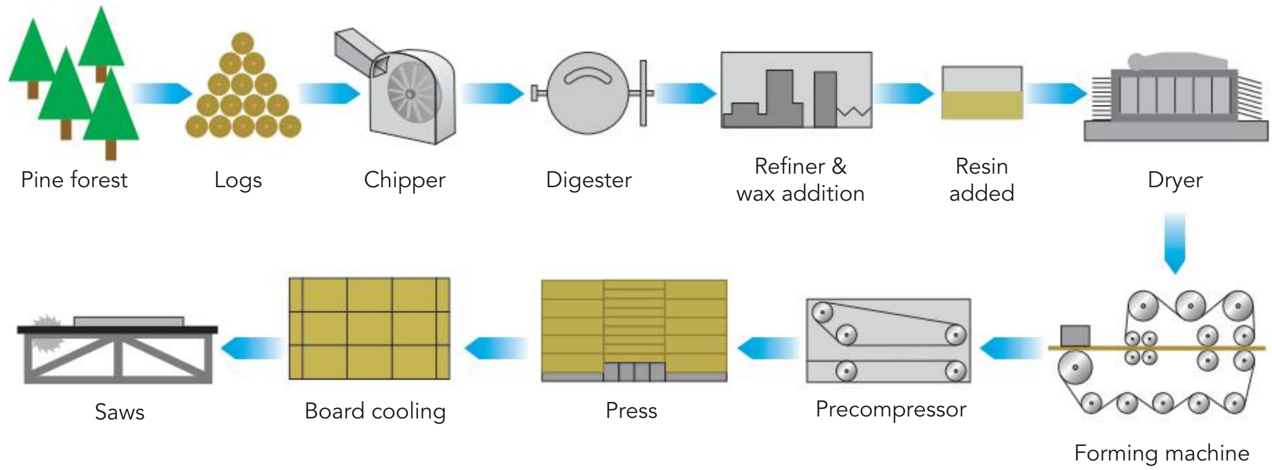

Figure 6.8 Typical steps in the manufacture of MDF

Medium-density fibreboard

Medium-density fibreboard (MDF) is manufactured under a variety of trade names, such as *Craftwood* and *Fibron*. The steps involved in the manufacture of MDF are illustrated in Figure 6.8.

The major raw material for manufacturing MDF is radiata pine, which is obtained from thinnings and residual material. The thinnings are debarked and chipped to a special size. The chips are then washed to remove any grit. The clean chips are conveyed to steam digester units, which soften, or plasticise, the chips in a cooking process. Heated chips enter single disc defibrators, which rub the wood apart into fibres. The newly formed fibre is conveyed to dryer units, where urea formaldehyde resin and wax emulsion are added.

Unlike particle board, which requires a drying chamber to reduce the moisture content, MDF fibres return to their final moisture content between 10–12 per cent within a few seconds. The fibres are stored in a dry fibre bin prior to entering the forming machine. This machine forms the fibres into a mat, which it lays on a conveyor to form a mesh belt. The fibre mattress is passed through a pre-compressor, which reduces the mattress height from 300 to 100 mm. The thickness to be pressed determines the speed of the forming line. Where thicker boards are demanded, a facility for double-laying the mat is utilised. This is only possible because of the homogeneous nature of the product.

The mattress passes to a loading cage prior to entering a seven-opening hot press. The combination of heat and pressure cures the resin and produces a sheet of MDF. The hot board is checked for weight and density, then trimmed prior to cooling and cutting.

Advantages

- Available in large sheets, up to 3660 × 2440 mm, in a range of accurate thicknesses from 5–32 mm.
- Compared with solid wood, it is stable (i.e. subject to little expansion and contraction); it retains its shape well.
- Forms an excellent base for covering with veneer or plastic laminates because of its stability.
- MDF has no grain direction; therefore, it has uniform strength.
- Easily worked with hand or machine tools.
- Requires no framing for carcase construction.
- Easily finished with paint, lacquer and so on.
- Easy to cut, sand, rout or profile because of its uniform density and internal bond strength.
- Available with a moisture-resistant glue for use in damp conditions.

Disadvantages

- Gives off fine sawdust when machining.
- Liable to break away when nailing or screwing near edges.
- Can split when nailing into the end grain.

Working techniques

The working techniques for MDF are similar to those for particle board; however, due to MDFs uniform texture, no edge treatment is needed. This allows treatments, such as face routing to be done (for example, on kitchen cupboard doors, which are then sprayed with a durable paint finish to give a spectacular effect).

SAFETY

When cutting or sanding MDF, use the appropriate PPE. The fine sawdust created may be a health hazard.

Uses

Typically used as a base or core for veneers, plastic laminates or painted surfaces. The furniture industry uses large quantities of both normal MDF (for carcasses, tops, drawer parts, shelves, picture frames, plaques and trophies) and moisture-resistant MDF (for toys, internal doors, kitchen cabinets, shop fittings, partitions and wardrobes). MDF is also used in **patternmaking** because of its uniform texture.

Other manufactured wood products

FACT

Formaldehyde-based adhesives are in the process of being phased out due to their *gassing* properties, which lead to irritation of the eyes, nose and throat and allergy effects on skin and lungs. Formaldehyde is classified as a 'probable human carcinogen' by SafeWork Australia.

Finger-jointed timber

To maximise small offcuts, pieces are joined together using finger joints to form longer boards (Figure 6.9). If they are to be painted, finger-jointed boards are a better alternative to long, single-length fascia boards, which would have come from very large, old, majestic trees – of which there are too few left!

Shutterstock.com/burdika

Figure 6.9 A finger jointed board

Laminated veneer lumber

Laminated veneer lumber (LVL) is an engineered wood that is similar to plywood but has no cross banding; each layer has the grain running in the same direction.

Laminating has long been used to make large pieces of timber even larger; for example, to cover large roof spans. LVL is made from veneers of radiata or slash pine, glued under pressure (typically with phenol formaldehyde, also known as resourcinol).

The advantages of LVL include structural reliability, strength, stability and ease of use.

Hyspan and Hybeam are LVL beams manufactured by Forwood Products of Adelaide and Allspan is a composite pine/steel beam, suitable for long spans, with steel sandwiched in the middle.

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Alamy Stock Photo/Brian Brown

Figure 6.10 Manufactured I-beams using LVL and OSB

Glue-laminated timber

Glulam is made by laminating thick pieces of seasoned, dressed timber in order to make larger structural members, bench tops, stair treads, and so on. It is best used for interiors, where preservatives are not needed. Glulam has almost the same **tensile strength** as solid timber because of new gluing and production techniques. A high strength-to-weight ratio allows large spans to be made in modern buildings (Figure 6.11).

Oriented strand board

Oriented strand board (OSB) is a type of engineered wood similar to particle board, made by gluing layers of wood strands (flakes) in specific orientations under pressure. The strands are arranged in cross-oriented layers, giving the panel similar strength and performance characteristics to plywood. The board is made of strands or flakes of wood allowing the use of smaller trees with little to no waste so it is a very cost effective way of making boards.


Shutterstock.com/Maciej Bledowski

Figure 6.12 A sample of OSB


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Figure 6.11 An example of a large span laminated roof beam used in construction

The future of manufactured wood products

Large trees being used in solid timber and beams have become rarer and more expensive. Veneer-based timber and beams have relied on the traditional, expensive sawlog as a resource. Large engineered wood-based products will increase in usage due to the reasons listed below.

- Sawn timber logs with a large diameter are in severe decline.
- There is an oversupply of timber with a smaller diameter.
- The quality of much of the fast-grown sawn timber is not acceptable for many structural purposes.
- Homes have been getting larger, calling for longer spans.
- Engineered composite timber is super-strong and can effectively compete with steel and aluminium.

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CHAPTER REVIEW QUESTIONS

1 Briefly describe the stages in the manufacture of plywood.

2 State the advantages and disadvantages of plywood compared with solid timber.

3 List some typical uses of coreboard or blockboard.

4 Briefly describe the manufacture of particle board.

5 Why is particle board better than solid timber as a base for veneers or plastic laminates?

6 What precautions should be taken when inserting screws into particle board?

7 Briefly describe the manufacture of hardboard.

8 What are some of the main uses for hardboard?

9 Many varieties of hardboard are available. Name three types that are suitable for wall cladding.

10 What is MDF? How is it manufactured?

11 Name some special uses for MDF.

12 What is LVL and where is it used?

13 What is the advantage of using glulam beams over solid timber beams?

14 How does OSB differ from plywood?

CHAPTER 7

Joining timber

Joinery is a part of woodworking in which pieces of timber are combined with the aim of producing items of more complexity. Usually seen in the interior of a house or building, joinery can also employ fasteners, bindings, or adhesives in tandem with its wood elements. The characteristics of wooden joints (such as strength, flexibility, toughness and appearance) are a direct result of the properties of the materials involved and the purpose of the joint. For example, the joinery used to construct a house is different from that used to make wooden toys, although some concepts will always be common to the two objectives. In joining, as in all woodworking, studying the grain direction and working along it are vital. Eventually it will become second nature to look at the grain in a piece of timber to see how best to work it.

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Key terms

brace a thin strip of timber temporarily pinned across a joint to hold it rigid until the adhesive sets

driving the act of inserting a screw with a screw driver or a nail with a hammer

electrolytic action an electrical action between two different metals with differing reactions (e.g. a battery)

false front an extra front attached to a drawer, which thickens it to allow for curving, carving, etc

feathers thin slivers of timber, or plywood, that are glued and slotted into corner joints to increase their strength and beauty

flat packing items, such as furniture, that are sold unassembled to save on storage space and assembly labour

flush two surfaces that are level with each other

head the screws arranging the slots in screw heads so that they all line up with the grain of the timber

mitre shooting board a device that allows a plane to sit on it at exactly 45° in order to chamfer an edge of timber

pared lightly chiselled to level off or remove a small amount of wood

set mitre similar to a try square except that the blade is set at 45° rather than 90°

shank the straight, unthreaded part of a screw

shearing the action of cutting or breaking something sideways

short end grain an unusual situation in which the direction along the grain of a piece of wood is structurally weak

slip (loose) tongue like a 'feather' or 'tongue', a slip is usually placed in grooves for strengthening a joint between two pieces of timber

stay a device used to support an open lid during uncontrolled closure or excessive opening

tourniquet a loop of material (such as thin rope) with a stick that is inserted and twisted, which results in tightening

Joining timber

Timber can be joined in two ways: by purely gluing and joining the pieces or through mechanical means. A purely glued joint, such as a simple butt joint, relies on a large surface area for the glue to adhere to. A joint that uses mechanical means, such as by adding **feathers**, **slip (loose) tongues**, screws or nails or by using a joint that is designed to give its own mechanical advantage, such as a mortise and tenon joint, is much stronger. Mechanical means can be hidden from sight later, and you can further strengthen a mortise and tenon joint with dowels, wedges or biscuits. Some joints are used for their aesthetic appeal as well as their strength, such as dovetail joints.

All joints still use glue and you may use any of the methods above to further strengthen them.

When making something requiring timber to be joined, you generally have a selection of joints from which to choose. Your decision should be based on how strong the joint needs to be and whether it needs to be reinforced further (e.g. with nails or other fastenings).

TRY THIS

Ask your teacher to cut two pieces of knot-free, 100 × 15 × 12 mm pine, one with the grain going longways and the other across the width. Now, just using your hands, try to snap each in half and note the results.

Types of timber joints

Timber joints can be organised into three categories: box or angle joints, framing joints and widening joints.

Box or angle joints

The three main types of box or angle joints are butt, mitred and dovetail.

Butt joints

Nailing is the simplest form of fastening (Figure 7.1a) and is mainly used in simple box construction. Screwing makes a stronger join but is harder to conceal than a nail head. Check with a try square that all corners are 90° and that the parts being joined are the same width. Hold one piece of timber in the vice, apply the glue and join the other piece of timber to it. Centre the nails in the thickness of the timber and, for greater holding power, skew them across the width rather than driving them square to the face. This is called dovetail nailing (Figure 7.1b) and nailing a centre vertical nail first locates the two pieces of timber. Punch the heads slightly below the surface. You can increase the strength of the joint by securing a small piece of wood, square or quadrant in the internal angle (Figure 7.1c).

HINT

As a guide, it helps to square a pencil line across the piece that the nails first go in (at half the thickness of the lower piece)

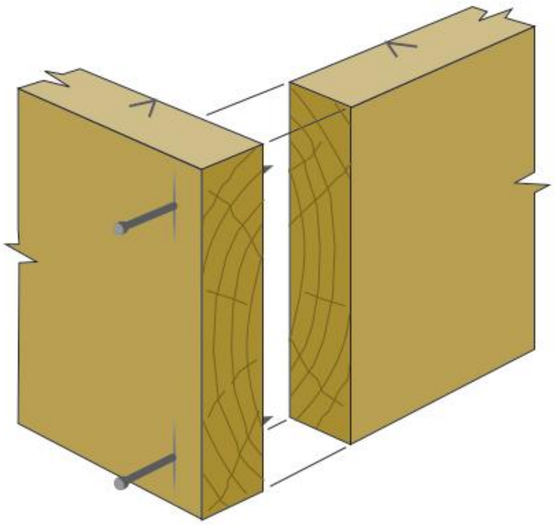

Figure 7.1a Nail and butt joint

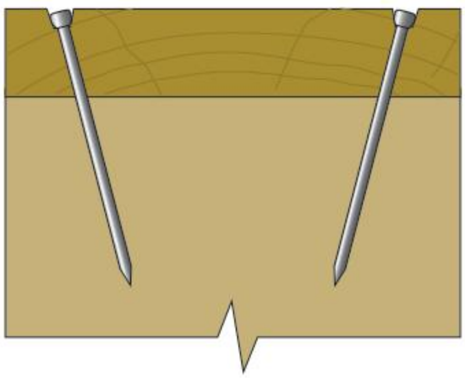

Figure 7.1b Dovetail nailing

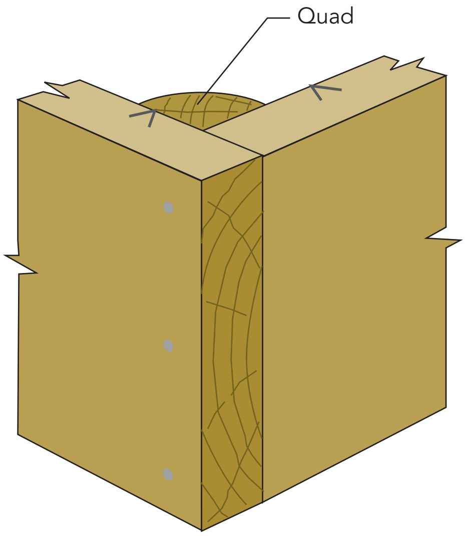

Figure 7.1c Nail and butt joint with strengthening block

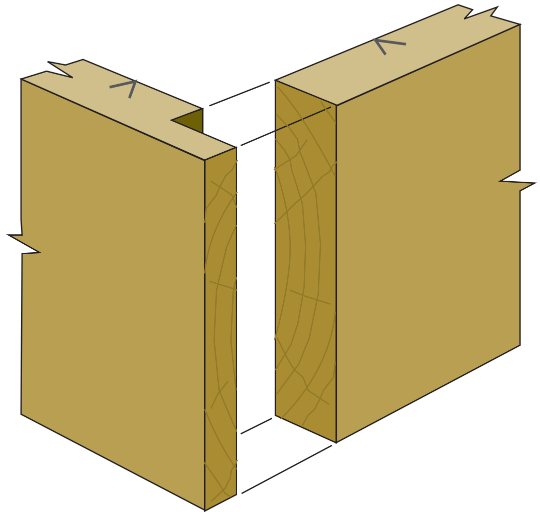

Figure 7.3 Rebate or shoulder joint

The scarf joint is a simple butt joint that is used to join two pieces of timber of the same width and thickness. It requires a large surface area for the glue to be effective. It can be additionally strengthened with dowels. Commonly used to repair broken chair legs (Figure 7.2).

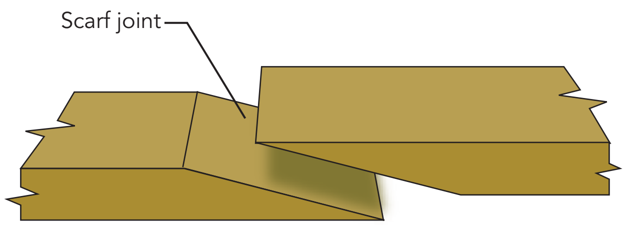

Figure 7.2 Scarf joint

Rebate joints

For a neater finish at a corner, and to produce a little more strength due to the increased surface area for gluing and a shoulder to butt against, rebate one piece and butt the other into it. Note that the amount of rebate cut out is normally from one-half to three-quarters of the thickness (Figure 7.3).

A tongue and trench joint, or barefaced housing joint, may also be used (Figure 7.4). Avoid too tight a fit for this joint or the small end piece will break due to **short end grain**. This joint is time-consuming to produce and is not used very often anymore. The rebate is normally used for making boxes or drawer fronts designed for light-weight use.

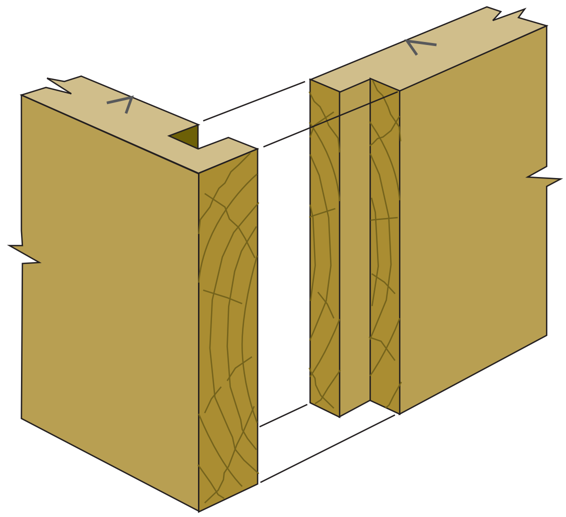

Figure 7.4 Tongue and trench or barefaced housing joint

Housing joints

A housing or trench is typically found in items such as, shelving, box dividers and drawer backs (Figure 7.5a). The depth of the trench should be no more than one-third the thickness of the timber or the joint becomes weak. A stopped housing joint (Figure 7.5b) is used when the housing is not meant to show on the front edge, providing a neater appearance.

Other less used housing joints include, the sliding dovetail, the single-sided dovetail and the tapering dovetail. All of these housing joints are time-consuming and infrequently used today.

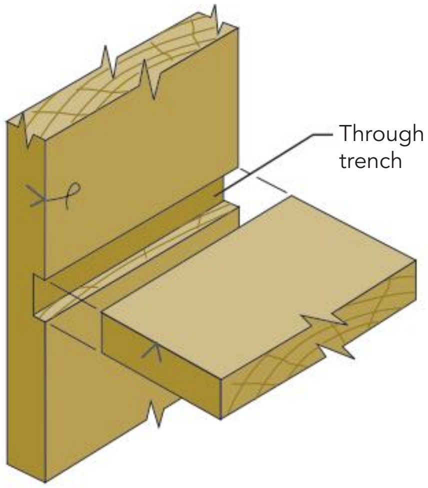

Figure 7.5a Through housing joint

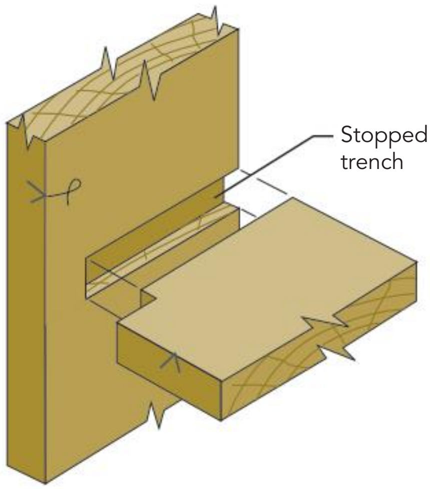

Figure 7.5b Stopped housing joint

CHECK YOURSELF

1. Name and sketch six methods of strengthening a joint.
2. Name and sketch a method that increases the holding power of nails.
3. Why is a rebate joint stronger than a butt joint?

Mitred joints

This is a form of butt joint whose advantage is that it shows no end grain. However, it offers a relatively weak end grain to end grain bond. Commonly used in small boxes, picture frames, in the fitting of mouldings and architraves and in furniture construction.

Use a mitre box (Figure 8.22) or set out with a sliding bevel or **set mitre** to cut each piece at an angle that bisects the full angle of the joint (normally 90°). When each piece is cut to 45°, the resulting right-angled joint is called a 'true' mitre, but any angle may be mitred (Figures 7.6 and 7.7).

Small mitres are typically joined straight from the saw; however, any necessary fitting can be achieved with either a **mitre shooting board** and a smoothing plane (while the timber is held in the vice) or a disc sander. Assemble with glue and/or nails. If nailing, hold one part in the vice and place the other on it slightly above its correct position; this allows for it to slide down as you nail. Mitre clamps can be used to hold both parts for gluing or nailing. A web clamp, rubber bands and string with a **tourniquet** are useful for holding the work until the adhesive sets.

Ideally, a mitre joint is strengthened with biscuits, because they are a shallow depth system.

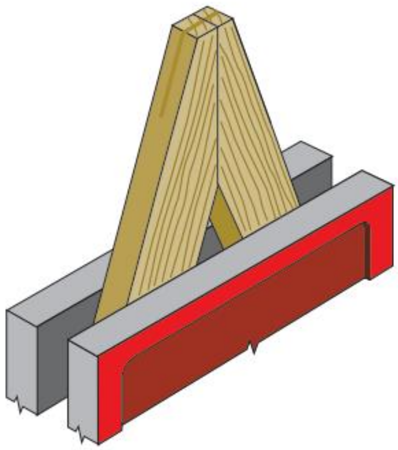

Figure 7.6 Acute-angled mitre (note *feather* for strengthening)

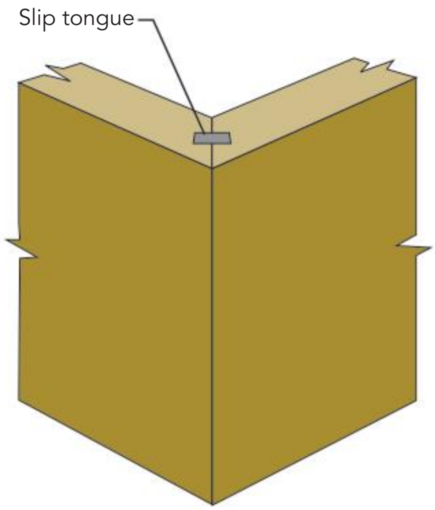

Figure 7.7 Plain mitre with slip tongue

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The joint may also be strengthened with a 'feather', a thin piece of wood glued into a saw cut across the external angle, which is trimmed and planed **flush** when dry (Figure 7.6). Another option is an internal slip tongue (Figure 7.7). Where internal appearance is unimportant, a strengthening block may be glued to the inside of the joint.

HINT

Using a feather (or veneer) spline with a contrasting colour creates a decorative effect.

Mitred joints may be rebated (Figure 7.8) but it is questionable whether the extra joint preparation time is worth the marginal extra strength.

Reliance on timber pieces end grain-joined by adhesive alone is not recommended because this produces a relatively weak joint. Preparing an accurate mitre joint across a wide piece of timber is difficult due to the possible cupping or twisting of boards.

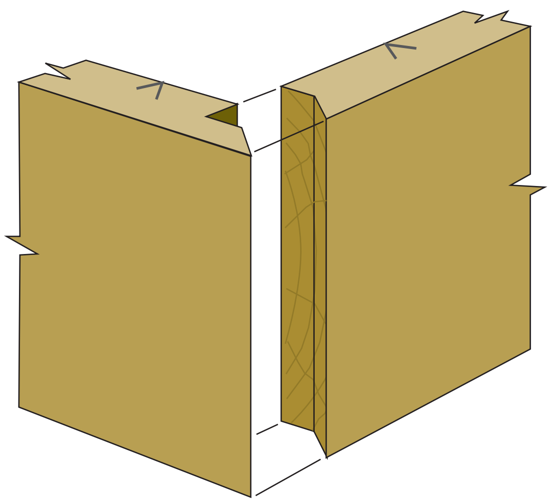

Figure 7.8 Rebated mitre

Dovetail joints

This is probably the strongest of all corner joints. It is often used in box and carcase construction and especially for the fronts and backs of drawers, where the strain is directly on the joints, tending to pull the front and back from the sides. Figure 7.9 shows drawer parts and assembly.

The three main types of dovetail joint are common, lapped and secret (or mitred). Note how the various parts are named in Figure 7.10.

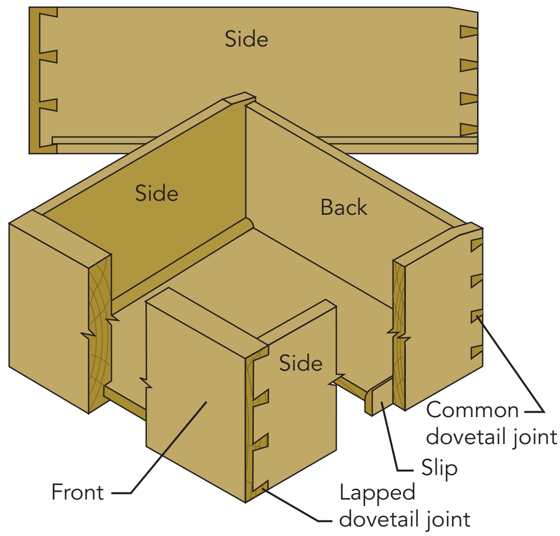

Figure 7.9 Details of joints found on a typical drawer

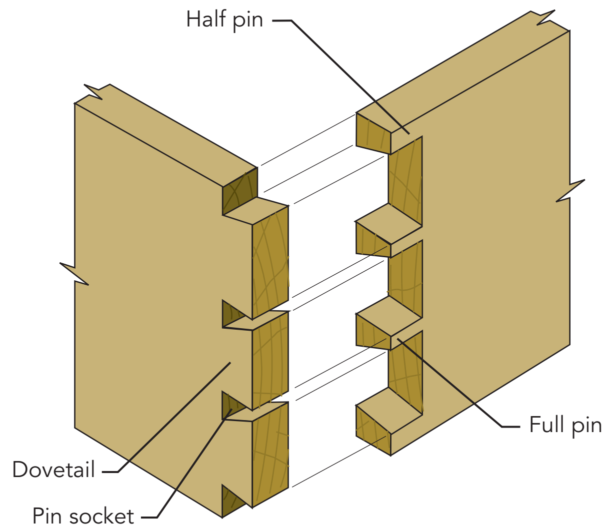

Figure 7.10 Common dovetail joint

When setting out, the slope, size and spacing of the pins is critical. A slope of 1 in 8 is used for harder woods (any higher angle could see the joint pull apart) and 1 in 6 for softer wood. Cabinet makers tend to use more slope: 1 in 4 despite the fact that this produces sharper, easier-to-break corners.

Listed below is the 'rule of three', a simple standard for setting out dovetail joints.

1. Divide the thickness of the timber by the chosen slope (typically 4, 6 or 8).
2. Take three of these parts as the width of the pins at their wider end.
3. Allow spacing between pins not more than three times the widest part of the pin (Figure 7.11).

Note: for a lapped dovetail (Figure 7.12) the lap is one-third the thickness of the timber being lapped.

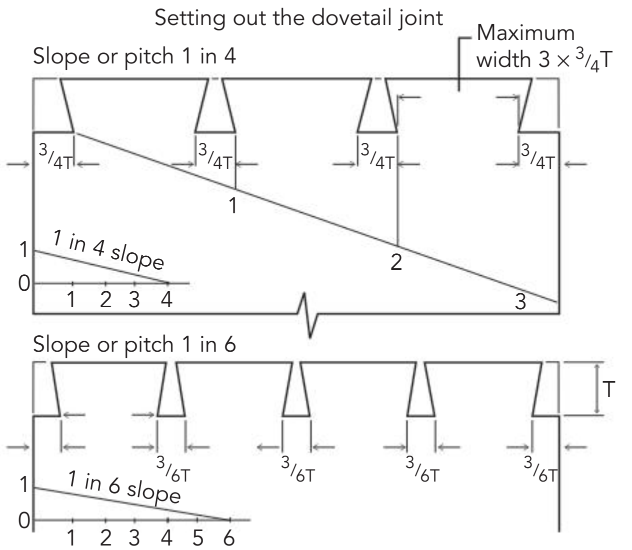

Figure 7.11 Suggested standard proportions for common dovetail joint

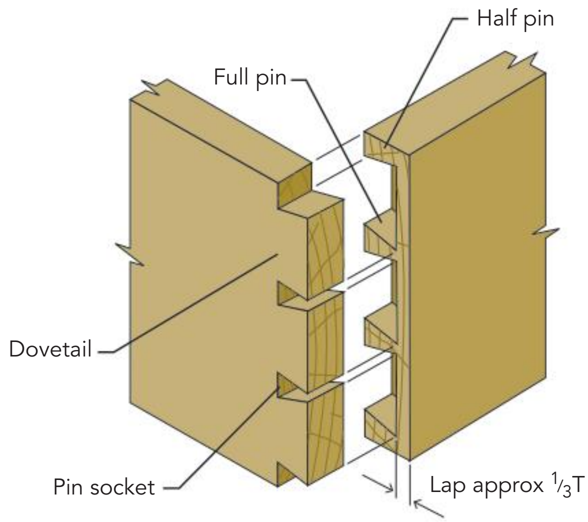

Figure 7.12 Lapped dovetail joint

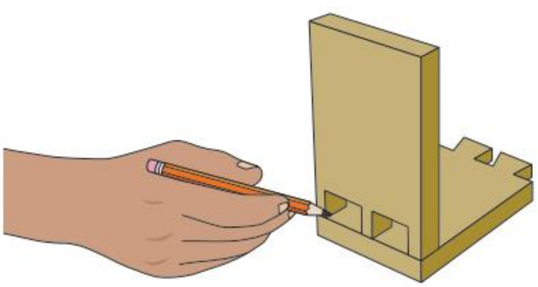

Figure 7.13 Marking dovetails sockets from pins

TRY THIS

STEPS TO MAKE A COMMON DOVETAIL JOINT

1 Carefully mark all face sides and edges. It is essential that these be accurately positioned in the whole assembly. Face sides and edges must all face the same way.

2 All marking is done from and on the ends; therefore, square the timber to length prior to setting out.

3 Set out the pins. Mark the waste parts clearly and then cut accurately to the lines on the waste side using a light, fine-toothed saw (special dovetail saws are available) with gentle pressure. The waste is chiselled out from each side (to prevent splintering) and carefully pared to the marked line. Use a coping saw to cut out the bulk of the waste. Note: an alternative method is to construct dovetails first.

4 Mark the pin sockets, using the pins as a template (Figure 7.13). Your pencil needs a long taper and a sharp point for clear marking.

5 Saw down the sides of the sockets to the gauged depth (Figure 7.14) then remove waste with a bevel-edged chisel, working from each side (Figure 7.15). A coping saw may be used to remove the majority of waste prior to chiselling.

6 Assemble the joint dry to test for fit and squareness. Also test for wind, which is typically caused by inaccurate marking or cutting. Adjust as necessary, then glue together and test again with a try square. Leave to set, before cleaning off.

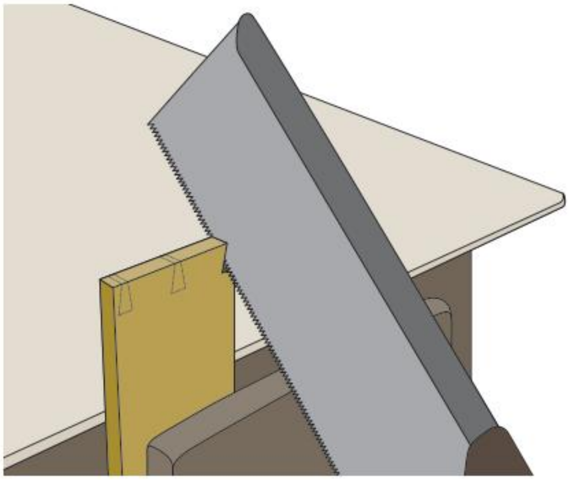

Figure 7.14 Sawing pin sockets – note how waste is marked

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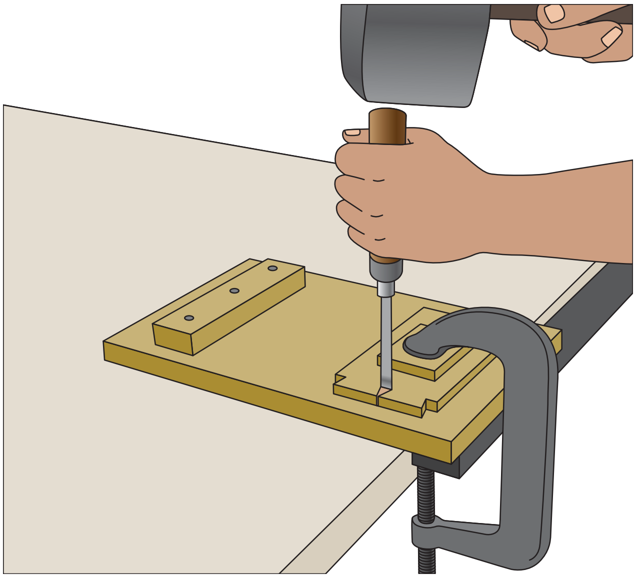

Figure 7.15 Chiselling waste from sockets; block under clamp shoe protects work and bench hook protects the bench

Lapped dovetail joints

Similar to the common dovetail, these joints were designed for use on the front of drawers so the joint was not visible (Figure 7.12). A little more difficult to construct, these joints require that the saw cuts for pins are not carried right through the timber; therefore, most of the waste must be removed with chisels. Figure 7.16 illustrates the marking of the pins and lap. Figure 7.17 illustrates the cutting of the dovetail sockets with a bevelled-edge chisel.

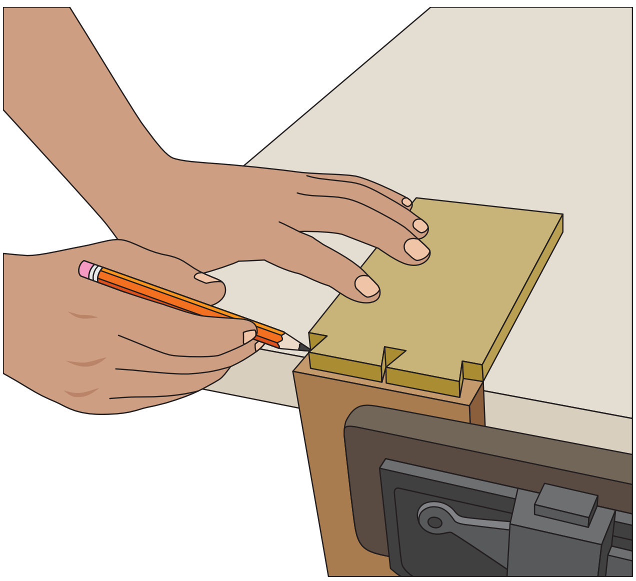

Figure 7.16 Marking pins on lap from dovetails with pencil

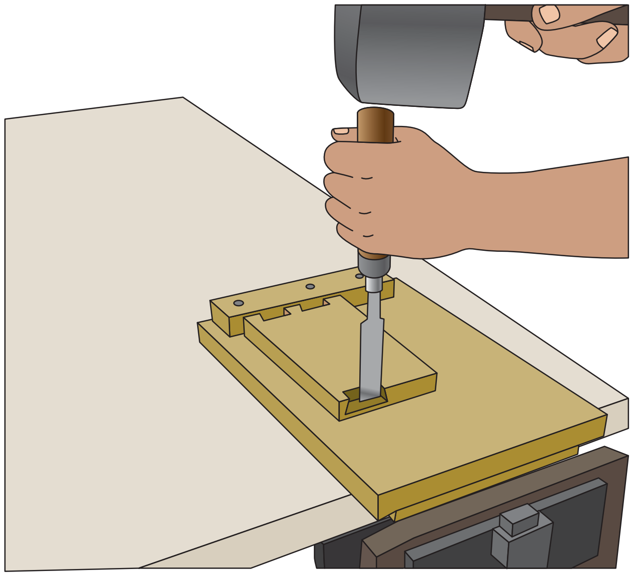

Figure 7.17 Cutting back edge of sockets with a bevelled-edge chisel

HINT

While marking the pins (Figure 7.16) use a try square on one side of the two pieces to improve accuracy and help reduce wind.

Secret dovetail joints

Secret dovetail joints (Figure 7.18) are lapped over both pins and dovetails so that neither show on the outside. Laps are best mitred for a neat finish. For both pieces, sawing and removal of waste are done as for the front piece of a lapped dovetail. In calculating the proportions of the pins, only the part actually dovetailed is considered (i.e. two-thirds of the total thickness).

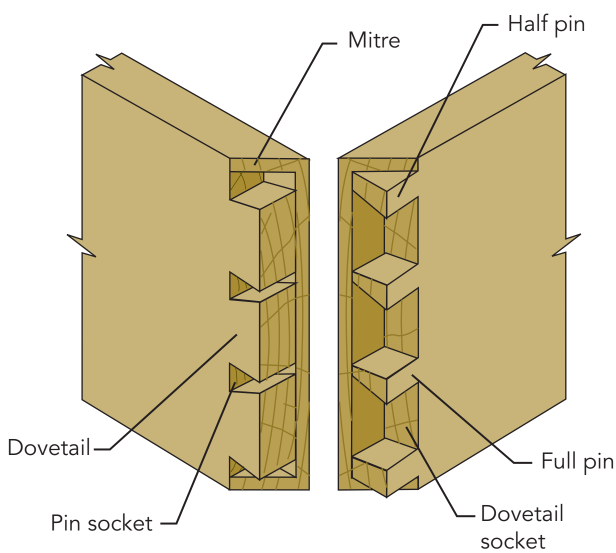

Figure 7.18 Secret or mitred dovetail joint

General notes regarding dovetail joints

- Dovetails should not be used under veneers. Shrinkage in the thickness of the timber will cause the ends of dovetails and pins to show through.
- Mark each part carefully, the parts are not interchangeable because it is difficult to cut all joints in an assembly exactly the same.
- Clean, accurate saw cuts make a better fitting joint than one that has to be **pared** to fit. Light pressure on the saw is essential; heavy-handed sawing makes a rough cut with burrs on the back.
- Joint recesses must be cut accurately to the thickness of the timber or subsequent cleaning off may alter the finished size of the project.
- Dovetail joints are secured using only glue. A four-part assembly may require a light **brace** to keep it square until the glue sets.
- Do not chisel, pare or clean up a joint that is clamped in a vice because, with no backing, it is likely that the joint will split. Clamp it to a solid backing board.
- When cleaning up a joint, less pressure is required by moving a wider chisel along a few millimetres at a time.

Finger, comb and box joints

Finger joints, which are sometimes called comb or box joints (Figure 7.19), are a decorative corner joint with a high surface area for gluing. They are normally cut by machine. When used away from a corner, this type of joint may also be used as a carcase construction joint (Figure 7.20), and may even be strengthened using diagonal wedges in the pins. Normally machine made, this is basically a pinned mortise and tenon joint.

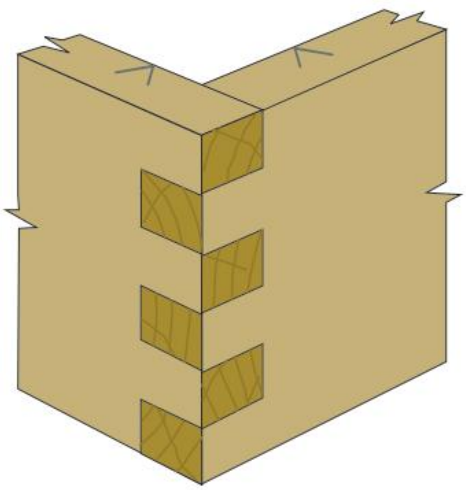

Figure 7.19 Finger, comb or box joint

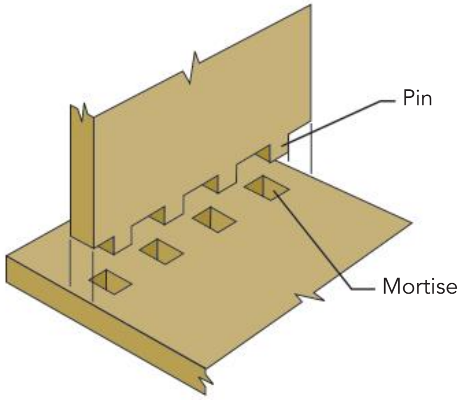

Figure 7.20 Carcase joint

Framing joints

Framing joints include halving, mortise and tenon, bridle, notched and loose tongue (i.e. dowelled, biscuited and domino).

CHECK YOURSELF

1. List four ways that a mitred joint may be held until the adhesive sets.
2. Why is a mitred joint generally a weak joint?
3. Draw a pictorial view of a single common dovetail joint and label all parts.
4. Should dovetails or the pins be marked and cut first? Why?
5. Apart from decoration, what advantage does a finger joint have and what disadvantage does it have?

Halving joints

Figures 7.21 to 7.25 show five types of halving joints. They are used for projects, such as mirror frames, furniture bases and carcases. They may also be strengthened using nails or screws. The glued surface area is good and includes a shoulder, which makes it a simple yet strong joint.

The width of the trench is determined by the width of the timber, and its depth is half the thickness of the timber. The depth for both pieces can be gauged using the 'guesswork' method. This involves setting a marking gauge to an estimated half thickness, making a small mark on one piece and then turning it around and repeating the process. If the marks are on top of each other, then it is no guess at all, it is spot on. If they differ, just reset the gauge to halfway between the marks, then gauge around both mating pieces.

For a dovetailed halving, mark and cut the dovetail first and use this piece to mark the trench (socket). A cross-halving joint can be constructed at angles other than 90° (e.g. BBQ table legs). Lightly clamp the legs at the desired angle, ensure equal leg lengths to the crossover, then mark both pieces to complete the joint.

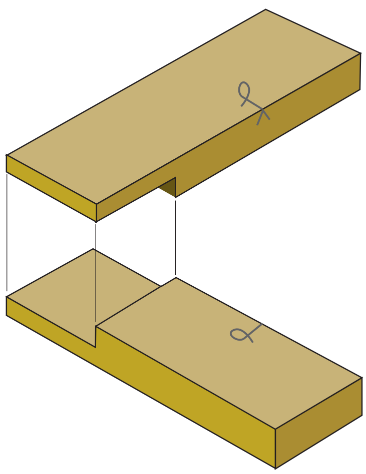

Figure 7.21 Corner halving joint

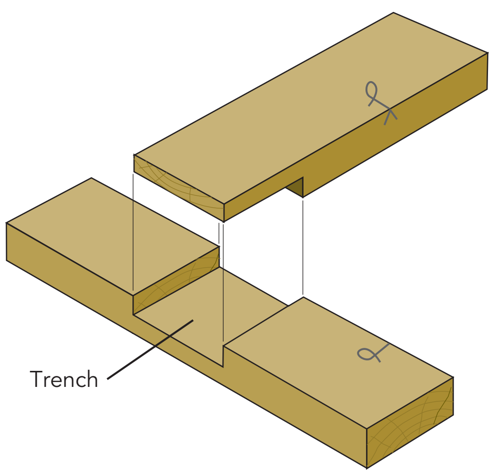

Figure 7.22 T-halving joint

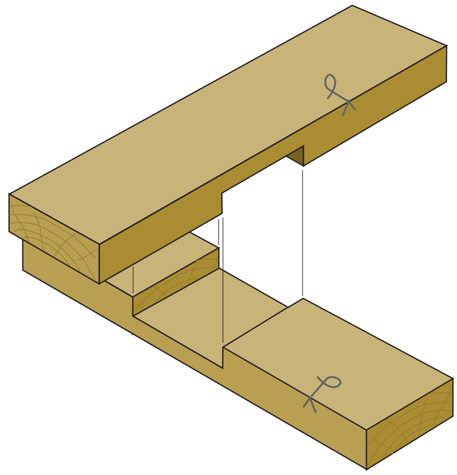

Figure 7.23 Cross-halving joint

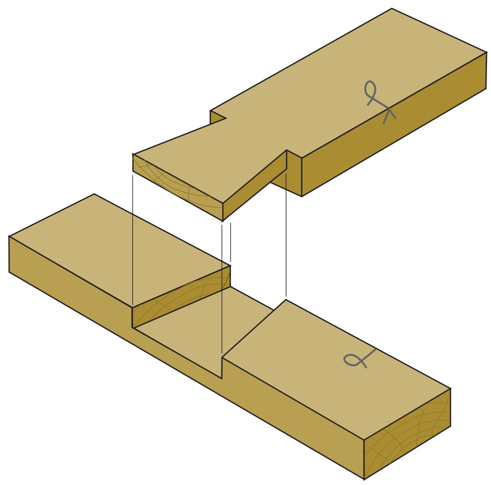

Figure 7.24 Dovetailed T-halving joint

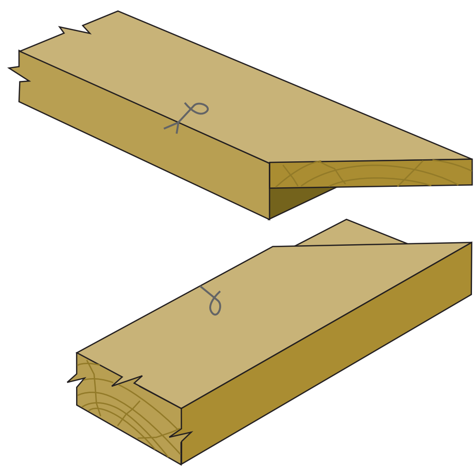

Figure 7.25 Mitred corner halving joint

In a properly made halving joint, faces will finish flush but may be lightly skimmed with a smoothing plane.

Mortise and tenon joints

A mortise and tenon joint is the strongest framing joint in terms of mechanical strength. This is why it is used where the effects of weight and stresses need to be countered, such as in door, table and chair construction.

HINT

When remembering the parts of a mortise and tenon, the tenon is the 'tongue'.

Set out and assembly of the three principal types, used for doors, window frames and structural framing, is shown in Figures 7.26 to 7.28.

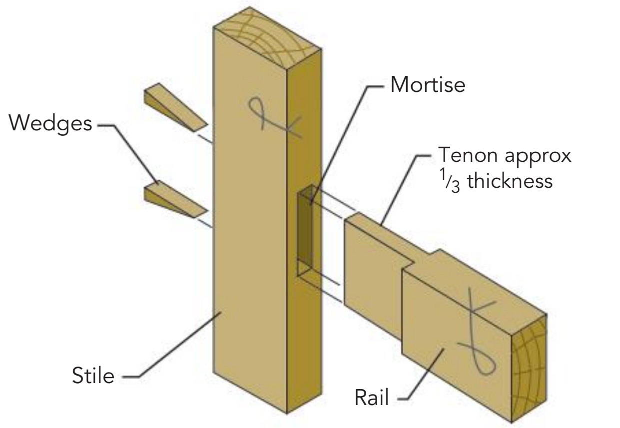

Figure 7.26 Common through mortise and tenon joint

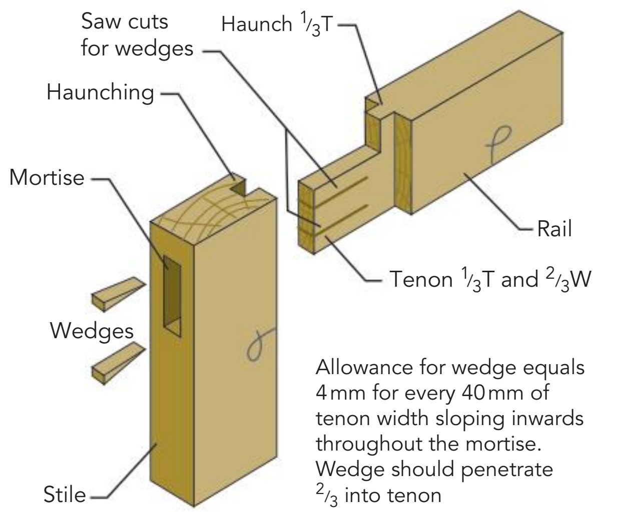

Figure 7.27a Through haunched mortise and tenon joint

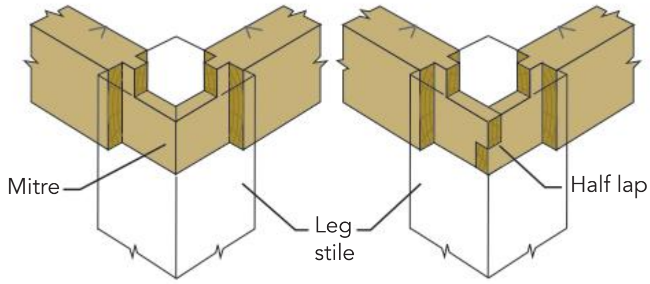

Figure 7.27b Alternative methods of making joints in table and stool construction. The half lap is stronger

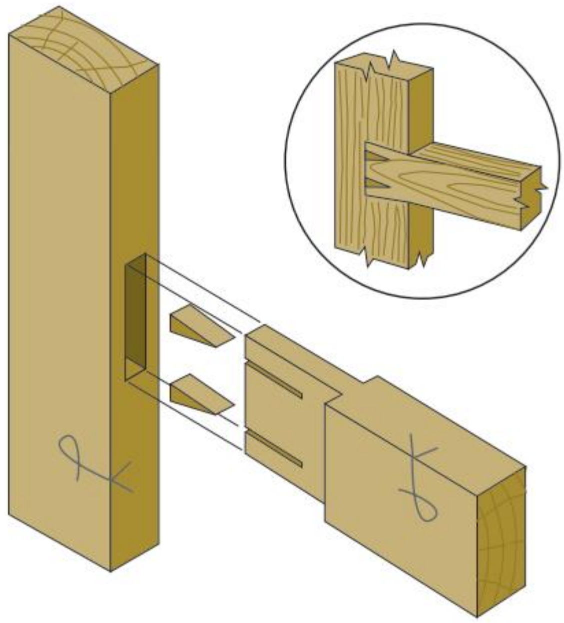

Figure 7.28 Stub mortise and tenon joint with foxtail wedging ready for insertion into tenon

The recommended thickness of a tenon is approximately one-third the thickness of the timber (to the nearest chisel size, which saves unnecessary paring).

Note the addition of wedges at both edges of the tenon. These compensate for any shrinkage in the width of the rails and also help to square the frame. For the common through mortise and tenon, wedges are cut separately from timber equal in thickness to the tenon, but for the haunched joint, wedges are cut when forming the haunch (Figure 7.29).

Tenon joints may also be pinned rather than wedged (Figure 7.30). A round piece of timber equal in diameter to the thickness of the tenon is glued into a hole bored through the assembled joint. Sometimes holes are drilled through the stile and then the tenon is inserted and marked, separated and drilled about 1 mm further towards the shoulder to allow for draw (Figure 7.30). Note the extra tapered pin to locate the offset holes.

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The common mortise and tenon (Figure 7.26) is seldom used on a corner; it would become a corner bridle joint, with the mortise becoming a slot.

The stopped haunched mortise and tenon is a corner joint, the tenon being narrower than the width of the rail, leaving the outside end of the mortise closed. Haunching increases the adhesive area, offers side grain gluing, resists twist and prevents a crack showing if the stile shrinks.

Figures 7.31a and b show two variations of tenon design, made for thick and wide rails respectively. If only one tenon were to be used in these cases, the size of the mortise required would weaken the stile.

Stub or stopped mortise and tenon joints (Figure 7.28) are used where the joint is to be hidden from the outside edge of stiles. The depth of the mortise is one-half to two-thirds of the width of the stile. Note that foxtail wedges may be fitted into the stub end of the tenon.

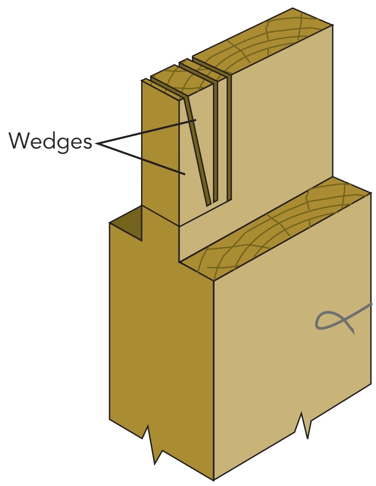

Figure 7.29 Wedges for haunched mortise and tenon are cut when forming the haunch

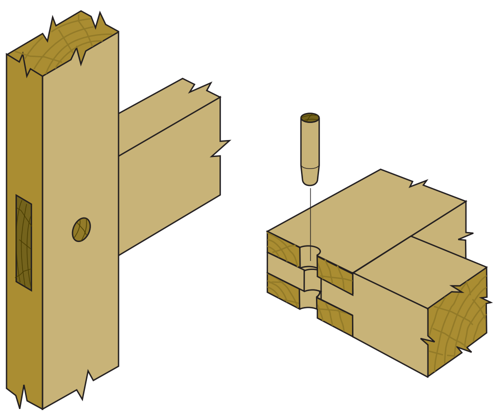

Figure 7.30 Pinned mortise and tenon – dowel inserted in staggered holes draws joint tightly home

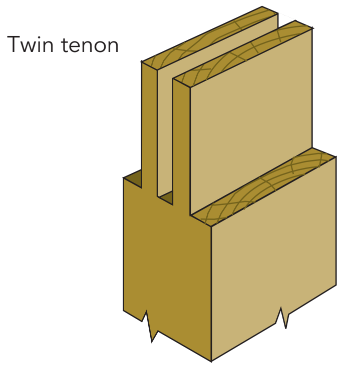

Figure 7.31a Twin tenons for thick rail

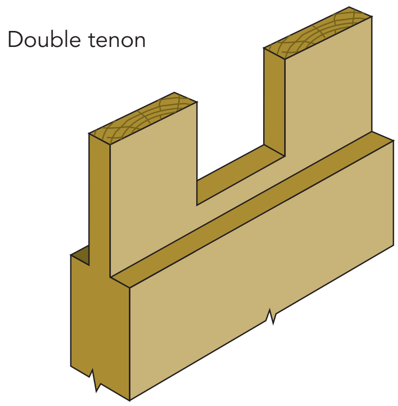

Figure 7.31b Double tenon for wide rail with haunch between

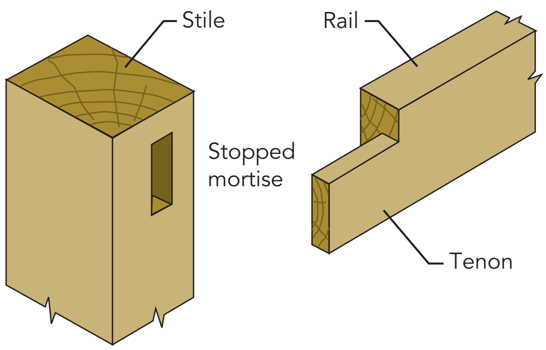

Figure 7.32 Barefaced mortise and tenon joint

Figure 7.32 shows a barefaced mortise and tenon for use where the rail is thinner than the stile and the rail face (shoulder side) needs to be flush with one side of the stile: the tenon has a shoulder on only one side.

If the project is a cabinet door frame, where the stile is rebated, the tenon is cut with long and short shoulders: one shoulder is longer to allow for the depth of the rebate (Figure 7.33).

There is a loose-tongued mortise and tenon joint that probably evolved as the first 'knock-down' fitting (no glue is used). It uses a longer tenon that protrudes through the stile, and there is a hole cut in it touching the outer edge of the stile through which a wedge is fitted. This draws the shoulder of the tenon up hard against the inside of the stile and makes a solid yet demountable joint. It is bad practice to fit rails to a leg with mortise and tenons positioned close to the inner leg corner because a knock or kick at the leg's base could split the joint, due to a lack of supporting timber.

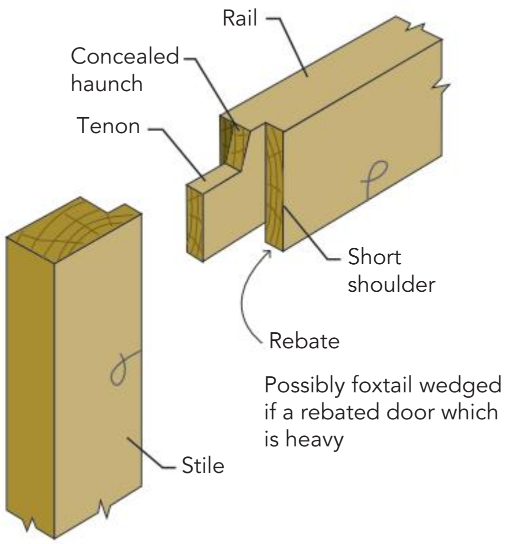

Figure 7.33 Long- and short-shouldered mortise and tenon joint, with rebate

HINT

- When setting up a mortise gauge for marking out, do not set it to one-third the rail width, set it to a chisel width that is as near to one-third as possible. For example, if the rail is 19 mm wide, use a 6 mm wide mortise or firmer chisel.
- When cutting the tenon, always saw in the direction of the grain rather than across it.

Accuracy, when cutting a mortise and tenon joint, comes with practice.

Clamp the wood in a vice at 45°. Start at a corner and saw with the grain, slowly dropping the saw blade angle along the marked tenon line to make a shallow cut. This shallow groove helps guide the saw. Now, go back to the corner and start cutting (Figure 7.34a), this time dropping the saw angle across the end and side but watching the saw line across the end as the blade will tend to stay in the groove you first made along the side. Turn the timber over and repeat this process from the other side of the tenon. Finally, place the tenon upright and cut the remaining triangular section until the blade is level with the base of the tenon cheek. Repeat for the other side of the tenon.

Now, mount the timber on a bench hook and carefully cut down the shoulders – take care to ensure that both cut level. Use a marking knife for the marking out rather than a pencil. This has the advantage of producing a spot for the chisel to rest in for cleaning up. You may prefer to chisel a small amount of waste away at the shoulder to rest the saw in for a clean cut.

Bridle joints

Bridle joints are similar to mortise and tenon joints in terms of marking out, and the cutting method is similar to the halving joint (only in one-thirds). This joint is quite strong due to a very large surface area for gluing. On a T-bridle, if the tenon piece is thinner it can be cut 'barefaced', becoming two-thirds with a one-third trench on one side, to maintain strength.

Bridle joints are found joining through rails to legs in cabinet work and in certain frames where it does not matter if the end grain is seen, such as in frames under art canvases. Figures 7.35 to 7.38 illustrate four types of bridle joint.

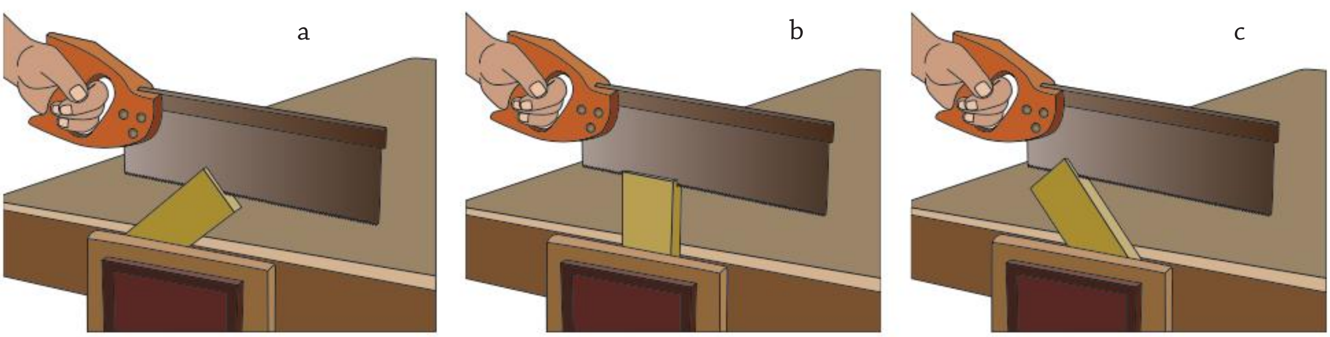

Figure 7.34 a Sawing with the grain **b** across the grain and **c** against the grain

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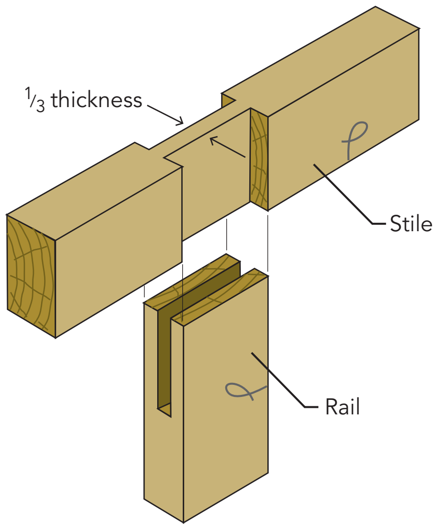

Figure 7.35 Common or through bridle joint; also called a T-bridle joint

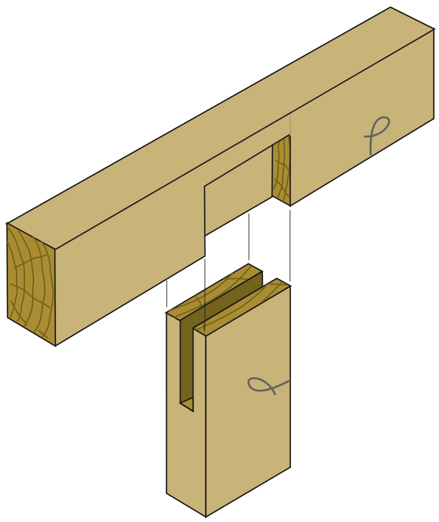

Figure 7.36 Stopped bridle joint

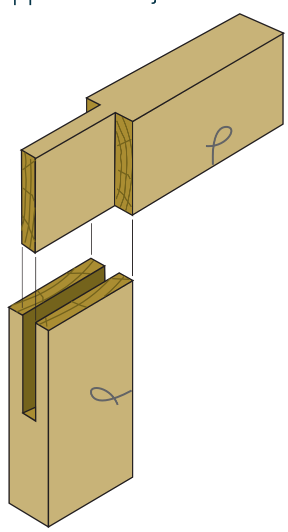

Figure 7.37 Corner bridle joint; also called an open mortise and tenon joint; pinning may be necessary to prevent lateral movement

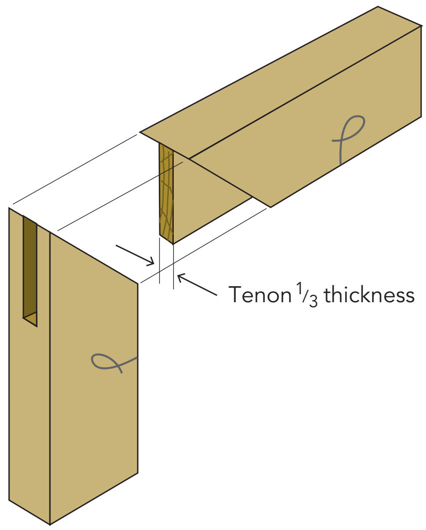

Figure 7.38 Mitred bridle joint

Notched joints

Used chiefly in carcase construction, notched joints are similar to halving joints, but the timber is usually on edge rather than flat. These are suitable for framing to take a heavy load, such as for a fish tank. A trench or recess is made, either through or stopped, and the rail is fitted into it (Figure 7.39).

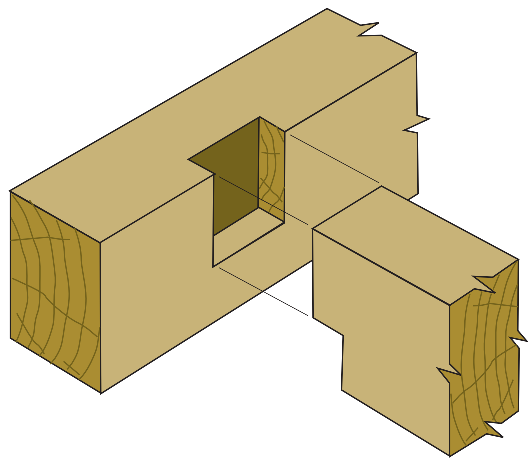

Figure 7.39 Notched joint

Loose tongue joining

Dowelled joints

Dowelled joints are made by boring holes in the pieces to be joined and gluing-in round pieces of timber called 'dowels' (Figure 7.40). Dowelled joints are invisible and strong.

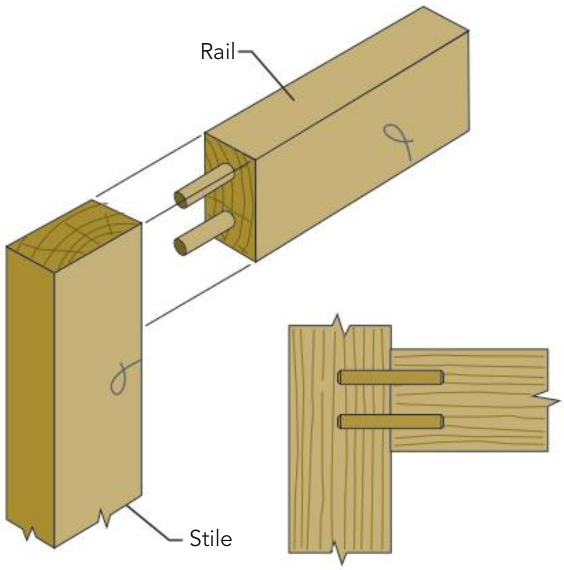

Figure 7.40 A dowelled joint – length of dowel should be three times the diameter going into the grain and two-and-a-half times the diameter going across the grain

Dowels may be purchased in lengths between 1–2 m and diameters between 6–25 mm. Some dowels come pre-cut with grooves machined for the escape of trapped air and excess glue when the joint is clamped. The most common dowel sizes are 10 and 13 mm diameter. Dowels used for jointing should be at least 2 mm shorter than the total depth of both holes, and half the thickness of the timber in diameter. Note: If using non-grooved, plain dowel, a groove must be cut or the hydraulic pressure build-up from clamping may split the wood.

Accurate positioning of the dowel holes is essential; they must be bored square to ends and edges and exactly opposite in both parts (Figure 7.40). Many dowelling jigs and templates are available to assist with accuracy and speed. Therefore, it is hardly worth marking out and drilling them manually.

When gluing, ensure there is not an excess of glue going into the hole. Use a smaller stick to ensure that the glue is smeared around the wall of the hole rather than welling in the bottom of the hole. Do not forget to smear glue along the joined surface of the wood (preferably both surfaces).

Clamping should only be hard enough to close the joint and squeeze out the excess glue. Extra clamping pressure may force the two pieces of wood out of alignment.

Biscuit joints

The biscuiting machine, and its operation, is detailed in Chapter 9.

Biscuit joints are a type of widening joint. They have been a welcome addition to the field of cabinet making and have revolutionised the speed at which projects can be set out and assembled. Biscuiting bypasses much of the layout work and many of the cutting operations associated with constructing traditional joints, such as dovetails, dowels and rebates.

A biscuit or plate joint is a type of spline or 'floating tenon' joint. It is fast, accurate and safe to produce. It is suitable for all types of wood and wood based materials, such as plywood and particle board (Figure 7.41). Slots are cut in both pieces to be joined and precut biscuits, or plates of compressed wood, are glued into the slots. Similar to dowel joints, the members or parts of a project can be cut to final size before joining; however, the slots for biscuits are easier to fit and more forgiving than dowel holes. There are three different sizes of biscuits available for different widths and thicknesses of material.

The biscuits are made by pressing with a die so they are in a compressed form and should fit snugly into the slot (provided they are kept dry). When the glue is applied and the joint is clamped, the biscuits swell in the slots making a strong joint. The slots are 1–2 mm longer than the biscuits, allowing the joint to be shifted along its length (Figure 7.48).

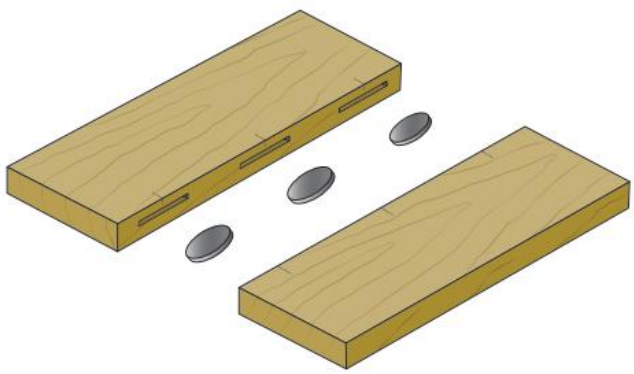

Figure 7.41 Biscuit or 'floating tenon' joint is an alternative to dowelling for edge joints

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TRY THIS

MAKING A BISCUIT JOINT

1. Cut the timber to size and place the two mating pieces together.
2. With a pencil, mark the centre of each face of the pieces where the biscuits are to be placed (typically about 50 mm apart).
3. Set the fence to locate the position of the slot, generally in the middle of the edge, and the depth of cut to correspond with the size of the biscuit used.
4. Separate the two pieces and the joint is ready to be cut.
5. Align the biscuiting machine with the marks on the project.
6. Switch the machine on and push it into the project, cutting the slot.
7. Repeat the operation until slots are cut at each pencil line.
8. Place adhesive in the slot and on the edge to be jointed and place a biscuit in each slot in one side of each mating pair.

Domino joints

Introduced to the market by Festool in March 2006, the Domino joining system, and its operation, is covered in Chapter 9. This system and the dimensions of the dominos provide superior joint strength for all the types of joints they can be used on.

This tool is a cross between a biscuit joiner and a router and is versatile and simple to use. The system consists of a precision joiner and oblong-shaped 'dominos' which together create mortise and tenon joints.

Tool Technic Systems

Figure 7.42 Dominos in multiple sizes

The joining system works on the principle of routing a mortise in each workpiece to be joined, then using a domino to act as a loose tenon to connect the two workpieces. The cutting action combines cutter rotation with an oscillating movement while being plunged.

The result is a precisely cut mortise rather than a single round hole. The joiner uses four different sizes of tungsten-tipped spiral cutters in 5, 6, 8 and 10 mm diameters and will rout mortises between 12–28 mm.

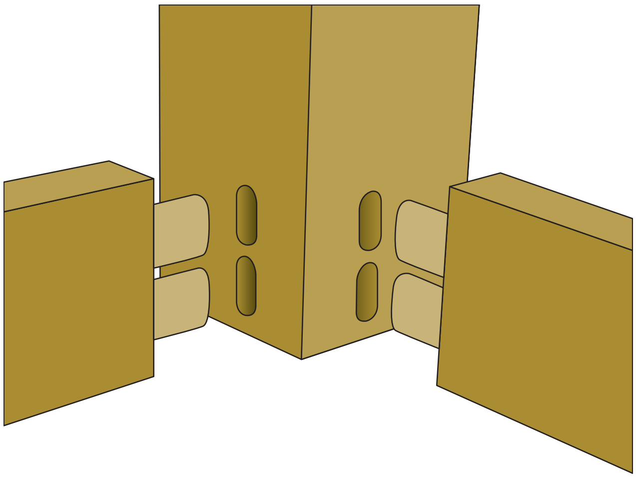

Figure 7.43 A domino joint

General notes on assembling framing joints

- All framing joints should fit accurately hand tight without undue force (excessive force may split the timber). Test by assembling them dry before gluing.
- Housed, halved, notched, mitred and rebated joints may be nailed or screwed as well as glued. Bridle joints may be dowel pinned, and mortise and tenon joints dowel pinned and wedged. Other joints should be glued only.
- For exterior work use a waterproof glue.
- A small amount of glue should squeeze from the joint when pressure is applied: wipe it off with a wet cloth before it sets. Do not allow glue to set in brushes or on tools.
- End grain, which is more absorbent, should be given a preliminary coating of adhesive and then recoated when other parts have been glued. A small spatula-shaped scrap of wood is useful for gluing dovetail sockets.

- Sash cramps are used to bring shoulders of joints tightly together. Cramps should be parallel and square. Test the frame for squareness by measuring the internal diagonals with a thin rod (Figure 7.44). If out of square, a sharp tap on the end of the stile at the long diagonal corner or moving the end of one or both cramps towards that corner should correct the situation (Figure 7.45).

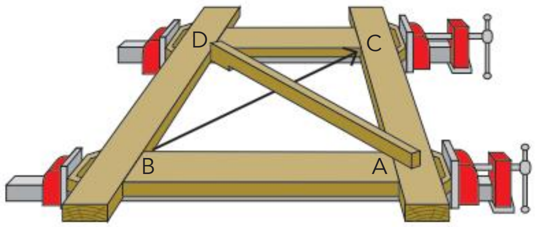

Figure 7.44 Diagonal stick compares distances AD and BC; to square frame, cramps are adjusted until diagonals are equal

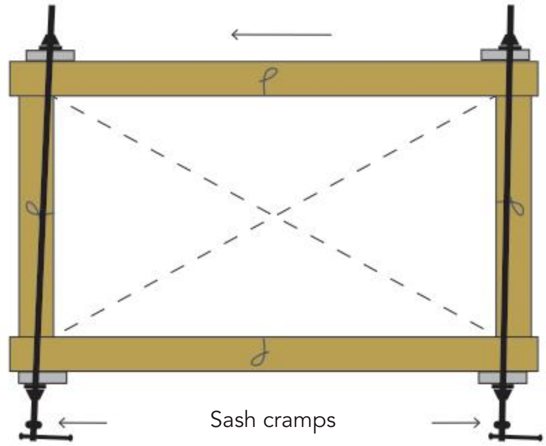

Figure 7.45 Cramps adjusted to pull frame square

- Wedging of mortise and tenon joints is done after the frame is cramped. Preferably, two people should work on this so that wedges can be driven in pairs, the outside wedges being inserted first. Do not forget to glue the wedges.
- Wedged frames may be removed from cramps without bracing before the glue sets. Other frames may require a light brace across the corner to keep them square. Dovetail joints should not need cramping, but may require bracing.
- Never attempt to flush plane any joint before the glue has set.
- On joints that have an exposed end grain (such as finger or comb, halving, through mortise and tenon, and bridle), when setting out the joint, allocate an extra 1 mm on exposed parts. This allows for flushing off with a smoothing plane after.

HINT

Before flushing, if there is a small gap in the joint it can be filled by lightly tapping the excess 1 mm with a small ballpeen hammer, which spreads the fibres into the gap. However, this trick does not work miracles!

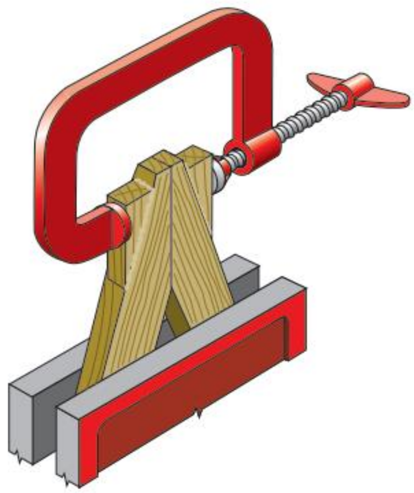

Figure 7.46 Blocks glued to edges of joint with paper separators permit use of G-clamp

- Mitre joints can be clamped with a G-clamp if tapered blocks with paper separators are temporarily glued to the work (24 hours drying time) to provide parallel surfaces (Figure 7.46).

Widening joints

Widening joints are used to produce a board that is broader than those generally available. The end result is almost certainly more stable than a single wide timber board. Examples include, deep book shelving, the sides of a storage chest or a tabletop.

HINT

You can, of course, decide to use a manufactured board with a veneered surface and edging, which will be more stable, probably cheaper and certainly less labour intensive and time-consuming to produce.

The plain butt or glued and rubbed joint is simple and quite effective for thicker timbers but is weak with thin boards under 12 mm. This joint can be strengthened with dowels, biscuits or dominos when extra strength is required (Figures 7.47 and 7.48).

The other widening joints, such as rebated, tongue-and-groove, and slip tongue require accurate machining (Figures 7.49 to 7.51).

Widening joints demand consideration of the following two aspects.

1. Try to organise the grain to match the next piece to be attached so that the overall effect looks like one piece of timber (assuming that the board will show and aesthetics are to be considered).
2. Ensure that the finished board is stable (take care to minimise cup and warp).

Laying out of the separate boards will affect both of these aspects, so care and forethought is required.

With respect to matching the grain, tangential cut boards are more prone to cupping and are harder to match up due to the general curved lines of the grain. Radial cut timber is more stable and has straighter, more parallel grain lines, which are easier to match up. The problem is that most stable radial cut timber (mainly pine) goes to the furniture industry, while retail outlets receive the tangential cut wood. Therefore, inspect and select your timber carefully.

When considering ways to minimise cupping, boards should be arranged so that the end grain of each adjacent board alternates between curving up and down. This has the effect of opposites cancelling out any cupping (Figure 7.52). If the boards are radial cut (quarter sawn) then cupping is virtually eliminated and this process is not necessary; this gives twice as many grain matching options. If you are only joining two or three boards, the combinations for matching the grain are considerable – check them all. When you have your parts set out as you want, mark each touching edge '1' and '1', '2' and '2', and so on, so they will always go back the same way (Figure 7.52).

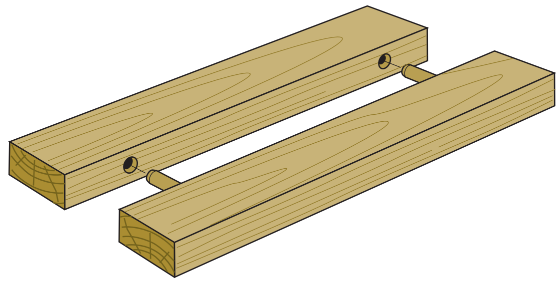

Figure 7.47 Dowelled widening joint

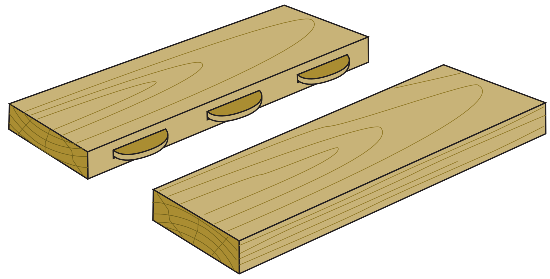

Figure 7.48 Biscuited widening joint

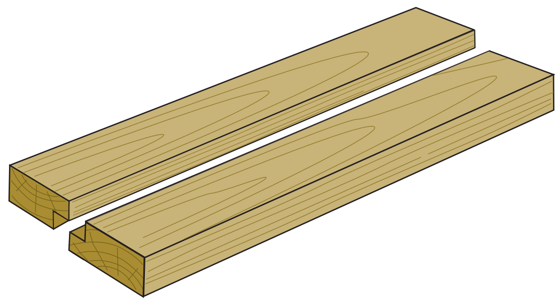

Figure 7.49 Rebated widening joint

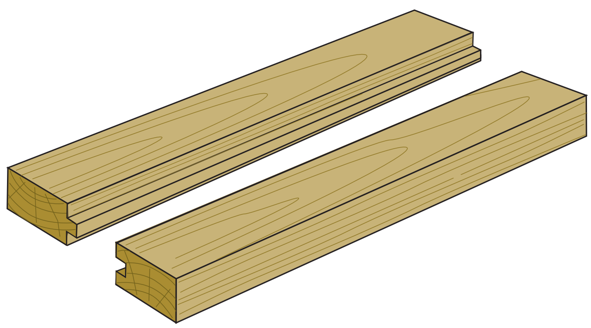

Figure 7.50 Tongue-and-groove joint

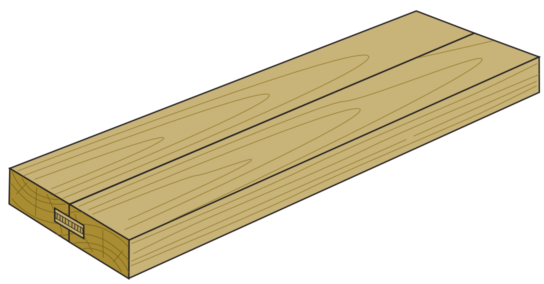

Figure 7.51 Slip or loose tongue using plywood or solid wood as the insert. Plywood has better cross-grain strength

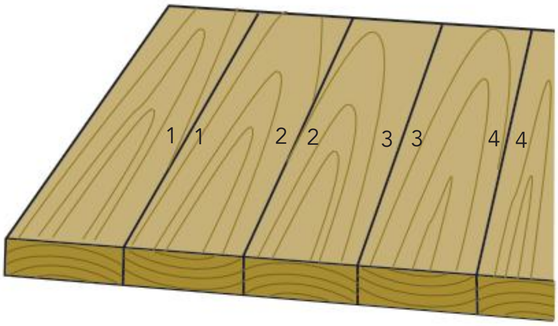

Figure 7.52 Alternating growth rings to cancel cupping. Note numbering

It is now time for the planing. First, clamp the two edges to be joined in the vice and ensure they are level with each other and the marked numbers are both facing the same way. Next, use a sharp trying plane, set finely, and gently skim the edges.

HINT

With the plane set fine, skim a pair of mating surfaces, clamped level in a vice, at the middle area (not the two ends) until you no longer get a shaving. Now, check along the surface with a straight edge and you will probably find that the ends of the board are a fraction higher than the rest. Take a careful shaving off each end, taking care not to let the plane drop as its weight comes off the end. Recheck with the straight edge; the board should be virtually flat. Check for any light showing through the joint or feel for gaps by inserting a thin paper edge.

When the edges are straight, gently place the plane on its side on the bench. Look along the edges with your eye and note they might both be angled slightly. This does not matter because when you take one piece out and re-clamp the other, resting one piece on the other (number '1' touching the other number '1') the low side will be counteracted by the high side and, therefore, they should end up in line as you look down the two surfaces (Figure 7.53).

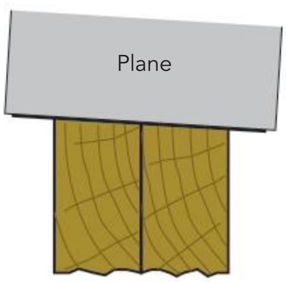

Figure 7.53 Complementary angles provide a flat face

HINT

If the two pieces rock slightly (i.e. are low in one corner) it is probably because you are stretching to complete the plane stroke rather than moving your whole body. Keep your hand and arm stance constant and, if necessary, taking a short step as you go. If you have this problem, preparing one of these joints may take over 30 minutes. If this happens just think, 'What am I doing wrong?' This requires patience. Persist and with practice your angles will get squarer and your preparation will become faster and more efficient.

Before gluing and clamping the joint, you must decide whether to reinforce it with dowels, biscuits or a loose tongue. This will depend on how the piece is being used and the strength required.

HINT

Plan carefully where you put the dowels, dominos or biscuits if you are going to cut a shape from the board after, because you may uncover half a dowel, domino or biscuit!

Drawer construction

High-quality drawers are typically constructed with a lapped dovetail at the front and a common dovetail at the back.

Front joint

For light use, a tongue and trench joint or a rebate may be used (Figures 7.3 and 7.4); with the simple rebate, cut to three-quarters depth. The side can be strengthened by two or three thin panel pins nailed into the end grain of the front piece from the side. This puts the pins into a condition of **shearing** if the front were to be pulled off.

If a **false front** is to be fitted then the inner front and sides can be joined with butt joints because adding the false front virtually changes the joint to a rebate (Figure 7.54). False fronts are fitted when a thicker front is needed for shaping (i.e. a gentle curve), or if it is necessary for the front to extend to a wider width all around and locate against the front of the carcase rather than be flush with it. When using solid timber, always select the best grain figure for the front where it will be noticed and appreciated.

Back joint

For the back of the drawer, a joint that is simple yet strong is the through housing. The main load on a drawer back occurs when the drawer is opened quickly and loose items inside it slide to the back of the drawer. The housing cannot come apart because it is captive in a groove. Another advantage of this joint, because it has to be set forward of the corner by about 30 mm, is that you can open the drawer to view all of its contents yet still have the drawer supported by the last 30 mm or so; a small amount of internal space will be lost (Figure 7.54).

The base

Unless a drawer is very shallow, it is not recommended to just nail a base onto it, because the whole drawer rubs on the shelf below and the front edge of the base will be seen. The typical, and easiest, method for attaching a base is to cut a groove around all the pieces before they are joined. The back, however, has the lower section under the groove completely removed. This allows the four sides to be glued up; then the base can be made, fitted and slid in from the back with a couple of fine countersunk brass wood screws inserted from underneath into the back to stop it coming loose and to support it. Slide-in bases like this do not have to be glued; this makes replacement easy should damage occur.

Another method of fitting a base is to nail and glue a **slip** around the inside of the drawer. A slip is a strip of wood with a slot cut into it to allow the base to slide in on it (Figure 7.54).

Materials for bases include MDF, veneered MDF (one side), hardboard, embossed hardboard and, best of all plywood, because the grain can be matched and has uniform strength in both directions due to

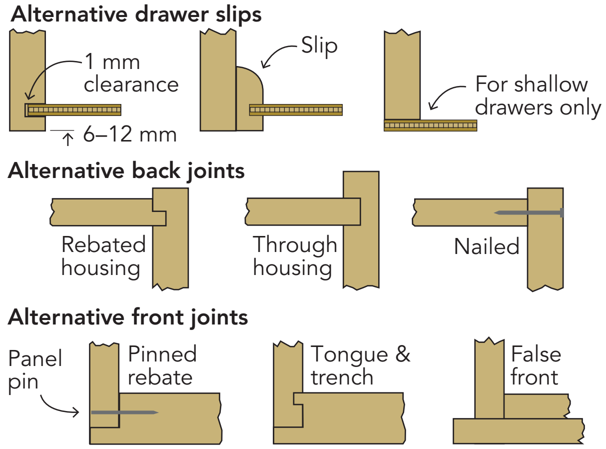

Figure 7.54 Joints commonly used in drawer construction

cross banding in its construction. Solid wood drawer bases are mostly not used anymore because of a lack of long-term seasoning, and because of the time and expense involved in constructing them.

Drawer stops

Drawers should not hit the back of the carcase. If stops (small wooden blocks) are placed near the back, the position of the drawer front will alter with expansion/contraction of the drawer length (EMC change). However, if thin stops are placed near the front, this is less noticeable. The recognised method is to make two small pieces of plywood, about 40 mm long × 20 mm wide, and glue them to each side, so that the lower inside of the drawer front just touches them at the closed position (5 or 10 mm before touching the back of the carcase).

Manufactured board products have unavoidably altered the construction of drawers. Made of woodchips or fibres, manufactured boards have no continuous grain. Therefore, new joints were developed because ones like dovetails could not be used because they would break easily. Design changes have also been necessary because of **flat packing** since construction must be straightforward for the person (who may have no woodworking ability) assembling the product. Some plastic drawers are made in a continuous strip that just has to be folded into shape and tapped (no glue necessary) into a pre-jointed front (the base being the dependent part keeping everything square).

CHECK YOURSELF

1 Explain why it is important to be accurate when cutting a halving joint.
2 What projects are ideally suited to using mortise and tenon joints and why?
3 Why are mortise and tenon joints not used on corners?
4 When setting out a mortise and tenon joint, what are the points of the mortise gauge set to and why?
5 What gives a bridle joint its strength?
6 Describe how a bridle joint may be reinforced without using screws and nails.
7 Given a choice of biscuits or dowels when widening boards, what would you choose and why?
8 Having just used sash cramps on a glued frame, how would you check it is square? If it is found to be 'out of square', how would you square it?

Adhesives

Glues and gluing

Egyptian tombs show evidence of glue used in association with wood. An elaborate veneered cabinet, plus wall paintings and carvings showing the manufacture of the cabinet, were found in the tomb of Pharaoh Rekhmara, dated to around 3000 BCE. The artwork clearly shows the heating of a glue pot over a fire, the spreading of the glue and the placement of the wood veneer.

A glacier on the Austria-Italy border preserved the 5200-year-old body of the Tyrolean Iceman, along with two arrows and a copper hatchet, each with evidence of organic glue used to connect the stone and metal parts to the wooden shafts. Centuries later the rubber tree was tapped for its sap, yielding natural rubber, still the base ingredient in contact adhesives.

Casein glue, made from cow's milk, was the first water-resistant adhesive available until the discovery of waterproof resins during World War II. The famous moulded, wooden-framed and plywood covered 'Mosquito' fighter-bombers were first assembled with casein adhesives. However, when these aircraft were posted to the tropics, it was found that fungal attacks weakened the glue. Necessity being the mother of invention, the problem stimulated research into synthetic rubber and resin adhesives, which led to the development of glues for almost every purpose. These glues are often stronger and more durable than the materials they bond!

Why does glue stick things? The fact that two porous surfaces could be bonded together by glue was once attributed solely to the keying of the adhesive round the fibres and into the crevices of the materials. However, scientists, particularly in the field of polymer chemistry, now theorise that this only accounts for a small fraction of the joint strength, and that molecular attraction is considered primarily responsible.

Despite the many and varied woodworking glues now on the market, not all of them are suitable for the small workshop. Some, like the film-type formaldehydes, require carefully controlled temperatures or special apparatus. Some are available only in large quantities, or limited a shelf-life (they do not keep long enough without deteriorating to be of value to the small user).

It is advantageous to know the characteristics of the various adhesives generally available.

Polyvinyl acetate adhesive

Polyvinyl acetate adhesive (PVA) is generally referred to as wood glue, it is a white, ready-to-use emulsion with a creamy consistency produced by reacting acetylene with acetic acid; dries clear. Though not water-resistant, it does resist fungi and bacteria; has excellent gap-filling properties; is non-staining; can be cleaned up easily with a damp cloth; is non-flammable and cheap to purchase. It is a good general-purpose adhesive. However, it will not bond a non-porous surface to any other surface; and therefore, is not suitable for joining metal to timber. Other uses include bookbinding, paper and cloth. A thermoplastic, PVA is cold-setting; however, drying can be accelerated by the application of heat, which should not exceed 65°C or the glue will melt. Waterproof versions are available. Even when dry PVA is slightly flexible and will 'creep' under tension.

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Contact or rubber-based adhesive

Although not generally suited for binding wood to wood, contact adhesive is very good for edge veneering and well-suited to bonding plastic laminates with timber. Adhesive is applied to both surfaces (smooth surfaces should be roughened first) and allowed to dry 10–20 minutes before the pieces are brought into contact. The bond is immediate so take care to align parts precisely before contact. Strength increases as the glue cures, which can take several days. Clamping is unnecessary, but care must be taken to position the panels exactly and press them from the centre outwards to avoid trapping air.

Gene Anderson-Conklin

Figure 7.55 a Contact adhesive **b** PVA glue

Epoxy resin adhesives

Epoxy resin adhesives are waterproof and very strong. They will bond wood to wood, metal to metal, rubber to metal, glass to glass, glass to metal and plastics to plastics (e.g. fibreglass). They will not; however, join thermoplastics, such as perspex, PVC or polyethylene. They are set via a chemical reaction when a glue and a hardener are mixed together. Some glues require the adhesive to be put on one joining surface and the hardener on the other. There are epoxies that come in a powder form with the hardener already included – simply add water prior to using. Depending on the formulation, the glue remains workable for between five minutes and five hours and dries clear. Normal setting time is about eight hours; however, this can be considerably reduced by heating. Epoxy resin adhesives are non-flexing.

Hot-melt adhesives

Hot-melt adhesives generally come in stick form and are applied with a glue gun that heats the glue in order to deliver it to the project. These multipurpose adhesives are suitable for mounting dry timber on a wood lathe for face-plate work and bonding a variety of materials, such as particle board, many plastics, paper products and fabrics. In a school environment, hot-melt adhesives can only be used in small areas because the gun can only deliver small amounts of molten glue at a time. Industrial applications can handle much larger areas. Hot glues eliminate the need for clamping or pressing, and the piece that has been glued is ready to use within minutes – after the glue has cooled down.

Shutterstock.com/nanantachoke

Figure 7.56 A hot melt glue gun and three glue sticks

SAFETY

Some hot-melt sticks have inferior adhesion qualities and others are only for caulking (filling gaps). Select carefully when using for lathe bowl turning.

Polyurethane adhesive

Polyurethane adhesives, commonly touted by manufacturers as 'the toughest glue on planet Earth', hit the market a few years ago. Unlike PVA or yellow glue, which is designed to bond wood, this type of glue is waterproof, much easier to apply than an epoxy and gives the woodworker incredible versatility.

Gene Anderson-Conklin

Figure 7.57 Polyurethane adhesive

Polyurethane glue can bond wood (including green timber), glass, metal, concrete and laminates, to name just a few. The glue must be applied to a damp surface. Once applied, the glue reacts with moisture from the air or the work piece and hardens within 24 hours, drying to form an invisible glue line. Polyurethane glues can also be stained and painted. Polyurethane adhesives allow you to assemble a project in about 30 minutes, and then unclamp and move pieces around if working on an intricate design or project. Waterproof properties make it the right choice for outdoor projects, such as planter boxes.

Animal adhesive

Animal adhesives, or hide glue, is one of the oldest glues known to mankind and is still used by traditional woodworkers and antique restorers. However, in general interior assembly it has been superseded by PVA. It is not an easy glue to use; does not 'creep'; is strong and long-lasting; requires heating to a certain consistency for use and can be unglued using damp and heat. It is made principally from the hooves and hides of cattle and comes in cake, pearl and powder forms, requiring soaking and heating in a special container before use. A jellied form is available, also needing heat. Animal glues are non-staining and are very strong and durable in dry locations. However, they are not water-resistant, and assembly time is limited because they must be used at temperature.

Lee Valley Tools Ltd., 814 Proctor Ave., New York, NY 13669-2205, 1-800-871-8158, www.leevalley.com

Figure 7.58 Animal or hide adhesive

Formaldehyde adhesives

Formaldehyde adhesives include urea, phenol, melamine and resorcinol formaldehydes. All are thermosetting resins that are hardened by the addition of a catalyst (hardener). The setting action involves a chemical change (polymerisation or cross-linking of molecules) and, while the process may be accelerated by heat, the plastic cannot be softened once set.

Urea formaldehyde

Urea formaldehyde is probably the most commonly used adhesive in industrial situations. It comes in both powder and liquid forms. In the powder form,

Vaccuum Pressing Systems

Figure 7.59 Formaldehyde adhesives showing resin and powder hardener a hardener is available. If wood flour or walnut shell flour is added this improves its gap-filling properties. Where exceptionally long, open working times are necessary, resin may be applied to one part and hardener to the other so that setting does not take place until the parts are brought into contact with each other. There are health concerns over the emission of gases from products that utilise this glue.

Phenol formaldehyde

Phenol formaldehyde is a waterproof glue that is used primarily in the industrial manufacture of plywood intended for use in very moist conditions. Available as a liquid or a powder, this adhesive is more commonly used as a film, which is made by impregnating a porous paper and allowing it to dry. This film is placed between the layers of ply before applying a high-pressure hot press drying process.

Melamine formaldehyde

Melamine formaldehyde is ideally suited to caravan and boat building. This waterproof, heat-resistant, non-staining adhesive is prepared for use by mixing the powdered resin with water then adding the liquid hardener to form a thick, smooth glue. As with urea formaldehyde, separate application is also possible.

Resorcinol formaldehyde

Resorcinol formaldehyde is supplied as a dark-coloured liquid with, typically, a powder hardener. It is generally accepted as the best adhesive for the construction of boats and aircraft (and wherever extreme durability is called for). Resorcinol formaldehyde is resistant to cold or boiling water, heat, solvents, mould and fungi. The only disadvantage is that its dark colour stains timber.

Table 7.1 Characteristics of common adhesives

Type of glue	Characteristics	
PVA	Preparation	no preparation required
	Shelf-life	no limit in plastic containers
	Assembly time at 21°C	up to 10 minutes; 20 minutes with special formulations
	Pressing time and temperature	from 10 minutes to 2 hours at room temperature; from 30 seconds at 50°C
	Setting mechanism	loss of water
	Time to develop ultimate strength	1 week
	Gap filling properties	good
	Weather resistance	low
	Uses and remarks	assembly gluing, veneering, book binding; a strong adhesive under permanent load, i.e. has a low 'creep' strength

Type of glue	Characteristics	
Urea formaldehyde (powder or liquid)	Preparation	mixing of resin and hardener or separate application
	Shelf-life	3–6 months for liquid resin; 1–2 years for powdered resin; no limit for hardener
	Assembly time at 21°C	cold-set: up to 30 minutes; hot-set: up to 12 hours
	Pressing time and temperature	2–24 hours at room temperature; several minutes at 90–120°C
	Setting mechanism	polycondensation (cross-linking and splitting off of water)
	Time to develop ultimate strength	1 week for cold-setting; 48 hours for hot-setting
	Gap filling properties	poor, but improved with gap-filling hardener
	Weather resistance	moderately good, but lowered by extension
	Uses and remarks	plywood, veneering, laminating, light boat construction, general assembly; leaves a clear glue line
Melamine formaldehyde (powder)	Preparation	mixing with water and hardener
	Shelf-life	at least 2 years
	Assembly time at 21°C	up to 24 hours depending on type
	Pressing time and temperature	24 hours at room temperature; several minutes at 90°C
	Setting mechanism	polycondensation
	Time to develop ultimate strength	1 week for cold-setting; 48 hours for hot-setting
	Gap filling properties	moderate to good
	Weather resistance	good; waterproof
	Uses and remarks	veneering, waterproof plywood, light boat construction, general assembly; leaves a clear glue line

Type of glue	Characteristics	
Resorcinol/ phenol formaldehyde (liquid)	Preparation	mixing liquid or powder hardener with resin
	Shelf-life	resin 3 months or more; hardener, 6 months or more
	Assembly time at 21°C	up to 1 hour
	Pressing time and temperature	24 hours at room temperature; several minutes at 90°C
	Setting mechanism	polycondensation
	Time to develop ultimate strength	1 week at 20°C
	Gap filling properties	good
	Weather resistance	excellent; waterproof
	Uses and remarks	laminating assembly, metal to wood, radio frequency gluing; best waterproof adhesive for boat building; stains due to red colouring
Epoxy resin (liquid or powder)	Preparation	careful mixing with hardener
	Shelf-life	resin at least 6 months; hardener at least a year
	Assembly time at 21°C	from several minutes to 1 hour
	Pressing time and temperature	up to 48 hours at room temperature; 1 hour at 90°C
	Setting mechanism	polymerisation (cross linking of molecules)
	Time to develop ultimate strength	from 2 days to several weeks
	Gap filling properties	excellent
	Weather resistance	good; waterproof
	Uses and remarks	wood to metal, metal to metal, waterproof plywood; a universal glue; high chemical resistance; expensive

Type of glue	Characteristics	
Contact (liquid rubber)	Preparation	no preparation required
	Shelf-life	approximately 1 year
	Assembly time at 21°C	10–20 minutes; parts must not be assembled until adhesive is touch dry
	Pressing time and temperature	several seconds to several minutes at room temperature
	Setting mechanism	loss of solvent
	Time to develop ultimate strength	several weeks
	Gap filling properties	good
	Weather resistance	fair
	Uses and remarks	practically a universal adhesive; pressing not required, but a stronger joint will result if normal pressure methods are used; weakest of wood glues
Hot-melt (solid stick)	Preparation	heating in glue gun
	Shelf-life	1 year
	Assembly time at 21°C	50 seconds, less if project is cold
	Pressing time and temperature	from 30 seconds to 1 minute at room temperature
	Setting mechanism	cooling
	Time to develop ultimate strength	from 30 minutes to 1 hour
	Gap filling properties	good
	Weather resistance	moderate
	Uses and remarks	a multipurpose adhesive suitable for bonding a variety of materials; eliminates the need for clamps and presses

Type of glue	Characteristics	
Animal glue (pearl or powder)	Preparation	soaking in water followed by suitable heating
	Shelf-life	no limit
	Assembly time at 21°C	up to several minutes, i.e. until it gels
	Pressing time and temperature	up to 1 hour at room temperature
	Setting mechanism	cooling combined with loss of water
	Time to develop ultimate strength	1 week
	Gap filling properties	good
	Weather resistance	low
	Uses and remarks	assembly gluing in wood, veneering and book binding
Polyurethane (liquid)	Preparation	1 and 2 part available (2 part with a curing aid)
	Shelf-life	9 months to 1 year
	Assembly time at 21°C	60–90 minutes
	Pressing time and temperature	up to 1 hour at room temperature
	Setting mechanism	exposure to atmospheric moisture
	Time to develop ultimate strength	3 days above 20°C
	Gap filling properties	excellent
	Weather resistance	excellent; waterproof
	Uses and remarks	widely used in manufacture of various wood products; UV resistant, high mechanical strength

General notes on gluing

- Glue that is carelessly wiped or left on a wood surface will soak in and cause lighter patches when using stains and lacquer finishes.
- PVA glue is water-based; therefore, when cleaning up a joint after clamping use wet, but not dripping, paper towel or rags to wipe away excess. Keep turning the rag and rinse if necessary so that the glue is very weak and does not affect staining or other finishes.
- Do not attempt to glue and clamp a developed split in timber or joined boards with PVA. It will ‘creep’ and slowly open up again. Use a glue that has high strength under tension, such as epoxy glue, and keep the project clamped for several days.
- Gloves and masks are recommended for certain glues because they may irritate skin or cause respiratory problems; always read the adhesive instructions and SDS.
- PVA glue may be washed off hands and out of clothing because it is water-based.
- Unless it is mechanically strengthened, gluing two pieces of wood together by their end grain will not provide a secure joint.
- Use two coats of glue on absorbent timbers and end grains for best adhesion.
- Oily timbers, such as teak, glue better if degreased first with methylated spirits.

Hardware

Many fixtures and fittings may be used in woodworking projects. They can be made from metal, plastic or even timber. Common types are detailed below.

Screws

A screw turns its way into wood by means of a spiral thread. Archimedes is credited with having invented the spiral around 250 BCE. Wooden screws for screw presses have been in use for hundreds of years, but it was not until the 19th century that a way was found to make metal screws quickly and cheaply, bringing them into general use as fasteners.

Figure 7.60 details the various parts of a screw, and their names. Modern styles of wood screws are available that have parallel threads and shanks, which are less prone to splitting the timber and only require one size hole if pre-drilling. Some screws (self-tapping) are produced with their own drill-shaped tip so they can go through a steel roof into timber.

The choice of screws is bewildering because specialist screws are being produced for virtually every purpose. Some have steeper spirals (for quicker fixing) or coarser threads (better holding ability – as in particle board). There are screws with twin threads, screws that are threaded all the way to the head and even screws with special heads like ‘bugle’ for plasterboards.

Size

The size of a screw is determined by its length; measured from the screw tip to where the screw will finish at the surface of the timber. For example, a round head sits above the surface and is measured to the flat underside of the head; however, a countersunk head is measured over its total length because it ends flush or beneath the surface of the wood.

The diameter (D), or gauge to be precise, is measured at the **shank** just under the head. The measurement used is slowly changing to millimetres but some are still sized by a gauge number (1–20: the larger the number, the thicker the shank). To maintain strength, as the length increases, so does the gauge.

The top (approximately 30 per cent) of the shank is unthreaded because when two pieces of timber are joined together, the first piece is a clearance size

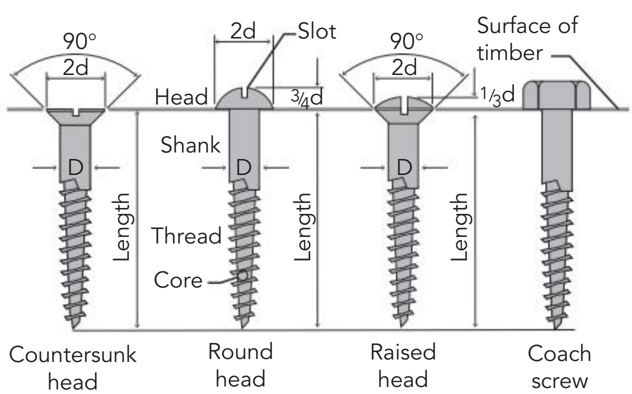

Figure 7.60 Details of wood screws. Note: *length* is only that part of the screw that is inserted in the wood

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so the screw just pushes through and is stopped by the head. Threading only occurs in the second piece, which firmly draws the top piece tight via the head pulling it down.

Head shape

There are four common types of head shape for wood screws: countersunk, round head, raised/ countersunk (more simply called 'raised') and coach. There are other heads, such as pan head, among a range that have evolved for specific uses.

Countersunk heads are for sinking below the surface of timber and disguising with putty, a timber plug or a plastic cap.

Round heads are used to pull an upper surface down to a base; for example, a plastic fixed lid. Note: The plastic hole must be shank clearance size so that the screw just drops into it but the head prevents it going clear through.

Raised heads are used with a surface-mounted or recessed screw cup for circumstances where regular removal might be necessary. The screw cup prevents damage to the wood and enhances the appearance of an otherwise plain screw head.

Coach screws are a square or hexagonal headed screw, normally of a large gauge. These are used to screw down machinery to wooden floor joists and are tightened with spanners (Figure 7.62).

Driving screws

1 Screws must always be driven in using the correct fitting screwdriver or drive bit.
2 Use appropriately sized wood drills to bore holes for the shank, the core and for countersinking (when necessary). Special bits are available that bore core, shank and countersink in one operation. The shank hole must be slightly oversize to allow easy turning. The core hole must be deep enough for the screw to be driven in without touching the bottom and must be equal to the core in diameter. The countersink must be such that the head neither protrudes nor sinks below the surface. Extra care is needed when countersinking screws in plywood because the inner plies are often softer, allowing the screws to 'bury'.

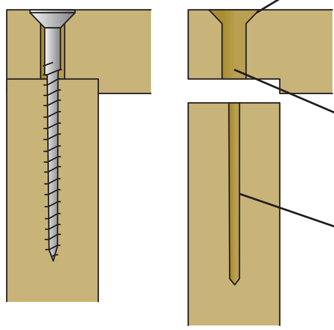


Figure 7.61 Showing the correct method of drilling clearance holes when screwing

Methods for tightening wood screws

Straight slotted, Philips (four points), Pozidriv (four points plus four smaller points in between – it also has a cross scribed on the head for recognition), square (used on high torque applications such as screwing a hardwood deck so the driver bit does not slip). There are different sizes of each type of screwdriver to match the head slot of the screw. There are at least four numbered sizes of Philips and Pozidriv, and even more for flat blades, that suit the differing gauges of screws (e.g. 4, 6, 8, 10 and 12). Miniature watchmaker sets of screwdrivers and special screwdrivers for knock-down furniture make the range even more extensive.

Figure 7.62 A variety of screw tightening methods

Materials used to produce wood screws

The materials most commonly used to produce wood screws are mild steel (cheap and strong), brass (non-rusting and looks good), aluminium (to use with aluminium windows to prevent **electrolytic action**), Monel, stainless steel and silicon bronze.

Coatings

The following coatings are commonly found on screws: zinc-plating (prevents oxidisation (rust) and looks good), hot-dipped galvanising (for use with treated pine to prevent corrosion), brass-plated and coppered (anti-corrosion and looks good), antiqued (for an aged effect) and black japanning (black paint and anti-rust). There are many others for various uses and specialist needs.

Purchasing screws

To purchase screws, certain information is essential: head type, length, gauge, material, coating (if any) and the amount required. Screws are sold individually, in plastic packs or by the boxful.

Advantages over nails

- Screws provide better grip.
- Screws are easily removed without damaging surrounding timber.

Hints for using screws

- As a general rule, when choosing the length of a screw it should be approximately three times the thickness of the top piece of material.
- Always ensure that a screwdriver fits correctly into the screw slot and is not worn (if a flat bladed one is worn it can be reground but the Philips and Pozidrive type must be replaced).
- To avoid problems when **driving** screws into timber, always ensure that the screwdriver is vertical and that your hand and elbow are perfectly in line with it. Always push as you turn – whether tightening or loosening the screw (until it is really loose).
- Rubbing a little wax or soap across threads will reduce friction when driving the screws.
- When using several slotted screws, such as in shelf supports or hinges, it is good practice and looks better to **head the screws**, which means ensuring that all the slots in the screw heads line up and follow the direction of the wood grain.
- When mounting a frameless mirror (through holes drilled in the glass), special brass countersunk screws are used that have a small threaded hole in the top. Screw on small domed chrome caps to hide the screws. It is important not to overtighten and break the glass.
- When using brass screws, which tend to break easily, first use a steel screw of the same size. This creates the thread, which is then ready to take the brass screw.

Nails

Examples exist from Roman times, when nails were forged from pure iron. In the 19th century the invention of steel created the drawn wire nail. Table 7.2 illustrates a selection of commonly used nails, their heads and uses.

Size

Nails are measured in terms of millimetres, based on their overall length and diameter.

Materials used to produce nails

Today, a high percentage of the steel wire that is produced is used in the manufacture of nails. For external and marine applications, nails are also made from copper, silicon bronze and Monel metal.

Table 7.2 Frequently used nails (Images: Andrew Kay Photography)

Nail name	Use	Photo
Flat head	Packing cases and fences	
Bullet head	General carpentry	
Clout	Sheet metal and soft materials (gyprock) to wood	
Galvanised bullet	General carpentry where corrosion is possible, especially treated pine	
Twisted	Very secure holding power	
Annular	Very high holding power, expensive	
Square copper	Boat building	
Brass escutcheon pin	Fixing escutcheons (keyhole surrounding plate), decorative hinges and catches	
Fibro	Fixing fibrous cement sheets, (Note: blunt tip to punch through rather than split the sheet)	
Masonry	Fixing items to brickwork	
Panel pin	Fine cabinet work	
Cut tack	Hidden upholstery	
Corrugated fastener	Reinforcing a weak joint in rough woodwork	
Gang	Roofing and housing construction	
Staple	Securing cables or wires	

Coatings

Hot-dipped galvanised (for use with treated pine to prevent corrosion), nickelled, brassed, blued and cadmium plated coatings are available for nails. These coatings all prevent various forms of corrosion.

Purchasing

To purchase nails certain information is essential: head type, length, diameter (in millimetres), material, coating (if any) and the amount required. They are sold loose by weight, in plastic packs or by the boxful. Nails for nail guns are sold in strips.

Advantages over screws

- Nails are cheaper than screws.
- When used in a nail gun, nails are much faster to use.

Hints for use

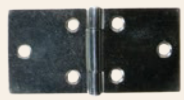
- See the section on hammers and mallets in Chapter 8 for advice on using hammers.
- See the section on butt joints (Figure 7.1b, page 104) for information on dovetail nailing, which leads to improved holding power.
- When nailing two flat pieces of timber together, avoid nailing the nails all in line because this may split the wood. Stagger the nail positions by zigzagging them.
- As a guide for choosing the correct length when nailing across the grain into the second piece of wood, use nails with a length that is approximately three times the thickness of the top piece. If going into the grain of the lower piece, there is less holding power; therefore, use a nail with a length that is approximately four times the thickness of the top piece.
- Use the thinnest nail that will do the job; this reduces the chances of the wood splitting.
- For using nail punches and putty see Chapter 6.
- For removing nails with pincers and claw hammers see Chapter 8.
- If you are using nails near the end of a board; for example, when assembling a corner joint for a box, there is a possibility of splitting the wood up to the end grain. This can be avoided by blunting the tip of the nail so that it acts like a punch rather than a pointed wedge while it is going through the wood. To blunt the tip, turn the nail upside down on a solid metal part of a vice and lightly tap it with a Warrington hammer (do not bend it). Another method to avoid splitting the wood is to pre-drill holes slightly smaller than the nail's diameter; however, this is time-consuming.

Hinges

Hinges have evolved rapidly over recent years. Timber products, such as MDF and particle board, have caused a rethink on hinge design in order to produce hinges that provide better holding power. There are concealed cabinet hinges with a variety of opening angles, self-closing hinges incorporating a catch system and quick release mechanisms. Table 7.3 lists commonly used hinges and their use. However, because there is such a wide range, only the fitting of a standard butt hinge is described below. Materials for most hinges include steel, brass, plastic and electro-plated zinc, antiqued and specialist coatings.

Table 7.3 Frequently used hinges (Images: Andrew Kay Photography)

Hinge name	Use	Illustration
Butt	Cabinet-making, doors up to room door size. Some have a removable pivot pin	
Piano	Strip hinge (2 m) for continuous support. It is cut to length and surface mounted	

Hinge name	Use	Illustration
Flush	Light-weight use, surface mounted and easy to fit	
Lift off butt	For situations requiring easy removal. Pin is removable	
Rising butt	For room doors. Has three benefits: lift off, rises as opened to clear carpet and a self-closing tendency	
Concealed cabinet	For use in MDF and particle board cabinets. See introduction in hinge section	
Back flap	For bureau drop flaps and table ends	
Parliament	Knuckle sticks out to allow external and room doors to fully open 180°	

There are specialised hinges for nearly any application making them too numerous to fully detail in this book.

Cabinet hinges require accurate positioning and are typically packaged with a template to drill in the correct position.

Fitting a butt hinge

Marking

First, mark the position of the hinge. This is generally in from the end of the door by one length of the hinge. If the door is framed, line the hinge up with the inner edge of the rail. If the door is to be flush with the carcase, the position of the hinge is square across its edge. If the door is to be surface-mounted square, position the hinge across the back of the door.

Next, sit the hinge exactly on the mark and square across the other end of the hinge (there should be no gap between hinge and mark).

The centre of the hinge knuckle must be level with the outer surface of the door to allow it to open 180° (failure to do this will strain the hinge and screws); therefore, set a gauge from the middle of the knuckle to the outer edge of the hinge and mark a line showing how far in to chisel out waste.

Finally, set the marking gauge to half the thickness of the knuckle (assuming you are placing a hinge flap equally in both door and carcase) and mark the depth of waste to be removed. Do not take out more depth than this or the screws will be under tension when the door is closed.

Fitting

You may prefer to make a few shallow, angled saw cuts across the waste area for ease when chiselling (caution – do not cut too deep!). With a chisel, groundside facing the waste, lightly tap with a mallet right on the marked waste lines (note – the long edge is running along the grain and may split if hit too solidly; also there is a likelihood that you will be chiselling very close to the inner edge of the door so do not lever the chisel or the wood could break away). The angle of the waste that is cut out should gently slope from half knuckle depth up to just the thickness of the flap. Now gently remove the waste and then pare smooth.

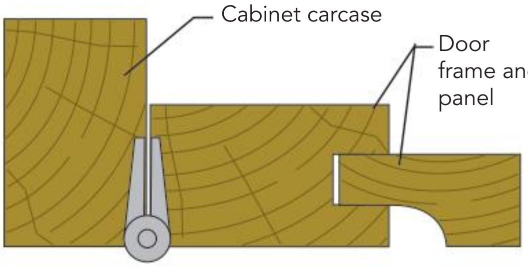


Figure 7.63a Equally recessed hinge in a flush mounted door

Position the hinge, mark the centre of each hole and make small holes to position the countersunk screws. Screw only one screw in initially and ensure it travels square until flush in the hinge.

Next, move the door up to the carcase and mark across (remembering it might be inside, or on the edge, of the carcase depending on your door size – recessed

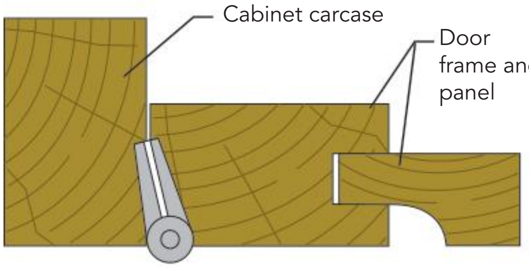


Figure 7.63b Offset hinge leaves an unbroken line round the carcase

or surface-mounted). Mark out the area to be chiselled by marking around the hinges (removed from the door), then cut and chisel out the waste. Attach both hinges to the carcase with one screw in each then gently attach the door and try it for fit. If all is well, fit the remaining screws; if it is misaligned, make fine adjustments and refit using different screw positions (so the hinge doesn't get pulled back to the original spot).

Knock-down fittings

These fittings have been developed to enable flat packing of furniture items made of solid and manufactured wood. They are especially suitable for particle board and MDF, because they lack the grain strength found in solid timber.

The large array of knock-down fittings are classified in three ways: either thread tightening, locking with a wedge action or locking with a cam action (Table 7.4).

Table 7.4 Frequently used knock-down fittings (Images: Andrew Kay Photography)

Hinge name	Use	Illustration
Bolt and cross dowel	Normally used on beds, tables and chairs	
Tee nut and screw	When tightened for the first time the nut pulls into the wood and stays captive	

Hinge name	Use	Illustration
Panel connector	Typically used to join two kitchen surfaces together	
Cam fitting	Used in desk assembly; only requires a quarter turn to lock tight	
Cabinet connector	Often used to link kitchen cabinets, and still looks good inside	
Block connector	Used for low-stress connections with less movement; not seen from the outside	
Screw connector	Coarse-threaded for particle board use; supplements other fittings, such as supporting the centre of a shelf	
Particle board insert	Inserted in particle board allowing wood screws to be used; expand and grip the drilled hole	

Tabletop fitting

When a top is fitted to a table frame, you must assess the rate of expansion or contraction of the wood in order to avoid joining two or more pieces of wood that expand at different rates.

In timber, expansion along the grain is almost non-existent; however, tangentially or radially expansions range between 2–9 per cent. Therefore, joining a piece of wood along the grain to a piece across the grain may produce a movement difference of about 1 mm for every 100 mm of joined timber. Figure 7.64 illustrates what can happen if expansion is not allowed for. Allowing for expansion is not necessary if the table top is manufactured board, because expansion is very low and matches the underframe rails (which always run along the grain right around; and therefore, have very low expansion also). Figure 7.65 a and b demonstrate some methods of attaching tabletops to frames.

Figure 7.64 A joint forced open due to not allowing for expansion

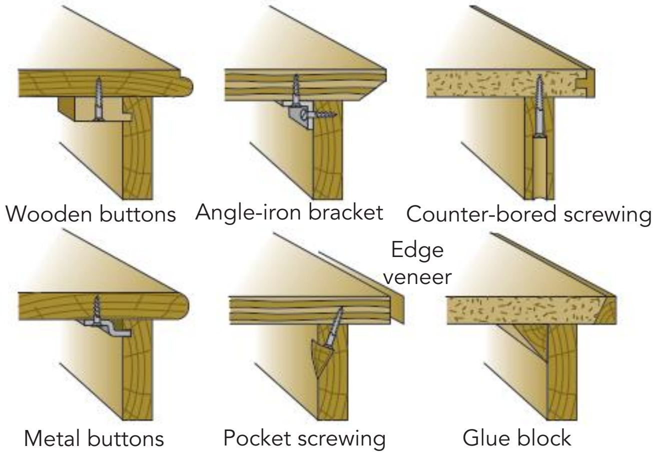


Figure 7.65a Methods of securing table tops of solid timber (buttons being the most suitable), plywood and particle board (can use either method) to frame

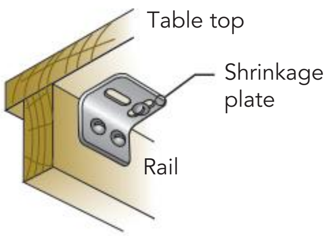


Figure 7.65b Shrinkage plate (button) may be made from wood or metal but must have the elongated hole placed along the direction of expansion/contraction

Other hardware

The vast range of other hardware items available means that choice is governed by the job at hand. For example, consider the following points and think about what you would do and what hardware you would choose.

- Is the knob or handle you are fitting too large for the project, or out of proportion?
- If aesthetics are important in your project, would you use a hasp and staple with a padlock or fit a neat brass lock?
- If you have a lid, will it fall back and strain the hinges or could you fit a **stay** to control the movement?
- Does that knob stick out too far? Would a drop handle look better sitting flat?
- What keeps the door closed, a magnetic catch or a ball catch?
- If using a glass door, would a magnetic touch latch be preferable to a stuck-on handle?
- Is the area of wood where the key goes into the lock getting marked? Would a protective escutcheon be useful?

Project sheets

Project sheets

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CHAPTER REVIEW QUESTIONS

1. Explain the two aspects that make an effective timber joint.
2. State the advantages of a stopped housing.
3. What are three ways a mitred joint can be made more accurately?
4. What is one alternative to joining two or three boards to make a wider board?
5. When making a loose-tongue widening joint, what advantage does plywood have over a solid timber tongue?
6. When making a drawer, what factors will influence your choice of joints?
7. Identify and sketch a simple yet strong joint suitable for the back of a drawer.
8. Drawers should not hit the back of the carcase. Describe how this is avoided.
9. List the advantages of using PVA.
10. Why is contact glue so named, and what are its advantages and disadvantages?
11. State the curing/drying methods of epoxy and hot-melt glues.
12. What is the best adhesive to use in marine plywood, boat and aircraft building?
13. Why use disposable gloves when using adhesives?
14. What type of head is used on a screw to be used with a butt hinge and why?
15. Sketch four methods of tightening screws (recesses in the head).
16. Why might screws be zinc-plated and nails galvanised?
17. Name six pieces of information necessary when purchasing wood screws.
18. Explain what 'heading' screws entails and why you would do it.
19. Describe a method of removing a bent nail without damaging the timber.
20. When hinging a lid on a small box, what happens if you do not let the hinges into the timber?
21. List some advantages of 'knock-down' fittings.
22. Describe how a solid timber tabletop should be connected to the frame of the table to prevent warping or cracking of the top.

CHAPTER

8

Hand tools

Even though power tools have made big inroads into the woodworking industry, hand tools are still an essential part of any woodwork project, especially for craftspeople. Selecting the correct tool and knowing how to properly use it, sharpen it and adjust it is key to producing succesful woodworking projects.

This chapter provides insight into usage, safety, care and maintenance of essential hand tools.

Key terms

2B a particular hardness of graphite within pencils; 2B grade is a softer pencil best used for marking out

alloy a mixture of two or more metals or a metal and a nonmetal

arc part of a circle, as drawn by a pair of compasses

back-saw a saw with a stiffening 'backbone' to prevent flexing

bastard intermediate grade of file

bevelled a chisel with angled sides

burnishing polishing (a surface) by friction

burr a small sharp turned edge on a cabinet scraper that acts like a tiny plane

calibrated marked out using a scale of measurement

cast iron an alloy of carbon, iron and other elements, cast either as soft and strong or hard and brittle iron

concave curving inwards (e.g. a hollow)

convex curving outwards (e.g. a moulding)

crosscutting sawing across the grain in timber

ferrule a metal cast or ring on the end of a handle for protection (i.e. to prevent splitting)

grinding removal of metal using an abrasive wheel

groove a recess cut along the length of timber in the direction of the grain

hone the fine finishing in the blade sharpening process that produces a keen (sharp) edge

high-carbon steel hard wearing steel with 0.6–1.0 per cent carbon included; may be heat-treated

interlocked grain fibres on each layer spirally inclined in opposite directions

kerf the gap created in timber by the thickness and set of saw blade teeth

mortice and tenon a hole cut in a piece of timber that pairs with a close fitting tongue on another piece creating a very strong joint

multi-toothed having many teeth, such as a surform or rasp

on the skew holding the tool at an angle to the work

parallel two or more lines equidistant from each other at all points

paring lightly chiselling to level off or remove a small amount of wood

philips head a screwdriver tightening system resembling a tapering cross; originally invented for faster car assembly line work

Pozidriv a screwdriver tightening system, similar to the Phillips system, designed not to slip. It has four additional points of contact

rasp a course file used to shape wood

ripping sawing along the grain

rivet a metal pin with a head on one end, inserted through aligned holes and then hammered on the plain end so as to form a second head

scribe to mark or write with an implement or tool (e.g. a pair of compasses)

second cut a grade of file used for cutting hard metals (a grade finer than a bastard file)

set on a saw blade, the alternate bending of teeth to the left and right to prevent binding of the saw

smooth a fine grade of file (a grade finer than a second cut file)

spur sharp points on a marking or mortice gauge that scribe the timber

steel a metal alloy that is a mixture of iron and carbon (up to 2.1 per cent)

stem the long narrow part of a marking/mortice gauge that has the spur or spurs attached

stock the wooden part of a try square that the blade is fixed to at 90°; a block of wood, generally that which is being worked on

squaring marking a line perpendicular (90°) to an edge using a try square

tang the pointed end of the file or chisel that fits into a handle

teeth per inch (TPI) is now teeth per 25 mm but still referred to as TPI

try square an accurate tool for measuring or marking 90° in woodwork

veneer a thin layer of wood (or other material) used for facing or overlaying wood (typically inferior or unattractive wood)

SAFETY

Safety aspects are discussed in detail in Chapter 1; however, safety related to specific tools will be highlighted in the following sections.

Safe handling of hand tools

An essential element in relation to the proper handling of any tool, whether it be a marking pencil or a plane, is the way you hold it. Use a firm but light and flexible grip that allows you to control the pressure on the tool with your fingers, wrist, arm and shoulder – as required. Too tight a grip causes tensing of the muscles so that the hand and arm become rigid and the fingers lose their fine sense of touch.

The strength of your grip will vary with the size of the tool and the nature of the work. Obviously, a ripsaw, with its large blade and teeth, will call for a stronger hold than the much smaller and lighter dovetail saw, which will make a finer cut with its smaller teeth. Similarly, a 10 mm chisel cuts less wood per stroke than a 25 mm blade; therefore, it requires less pressure to operate. You will learn by experience.

Tools for marking and checking angles

Pencils and marking knives

A sharp grade **2B** pencil can be a very useful implement, as long as it is kept sharp. If blunt, a pencil line may be 2 mm thick; and therefore, inaccurate. A carpenter's pencil has a wide, stronger, writing edge, which makes it ideal for use on rough timber. Use a sharp marking knife to mark across grain. This cuts the fibres and allows a chisel to sit in the **groove** to accurately finish cutting a joint. It also prevents tearing of the fibres when sawing.

HINT

Do not press heavily on a pencil. Lean the pencil in the direction of travel and slightly away from the rule to keep the tip close to the rule.

FACT

Modern pencils do not contain any actual lead. The 'lead' of a modern pencil is actually a mixture of graphite and clay.

SAFETY

Some marking knives have a point at both ends. Be careful when using and walking with them.

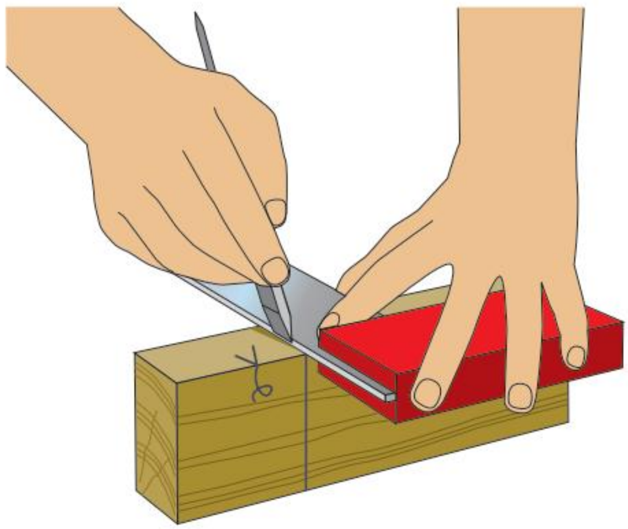

Figure 8.1 Correct handling of a knife

Measuring rules and straight edges

Quality *steel rules* are available in 300, 600 and 1000 mm lengths and, although flexible, they may be used on their edge to test for a flat surface. Wooden, or plastic, *folding rules* are ideal to avoid carrying a long rule around; however, a *retractable tape measure* is far more useful and comes in lengths of two metres and longer. A *straight edge* is less flexible and is ideal for testing flat surfaces – especially if using its thinner splayed edge.

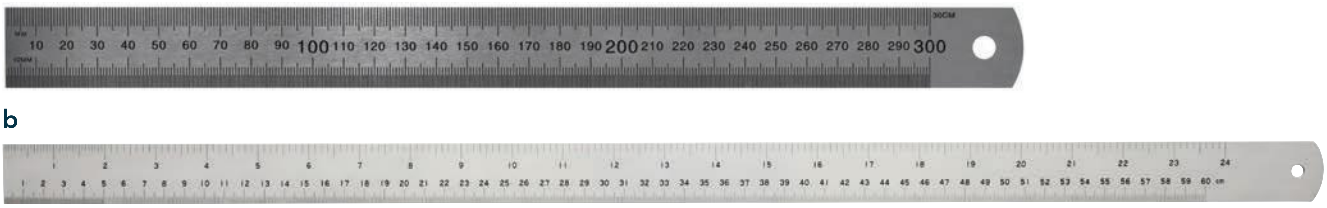

Figure 8.2 **a** 300 mm rule, **b** 600 mm rule

HINT

The hook on the end of the tape measure is deliberately loose and can move exactly the thickness of the metal hook. This is to maintain an accurate reading regardless of whether you are measuring an internal or external length.

Try squares

Try squares consist of a **stock** attached to a rectangular **high-carbon steel** blade generally by **rivets**. The stock is normally made of a fine, straight-grained and stable timber, such as beech, with a brass rubbing (wear) strip attached to the inner edge (Figure 8.3). A stock can also be made of plastic or cast iron. Try squares are available with blade lengths between 100–300 mm, and both the inner and outer edges of the blade may be used. They are precision tools and need to be treated with care.

When using a try square for marking perpendicular lines (**squaring**), hold the timber against the stock with the thumb, use the index finger to press the blade flat on the timber and the other fingers to push the stock against the timber. Use a sharp 2B pencil or a marking knife to mark the surface (Figure 8.1). When checking with a try square always hold the stock of the square firmly against the timber with the blade just clear of the 90° angle to be checked. While keeping the stock against the timber, slide it towards the angle to be checked by resting, rather than pressing it into position (Figure 8.3).

FACT

Timbers such as Indian rosewood and ebony were typically used for stocks; however, they are very rare today.

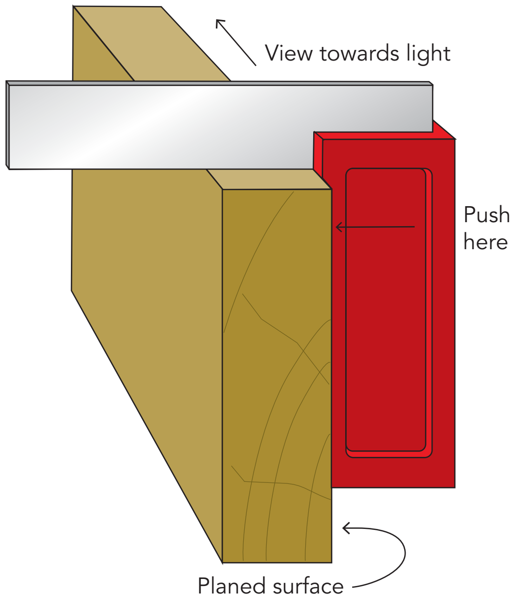

Figure 8.3 Correct use of a square

HINT

- Check a try square for accuracy by placing it on a straight-edged piece of material, drawing a 90° line then turning the square over to see if the blade still lines up with the drawn line.
- To get close in for accuracy, lean the pencil or knife slightly away from the blade of the square.
- It is easier to get a clear view of the angle being checked if you hold the project and square towards a light background, such as the sky, a white paper or wall.

Mitre squares

Mitre squares are made and used similar to a try square except the angle is set at 45° (135° the other end). The most common use for a mitre square is marking out picture frames. Blade lengths vary between 200–350 mm.

iStockphoto.com/Difydave

Figure 8.4 A typical mitre square

Builder's square

A builder's square is an L-shaped piece of 3 mm steel 600 × 400 mm stamped out and marked in millimetres on all edges with information on angles that are useful to builders. Excellent for checking and marking out large angles.

JPeckham/Avonmedia

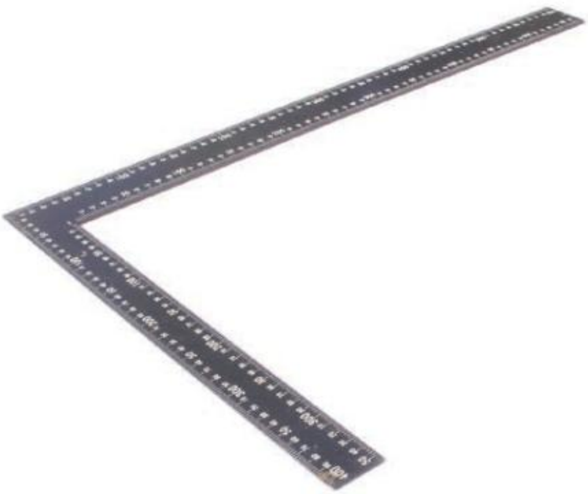

Figure 8.5 A typical builder's square

Sliding bevel squares

Sliding bevel squares are used for marking and checking angles other than 90°. Adjust the blade in length and

Alamy Stock Photo/Richard Heyes

Figure 8.6 A typical sliding bevel square

set the desired angle; then tighten the locking screw to hold it in position. Sliding bevel squares are available in blade lengths between 150–300 mm. They are ideal for setting out dovetail joints.

Combination square (set)

A combination square consists of a **cast iron** or **alloy** stock with a carbon steel **calibrated** blade that slides in and is locked to the stock (Figure 8.7). One side of the stock is used for 90° angles and the other for 45° angles. A combination square can be used as a depth gauge for rebate joints and as a pencil gauge. The stock generally incorporates a spirit level. High-quality combination square sets also have an internal 90° angled stock that, when operated with the blade, can be used as a centre finder for circular **stock**. Another stock is available with angular markings and is fully adjustable to any angle, then locked into position.

Alamy Stock Photo/Richard Heyes

Figure 8.7 A typical combination square

Dividers (pair of compasses)

Dividers have an adjustable pair of metal pointed legs that are used to mark or **scribe** circles and **arcs** or step off measurements. Generally larger, a pair of compasses have a holder that takes either a pencil or chalk (Figures 8.8b & c).

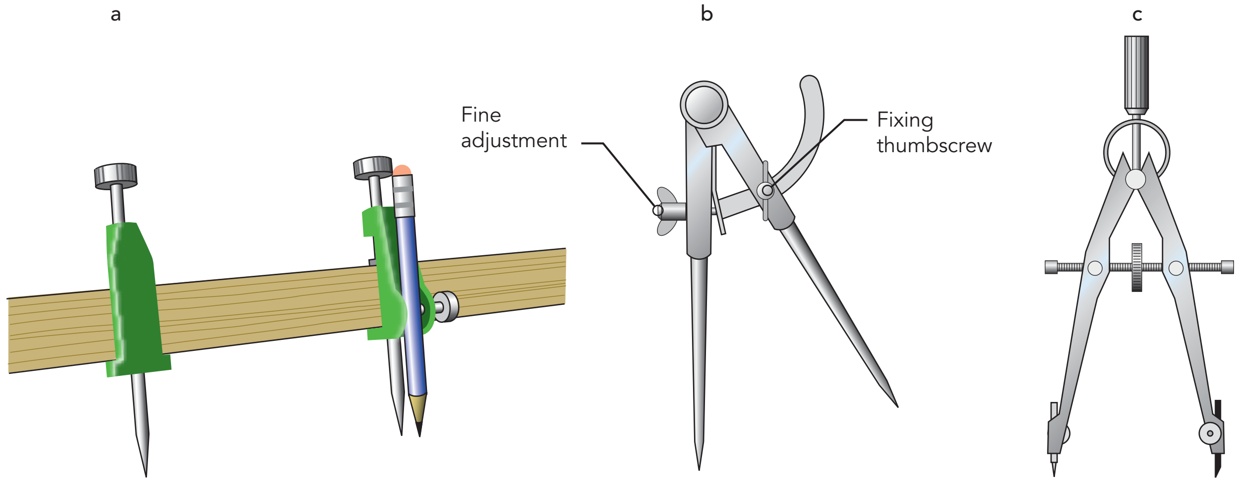

Figure 8.8 a Trammel points on a length of wood, **b** dividers and **c** a compass

Trammel point

A trammel point, used in pairs, is basically a metal point that can be clamped to a length of timber to form a beam compass. One point may have a clip to attach a pencil (Figure 8.8a).

Pencil or thumb gauge

A pencil or thumb gauge is typically made from scrap wood. This simple device is used to mark lines parallel to an edge without leaving a groove, such as for marking out chamfers (Figure 8.9).

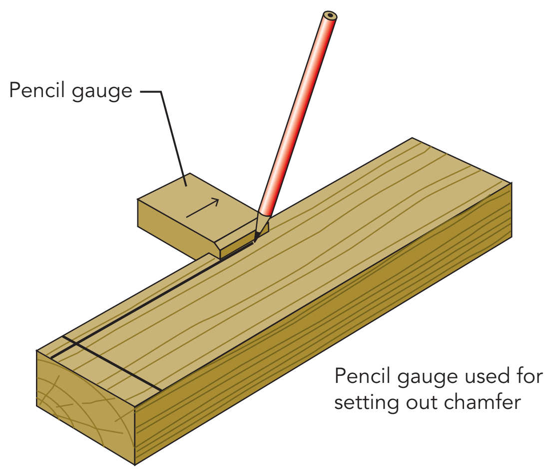

Figure 8.9 A pencil gauge

Profile gauge

A profile gauge has a row of thin metal pins that are held in position using friction. When pushed against a shape, the profile gauge retains that shape. This can then be used to reproduce the shape (Figure 8.10).

Figure 8.10 A profile gauge

Winding sticks

Winding sticks consist of a pair of straight pieces of metal or wood (approximately 400 mm long) that are placed across timber in order to easily check if the board has any twists (in wind) by sighting along the two sticks to see if they are sitting **parallel** (Figure 8.11).

Tony Clarke

Figure 8.11 Winding sticks in use

Marking gauges

Marking gauges have one fixed sharp **spur** set in the end of a **stem** (Figure 8.12). This gauge is set to the desired measurement by moving the stock along the stem and locking it into position. It marks a line parallel to whatever the gauge is moved along. It may be use to mark widths, thicknesses, depths of trenches, grooves or recesses and lengths of dovetails.

HINT

When using gauges, rest the stem of the gauge on the wood you are marking and turn the stem until the spur just starts to bite into the timber then gently trail the spur either away or towards you, whichever you prefer. Keep your hand over the stock for a smoother action (Figure 8.12).

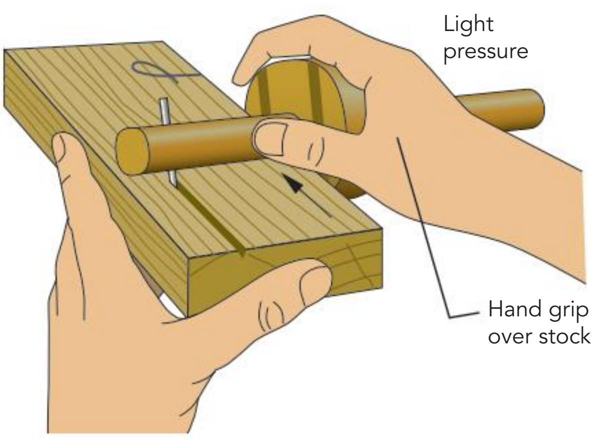

Figure 8.12 A marking gauge in use

Mortice gauge

A mortice gauge makes two marks parallel to a side, edge or end (Figure 8.13). One spur is fixed and the other is movable allowing it to be set to match the width of the chisel that will be used to make the mortice in a **mortice and tenon** joint. Typically, there is a single spur on the other side of the stem, which allows the mortice gauge to be used as a standard marking gauge.

Cutting gauge

A cutting gauge has a wedge and knife blade instead of a spur and is mainly used for marking across the grain to cut the surface wood fibres. It is sometimes used for cutting thin timber or **veneer** (Figure 8.13).

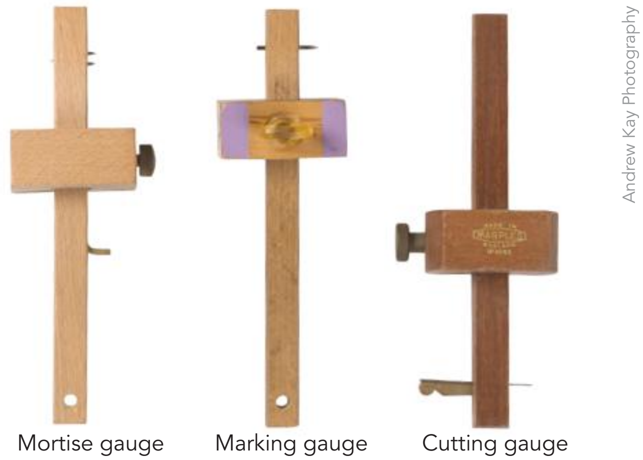

Figure 8.13 Mortice, marking and cutting gauges

Dovetail marker

There are a variety of dovetail templates, normally made of brass, that are shaped to one of the angles of a dovetail joint. They can be bent to rest over the end of a piece of timber while marking out (Figure 8.14).

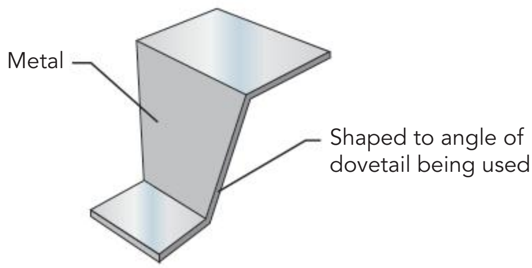

Figure 8.14 A dovetail marker

CHECK YOURSELF

1. What marking out process is a try square used for?
2. What is a marking knife used for?
3. What tool would you use to mark a 65° angle?
4. What tool would you use to check a 45° angle along an edge?
5. Name the tool used to mark large diameter circles on timber.
6. Describe when to use marking and cutting gauges.

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Saws

For over 4000 years, various saws have been created for specific needs. Saws have been designed to cope with many different applications; for example, cutting straight or curved lines, cutting quick rough lines or accurate fine lines, cutting along or across the grain, cutting on the forward stroke or the back stroke and for special purposes. Modern technology has produced electrically powered or rechargeable tools that achieve virtually all of these applications, but there is no doubt that the development of good hand skills plays an important part in being a quality woodworker.

Teeth per inch (TPI) is an old imperial expression, which due to the conversion to metric has now changed to teeth per 25 mm (still known as TPI). This refers to the size of the teeth of the saw; basically, the larger they are, the rougher and quicker the cut will be. **Ripping** is sawing along the grain while **crosscutting** is cutting across the grain. All saw teeth are bent slightly out in an alternative pattern; this is known as the **set** of the teeth and prevents the the saw blade from jamming in the cut. The channel made in the timber by the saw teeth is known as the **kerf** (Figure 8.15).

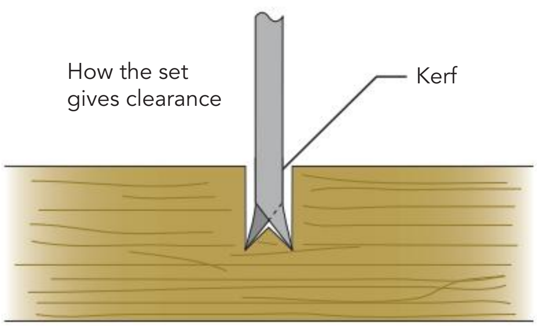


Figure 8.15 The set and kerf. The kerf gives clearance for the blade

Types of saws

Saws are generally divided into either straight or curved cutting saws.

Straight cutting saws

Straight cutting saws come in two categories:

1. *Saws without backs* are used for cutting larger pieces of timber to approximate size (Figure 8.16). Examples include rip, hand and panel saws.
2. *Saws with backs* have a stiff spine along the back and generally finer teeth. They are used to accurately cut to a line (Figure 8.19). Examples include tenon, dovetail and gentleman's saws.

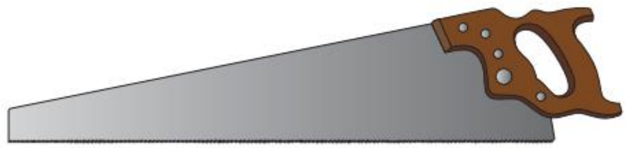


Figure 8.16 Saw without a back

Rip saws

A rip saw is a large hand saw, 650–700 mm long with 4–10 TPI. Rip saws are specifically designed to cut along the grain of wood with teeth that act as small chisels (Figure 8.17).

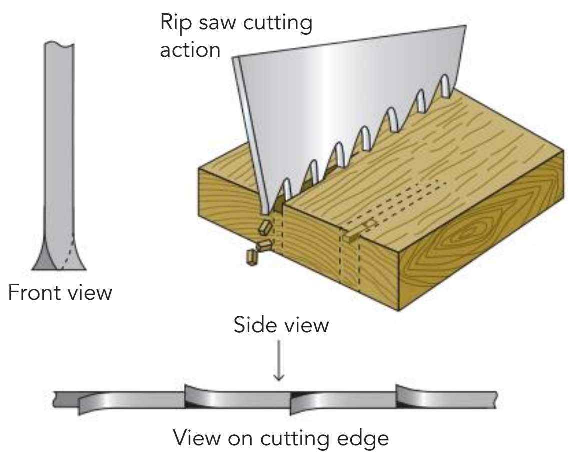


Figure 8.17 Rip saw teeth

Crosscut saws

Crosscut saws include most other saws including backed saws and saws without backs. The main difference being the size of the teeth (the more teeth the smaller they are) and the length of the blade.

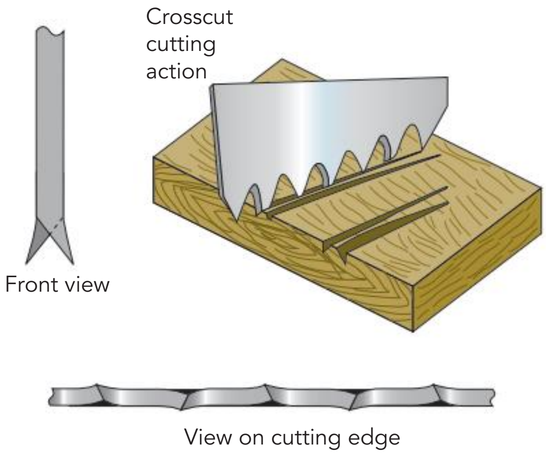


Figure 8.18 Crosscut teeth

Hand saw

A hand saw is a backless saw with a blade length between 600–650 mm. It has smaller teeth, generally, >10 TPI. A hand saw is used for cutting thick timber across the grain and thin timber along the grain.

Panel saw

A panel saw is a backless saw with a blade length between 500–600 mm and 6–9 TPI. It is used for cutting thin timber across the grain. A panel saw is a good choice for cutting plywood.

Back-saws

Tenon saw

A tenon saw is a **back-saw** because it has a strip of steel or brass folded over and along the top of the blade to reduce flexing of its thin blade. This strip, or spine, also adds weight to help feed the saw through the wood. A tenon saw has a 250–350 mm long blade with 13–15 TPI, and a closed handle. Its uses include general cutting of battens and larger joints along or across the grain (Figure 8.19).

Dovetail saw

A smaller back-saw consisting of a blade 150–200 mm long and having 16–22 TPI. Dovetail saws are used for cutting joints, such as in cabinet drawers or other fine work (Figure 8.19).

Gentleman's saw

A gentleman's saw is a lighter weight back-saw that has a straight handle (like a file) and 24–33 TPI. These saws may also be refered to as a gent's saw, bead saw or blitz saw. They produce fine cuts for very detailed work and model making (Figure 8.19).

Andrew Kay Photography

Figure 8.19 Backed saws

HINT

When using any saw designed for straight-line cutting, always point your index finger along the handle to assist with control and prevent the handgrip twisting. Keep your forearm directly in line with the blade to prevent jamming. Start sawing the timber on the far side of the marked line to prevent splintering the wood, taking the weight off the cutting action until a kerf is established. To cut accurately, one side of the kerf should touch the marked line and the other should be in the waste wood.

Curve cutting saws

Bow saw

A bow saw is about 300 mm long, has a 6 mm wide blade and 8–12 TPI. By loosening the tension and turning the handles, the blade may be rotated allowing the frame of the saw to be positioned out of the way of the project. A bow saw is designed to cut curves in thick timber. Tension is applied to the blade by a tourniquet method at one end of the frame (Figure 8.20).

Coping and fret saws

A coping saw is a smaller curve cutting saw (compared to a bow saw) that is about 150 mm long with 14–16 TPI. The blade is narrow and tensioned in a sprung steel frame. By unscrewing the handle to reduce tension, the blade may be rotated; however, the size of the frame does not allow it to be used far from an edge.

A *fret saw* is similar in operation with a deeper frame and finer, more fragile, teeth (32 TPI) used for cutting very tight curves.

A *coping saw* is used on thin timber and manufactured boards. The blade is inserted so that the saw cuts on the back stroke. This keeps the frame under **tension** and prevents the blade from falling out.

Blades for these saws are inexpensive and are replaced rather than resharpened (Figure 8.20).

Compass, keyhole and pad saws

All of these curve-cutting saws are similar in that they consist of a blade attached to a handle, with no frame. This allows shapes to be cut in the middle of large boards, after drilling an entry hole. One problem with these saws is because they cut on the forward stroke, blades often get bent when the saw jams in the wood (Figure 8.20 shows a pad saw).

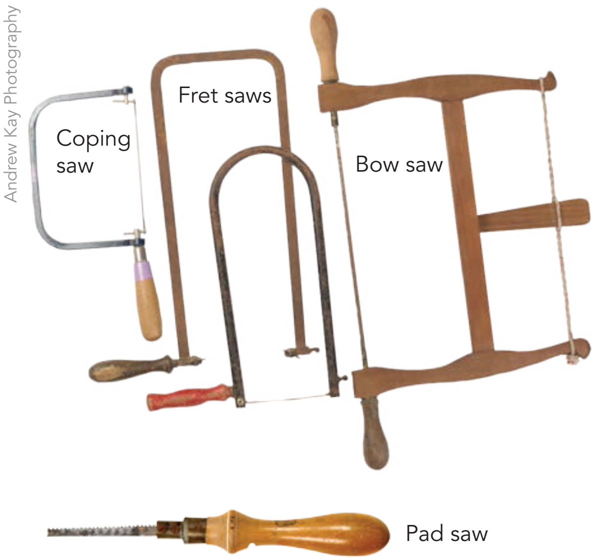


Figure 8.20 A sample of the saws typically used for curved cutting

Japanese saws

Japanese saws are designed to cut on the back stroke. It is argued that this is a more natural action than the push stroke of Western saws. This also overcomes the problems of bent blades and saws jammed in wood. Japanese saws may be thin-bladed flexible saws or have a stiffening back fitted. Both types cut a narrow kerf because of their thin blade. A Ryoba model is very handy because it has a blade with two cutting edges:

Figure 8.21 A collection of Japanese saws

one set for ripping and the other edge for cross- cutting. Japanese saws are recognisable by the split bamboo that is wrapped round the handle of most models.

Tools to assist sawing

A **bench hook** assists with cutting timber and is positioned over the edge of a bench, or clamped in a vice. The timber is placed across the bench hook and sawing takes place over the base of the bench hook. The bench hook can be used by left- or right-handed people and supports the timber, preventing it from splintering underneath and protects the bench's surface (Figure 8.22).

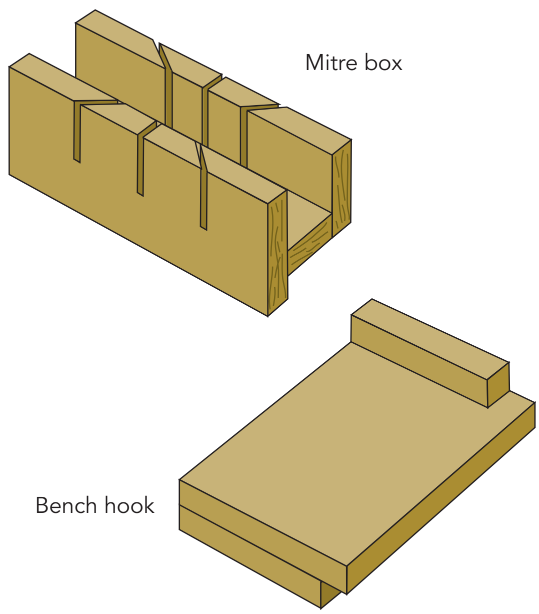


Figure 8.22 Mitre box and bench hook

A mitre box allows timber to be accurately cut at specific angles – typically 45°. It might be a simple U-shaped wooden frame with angled slots cut into it or an angular device with a metal frame, which can be altered to any angle (Figure 8.22).

CHECK YOURSELF

1. What does the term kerf refer to?
2. Why do the teeth on a saw have a set?
3. What are the two categories of saws available?
4. What is the difference between a handsaw and a tenon saw?
5. What is a bench hook used for?

Planes

Planes are fitted with a sharpened tool steel blade that is used to gradually reduce a piece of timber to its marked size (Figure 8.23). They are manufactured from either wood or metal. Metal planes are heavier but generally cheaper, due to mass production. The four most commonly used planes are described in Table 8.1.

There are various other planes that have been designed to fulfil special purposes. These planes are typically used by woodworking specialists and include router, rebate, plough, shoulder, bull-nosed, combination and compass planes.

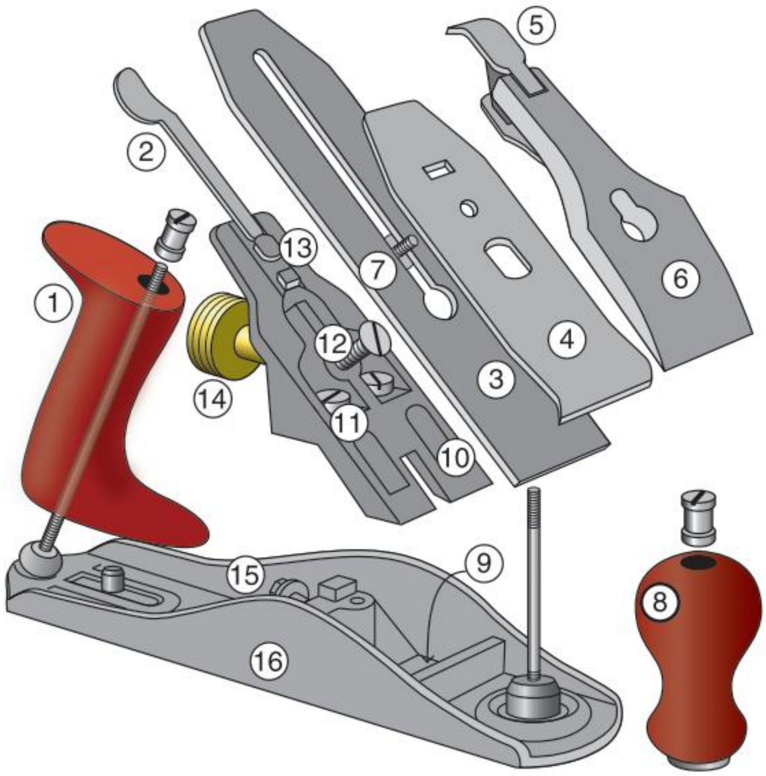
FACT

The name 'jack plane' comes from the saying, *he's a jack of all trades but master of none.* This describes the jack plane as well because it is a general purpose plane not used for any specialised purpose.

Figure 8.23 Various types of planes

Table 8.1 Information about planes

Name	Length (mm)	Blade		Special details	Uses
		Width (mm)	Mounted angle		
Trying	550–600	57–70	45°	Ground side of blade down and corners relieved	Planing long edges and surfaces straight
Jack	350–380	50–60	45°	Ground side of blade down, blade cutting edge slightly curved (convex)	Planing to approximate size. 'Jack of all trades.'
Smoothing	230–250	38–60	45°	Ground side of blade down and corners relieved	Flushing and finishing off joints
Block	125–200	35	12° or 20°	Ground side of blade up and corners relieved.	Planing chamfers, splays, small mitres, bevels, fine end grain work (must be sharp) and may be used single-handed



1	Handle
2	Lateral adjustment lever
3	Blade
4	Cap iron
5	Lever
6	Lever cap
7	Cap iron locking screw
8	Front handle
9	Mouth
10	Frog
11	Frog locking screws
12	Lever cap screw
13	Depth adjustment lever
14	Depth adjustment nut
15	Frog adjusting screw
16	Soleplate

Figure 8.24 An exploded view of a plane showing the typical parts

Adjustable parts of a plane

The cap iron is used to stiffen the blade at the cutting edge and its curved part curls the shaving out so it clears the plane. The cap iron should be set approximately 2 mm from the end of the blade (closer if **interlocked grain** is evident in the wood) and should be bent to not allow shavings to wedge between the two parts (Figure 8.25).

J Peckham/Avonmedia

Figure 8.25 Adjust the cap iron to approximately 2 mm from the end of the blade

Fit and adjust the lever cap so that it is tight enough to keep the blade in position once it is adjusted.

The frog can be adjusted slightly to reduce the gap between the blade and the mouth; this reduces the risk of tearing the fibres of difficult timbers and timbers with a wavy grain (label 15 on Figure 8.24).

Popular Woodworking

Weblink

HINT

The best way for a beginner to adjust the cut is to first ensure the blade is level (lateral) then adjust the blade back until it just disappears inside the soleplate. Try to plane a shaving; if it takes a shaving then adjust the blade back further until it will not work. Now the blade may be wound forward a quarter of a turn at a time and tested with a shaving until the desired thickness is achieved. Now turn it over and look at the blade; remember how much protrudes.

Lateral adjustment is achieved by gently moving the lever situated at the top of the plane either left or right (not on the block plane) (Figure 8.26). Lateral adjustment can be checked and changed by holding the plane upside down, by the front knob, and looking along the **soleplate** against a light background.

Taunton Press, Fine Woodworking

Figure 8.26 Lateral adjustment by moving the lateral adjustment lever left or right to straighten the blade

Adjustments to the depth of the cut are achieved by simply rotating the brass knob (nut), which pushes the blade in or out. As with lateral adjustment, the best way to hold the plane is to turn it upside down and hold it by the front knob, and the best way to check adjustments is to look along the soleplate against a light background (Figure 8.27).

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Alamy Stock Photo/Adrian Sherratt

Figure 8.27 Adjustment of the blade is best done while looking along the sole of the plane

Using a plane

When using a plane, stance is important. Stand in a relaxed position, feet apart, shoulders bent slightly forward, and your right hand and arm behind the plane and in line with it so that, working from the shoulder, they push the plane along.

Taunton Press, Fine Woodworking

Figure 8.28 Correct stance while using a plane

The left hand (right hand if you are left-handed) controls the toe, or front part, of the plane. When taking a shaving, initially, most of the weight of the plane is off the wood so more downward pressure must be applied to the front handle. Towards the end of the stroke the opposite occurs and most of the plane is off the front of the wood so the downward pressure must be transferred to the rear handle of the plane to stop the plane dropping and rounding off the end of the wood.

iStockphoto.com/Dmitriy83

Figure 8.29 Apply downwards pressure on the front handle initally then towards the end of the stroke transfer the pressure to the rear handle

To help make a straight cut, keep the sides of the plane parallel with the length of the wood, except when planing end grain or timber with wavy or knotty grain. End grain is difficult to work with. The fibres that make up the grain/structure of wood can be likened to a large, magnified bunch of straws, with the end of the straws representing the end grain. If you hold the bunch of straws in one hand and brush your other hand across the ends, the last few that are brushed against will bend out. This is exactly what happens to the end grain fibres of wood if an attempt is made to plane across them because the last few fibres are unsupported. Knowing this means we can apply one of the following methods to stop this happening.

For the best result, each of the methods that follows requires a sharp, finely set smoothing plane and possibly a little wax to reduce friction. Moving the plane **on the skew** rather than presenting the plane and blade square-on produces an easier slicing action (Figure 8.30).

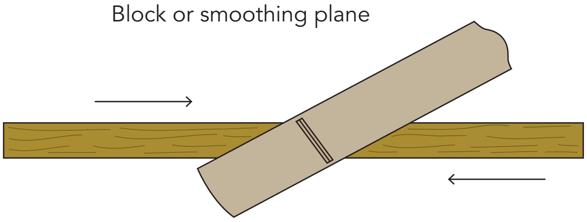

Figure 8.30 Plane end grain inwards from each corner; plane is moved on the skew producing a slicing action

If the end grain is part of an assembled and glued joint then simply flushing off by planing towards the joined piece of wood will supply the support necessary to prevent splintering.

If the wood is not assembled, there are a number of methods that can be employed. However, for all of these methods, the first step is to ensure that the wood has been cut as close as possible to the marked line, to reduce the amount of planing necessary.

One of these methods is to gently plane or file a chamfer at one end of the end grain, right to the marked line, then plane from the other end, constantly checking the marked line. Planing into the middle from each end is a safe method. Just remember to check with a straight edge or try square for a high spot in the middle.

J Peckham/Avonmedia

Figure 8.31 Plane or file a small chamfer at one end to prevent splitting when planing end grain

Another method is to clamp a sacrificial piece of wood at one end and plane towards it. The unsupported scrap piece will splinter instead of the main piece.

Finally, if the piece of end grain is small enough it can be squared to the marked line by disc sanding followed by hand sanding.

HINT

If the plane chatters it is probably set with too much blade protruding.

Work held in the vice should be kept parallel to the top of the bench: if it is raised at one end, the plane will tend to take more off the higher part. Aim to take a shaving off the full length of the timber where possible, but finish long work to a smoother surface with fewer plane marks by beginning at the forward end and working back.

Ensure the cutting iron (blade) is kept sharp and protrudes an even distance beyond the plane face or it will produce an uneven surface. You can begin planing sawn timber with a fairly deep cut, reducing the depth of cut, and hence the thickness of the shavings, as you approach the marked line.

HINT

A light rubbing of any hard wax on the soleplate of the plane will reduce friction and make it much easier to use.

SAFETY

Never run your finger along or across a blade to test for sharpness. When putting down a plane lay it gently (to prevent upsetting the adjustment) on its side (to prevent damage to the blade and bench).

Other tools with a planing action

Surform tools

Unlike other planes, the blade of this plane is **multi-toothed** and replaceable. It is used like a file but the teeth are pushed down leaving a hole for shavings to escape. It is used mainly for shaping, and may be used on other materials such as plastic, soft metals and plaster (Figure 8.32).

Wikimedia Commons/MartinK

Figure 8.32 Surform tools

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Spokeshave

A spokeshave has an adjustable blade and is typically used for curving timber. There are two types: one with a cast-iron frame and a flat base, to work on flat and **convex** curves, and the other with a curved base to work on **concave** curves. The blade must be set very fine or it will not work properly.

> **FACT**
> Originally, spokeshaves were used for shaping the spokes of a horse-drawn cart.

Lee Valley Tools Ltd., 814 Proctor Ave., New York, NY 13669-2205, 1-800-871-8158, www.leevalley.com

Figure 8.33a The two main types of spokeshave, straight for convex curves and round for concave curves

> **HINT**
> Always work a spokeshave down the grain to the lowest point.

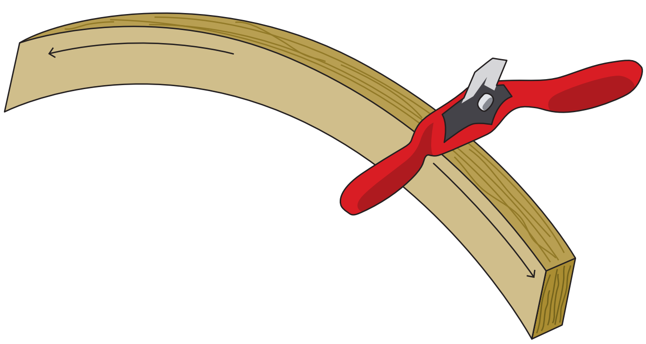

Figure 8.33b Convex curves, use flat spokeshave pushing down each side from the centre

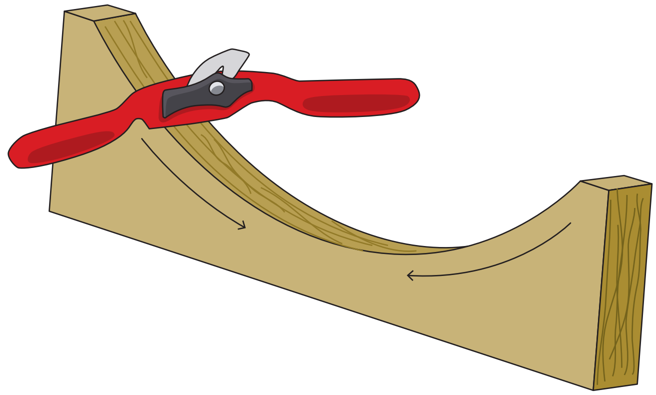

Figure 8.33c Concave curves, use curved spokeshave pushing down each side from the centre

CHECK YOURSELF

1. Name three types of planes.
2. What is the purpose of a cap iron on a plane blade?
3. What is the correct name for the base of a plane?
4. Describe two methods of planing end grain so it does not split.
5. What is a surform tool used for?
6. What spokeshave is best used for concave curves?

Cabinet and hand scrapers

A scraper is a finishing tool for removing or smoothing small amounts of timber, especially on tricky grain areas where hand planes would cause tear out. When a scraper is held in a cast iron frame (similar to a spokeshave) it is referred to as a cabinet scraper. These are used for larger flat areas (Figure 8.34a). When the scraper is held in the hand for smaller flat or shaped areas it is referred to as a hand scraper (Figure 8.34b).

Shutterstock.com/farbled

Figure 8.34a Cabinet scrapers

Figure 8.34b Hand scrapers come in different shapes.

Generally made of **carbon steel** and available in various curved (convex and concave) or rectangular shapes, scraper thicknesses vary between 0.4 mm for very fine work and 1.5 mm for heavy-duty work. The cutting action results from a **burr** formed on the edge of the scraper that acts like a mini plane. Cabinet scrapers are held in a cast-iron frame, are adjustable and ground to 45° before producing the burr. Hand scrapers are ground to 90°; the burr is produced and is then used by hand. They work very well, when sharpened correctly, and can produce a fine surface that needs very little sanding (Figures 8.35a and b).

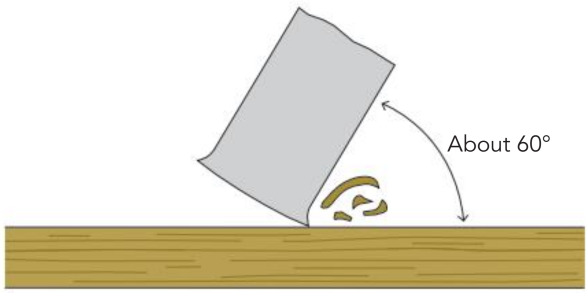

Figure 8.35a Magnified view of the effect of a sharp hand scraper

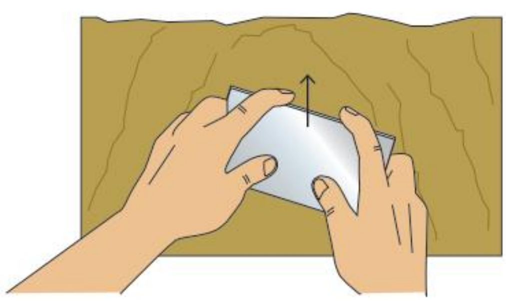

Figure 8.35b Push the scraper at a skewed angle when starting near an end and change the angle with each stroke

Chisels

A chisel must be strongly made so that when it is hit with a mallet the **tang** of the blade does not split the handle. There are two styles of construction to prevent this from happening. The first style consists of a hollow, tapering socket at the upper end of the blade. The other type has a tang followed by a flat lip against which a **ferrule**, on the end of the handle, rests. A leather washer is positioned over the tang to absorb the shock of the mallet's blows. Metal ferrules are sometimes placed around the end of the wooden handle to prevent the mallet splitting it (Figure 8.36). Ferrules and washers are not required with quality plastic handles. The size of the blades range between 3–51 mm wide and 75–250 mm long, depending upon use and preference.

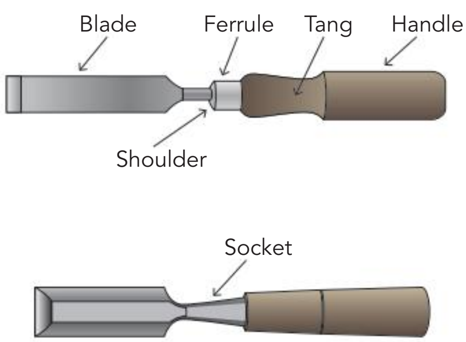

Figure 8.36 Parts of a chisel

As with all edge tools, a keen cutting edge is essential for clean work. For removing waste from a trench or groove, clamp the work and hold the chisel handle in the palm of your left hand, ground side downwards, while the right hand taps the end of the handle with the mallet. For morticing, clamp the work and stand behind it so that the chisel can be held vertically and struck squarely on the end with the mallet. For paring, hold the work in a vice or clamp it to a bench, leaving the right hand (if you are right-handed) free to grip the handle and exert the pressure while the left hand steadies and holds the blade, which is held with the flat side towards the wood.

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Figure 8.37 Chiselling a mortice joint. Stand behind the project so that the chisel can be held vertically and struck squarely on the end with the mallet.

To an expert craftsperson, accuracy with a plane, saw or chisel means making the cut precisely where it should go, even to the extent of cutting exactly through the centre of a gauge line or leaving a pencil line just showing on the edge of the cut (Figure 8.37). Remember that this degree of skill comes only with practice.

SAFETY

Never place either one of your hands in front of the chisel or work a chisel towards your body. Always carry a chisel with your hand near the sharp tip so you are aware of its location and have your arm by your side.

Types of chisels

Firmer chisel

A firmer chisel is a general-purpose chisel with a rectangular-sectioned blade, for strength, that can be used with a mallet. Firmer chisels are mainly used to remove waste wood in joint construction (Figure 8.38).

JPeckham/Avonmedia

Figure 8.38 A firmer chisel

Mortice chisel

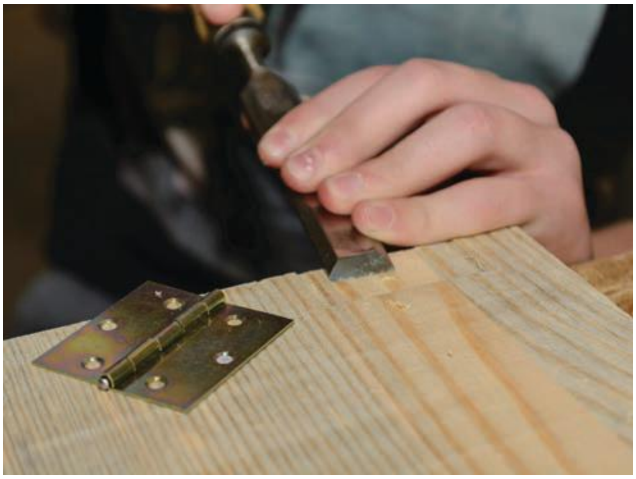
A mortice chisel is similar to a firmer chisel but is considerably thicker (not wider). This allows it to be used for making mortice joints, which require considerably more hitting and levering. A *register chisel* is slightly thinner than a mortice chisel but still stronger than a firmer chisel and may also be used to produce mortices.

Courtesy of Axminster Tool Centre Ltd.

Figure 8.39 A mortice chisel. Note the thick blade.

Bevelled-edge firmer chisel

As the name suggests, the two long edges of a bevelled-edge firmer chisel are **bevelled** (Figure 8.40). This chisel is best for lighter work. It can be used to clean up a dovetail joint because it has sides less than 90°. It may also be used for **paring**. A longer version of a bevelled-edge firmer is a *paring chisel*, which is used to clean up and finish joints without the use of a mallet.



Agefotostock/Alfred Hofer

Figure 8.40 Paring the bottom a trench for a hinge using a bevelled edge chisel and a slicing action

HINT

When paring timber make sure your chisel is sharp and hold the blade close to the end with your fingers, thumb on top to keep downward pressure. Keep the chisel flat and use a slicing action to take small shavings.

Firmer (or carving) gouge

A firmer gouge has a curved blade, comes in widths between 3–38 mm, a choice of curve radii and with a handle designed for mallet use. It is ground and sharpened on the convex side (outside) of the blade. It is used for shallow stopped grooves and general carving work.

Narex Tools, www.narextools.com

Figure 8.41 Firmer gouges. Note: they are ground on the outside.

Scribing (or paring) gouge

A scribing gouge, or incannel gouge, is ground and sharpened on the concave (inside) edge of the blade and is used to pare flutes across end grain and cut through grooves along the grain.

Specialist chisels and gouges include a drawer-lock chisel, mortice-lock chisel and a cranked gouge (used by pattern makers and wood carvers).

Figure 8.42 Scribing (or paring) gouge. Note they are ground on the inside.

SAFETY

All chisels and gouges should be carried carefully and held by your side with the hand grip near the sharp end so you know where it is at all times.

CHECK YOURSELF

1. What is the difference between a hand scraper and a cabinet scraper?
2. What is the term for the sharp edge formed on the end of a scraper called?
3. What metal is a hand scraper made from?
4. What is the most important safety rule when using a chisel?
5. What makes a mortice chisel different from other chisels?
6. What type of chiselling is a bevelled edge chisel best used for?
7. What is a scribing gouge used for?

Hammers and mallets

There are many uses for hammers and mallets (percussion and impelling tools) and it is important to use the correct hammer or mallet to avoid unnecessary damage to the project or tool.

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HINT

If nails keep bending it may be due to the angle at which the hammer head hits the nail, the timber might be too hard (use thicker gauge nails or pre-drill small holes), or the face of the nail head might be too smooth – this can be easily fixed by roughing it up with abrasive paper or rubbing it on concrete.

Types

Claw hammers

The size of a hammer relates to the weight of its forged steel head, which can vary between 200–900 grams. The choice of which hammer to use depends on the job it is doing, the frequency of repetitive use and the person using it. Hardwood handles, such as ash, hickory or spotted gum, are fitted with a system of wedges at the end to stop the head from flying off while in use. Handles may also be made from solid or tubular hardened steel or glass-reinforced plastic (GRP). Both types are generally covered with a rubberised grip. Claw hammers are mostly used for heavy work, such as house construction, where the claw can be used to remove nails.

Figure 8.43 A wooden handled claw hammer

HINT

When nailing near the end of timber, avoid splitting by blunting the point of the nail so that it punches through the wood rather than splitting it.

Warrington hammer

A Warrington hammer has a cross peen (pane, pean or pene), which is used to gently start small nails (approximately 10 mm) that fit between your thumb and index finger. Sizes range between 00–12 with the most popular being a No. 3 (350 grams). Compared to a claw hammer, a Warrington hammer is used for lighter work.

Figure 8.44 A Warrington hammer

SAFETY

Never hit two hammers together because they could disintegrate or chip off sharp pieces of metal.

Carpenter's mallet

Generally, both the handle and the head of a carpenter's mallet are made of solid beech and the socket in the head tapers to match the handle so that when in use the head will always be tight and not fly off. The faces of the head are angled so that, in use, they will hit the object flat and square. The mallet is used with a chisel, or for gently assembling or dismantling joints.

Figure 8.45 A carpenter's mallet

Rubber and plastic mallets

Plastic mallets may have interchangeable heads that screw off for different uses; however, generally, they are for assembling or dismantling joints.

Shutterstock.com/Stephen Bonk

Figure 8.46 A rubber mallet

Pincers

Pincers, which are generally 150 mm long, are used to extract bent or unwanted nails. By placing a piece of scrap wood under the curve of the lower jaw then gripping and rolling the jaw down and away from the nail, pincers will easily remove the nail without damaging the surface of the wood. One end of a pincer arm typically has a small claw that may be used to extract small nails.

Shutterstock.com/Oleksandr Kostiuchenko

Figure 8.47 Pincers

HINT

Always use pincers along the grain and away from an edge to prevent unnecessary marking and tearing of the wood.

Nail punches

Nail punches are made from high-carbon steel that has been hardened and tempered. They are available with tip sizes between 0.75–8 mm to suit most nails. They are used to drive nails 2–3 mm below the surface of the wood prior to filling with putty. Punches are used with hammers that have metal heads.

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Figure 8.48 Nail punch

HINT

Choose a nail punch that has a diameter just a bit smaller than the nail head. A punch with a hollow in the tip will help prevent it from slipping off the nail and damaging the project.

Screwdrivers

The most important attributes of a screwdriver include:

1 a tip that precisely fits the head of the screw
2 the grip of the handle
3 an overall length that suits the application (Figure 8.49).

A cabinet screwdriver has a slightly flattened handle providing you with an ideal grip and maximum torque. The size of a screwdriver is calculated by measuring from the tip of the blade to the handle, and measuring the size of the tip. Flat-bladed screwdrivers have a specific width tip and thickness to suit a certain gauge screw. For example, a 150 × 8 screwdriver has a blade that is 150 mm long and a tip that fits the slot of an 8-gauge screw. Similarly, **Philips** and **Pozidriv** heads have a scale that is numbered from one to four to suit the differing sizes of screw heads (Figure 8.50). High-quality hardened blades will maintain their tip shape longer. Do not use a screwdriver with a rounded or worn tip because it may strip the screw or slip off and damage your project.

Spiral and ratchet screwdrivers, designed for rapid and multiple screw work, are less popular today because they have been replaced by cordless screw guns. Short stubby, or offset, screwdrivers are ideal for restricted spaces. A jeweller's screwdriver (using an index finger on its revolving head) is useful for fitting screws to miniature hinges.

HINT

To use a screwdriver successfully try to keep your forearm in line with the blade. Whether you are tightening or loosening a screw press down as you turn to prevent the tip from coming out of the slot.

HINT

If the screwdriver is too hard to use and keeps slipping off the screw head, the problem is inevitably the incorrect pre-drilling of the holes (see the section on screws).

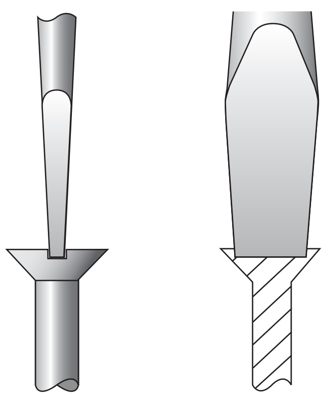

Figure 8.49 Correct fitting of a screwdriver

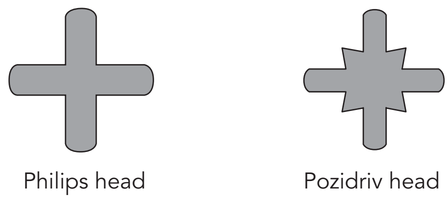

Figure 8.50 Philips and Pozidriv heads

Figure 8.51 A variety of screwdrivers

CHECK YOURSELF

1. What hammer is used to remove nails?
2. What is another name for a Warrington hammer?
3. Why should mallets be used to strike a chisel?
4. Describe the difference between a Phillips head and a Pozidriv screw head.
5. Why is it important to have the correct fitting screwdriver?

Files

A file is useful for shaping timber, especially irregular curves. Files and rasps are designed to work in the forward direction only and, for a fine finish, abrasive paper can be wrapped round a second-cut or smooth file to sand the project.

HINT

Do not use a file on a woodworking joint because it will round off the edges and create a loose and ill-fitting joint. You will get a much better result if you use a sharp bevelled-edge chisel to pare any excess material to make a joint fit.

Some of the different features that characterise files are listed below.

- **Size**: files are available in different lengths: 200, 250 and 300 mm.
- **Coarseness**: there are different grades of coarseness: **bastard** (rough), **second-cut** and **smooth**.
- **Cut**: this is the layout of the sharp, abrasive ridges on the face of the file: single cut, double cut and **rasp** (Figure 8.53).
- **Shape**: there are a variety of shapes to suit most situations (Figure 8.54).

SAFETY

Never use a file without a handle; it is very easy to stab your hand. If a handle becomes loose, place the tang back into it, hold the file blade with the handle facing down and tap it vertically on a bench to firmly reaffix the two parts.

Figure 8.52 A half round rasp

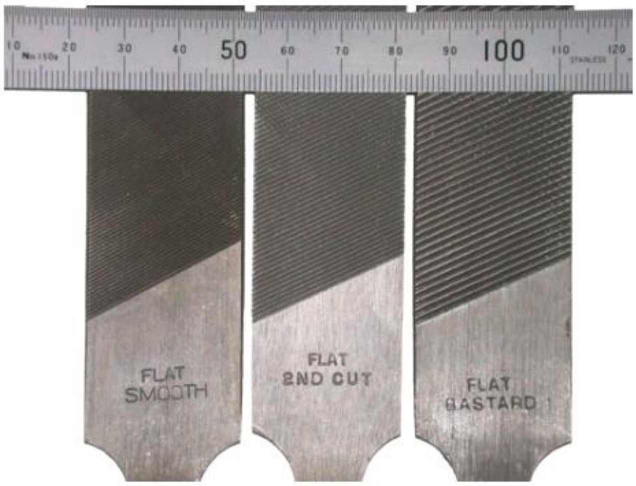

Figure 8.53 Close up of the three file cuts

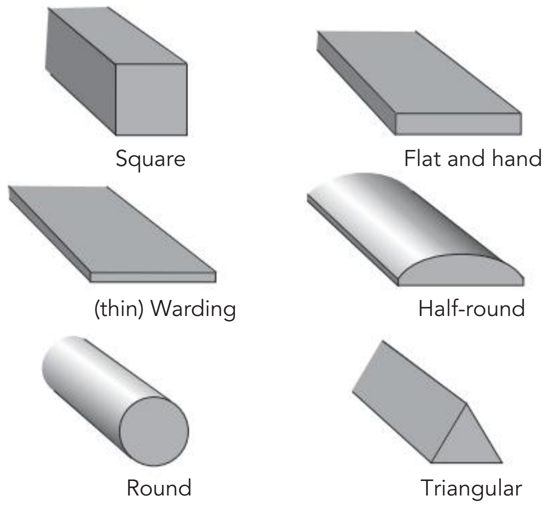

Figure 8.54 Common file shapes

Vices and clamps

An assortment of clamping systems have evolved to cope with a variety of operations including securing assembled projects of all shapes and sizes until the adhesive dries, holding long boards for planing or cutting and clamping a small piece of timber for drilling.

Types of clamps

Bench vice

The size of a bench vice is determined by how far it opens and the width of its jaws. Wooden inserts are screwed to the inside of the jaws to prevent damage to the clamped project and the top of the inserts should be level with the bench's surface. Some vices

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can be opened quickly by using a lever or undoing the handle a half-turn first (Figure 8.55).

Bench holdfast

A bench holdfast, which fits into a metal tube set into a bench's surface, allows timber to be clamped. One of the advantages of a bench holdfast is that projects can be positioned and secured further onto the bench's surface than with a G-clamp (Figure 8.55).

G-clamps, bar clamps and F-clamps

A G-clamp has a thread and must be wound in to hold an object while an F-clamp has one sliding jaw and only has to be screw tightened for the last few centimetres. A bar clamp is similar to an F-clamp but instead of the treaded tightening system, it uses a lever action to apply the pressure. Bar clamps are quick release once loosened. G-clamps are available in sizes 30–250 mm and F-clamps 100–1000 mm (Figure 8.55).

Spring clip

A spring clip is generally made of plastic and comes in various sizes between 30–100 mm with a powerful spring clip. They are ideal for holding small glued projects (Figure 8.55).

Sash cramp

A sash cramp is ideal for clamping long items because they are available in a large range of lengths (450–1200 mm). They are made of T-section steel, for rigidity, metal pipe, rectangular aluminium tube (for lighter use) or wood. One end has a screw-adjustable jaw and the other end has a sliding jaw that is positioned along the bar using a variety of systems, such as a tapered pin through a series of drilled holes, a sprung cam or a ratchet lock. Some can even be joined together for projects that are particularly long (Figure 8.55).

Mitre clamp

The purpose of a mitre clamp is to accurately hold a mitred joint together until the glue dries. They can clamp timber widths up to 112 mm (Figure 8.55).

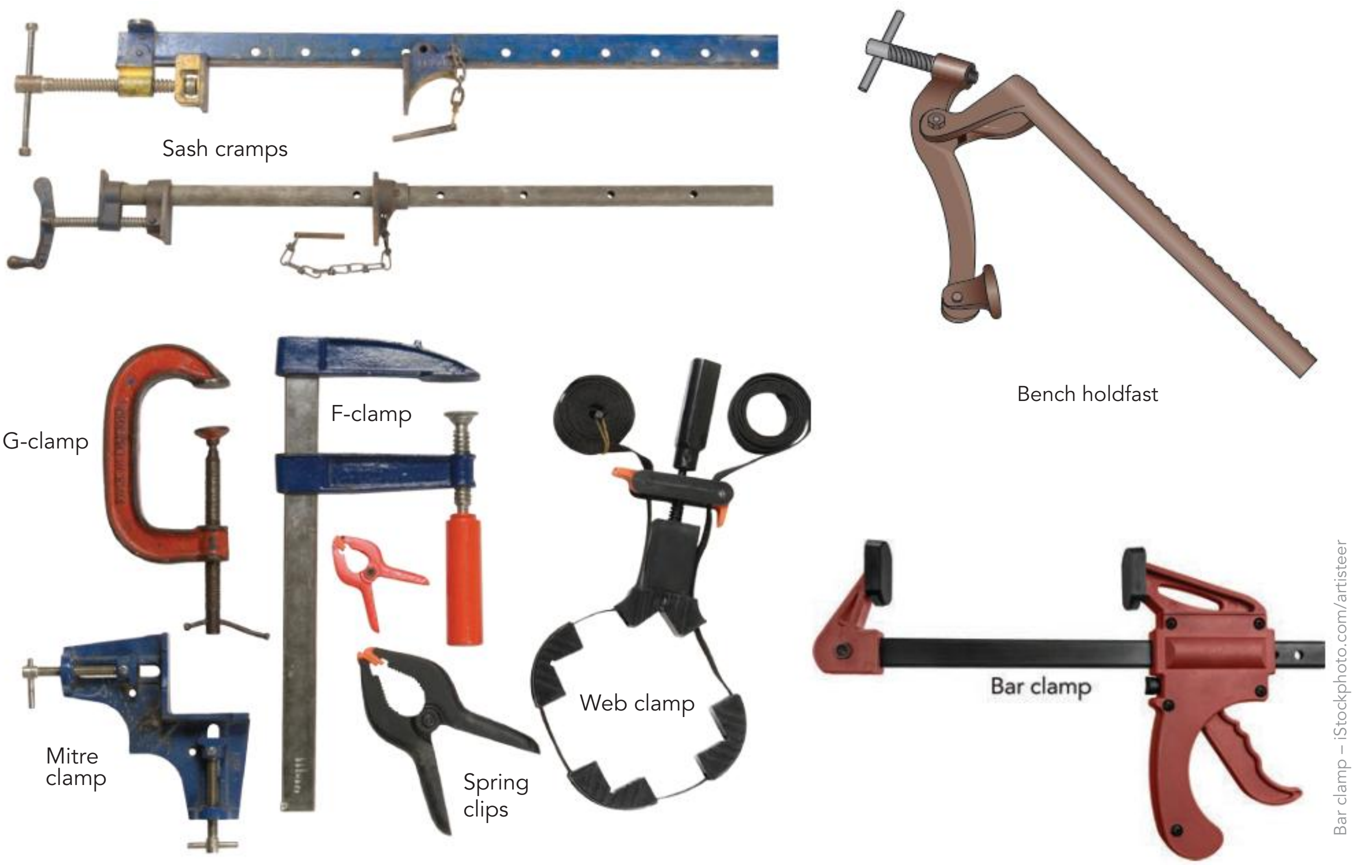

Figure 8.55 A selection of commonly used clamps and cramps

Web clamp

A web clamp consists of nylon webbing about 25 mm wide (or a spring steel tape) that is anchored to a mechanism, which can be tensioned. It is long enough to place round a picture frame or a chair with turned legs, where sash cramps would be too difficult to use (Figure 8.55).

Machine vice

Although a machine vice is an engineering vice, it is still useful for a woodworker because it is portable and very useful for holding items that need to be taken to a pedestal drill and be worked on without being held by hand.

Figure 8.56 A machine vice

CHECK YOURSELF

1. Name three grades of files.
2. Why should you never use a file without a handle fitted?
3. List four examples of files shapes.
4. What clamp is best used to clamp together a wide table top?
5. What is a web clamp best used for?

Maintenance and care of hand tools

- Do not drive nails directly into any part of the bench. Use clamps rather than nails to hold temporary cleats or blocks. If nails cannot be avoided, remove them as soon as they have served their purpose.
- When sawing or chiselling, protect the bench by using a bench hook.
- Always clean off spilt glue with a damp cloth before it sets.
- Do not strain the parts of a bench vice by using undue force in tightening the vice or by using it to hold work for morticing.
- Keep vice jaw faces clean and take care not to damage them when sawing.
- Protect work from damage by clamps with scrap plywood or hardboard.
- Do not use a hammer with a loose head. Fix it with the correct wedges first.
- Tighten a loose mallet handle by gluing veneer to the edge or side of the handle part that fits in the eye.
- Only use a nail punch for its proper purpose (i.e. punching nail heads) because if the recess of the tip is lost then the punch will not work as it is designed to.
- Always select a screwdriver to fit the screw slot snugly (Figure 8.49) and keep the tip of the blade ground square.
- Keep steel rules clean so that they can be read easily, and do not bend them unnecessarily.
- Steel tape measures should not be allowed to snap back into their case or be bent backwards until they click because this will shorten their life considerably as well as making them inaccurate.
- The thumbscrew of marking gauges should only be finger-tightened; over-tightening wears the stem and will eventually strip the thread or break the screw.

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- Keep the spur of a marking gauge sharp by filing the cutting edge on the forward side of the spur with a small file.
- Both spurs of a mortice gauge should be the same length.
- Keep sash cramps free of glue so they move freely, and ensure the adjusting pins are chained to the bar to prevent loss.
- Keep all files and rasps dry; these tools rust quickly, which destroys the teeth.
- Clean clogged files using a wire brush along the direction of the *cut* of the file.

When using sharp-edged tools

- Inspect used timber carefully and remove any nails or screws, especially broken ones embedded below the surface.
- Do not lay tools one on top of the other on a bench or in such a way that cutting edges may be damaged or timber parts of a project may get bruised.
- Replace tools in their rack or cupboard when they are no longer required.
- Saws, especially fine-toothed ones, are time-consuming to sharpen, and although they can be sharpened by a keen amateur, nowadays it is far simpler to take them to a professional saw sharpener.

Edge tools

Edge tools do their work with a cutting edge and include planes, spokeshaves, chisels, gouges, scrapers, saws, bits and brad awls. Frequent sharpening is necessary to keep them working efficiently and the various procedures are set out in this chapter.

First note these general principles for correct handling and use:

1. Never work with hands or fingers in front of a cutting edge.
2. Where possible, hold work in a vice or clamp it to the bench, leaving both hands free to control the tool.
3. Brush dust and grit from wood before beginning work.
4. Inspect used timber carefully and remove any nails or screws, especially broken ones embedded below the surface.
5. Do not lay tools one on top of the other on a bench or in such a way that cutting edges may be damaged. Use the well of the bench and lay planes on their sides and lay chisels so that they cannot roll. Face edges away from you.
6. Replace tools in their rack or cupboard when they are no longer required. Prevent rust on tools to be stored for a long period by smearing metal parts with nondrying oil, which must be wiped off before subsequent use.
7. A smear of camelia oil or wax on the toe of a metal plane will reduce 'drag' due to friction. Do not oil the face behind the blade because this will mark your work, and the mark will not be removed with the wood shaving. A rolled strip of felt placed in a round shallow tin so that its edge stands proud and soaked with raw linseed oil makes a handy lubricator over which to draw the toe of a plane.
8. Metal planes are equipped with screws and other mechanical devices for adjustment. Never use a hammer in setting or adjusting a metal plane.

Tool sharpening

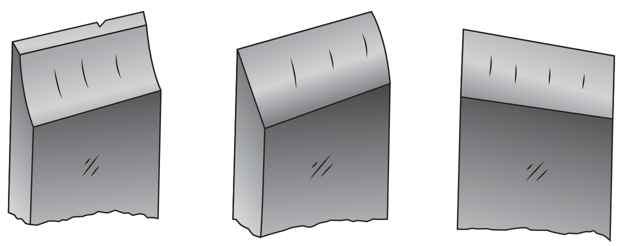
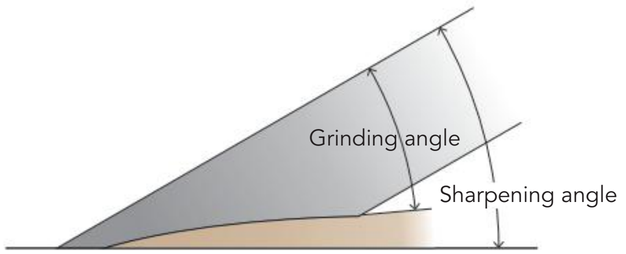


Figure 8.57 Chisels and plane blades need grinding if they are gapped, rounded or out of square

How to sharpen plane irons, spokeshave blades, chisels and gouges

1 Grind the edge on a grindstone or emery wheel only if it is badly gapped, out of square or rounded from frequent sharpening (Figure 8.57). If using an abrasive wheel, dip the tool in water frequently to avoid overheating, which will draw the temper out of the metal and soften the cutting edge. See Figure 8.58a for correct **grinding** angles.



Grinding angle for planes	20–25°
Sharpening angle for planes	25–30°
Grinding angle for chisels	25–30°
Sharpening angle for chisels	30–35°

Figure 8.58a Grinding and sharpening angles for edge tool blades

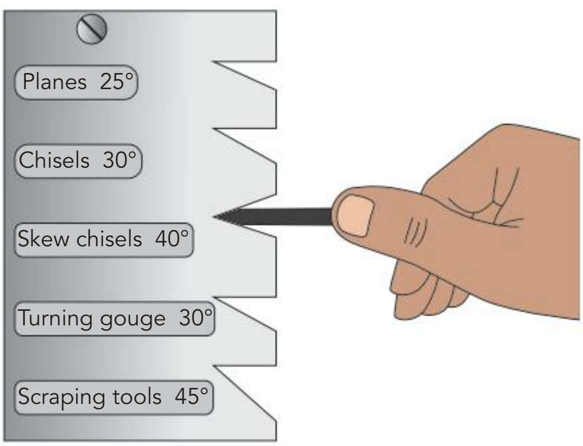


Figure 8.58b Gauge for testing angles

Alamy Stock Photo/Geoff Wilkinson

Figure 8.59a Maintain the chisel at the correct angle when grinding

Shutterstock.com/Dmitry Bodyaev

Figure 8.59b How to hold chisel for honing

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2 Grind the bevel to the required angle, moving it from side to side across the wheel to make an even cut (Figure 8.59a).

3 Next, **hone** the blade on an oilstone, waterstone or diamond stone using the correct type of lubrication to reduce friction and float out metal particles. Hold the blade bevel-side down at the correct angle (Figure 8.59b), rub it over the stone with circular or figure-8 motion. Carefully maintain the same angle throughout.

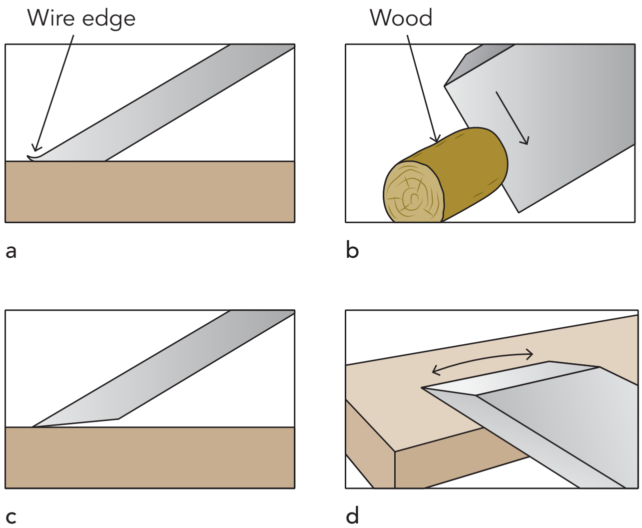

Figure 8.60 Steps in honing planes and chisels

4 Hone until a burr, or wire edge, is obtained (Figure 8.60 a).

5 Remove the burr by drawing the edge across the end grain of a piece of hard wood (Figure 8.60 b).

6 With the burr completely removed, the tool is ready for final honing to a very fine, sharp edge. Stroke the blade very lightly over a fine stone, using circular or figure 8 movements (Figures 8.60 c).

7 Reverse the blade occasionally and lightly stroke the face, holding it perfectly flat (Figure 8.60 d).

8 Sharpen moulding plane irons, scribing gouges and woodturning gouges with an oilstone slip.

9 Sharpen paring and turning gouges with a rolling movement on a flat oilstone, and hone the inside of the blade with an oilstone slip (Figure 8.61).

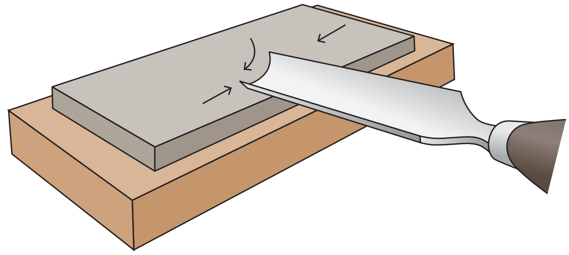

Figure 8.61 Sharpening outside of gouge blade on oilstone; inside is honed with oilstone slip

How to sharpen scrapers

Figure 8.62 shows the steps in sharpening a hand scraper. All scraper types cut by means of a burr formed on their edges by **burnishing**.

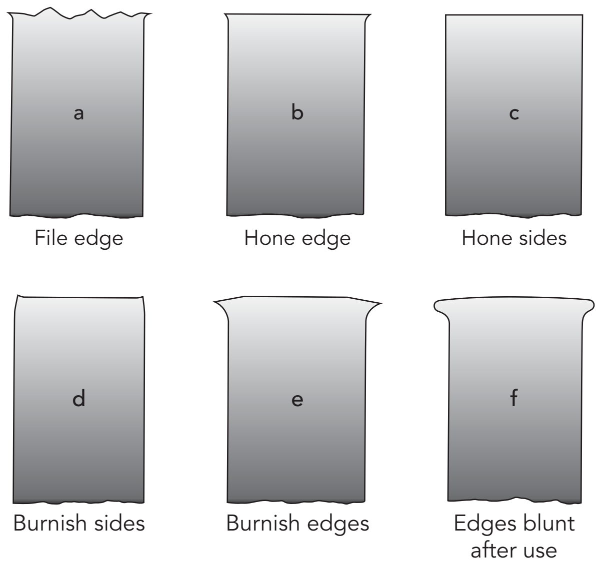

Figure 8.62 Sharpening hand scraper: **a** File edges straight and square with smooth file; file lengthwise; **b** Hone edge at 90° to face to remove file marks; lock wrist and use long stroke; **c** Hone sides on face of oilstone – this is the actual sharpening process; burnishing does not sharpen edge, but shapes it; **d** Burnish face flat; special burnisher shown was made from old rattail file, but back edge of gouge or nail punch is satisfactory; **e** Hold scraper in hand or vice and burnish edges at 5–10° to form burr; hand scraper may have eight cutting edges, which, if properly sharpened, should remove shavings, not merely dust.

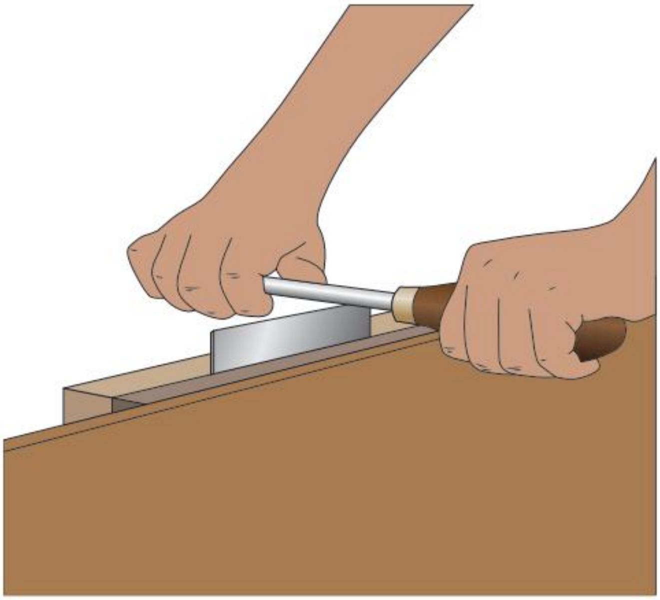

Figure 8.63 Using a burnishing tool to create a burr on the edge of a scraper

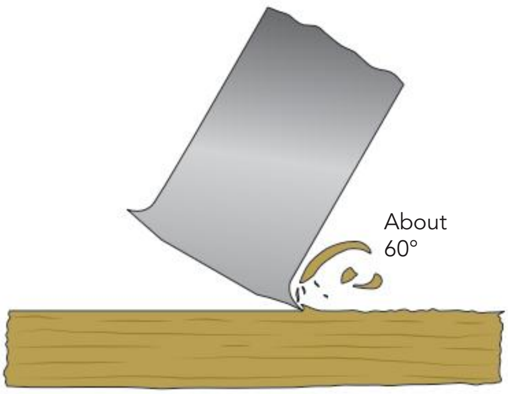

Figure 8.64 Magnified view of effect of sharpening hand scraper: fillet behind cutting edge acts like plane cap iron and curls shaving

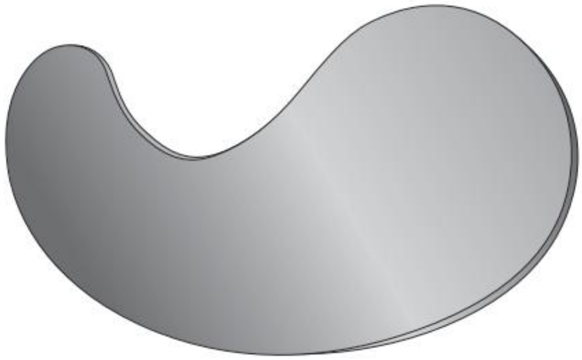

Figure 8.65 Hand scraper for curved work; in sharpening, take care to file smooth curves; use oilstone slip to hone concave edges, burnish as for rectangular scraper

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CHAPTER REVIEW QUESTIONS

1 When using a try square, from which edges of the timber must you mark?

2 What is the purpose of a combination square?

3 What is the purpose of winding sticks?

4 Distinguish between a marking gauge and a mortice gauge.

5 Define a 'pencil gauge'.

6 Identify two straight cutting saws mainly used on building sites.

7 Distinguish between a dovetail saw and a gentleman's saw.

8 Identify three curve-cutting saws.

9 List two different types of tools used for smoothing curved surfaces following the use of a curve cutting saw.

10 What determines the size of the saw?

11 Draw the shape of four crosscut saw teeth, approximately twice full size. State the angle at which the teeth should be filed.

12 Briefly state an appropriate use of each of the following:
- **a** panel saw
- **b** ripsaw
- **c** keyhole saw.

13 What is the purpose of a rasp?

14 What determines the size of a file?

15 List two common screwdriver heads.

16 Name two reasons why it may be necessary to grind a chisel.

17 Produce a simple sketch to show the position of the chisel on an emery wheel when sharpening it. Indicate the direction the wheel rotates.

18 Why are cutting tools honed after being shaped on the grinding wheel?

19 How is the metal wired edge removed during the sharpening process of a cutting tool?

20 Describe the process of sharpening a hand scraper.

CHAPTER

9

Power tools

Power tool technology has advanced rapidly in recent years. Ongoing research and development has created an environment of evolution in power tools. Improved battery life and increased power due to the development of brushless motors has seen the use of portable power tools increase in popularity over traditional mains-powered tools.

This chapter discusses the safe use of common power tools suitable for use by students in secondary school wood workshops.

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Key terms

amp hours (Ah) a unit of measurement for battery capacity; it is the amount of charge in a battery that will allow one ampere of current to flow for one hour

biscuits oval shaped pieces of compressed timber used to secure biscuit joints

brushless technology a DC electric power supply is directed through a circuit that produces an AC electric signal to drive a motor

collet chuck a chuck that forms a collar around the shank of a cutting tool to be held and exerts a strong clamping force when tightened

cordless no cord connected to mains power; a battery-powered tool

digitally of or relating to the use of computer technology

dominos timber plate that serves as the loose tenon in a domino joint

flutes the spirals in a drill bit that allow waste material to escape while drilling

grit-size paper the abrasive grade on abrasive paper; the lower the number the courser the abrasive

impact driver a tool that delivers sudden rotational and downward force. Used for driving in wood screws

induction electric current runs through a coil, generating a fluctuating magnetic field which induces many smaller electric currents in the connecting material

masonry refers to stone, brick, or concrete

orbits per minute (OPM) how rapidly a sander vibrates

oscillating travelling back and forth in a regular pattern

pilot hole a small drilled hole that helps guide an item, like a larger drill bit, or makes it easier to insert a wood screw

pilot-tipped bearing the bearing on a router bit that rests against the timber and runs along it, thereby maintaining a faithful shape

planes flat surface areas that are normally horizontal or vertical

plunge push down into; a plunge router allows the cutter to be pushed down into the project

tungsten-tipped (tungsten carbide) a hard and brittle metallic compound used on the tips of cutting tools

wireless charging charging batteries without a wired electrical connection

SAFETY

General safety topics such as PPE, safe conduct, and attitudes in the workshop are covered in Chapter 1.

General power tool safety

- Before plugging in and using any power tool, always visually check for any obvious problems, such as frayed power cords, an on/off switch that is 'sticking' or loose parts.
- Always report any faults or damage to your teacher. Do not use the tool.
- Check that any blades, cutters, drill bits, etc are secure before starting. If in any doubt, ask your teacher to check first.
- Ensure all adjusting keys and wrenches are removed before using the tool.
- Always securely clamp your project prior to working on it with a power tool.
- Never start the tool with the blade or cutter in contact with the work.
- Hold the tool securely when starting because the initial torque can cause the machine to twist.
- Do not overreach; good balance and stance are important for maintaining control.
- Keep all guards and dust collection bags in place when operating any machine.
- Do not obstruct the ventilation openings; this could overheat and damage the machine.
- Always keep hands clear and behind any cutting edges when operating the tool.
- Use overhead power sockets when available. Extension cords lying across the floor become trip hazards.
- Before switching on a power socket, always check that the tool itself is switched off. Likewise, switch the power off at the socket before inserting or removing plugs.
- Never pull plugs from a socket by the cord.
- Never carry a tool by its cord.
- Never attempt repairs on electrical equipment; this is to be undertaken by qualified people only!
- Avoid operating electrical tools if you have wet hands or are standing on a wet floor.
- If you feel the sensation of a shock, let go of the power tool immediately, and do not touch it until it is switched off and unplugged from the socket. Tell your teacher straight away.
- Always remove the plug from the socket when making adjustments and when you have finished using it.
- Avoid operating rechargeable power tools unnecessarily because the battery may be completely discharged when you need it; recharging takes time!

Power drills

Power drills are available in both mains and battery powered. Although most drills sold today are battery powered (or **cordless**) the mains-powered drill still has its place, especially when drills need to run at higher speeds and for situations where high-power is needed over a longer period of time.

The latest battery powered drills are generally available with a hammer drilling ability for **masonry**, an impact driver for driving screws and a two-speed drill.

Cordless drills are typically available in 12, 18 and 24 volts, with up to 6 **amp hours (Ah)** of power delivery.

There are specialist drills that have the chuck at 90° to the body for drilling in restricted places.

Common features

- Depth stop: a rod that can be adjusted to indicate when a certain drill depth is reached.
- Removable extra hand grip: used to steady the operation, achieve more accuracy and control, or apply more force.
- Two-position speed switch: use slower speeds for large holes and tough materials.
- Variable trigger speed switch or associated speed knob: as above, and good for gently starting a hole.

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Figure 9.1a A mains-powered drill

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Figure 9.1b A battery powered drill

- Adjustable clutch mechanism: useful when using a screwdriver bit to prevent over-tightening. May also be set to prevent driving screws too deeply into wood, especially particle board.
- Keyed or keyless chucks: keyless chucks are faster to use and have no key to lose but do not hold as tightly as a keyed chuck.
- Forward and reverse switch: useful for screwdriver bit use and jammed drill bits.
- Percussion or hammer drill switch: switchable for use on masonry.
- Lock-on button: used to keep the drill on thus freeing up your trigger finger.
- Carry strap: very useful; for example, when you need both hands free to climb up a ladder.

Proper usage

When drilling any material use a centre punch to make a small dent in the material. This will help to locate the bit and stop it from wandering off.

For accurate drilling, the drill and bit must be perpendicular in two **planes**. It is easy to see in one plane yourself just by standing back a little; however, you may find it useful to ask another person to look at the side view to guide you from that direction.

When drilling larger holes (>10 mm), first drill a **pilot hole** approximately half the size of the larger hole. Always clamp work when drilling large holes, especially in metal, because the drill can easily catch the metal and wrench it from the hand.

HINT

If drilling several blind holes to a certain depth, wrap masking tape around the drill at the depth you wish to drill to.

It is quite common to snap small drill bits when using a pistol-grip drill. It occurs because, when people push down on the hand grip, there is a tendency for the vertical grip to alter because the grip is not in line with the axis of the drill.

When drilling wood with a spade bit, feed the bit slowly until the full hole size has started then increase the feed to prevent the spade bit overheating. Stop drilling as the point of the spade bit just exits the wood, then turn the wood over and complete drilling from the other side. This stops the wood from splintering when the drill goes completely through the wood. Alternatively, clamp a piece of scrap wood under the wood that is being drilled to prevent it splintering.

HINT

Ease up on the feed pressure (pushing) when the drill is nearly through; this reduces splintering and increases accuracy.

When drilling, waste works its way up the **flutes** of the drill bit to escape. When drilling a deep hole regularly lift your drill to allow waste to exit and prevent overheating.

Apart from drilling holes, a variety of attachments allow a drill to perform more versatile operations, such as sanding discs on a rubber pad, polishing pads, drum sanders, wire brushes, hole saws and screwdriver bits.

SAFETY

- If possible, always clamp the project that is being drilled.
- Concentrate! Do not get distracted.
- Do not use your hand to slow down a drill chuck.
- Make all adjustments to the drill before plugging it in.

Impact drivers

An **impact driver** looks like a drill but is a very different tool, using both rotation and concussive force to drive a screw into wood. It has a collet that accepts ¼ inch hex shank driver bits (to insert or release a bit, pull the collet forward).

An impact driver is specifically designed to drive screws and bolts that would otherwise stall a normal drill. Capable of 2–3 times more torque than a drill, it is less likely to twist your wrist so you are less likely to get sore arms from using it. You are also less likely to strip screws, while being able to drive them with more precision.

Bosch

Figure 9.2 A battery-powered impact driver driving a lag bolt.

Jigsaws

Types

A basic jigsaw is relatively light-powered and has a blade with various methods of blade removal. Jigsaws come in both mains-powered (Figure 9.3a) and cordless varieties (Figure 9.3b). Jigsaws consist of an electric motor and a reciprocating blade which passes through a soleplate. The blade is narrow, making it ideal cutting curves. However, this also makes it less accurate for straight-line work, even when running the soleplate along a straight edge. Jigsaws are designed to cut on the upstroke which keeps the soleplate firmly on the wood being cut. However, there are specialty blades, such as laminate cutting blades, that cut on the downstroke instead. Speeds range between 500–3100 strokes per minute (SPM) and power between 400–720 watts.

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Figure 9.3a A typical mains-powered jigsaw

Makita Tools

Figure 9.3b A typical cordless jigsaw

Another type of jigsaw is the reciprocating saw which keeps the blade aligned to the motor so that only a small soleplate is required. This type is very powerful and useful for cutting flush to another surface, pruning trees, cutting thick timber (even cutting out holes in walls for doors/windows), and cutting light steel and pipes. It is widely used in the construction industry by plumbers and renovators. Reciprocating saws come in both mains-powered and cordless varieties (Figure 9.4).

Speeds range between 0–2500 SPM and power between 590–1020 watts.

iStockphoto.com/ElephantCastle

Figure 9.4 Battery-powered reciprocating saw

Common features included in jigsaws

- **Oscillating** or pendulum feature, which backs the blade away on the non-cutting downstroke.
- An adjustable soleplate (base), which facilitates bevelled cutting along the timber.
- Variable or two-speed facility, which allow matching the cutting speed to the material's hardness.
- Motor lock-on button, for extensive use.
- Attachment guide for straight-line work.
- Built in LED lights for illuminating the work.
- Suction devices to collect waste.
- A considerable range of blades are available including those that cut aluminium, thin steel, plastics, wood, plywood, leather and card. There are blades designed for fast cutting, narrow blades for tight curves, long blades for thick timber (120–375 mm for reciprocating saws; 80–130 mm for jigsaws), diamond dust-coated blades for ceramics and hard materials, and long flexible blades for cutting flush with other materials using a reciprocating saw.

Proper usage

First install the appropriate blade for the job at hand and select a suitable speed; all while the saw is unplugged. With materials like plywood, it is a good idea to experiment on waste first to see if the blade splinters the material. Generally, when using a jigsaw, draw a pencil line of the exact required part, then use the jigsaw to cut as near as possible to the waste side of the line without touching it. This leaves the minimal amount to file or sand off afterwards. Be aware; however, that sawing thicker items can cause the saw blade to bend and undercut into the project.

If a hole is required in the middle of a piece of timber, for example to mount a loudspeaker, first drill a 10 mm hole in the middle of the waste then insert the saw blade through the hole. Ensure that the blade is not touching any material when it starts because it may snap the blade. Ease off on the pressure and feed during the last 15 mm of the cut to prevent a large splinter breaking off and to stop yourself from lunging forward when the blade suddenly clears the material. Support the loose material with your free hand well clear of the blade.

Never lift a jigsaw with a moving blade because it will normally come down and hit the material, damage it and break the blade.

When using a reciprocating saw, fit the desired blade and select a speed (similar to the jigsaw), with the power plug removed. Position the blade close to the material being cut, start the motor and allow it to attain full speed before starting the cut. Do not apply too much pressure or the blade will bend, twist or snap. When cutting metal use a coolant (cutting oil) or the blade will wear rapidly. Ease up when you are near the end of the cut.

SAFETY

- Always clamp the work when using a jigsaw.
- All adjustments should be made with the cord unplugged.
- Concentrate! Do not get distracted.
- Never lift the saw out of the material while the blade is moving.

CHECK YOURSELF

1. Why must a power tool be turned off and unplugged when adjustments are made?
2. What PPE must you wear when using most power tools?
3. What is the difference between a cordless power tool and a mains-powered tool?
4. What does the oscillating feature on a jigsaw do?
5. Why should you always clamp the project when using a jigsaw?

Portable biscuit joiners

Biscuit joiners (or plate joiners) have proven to be fast and simple tools for producing mechanical joints, that are stronger than the basic butt joint (Figure 7.41). They are basically plunge-cutting circular saws with a guide that cuts a segment-shaped groove in marked positions in both pieces of timber to be joined. Pre-cut **biscuits** of compressed wood are glued into the slots to complete the joint. There are three different sizes of biscuits available for different widths and thicknesses of material. The biscuits are made by being pressing with a die, so they are in a compressed form, and when the glue is applied and the joint is clamped, the biscuits expand in the slots, making a strong joint. The slots are 1–2 mm longer than the biscuits, which allows for adjustments before clamping (Figure 9.5).

Proper usage

First, the two mating pieces of timber must fit together accurately, regardless of whether it is as a widening or angled joint. Next, the two pieces of timber are placed together and a pencil is used to simply mark across where the wood pieces are positioned – at roughly 200–300 mm intervals. Once the positions are marked, the height of the cutting blade is set to approximately the middle of the timber thickness and the depth of cut is adjusted to suit the biscuit size – ‘0’, ‘10’ or ‘20’.

HINT

- Carefully plan the outer biscuit positions if the project is to be further shaped; otherwise, you might cut through and expose a biscuit!
- With careful planning, two biscuits may be positioned above each other if extra joint strength is required. This is achieved by setting the guide to cut a slot closer to one surface then turning the wood over and repeating from the other side.

The adjustable fence can be removed if biscuiting in the middle of a piece, such as in a fixed shelf, and a clamped guide can be substituted. Secure the wood, then locate the biscuit joiner so it line ups with the marks you made on the timber. Hold the joiner so it does not tilt, or it will cut at an angle and later be difficult to assemble the project. Start the motor (it is normally a spring-loaded switch), and when the tool is up to speed, push inwards to make the cut then pull straight out, releasing the motor power switch as well. If you make a mistake, glue in a biscuit, wait for it to dry, then plane off the excess and start again.

Alamy Stock Photo/SoloStock Industrial

Figure 9.5 An example of a portable biscuit joiner

A dry fit can be made, if required; however, sometimes the biscuits are hard to remove. Use pliers and pull from one end rather than the middle. When gluing, ensure glue goes in the biscuit joints (use a paddle-pop stick) and the whole surface area being joined, then clamp the joint to squeeze out all the excess glue. Wipe up excess glue and clean with a wet cloth two or three times (rinse the cloth each time) to avoid glue stains.

SAFETY

All adjustments must be made while the tool is unplugged.

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Domino joining system by Festool

This tool is a cross between a biscuit joiner and a router and is versatile and simple to use. The system consists of a precision joiner and oval-shaped **dominos** which used together create mortise and tenon joints (Figure 9.6). The joining system works on the principle of routing a mortise in each workpiece to be joined, then using a domino to act as a loose tenon to connect the two workpieces. The cutting action combines cutter rotation with an oscillating movement while being plunged. The result is a precisely cut mortise rather than a single round hole. The joiner uses four different sizes of **tungsten-tipped** spiral cutters in 5, 6, 8 and 10 mm diameters and will rout mortises between 12–28 mm.

Tool Technic Systems

Figure 9.6 Festool domino joining system

Routers

The portable electric router is a precision power tool with a wide range of applications. Once set up, the router facilitates the fast and accurate production of intricate joints, decorative cuts and shaped edges. It can be used freehand or with the aid of guides and templates. Routers vary in size and power depending on the types of operations for which they are designed. Routers are named by their motor and chuck size. A small capacity router with a 6 mm collet chuck and a 440 watt motor would be used for fine work such as edge trimming (Figure 9.7a). At the top end of the scale, a router with a 2300 watt motor and a 12 mm collet chuck would be used for large cuts (Figure 9.7b). The speed of a router also varies with its capacity; for example, some edge trimmers rotate at 28 000 rpm and others at a maximum of 18 000 rpm; the average 1500 watt router rotates at about 23 000 rpm.

Newer electronic routers have a speed control which varies the speed between 8000–18 000 rpm and holds the cutting speed steady while the cut is being taken.

The **plunge** router (Figure 9.7b) allows the cutter to be lowered into the timber in a plunge type cut. The advantage of the plunge router is evident in joinery template operations where lots of material has to be removed. These include trenches, housings, tenons, mortices and template work. A cut can be started in the middle of a piece of timber, while a fixed-base machine has to be tilted to ease the bit into the cut, often resulting in loss of control and unsafe routing.

Getty Images/Hemera/Greg Epperson

Figure 9.7a Trim router

Shutterstock.com/Oleksandr Chub

Figure 9.7b Large plunge router

Table 9.1 Types of routers

Small (trimmers)	Medium	Large
6 mm chuck	12 mm chuck	12 mm chuck
From 440 watts (0.55 hp)	Approx. 1000 watts (1¼ hp)	Up to 2300 watts (3 hp)
Approx. 28 000 rpm	Up to 24 000 rpm	Up to 24 000 rpm
Fixed base	Plunge/ fixed base	Plunge
See-through base	Electronic soft start, constant torque electronics, variable speed, dust boots	Electronic soft start, constant torque electronics, variable speed, dust boots

Proper usage

SAFETY

The base of a router is quite open because it is necessary to see where you start and finish a cut. This brings your face quite near to the machine. The screaming noise that occurs when routing can damage hearing, and the dust that is created is quite considerable. When using a router, always wear appropriate PPE for your face, eyes, ears and breathing. This also applies to people near the area where the machine is being used.

Shutterstock.com/Monstar Studio

Figure 9.8 Collets

Chuck

Routers use a **collet chuck**, which tightens down onto a parallel shank. The diameter of the shank varies. A cutter must fit exactly into the collet. Be careful when selecting the correct size cutter for the collet because there are two standards of measurement used – imperial and metric. An equivalent metric cutter should not be used in an imperial collet because a 6 mm cutter shank is smaller in diameter than a ¼ inch (6.35 mm) shank. The cutter may work loose causing an accident. The most common imperial collet sizes are ¼, ⅜ and ½ inch diameters. The most common metric collet sizes are 6 mm and 12 mm.

There are two main types of collet chucks for the router, the split and the fingered collets. The fingered collet provides more holding power.

When setting the router up for use, insert the desired cutting bit and set the required depth of cut. Be careful when undertaking both of these activities and ensure that the cutting bit and depth of cut are locked firmly or it could result in the bit working lower into the wood. Prior to tightening, seat the bit fully in the collet chuck then pull it out about 2 mm.

HINT

All routers turn clockwise as viewed from the top and rotate about 10 times faster than a portable power drill. (This is why a drill cannot be used as a router.) If a router was set up with a cutting bit and introduced to a piece of timber to be pushed and cut freehand, it will always tend to veer off to the left. This is important so you can always work out where to place a guide to help maintain a straight cut.

Guiding the router

Five ways to guide a router are detailed below.

1 Use a clamped guide for the router to run along. Ensure the guide extends at least 100 mm before and after the wood being cut so that the router is straight when it enters and exits. Make sure the guide is low enough and wide enough to clear the clamps.

   The guide should be clamped on the left of the router as it is pushed.

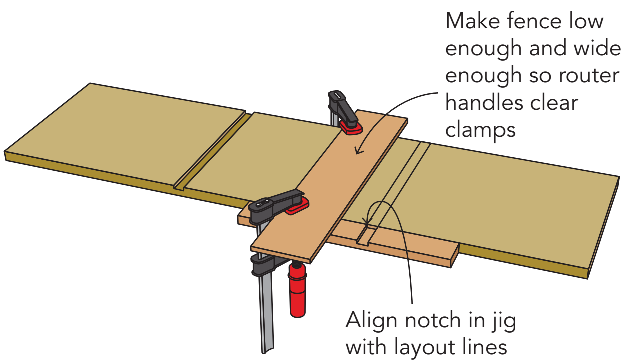

Figure 9.9 Using a clamped guide for the router to run along.

2 Use the guide attached to the router base. This requires that the guide be on the right side of the router so it remains against an accurate edge of the timber. Some woodworkers fix a wooden extension to this type of guide for extra accuracy.

Figure 9.10 Using a guide attached to the router

3 A **pilot-tipped bearing** on a bit allows cuts, such as fancy edging, rebating and trim flushing to be achieved because there is a ball bearing, of various sizes for different effects, mounted underneath the cutter. It is the bearing that rests against the timber and runs along it, thereby maintaining a faithful shape. If stopping at a corner in a piece of wood, approach it very slowly so that the bearing does not roll around the corner. If proceeding with the cut around the corner, be aware that three-quarters of the router may be unsupported and wobble. Before starting a cut, always check that the bearing is adjusted to wholly rest against the timber, and that it is in good condition and running smoothly when spun by hand. Always travel in an anti-clockwise direction when routing round the outside of an object; however, go clockwise if routing around an internal panel; for example, running a rebate for a glass insert in a table.

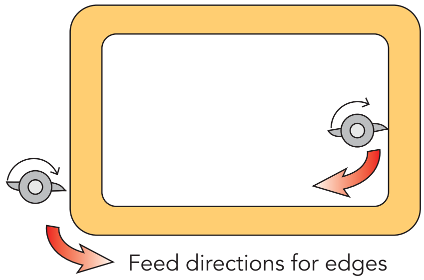

Figure 9.11 Correct feed direction for router

4 A template chaser is a system used when shapes (generally of a curved nature) are being reproduced repetitively. This system is a positive guiding device that does not allow the cutter bit to wander off in any direction other than that which is required. A flanged tube is mounted under the baseplate (guide bush spigot) and a special template is made that allows the tube to only run along a pre-set path and distance. The cutter protrudes through the middle of the spigot routing as it is moved. The entire jig must be securely clamped to the workpiece.

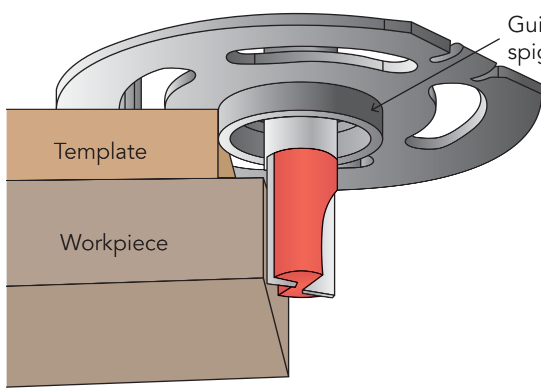

Figure 9.12 A template chaser system for a router

5 Freehand routing is used to rout out an area of wood to a certain depth. It could be used for inlay work, relief or recessed work, and lettering. If routing out an area larger than the router baseplate, always start in the middle and work outwards.

If you prefer, routers may be pulled towards you rather than pushed away. Remember; however, that the router's tendency to drift left will now be reversed so it will drift right as you view it – make allowances accordingly.

Routers may be used with other apparatus, such as dovetailing jigs. These jigs are very accurate and especially useful when making a large number of joints. One example is the Gifkins dovetail jig which works by setting the router up in a router table and clamping the project to the jig making it quick and easy.

Image courtesy of Gifkins Dovetail [www.gifkins.com.au]

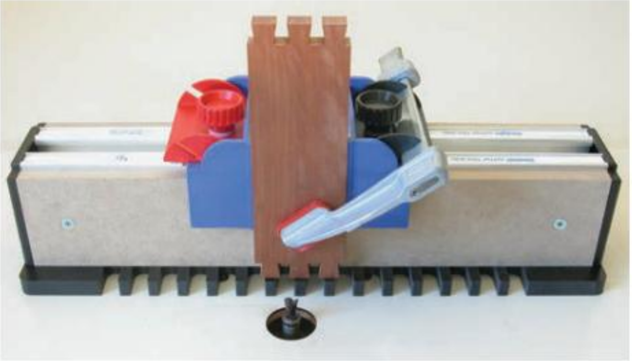

Figure 9.13 A Gifkins dovetail jig

Router bits (cutters)

The most popular material for the cutting tips of a bit is tungsten because it is inexpensive and long-lasting. High speed steel (HSS) is cheaper but blunts more quickly on hardwoods. Solid tungsten can be used for small bits, but is very expensive. Ceramic cutters are available – but normally only in industrial situations because they are brittle and very expensive.

The shank sizes come in metric or imperial sizes; make sure you use the correct size for the collet in your router. The most common metric shank sizes are 6 mm and 12 mm. The common imperial sizes are ¼ inch ½ inch. Less commonly you may find 10 mm and ⅜ inch shank sizes.

Types of router bits

- Straight: used for trenches, grooves, rebates and tenons.
- Fancy edge profiles: normally have a pilot-tipped bearing type in a large range, such as ovolo, roman ogee and beading.
- Other pilot-tipped types: such as rebate (rabbeting), flush trim and coving.
- Cabinet door set: matching interchangeable parts for door frames and panels.
- Other non-pilot types: such as vee (various angles), rounded (various hollows) and finger jointing.

General uses for routers

Factors that affect cutting are:

- how fast the feed is
- the depth of cut
- the size and sharpness of the bit
- the moisture content and hardness of the wood.

Experience and the sound that the router makes will indicate whether you should increase or decrease your feed speed or take multiple cuts (for example, half-depth followed by full depth). If the feed is too slow, it may burn the timber; if it is too fast it may leave rough edges. To avoid splintering when exiting an edge, scrap wood should be clamped at the same height to protect the joint.

Before plugging in and using the router, familiarise yourself with the grip and practise switching it on and off, as well as locking and unlocking the plunger. Practise on scrap wood if you are unsure of how a cut will look. Be certain the work is securely clamped; two clamps are far better than one, which may spin during the routing operation. When starting a router, make sure your feet are in a well-balanced position and hold the router firmly because initial torque will tend to twist it out of your hands. The soft-start models avoid this problem by initially lowering the current surge to the router. In general, the router should be moved along the project so that the speed of the motor does not slow by more than a third.

Ensure that the bit is clear of the wood before starting the router. When routing along an edge, remember that half of the router weight is hanging out over the edge of the work piece so apply more downward pressure on the side of the router that is resting on the wood.

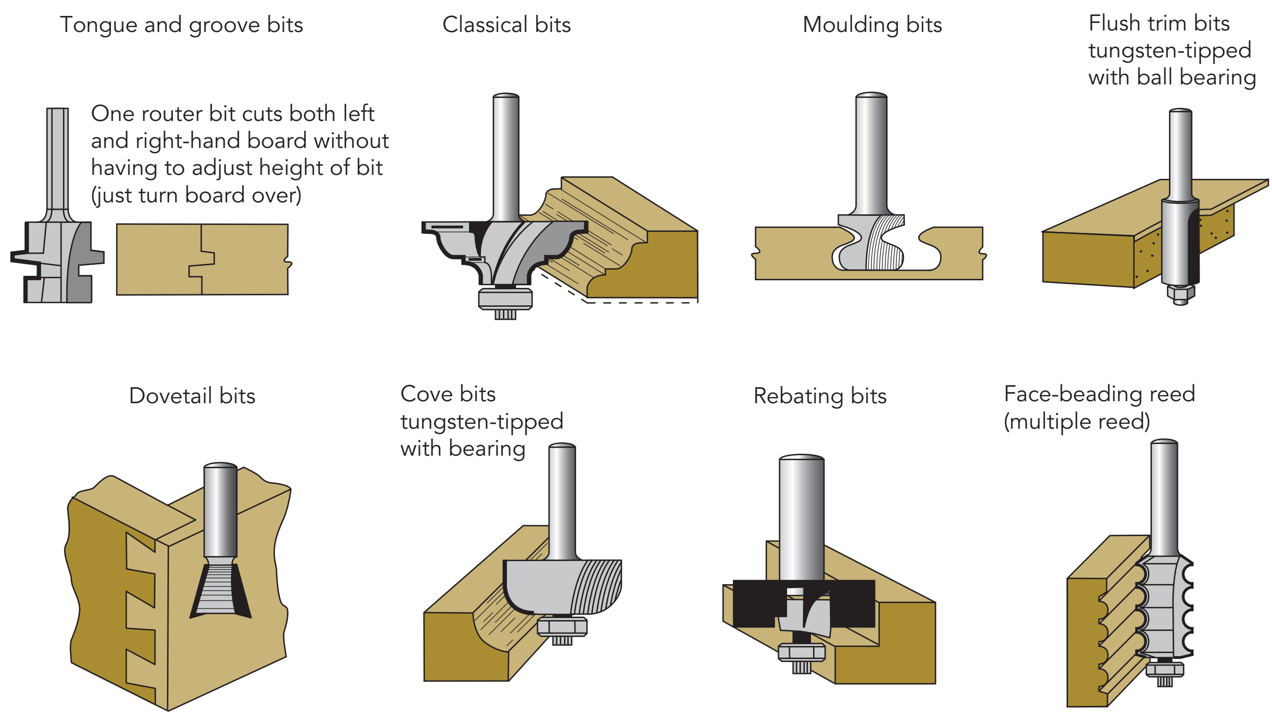

Figure 9.14 A small sample of the large range of router bits available

HINT

When possible, clamp a piece of scrap wood, of a similar thickness, approximately 30 mm from the work piece. This will provide support for the the outer part of the router base. Make sure the scrap wood does not interfere with the router bit.

SAFETY

- Always wear appropriate PPE equipment for eyes, ears and breathing.
- When you have finished making a pass, if the bit is still within the wood (for example, a stopped housing) move it back about 2 mm and keep it perfectly still until the bit has stopped before lifting it out of the wood. Once this is done, face the bit away from you, rest it on the bench, switch off the machine and remove the power plug. If the bit is clear of the wood, lift it, switch the machine off and hold it with the bit away from you until it is stationary.
- When possible, use power sockets suspended from the ceiling to avoid trailing extension leads. Ensure the cord is in no danger of being caught in the router; drape it clear.
- Bits are very sharp! Use caution when handling them.

Sanders

SAFETY

Dust particles from a sander are very dangerous when inhaled. The dust contains not only the abraded timber but also a significant amount of the abrasive used. Good quality sanders come with a dust bag which helps remove a lot of the dust; however, better-designed machines are equipped with an extraction system, such as the unit shown in Figure 9.17.

The use of abrasives on timber is very important to correctly finish a project. Hand-sanding with a cork block provides an excellent finish but requires a lot of effort and time. The portable power sander achieves the same finish with much less exertion.

Three types of portable power sanders are available, and are almost essential when a professional finish is desired.

Belt sanders

Belt sanders are commonly used for initial heavy sanding. They can remove splinters, paint (this may clog the abrasive belt) and marks left from hammers and saws. Belt sanders should be used along the grain of the wood (Figure 9.15).

Belt sanders have a drive roller to rotate the belt and a free-running roller that is made slack by a lever, which allows the belt to slip on or off from one side of the machine. The lever then re-tensions the belt and a knob can be adjusted to centralise the belt over the rollers. (Note: the belts must only be fitted one way due to the overlapping join process – arrows are typically printed on the inside of the belt to indicate which way.) Belt sanders are sold in various lengths and belt widths.

Proper usage

Ensure the power switch is off before plugging in; otherwise, it may begin to run and could fall off the bench. Check the belt is tracking properly before attempting to use it. Raise the sander above the project before switching on and lift it off the project before switching off.

Make sure the workpiece is secured to the bench in a position that facilitates sanding with the grain. The belt sander is used with the grain when sanding faces and edges. Depending on the state of the surface to be sanded, it may be necessary to start with a coarse grit (No. 60), switch to a medium grit (No. 80) and finish with a fine grit (No. 100). At this point it is advisable to use the straight line finishing sander. Some hand sanding with a sanding block may also be necessary.

For sanding a large surface, refer to the belt sander travel diagram, see Figure 9.15. Pressure should not be applied to a belt sander and it should always be kept moving, or it will create an uneven surface. Some manufacturers provide a special sanding shoe, which is a narrow surrounding guide for extra smooth flat sanding.

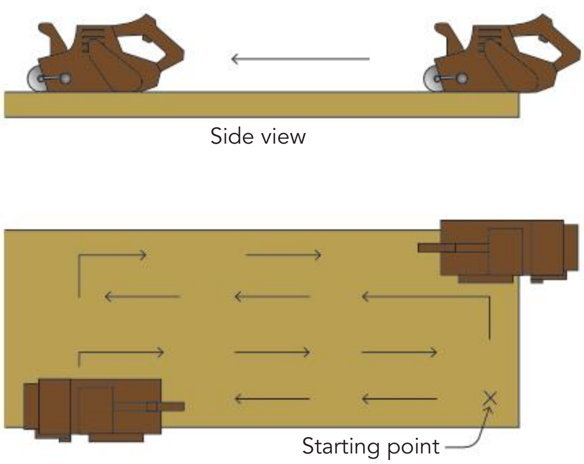

Figure 9.15 Method for using belt sander on large surfaces

SAFETY

- Wear appropriate PPE – in particular a dust mask or respirator (especially if sanding timber that has been coated with resin paints, lacquers etc.).
- If the machine has a dust bag, ensure that it is operating and empty the bag regularly (keep your mask on while doing so).
- Be aware of the power cord; it is easy to get it caught and dragged into the machine by the belt.

Shutterstock.com/Aliaksandr Yarmolovich

Figure 9.16 A standard belt sander with dust collection bag

Finishing sanders

Finishing sanders are designed for final finishing and are either orbital or oscillating in motion. A sander with a straight-line reciprocating action creates a better surface finish than an orbital sander because the orbiting action tends to leave circular scratches on the surface.

Combination finishing sanders are available with a switch allowing the selection of either straight line or orbital action.

Finishing sanders (Figure 9.17) are available in a range of sizes with variations in:

- motor power: 130–620 watts
- size of sanding surface: ¼–½ sheet of abrasive paper; plus special shapes for round and triangular palm sanders (Figure 9.18)
- **orbits per minute (OPM)**: 7000–22 000 OPM
- diameter of the orbit: 2–5 mm; giving a finer cut with smaller orbits
- weight of the machine: 1–3 kg.

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Most finishing sanders today use velcro peel-off abrasive sheets with holes to allow for dust extraction. There are three basic actions that finishing sanders perform; orbital, which removes material fastest; random orbital, which leaves fewer marks than the regular orbital type; and the straight-line reciprocating type, which creates the best surface finish because it is not travelling across the grain. To achieve an excellent finish, it is necessary to work through a range of **grit-size paper** starting with rough (80 grit) then medium grit through to fine (220 grit).

iStockphoto.com/pidjoe

Figure 9.17 Rectangular finishing sander (note the dust bag connected)

Shutterstock.com/Jaromir Klein

Figure 9.18 A small finishing sander with a shaped pad for sanding into tight corners

Proper usage

- Avoid pressing down because the motor will overheat, the surface will scratch and the abrasive paper might wander or shed particles on the work.
- Start and stop the machine in the air rather than on your work because it may leave a mark.
- Do not use the sander on small or narrow projects. If the baseplate is bigger than the project, the edges will be rounded off.
- Keep three-quarters of the baseplate on the work when sanding near an edge or rounding will occur.
- When not using these sanders, rest them on their side to prevent grit and so on from attaching to the abrasive paper and marking the project when they are used next.
- Always clamp the work to a bench to prevent vibration moving it.

SAFETY

- Wear appropriate PPE – in particular a dust mask or respirator (especially if sanding timber that has been coated with resin paints, lacquers etc.).
- If the machine has a dust bag, ensure that it is operating and empty the bag regularly (keep your mask on while doing so).

Bosch

Figure 9.19 A random orbital sander connected to a dust extractor.

Compound mitre saws

Compound mitre saws are used to cut mitres and dock timber to length (Figure 9.20). It is for use by senior students (with permission) and teachers only.

There are two common types of compound mitre saws.

Stationary compound mitre saws, also known as drop saws, are specialised saws which cut more than simple mitre angle cuts. A compound mitre saw can tilt the blade to the side as well, which results in a 'bevel' cut. Because the blade can be tilted at two angles at once, it is referred to as a compound cut, a mitre cut and a bevel cut.

The disadvantage of a drop saw is that the width of the cut is limited by the diameter of the saw blade.

A sliding compound mitre saw can also have the blade tilted in two angles but can slide as well allowing for wider boards to be cut, generally up to 300 mm in width.

Shutterstock.com/pryzmat

Figure 9.20 A typical sliding compound mitre saw

The drop saw is an excessive sound polluter and requires ear protection for those in close proximity.

SAFETY

- Only senior students (with permission) and teachers are allowed to use this machine.
- Always wear appropriate PPE for eyes and ears.
- Ask your teacher for permission before using the saw.
- Hands must be kept 150 mm from the blade.
- Do not cut timber less than 150 mm in length.
- Only crosscutting allowed, no rip cuts.
- Make sure the table and fence are clear of sawdust.
- Securely hold the work piece against the fence and make sure the blade is clear before switching on.
- Use dust extraction where possible.

Portable planers

The portable power planer is virtually a portable electric jointer. An electric motor is mounted in a lightweight metal or plastic frame and a barrel, fitted with cutters, is belt driven to produce a cutting action. Some planers have one spiral cutter blade but most have two straight blades.

Planers are available in mains-powered and cordless varieties. They are available in a range of sizes; from a small block plane weighing less than 2 kg with a 40 mm blade to the largest planer weighing 9 kg with a 170 mm cutter. The cutter head rotates at speeds ranging between 12 000–25 000 rpm.

Shutterstock.com/Kislitsin Dmitrii

Figure 9.21 A typical mains-powered planer

Operating adjustments

The body of the planer is an integral part of the rear fixed sole with the cutter blades set level to it. The front sole is adjustable and typically has marked calibrations or settings to indicate the depth of cut.

Some planers are supplied with a guide which allows you to plane rebates. An adjustable fence may also be attached to facilitate the planing of bevels. Newer planers allow you to choose left or right dust bag connection; therefore, the dust and debris can be collected no matter which side of the workpiece you are planing from.

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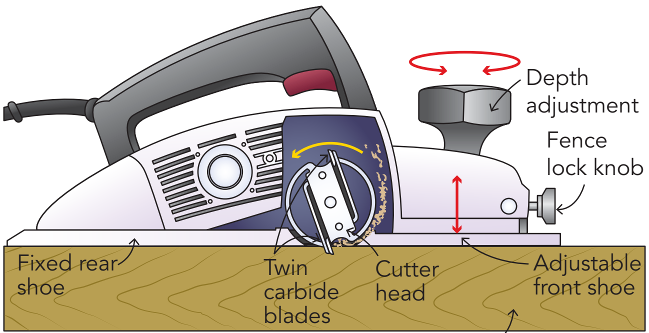

Figure 9.22 Sectional view of a portable power planer

Using a planer

Adopt a similar stance to that used for normal hand-planing, with feet comfortably apart and the body balanced. But here the similarity ends, as a firm and steady forward movement is required. Apply pressure to the front of the plane for the start of the cut and transfer it to the rear sole at the end of the stroke so that the plane remains level. Always allow the motor to reach full speed before proceeding with the cut.

SAFETY

- Not for student use in NSW secondary schools.
- Always wear appropriate PPE for eyes and ears.
- Always check for correct cutter depth adjustment prior to making a cut.
- Check for the correct bevel adjustment prior to making a cut.
- Do not attempt to remove or sharpen the blade or cutters without carefully reading the manufacturer's manual.
- Check timber for loose knots, or the presence of nails or foreign objects that will damage the blades.
- Check grain direction to ensure a smooth cut.
- Always keep the power lead away from the surface to be planed. Position the lead over your shoulder to avoid contact with the machine.

Emerging power tool technology

Today's cordless power tools rival traditional corded models in every category. The development of lighter, more powerful batteries that last longer has led to a dramatic development in these, much more portable power tools. Along with **brushless technology,** they now offer similar torque and speed in a package that keeps getting lighter and better, all the while providing longer usage on a single battery charge and with the convenience of no electrical cord.

Getty Images/Business Wire

Figure 9.23 A typical set of cordless power tools a tradesperson would use

Recent innovations in connectivity and charging technology are pushing power tools even further into the realm of high-end electronic devices. New battery technology is helping to solve the problems faced by tradespeople on building sites by making them easier to charge and harder to lose, as well as giving the operator more control over the features of the tool.

Wireless charging

The time lost by professionals having to recharge or change the batteries in their cordless power tools can be frustrating; removing the battery from the tool then plugging it into the charger takes time. The development of **wireless charging** allows the user to simply sit the tool on the charge base when they are not using it and it will recharge the battery. This type of charging is based on the concept of energy transfer, just like an **induction** cook top on your stove. When the battery is placed on the charging platform it wirelessly transmits an alternating magnetic field to the battery which produces a current flow to charge the battery.

The introduction of brushless technology allows manufacturers to control torque, speed and clutches **digitally**. These power tools can be connected to a smartphone via Bluetooth. Once connected the tools can be customised, allowing users to use pre-determined set-ups for different fasteners and materials – or even completely customise their own profile with torque and speed settings for the application at hand. The battery can be locked to one user, located if lost and disabled if stolen. A manager can remotely view all the information from the project site (with all tools on site checking in). They can even create a project report documenting any incidents that may have occurred. You can also keep track of when tools have been used and which tools are due for routine maintenance.

Power tool innovation

Weblink

Bosch

Figure 9.24 A Bosch cordless drill sitting on a wireless charging mat

CHAPTER REVIEW QUESTIONS

1 When using any power tool, state three things to do or check before plugging in the power lead.

2 Explain what percussion action is on a drill and provide an example of its use.

3 When drilling thin material, why is it important to clamp the material to prevent it moving?

4 Define a 'blind hole'.

5 What is a common reason for snapping small drill bits when using a portable power drill?

6 a With jigsaws, in what direction is the blade going when cutting?

b What is a narrow blade best suited for?

7 What type of saw, mentioned in this chapter, is best for pruning trees out in the paddock?

8 What advantage does a biscuited joint have over an ordinary butt joint?

9 What is a common reason for cutting a biscuit slot at an angle rather than straight?

10 What would a trimmer router be particularly useful for?

11 What is the name of the chuck found in routers?

12 a In relation to routers, what does 'soft-start' mean?

b How is it beneficial?

13 What rotational direction do routers travel in if you are looking up from the cutter-bit end of the router?

14 Outline three methods of guiding a router.

15 From what material are the cheapest router bits made?

16 How can you prevent a router bit from chipping out the last part of a rebate?

17 Routers can turn at 28 000 rpm so safety is very important. When you stop using the router after cutting a groove across a piece of timber, what is the safest way of finishing using the router?

18 Are belt sanders useful for fine cabinet work? Where might you use them?

19 Are finishing sanders good for sanding slim table legs? What grit would you use first: 80 or 180?

20 What does OPM mean with regards to finishing sanders?

21 What type of sander will give the best finish and why?

22 Explain what an orbit is when talking about finishing sanders.

23 Discuss how brushless technology has improved the use of portable power tools.

CHAPTER

10

Machines

Machines are an important and often essential part of any woodworking workshop. When the appropriate machine is used correctly by a practiced woodworker, the scope for beautiful and useful projects is almost limitless.

The use of machinery can be timesaving but the user must be safety conscious at all times, not only of your own safety but the safety of people around you.

This chapter deals with the safe usage of machines commonly found in schools and used by Years 7–12 students for sanding, cutting and shaping wood.

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Key terms

3D printing an additive process that builds up a 3D shape from a three-dimensional digital model (CAD drawing) by laying down multiple layers of material

automated assembly robotic movement of materials and assembly. Automated quality control and product testing

automated fabrication parts fabricated on numerical control and flexible manufacturing systems involving control and movement of material

automated warehousing robotic movement of material for storage and order picking. Automated order picking and shipping

CAD/CAM software used for designing and manufacturing of products

computer integrated manufacturing (CIM) the use of computer-controlled machines and automation systems in manufacturing

dust extraction removal of solid particles suspended in the air and deposited in a capture bag or bin for disposal

laser cutting a non-contact process that works by focusing a laser through a nozzle onto the work piece resulting in high quality and extremely accurate cuts

linisher a belt sander

machining centres A CNC machine that includes an automatic tool changer and a table to clamp the material being machined

metal fatigue weakening of the metal due to repeatedly applied loads

mortising cutting a hole in a piece of wood – normally to fit a tenon into it

nesting arranging shapes to be cut in such a way as to minimise waste and maximise the number of items that can be cut from one sheet

pre-drilling to drill the holes in advance

push board a length of material used to push timber (generally thinner than the stock being machined) through a thicknesser

push stick a notched piece of wood used to feed timber into a machine to prevent the operator's hands getting too near the machinery

rapid prototyping the fabrication of a scale model of an object using CAD data usually achieved using 3D printing

raster closely spaced rows of dots that form an image used for etching or engraving with a laser

reciprocate to move back and forth in an alternating fashion

resaw cut a board to thickness. This allows you to get a number of thin boards out of one larger, thicker piece of wood

Velcro two thin pieces of material sheet, one covered by tiny hooks and the other with tiny loops, which stick to each other when pressed together

water jet cutting cutting using a very high-pressure jet of water, or a jet of water mixed with an abrasive (usually garnet)

General machine safety

Fixed or stationary woodworking machines are safe when proper precautions are observed. Specific precautions are included in the sections dealing with individual machines. The following general safety rules apply to all machines throughout the chapter.

1. *Seek permission*. Always obtain permission from your teacher or instructor before operating any machine.
2. *Specific safety rules*. Read the instruction manual for any machine you wish to use and make yourself familiar with all special precautions that may be necessary.
3. *Eye protection*. Always wear safety glasses or goggles when operating power machines.
4. *Hearing protection*. Always wear earmuffs or earplugs to avoid hearing damage when working on or near noisy machines.
5. *Jewellery*. Metal rings on your fingers can be dangerous if splinters are present on the timber. Remove rings before using any machines.
6. *Clothing*. Do not wear loose clothing, wear an apron or dust coat, roll your sleeves up and tie back long hair.
7. *Dust*. Protect yourself from the long-term health problems that can result from dust inhalation. Wear a dust mask if an efficient dust extraction system is not available.
8. *Lighting*. Make sure that shadow proof lighting is available to provide an unobstructed view.
9. *Cutters and accessories*. Never use blunt cutters; they are dangerous. Always check accessories for secure fit before operating a machine.
10. *Safety guards*. Ensure that safety guards and hold-down devices are fixed securely before starting any machine.
11. *Waste material*. Always remove offcuts, sawdust or shavings from the work surface of machines before turning on the power.
12. *Starting*. Always allow a machine to attain maximum speed before commencing work.
13. *Hand protection*. Never reach across the path of any cutter on a power machine while it is in operation.
14. *Adjustments*. Never make adjustments while a machine is operating. Make sure adjustments are secure and check for accuracy on a waste piece if necessary.
15. *Stopping*. Never leave a machine running unattended. Turn the power off, and make a point of remaining with the machine until it has come to a complete stop.

Disc sanders

Operation

A disc sander is an electric motor with an extended shaft that holds a metal sanding disc on which abrasive paper is fixed (Figure 10.1). The paper may be attached by a drying adhesive, a ‘peel off’ non-setting adhesive or by **velcro**. A table is mounted in front of the disc which stretches across the full diameter and typically has a 45° tilt facility.

SAFETY

The disc may rotate in either direction depending on which end of the motor the shaft extends from. There should be a visible arrow to show the direction of disc rotation. Make sure you know before using the sander.

Figure 10.1 Disc sander

Proper usage

- The disc sander is for sanding end grain, straight or curved, and the convex shaping of material (like rounding corners). It is not for straight sanding along the grain; this will result in a considerable amount of hand sanding needed to achieve a satisfactory end result.
- Ensure that **dust extraction** is operational.
- Do not use a disc sander for sanding more than 1 mm off thicker wood (cut more precisely beforehand). The exception to this is thin material (>6 mm thick).
- Any work being sanded must be held flat to the table at all times.
- Pushing pressure on the sander should be very light with a small amount of sideways travel if possible to even wear and avoid bumps that might exist in the sanding disc. The four aspects listed below will affect whether the work overheats and burns.
  1. Condition of the abrasive disc.
  2. Force exerted on the disc.
  3. Hardness of the material being sanded.
  4. Surface area of the material touching the disc.

  Note: Burning a disc surface reduces its ability to sand effectively and be cleaned.
- For accurate and effective operation check that the abrasive disc is clean and the table set at 90° to the disc.

HINT

Pine with excessive sap will quickly clog the abrasive disc; try to avoid using the sander in this situation.

- An abrasive disc is power cleaned by pushing a soft rubberised block sharply into the downside of the rotating disc while resting it on the table.
- To avoid guesswork, always sand to a marked line and ensure that you can just see the remains of the pencil line when finished.

SAFETY

- Always obtain your teacher's permission prior to starting any machine.
- Ensure that dust extraction is operating and you are wearing appropriate PPE.
- Keep fingers at least 50 mm away from the abrasive disc.
- Use the sliding mitre fence when possible.
- Never leave a disc sander switched on and rotating.
- Only sand on the *down side* of the disc and do not use material that is so large that it touches the *up side* of the disc or it could catch and fly upwards.
- Do not get distracted by others.
- Do not use the work piece to slow the machine down.

Belt sanders

A belt sander or **linisher** may be a belt-only machine or a belt and disc combination. It is used for sanding the edges of timber with concave curves on the drum ends of the sander. Straight edges may be sanded against a stop, which is set along one end of the flat section with the direction of belt rotation travelling towards the stop. The work must be held with two hands and requires experience to keep sanding square to the faces.

Jet Tools

Figure 10.2 Jet Tools' OES-80CS Oscillating 6 × 89" Belt Edge Sander

Bobbin sander

A bobbin, or vertical spindle drum sander, is used for internal curved sanding of timber (Figure 10.3). Hands must be kept more than 50 mm from the drum. Your teacher will select the drum size and sleeve.

Figure 10.3 Jet Tools' JBOS-5 Oscillating Benchtop Spindle Sander

Drill presses

Drill presses come in bench and floor models (pedestal drill). The only difference between the models is the length of the central column. They are most frequently used for drilling or boring holes, but attachments are available to carry out a number of other woodworking operations, such as sanding, morticing and routing.

The size of a drill press is determined by measuring twice the distance from the centre of the chuck to the front of the vertical column. Some manufacturers also specify the maximum travel of the spindle in determining the capacity of the machine. For example, a 400 mm drill press with a 150 mm stroke measures 200 mm from chuck centre to column and has a spindle that can travel 150 mm. The 400 mm designation indicates that the machine will drill a hole in the centre of a 400 mm circle.

Spindle speeds vary between 300–3000 rpm. The drive is mostly by V-belt on four or five-step cone pulleys. The correct speed for drilling depends upon the material being drilled and the diameter of the bit or cutter being used.

A 'clampable' table is mounted on the column. The table is adjustable in height (via the rack and pinion system) and angle. A Jacobs chuck typically has a 13 mm capacity and may be key tightened, or keyless. In a woodworking environment, this drill is mainly used to produce holes using either twist drill bits, flat speed-bore bits, Forstner bits or hole-saws. To assist in drilling blind holes, an adjustable depth stop is mounted next to the chuck spindle. Other useful items and attachments that can be used on a pedestal drill include sanding drum sets of various diameters, a mini belt sander and **mortising** attachments. The use of a machine vice on the table facilitates safe and accurate operation.

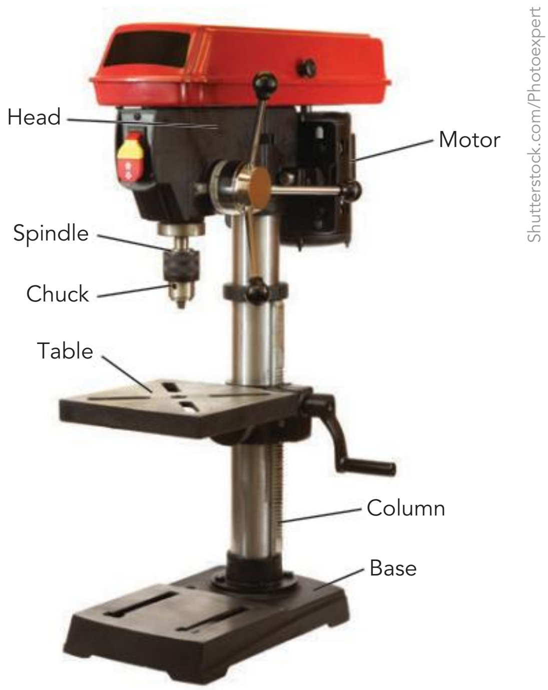

Figure 10.4 Typical parts of a drill press

The size of a drill press is determined by the chuck feed depth of movement and the distance between the chuck and the column, which will limit the maximum size of the material being drilled.

Proper usage

- Before any work begins ensure you have adjusted the speed of the pedestal drill to suit the work being undertaken, clamped the project securely with waste board underneath (to stop the wood splintering as it goes through) and set the depth stop.

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HINT

Even if you are drilling a hole right through a work piece, a depth stop should be set to prevent the drill from going through the waste board and into the metal table. The metal table may also be moved sideways so that the drill bit will miss it. Do not forget to re-clamp the table!

- Operate the drill using your right hand and switch it on or off with your left hand (or off with your knee). After you have started, steady the project with your left hand.
- Punch a mark in the drilling position with a centre punch to help locate the drill bit so it is less likely to wander off position.
- Feed the drill slowly at first until the full circle of the hole is made (this prevents the grain from lifting and splintering) then feed the drill more quickly to prevent overheating. If you are drilling a hole deeper than 30 mm, lift the drill bit to clear any waste material then continue feeding, repeating as necessary.
- When the hole is completed, stop the machine, unclamp the work piece, sweep the table clean with a brush and return the drill bit to its proper place.
- See your teacher for guidance when using other drill attachments.

SAFETY

- Always obtain your teacher's permission prior to starting any machine.
- Wear the appropriate PPE.
- Long hair is dangerous when using the drill; tie it back.
- If a project ever becomes unclamped while drilling is in progress, never try to stop it by hand. Switch the drill off and stand clear until it stops.
- Do not try to slow the chuck down by hand when you have finished drilling.
- If the chuck has a key, ensure that it is removed before starting the machine.
- Whenever possible, always hold articles for drilling with a machine vice or by clamping them to the table.
- Ask your teacher, not another student, for assistance if you are having problems holding a work piece.

Bandsaws

Bandsaws are one of the most versatile machines in the workshop. They can rip, cut curves, **resaw** and cut joints. They are reasonably easy to maintain and do not require much floor space.

A bandsaw cannot make as smooth a cut as a table saw because the table saw has a stiffer, thicker blade that stays straighter in the cut. However, a bandsaw is best for cutting curves and resawing wide stock with minimal waste because the depth of cut is greater and the blade is narrower.

A bandsaw typically has two wheels around which a continuous blade rotates (Figure 10.5). Each wheel has a smooth but slightly curved rubber band glued to its perimeter for the blade to sit on. The lower wheel is driven by a motor via a belt and pulley. The upper wheel is freewheeling and can be raised or lowered in order to apply tension to the blade or to change a worn blade.

There is also a tilting adjustment for the upper wheel, which allows the blade to be tracked to the middle of the rubber band. The wood rests on a tilt table (for bevelled cuts) between the two wheels, with the blade passing through a slot in the table.

To prevent the blade being pushed off the wheels when wood is being cut, the edge of a ball bearing is positioned just behind the blade to stop the blade moving backwards. There are two of these bearings; one fixed under the table and the other adjustable in height above the table. Coupled with these ball bearings are brass guide plates that are adjusted to prevent sideways movement of the blade, thereby increasing cutting accuracy.

Getty Images/Richard Drury

Figure 10.5 Standard two-wheeled bandsaw

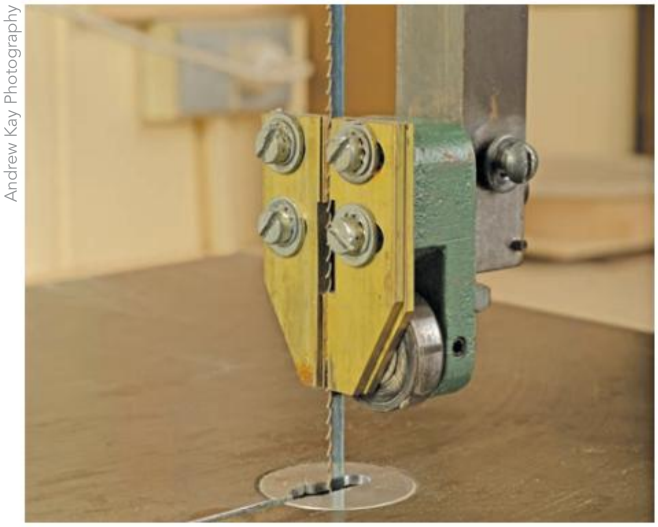


Figure 10.6 Close-up of blade guide and ball bearing. Note: guard removed for photographic purposes only

A recent design change has ball bearings rolling either side of the blade instead of the guide plates; this reduces machine maintenance and blade flexing (Figure 10.7).

Figure 10.7 Ball bearings rolling either side of the blade instead of the guide plates, which reduces machine maintenance and blade flexing. Note: guard removed for photographic purposes only

Blades are generally the same thickness but can be obtained in various widths. The widest blades are better for straight cuts, the narrowest for curve cutting and the medium widths are more a general purpose compromise.

Proper usage

- First, set the upper bandsaw guide and ball bearing to just over (about 10 mm) the thickness (height in this case) of the wood being cut. This will:
  1. prevent your fingers fitting between the wood and guide and touching the moving blade
  2. reduce side play of the blade to a minimum for cutting accuracy.
- Only one operator should be in the machine space at any given time.
- The bandsaw is mainly for freehand work. However, if the saw is equipped with a fence, sliding mitre gauge or clamped guide then its use is also acceptable for straight line work.
- Cuts should be made on the waste side of the marked line – but close to it. This reduces filing and sanding time afterwards.
- Backing out of short incomplete straight cuts is acceptable but always stop the machine and back out, after the blade has come to a rest, with long straight, or any curved, incomplete cuts (Figure 10.8).
- When cutting tight curves that the blade cannot follow, first cut some short straight lines into the waste, which will drop away as the curved cut proceeds. This allows for slight repositioning of the blade as you continue your cut (Figure 10.9).
- When cutting circles, place a finger in the centre of the circle and slowly rotate the material; this makes for a smoother cutting line. Keep your finger well clear of the blade at all times!

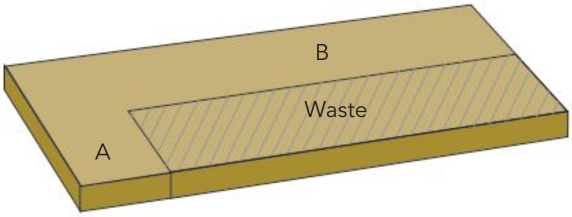
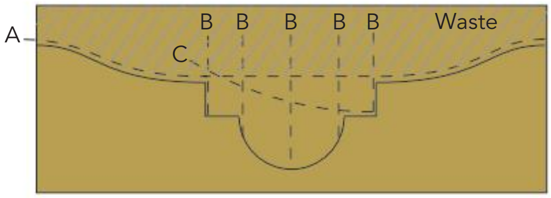


Figure 10.8 Preferred order of long and short cuts – 'A' first because this avoids backing out of 'B'



A: Removes bulk waste
B: Initial cuts for corners and curves
C: Cutting across allows removal of parts

Figure 10.9 Tight curve cutting procedure

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Blade breakage

The following is a list of common reasons for blade breakage and how to best avoid them.

- Backing out of long incomplete cuts – turn off the saw and allow the blade to come to rest before backing out.
- Starting with the teeth touching the blade – allow the blade to come to full speed before beginning cut.
- Exerting too much force on the blade – always let the blade do the work.
- Cutting a curve that is too sharp for the blade and twisting the blade – use relief cuts when cutting tight curves.

HINT

You must feed the wood in as well as turn it.

- Sudden stopping by jamming a thick piece of wood or switching off the machine while it is still cutting – ease large pieces into the blade and slightly back off your cut before stopping the machine.
- **Metal fatigue** at the blade joint – if you start to hear unusual noises or a clicking sound from the machine, stop your work and ask your teacher to inspect it.

SAFETY

If you hear a clicking noise from the rotating blade, switch the machine off and let your teacher know.

Safety tips

- Never use a bandsaw with a guard removed.
- Ensure dust extraction is on.
- Do not wear loose clothing or jewellery.
- Always use the appropriate PPE.
- Switch off the power before making adjustments.
- Stay with the saw until the blade comes to a complete rest.
- Round stock, such as dowel or broom handles, must not be cut on this saw; they are likely to spin and get drawn into the blade.
- Do not distract the operator.

Scroll saws

A scroll saw may be fixed to a bench or be portable (Figure 10.10). They are used for cutting freehand lines and curves in thin timber and manufactured boards >20 mm. Single or double speed switching is available to suit the material being cut. The cutting action consists of a short narrow blade (approximately coping saw size) that is clamped top and bottom and set to **reciprocate** vertically by an electric motor. Being narrow, the blade is ideal for tight curve cutting but poor for straight line work. Most scroll saws have a device that can be adjusted to the thickness of your material that prevents it jumping up on the blade upstroke and to prevent fingers from touching the blade.

Alamy Stock Photo/Romarn Milert

Figure 10.10 A typical scroll saw

Proper usage

- First, with the power isolated, ensure that the blade is attached at both ends. If it is not, see your teacher.
- Place your work next to the blade and set the guard/anti-lift device to touch the top of your work.
- Switch on, allow the blade to come to full speed then start guiding the work along the moving blade. Cut on the waste side of your marked pencil line but as close as possible to it so that sanding and filing is minimised.

- To make tight curves in thinner material you may turn the work slowly with very little forward motion.
- When the work is cut, stop the machine and gently slide the cut parts out.
- Holes can be cut in the middle of a piece of material by **pre-drilling** a hole first then fitting the blade through the drilled hole and reattaching it to the saw. This process will have to be repeated in reverse to remove the work when cutting is complete. The blade will need to be re-tensioned.
- Thicker material slows down the rate of sawing considerably.
- Clean the machine and work area and place rubbish in the bin after use.

HINT

Do not be tempted to push harder – the thin blade will break!

SAFETY

- Always obtain your teacher's permission prior to starting any machine.
- Ensure you are wearing appropriate PPE.
- Hands should be no closer than 50 mm from the moving blade.
- Only one operator in the machine space at a time.
- Do not allow yourself to be distracted.
- Set the guard/anti-lift device for your work before starting.
- If you snap a blade, switch the machine off and report the breakage to your teacher.

CHECK YOURSELF

1. List three safety rules that must be followed before using any machine in the workshop.
2. Name another machine that must be running when using the disc sander.
3. What is the maximum width that is safe to sand on a disc sander?
4. Why should your project be secured to the table when drilling on a drill press?
5. On a drill press, how do you stop the drill damaging the table when you drill through your work?
6. When using a bandsaw, how far should the upper guide be set from the material being cut?
7. When cutting tight curves on a bandsaw how can you prevent the blade from geting caught in the cut?
8. List three common reasons that causes bandsaw blades to break and how they can be avoided.
9. Describe the method you use to cut a shape out of the centre of a piece of material using a scroll saw.

Hollow chisel morticer

A morticer is a woodworking machine used to cut square or rectangular holes in a piece of timber. It is commonly used to produce a mortice in a mortice and tenon joint.

The machine works like a drill press in many respects, the cutter (also called a square hole drill) uses a drill bit in the centre which removes most of the waste and a four-sided hollow chisel which cuts out straight and clean edges (Figure 10.12). The cutters come in a variety of sizes that are similar to the common sizes of mortice chisels: 6 mm, 10 mm and 12 mm (¼ inch, ⅜ inch and ½ inch).

HINT

Leave a gap. Position the drill bit with its cutting head about 2 mm away from the inside surface of the hollow chisel. The gap is important; this allows the shavings from the drill bit to be lifted into the hollow chisel and ejected. If the gap is too small or too large, the shavings will clog the bit.

Jet Tools

Figure 10.11 Jet Tools' Benchtop Mortise Machine, ½″ Capacity, ½ HP, 1725 RPM

iStockphoto.com/InCommunicado

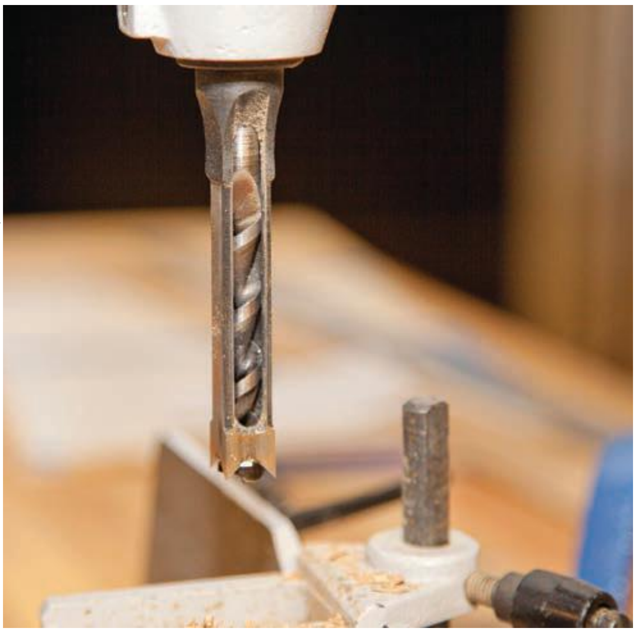


Figure 10.12 Hollow chisel bit also known as a square hole drill

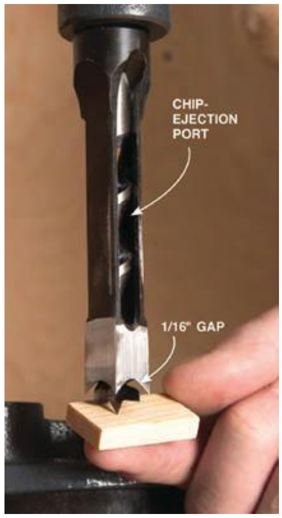


Figure 10.13 It is important to leave a gap of about 2 mm between the drill and the chisel to allow for the shavings to escape

SAFETY

- Always obtain your teacher's permission prior to starting any machine.
- Ensure you are wearing the appropriate PPE.
- Make sure all fences and depth stops are in place and tightened.
- Only one operator in the machine space at any given time.
- Do not allow yourself to be distracted.
- Set the anti-lift device for your work prior to turning the machine on.

Thicknessers

The thicknesser, also known as a thickness planer, will plane (or dress), one side of the timber at a time, to a set thickness.

iStockphoto.com/InCommunicado

Figure 10.14 An example of a 410 mm thicknesser

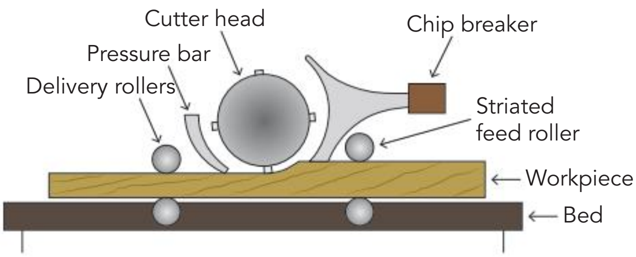


Figure 10.15 Cross-sectional view of thicknesser

Thicknessers reduce the thickness of a board by feeding it under a set of rapidly rotating planer blades (Figure 10.15).

The thicknesser will not remove twist, wind or warp from a board. The pressure of the infeed and outfeed rollers flattens the board as it passes through; however, it will spring back on exit. Therefore, any warp should be removed beforehand from the face that is to be on the table by dressing it with a hand or portable electric plane.

The size of the thicknesser is designated by the maximum width and thickness of material it can handle. For instance, the machine in Figure 10.14 would be referred to as a 410 × 225 mm thicknesser.

Planing to thickness

1. Plane one face flat. Place this face downwards on the thicknesser table.
2. Set cutter head to take a light cut (no more than 1–2 mm).
3. Determine the grain direction on each face to be surfaced and mark with an arrow. When feeding the workpiece into the thicknesser, the grain on the surface being dressed should point towards the front or infeed side of the machine.
4. Select the feed rate required (slower provides the best finish).
5. Start the machine and feed the workpiece into the front of the machine.
6. Move to the delivery end on the machine and support the workpiece as it passes through.
7. For each successive cut, reverse the faces of the board to minimise any tendency for it to warp.

If a number of pieces are to be dressed to the same thickness, each piece should be surfaced in turn, at the one setting. This is to ensure uniform width or thickness of material.

SAFETY

- Always obtain your teacher's permission prior to starting any machine.
- Ensure you are wearing the appropriate PPE.
- Check the material to be planed for the presence of nails or any objects that could damage the blades.
- Do not attempt to surface boards less than 300 mm in length because delivery rollers may not be able to feed the piece through.
- Always stand to one side of the machine while it is in operation to avoid kickback.
- Restrict the maximum cut to 3 mm because a deeper cut will overload the machine.
- Keep fingers away from the table when the machine is in operation. Use a **push board** if necessary to move a stalled piece past the delivery rollers.

Circular saws

Circular saws were one of the first power machines used in woodworking. Most modern table saws have a tilting arbor (up to 45°), a raising and lowering mechanism and provision for dust extraction. Sliding and extension tables are also available where easier handling of large sheets of plywood or particle board is required. The 300 mm blade runs at approximately 3000 rpm. The cutting speed, measured in surface metres per minute (mpm), is approximately 3000 mpm. The table saw in Figure 10.16 is an example of a modern sliding table saw suitable for use in industry and school workshops. It has a sliding table, a single tilting arbor and a blade driven by an electric motor via twin V-belts.

The specified size of a circular saw is measured by the largest diameter saw blade it will accommodate. The saw shown in Figure 10.16 is classed as a 300 mm sliding table saw, but it can use smaller diameter blades when required.

Parts and uses

The main parts of the circular saw are shown in Figure 10.16.

- Table: the top of the saw bench which supports the rip fence, cut-off guide and safety guard.

Figure 10.16 A sliding table saw

- Fence: used as a guide for ripping or cutting parallel to the blade.
- Cross cut fence: used as a guide for crosscutting.
- Arbor: holds the blade or dado head to the shaft.
- Saw-tilt handwheel: used for tilting the blade to the desired angle for cutting bevels, mitres and right-angle cuts.
- Blade raising wheel: used to regulate the cutting height of the saw blade.
- Riving knife: prevents the timber closing in on the blade and being thrown back towards the operator.
- Guard: designed to protect the operator from the saw.
- Electric motor: drives the circular saw, usually by means of twin V-belts.

Circular saw blades

There are two types of circular saw blades available: those made of carbon steel alloyed with nickel and chrome and those made of spring steel with tungsten carbide tips brazed on to form the teeth. Carbon steel blades are rarely used these days because carbide tipped blades not only last longer between sharpening but generally make a smoother cut. There are four types of blades generally used for cutting wood.

1. Rip blade (24 teeth in a 300 mm blade): used for cutting thick timber along the grain (Figure 10.17). They have less teeth than other types of blades. This allows shavings to escape more easily which reduces the effort needed to cut. The teeth are sharpened so that they have a chisel-like action.
2. Crosscut blade (50–70 teeth in a 300 mm blade): used for cutting timber across the grain. The teeth should be sharpened on alternate sides to produce a knife-like action that cleanly cuts the fibres.
3. Combination blade (40–60 teeth in a 300 mm blade): general purpose blade designed to cut both along and across the grain and to provide a smoother finish (Figure 10.17). Generally consists of four alternately bevelled teeth preceded by a flat ground raker tooth.
4. Triple chip tooth blade (50–70 teeth in a 300 mm blade): used for cutting manufactured boards that have a brittle surface, such as melamine or plastic laminate. The teeth have a bevelled tooth followed by a raker tooth.

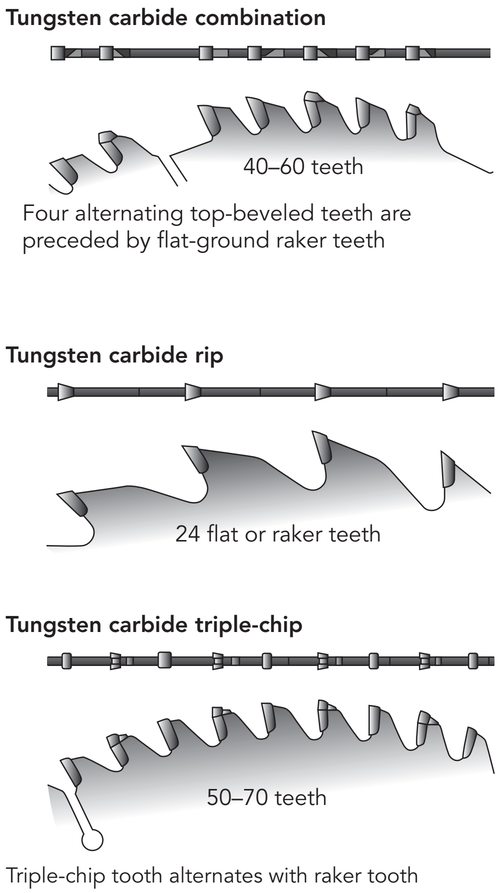


Figure 10.17 Tungsten carbide tipped circular saw blades

SAFETY

- Not for student use in NSW secondary schools.
- Always observe the general safety rules given at the beginning of this chapter.
- Ensure you are wearing the appropriate PPE.
- Adjust the blade so that it only projects slightly above (approximately 5 mm) the wood to be cut.
- Always use a safety guard if the saw teeth project above the stock being cut.
- Always use the riving knife to prevent kickback.
- Always use a **push stick**, especially when ripping narrow stock.
- Do not use a blunt blade because it tends to burn the wood and jams in the cut.
- Stand to one side of the saw to avoid stock that may kickback. Never reach over the saw blade to support or catch a piece of stock.
- Avoid sawing freehand; it is dangerous!
- Take care when crosscutting wide stock. It tends to slew around and catch on the blade. This can be avoided by using a shortened fence.

Jointers

A jointer is an electrically driven planer, used mainly to straighten a face or an edge of timber before putting it through a thicknesser to dress the timber to its final size. It may also be used to plane bevels, chamfers, tapers and rebates. The size of a jointer is specified by its maximum width of cut; the sizes varying between 100–400 mm. Cutter heads revolve at approximately 3600 rpm.

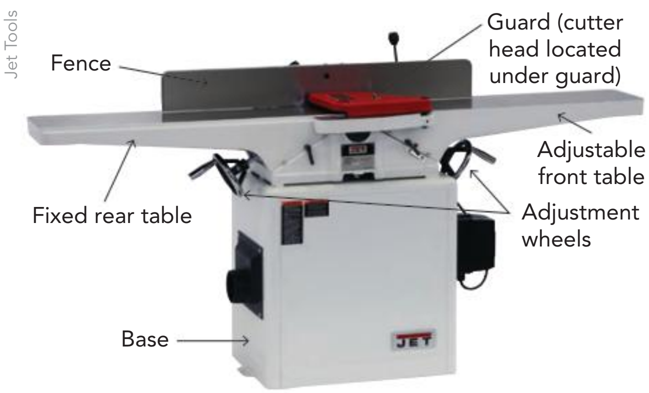


Figure 10.18 Jet Tools' 8" Jointer with Closed Stand

Parts and uses

The main parts of the jointer are shown in Figure 10.18.

- Table: consists of two parts; the front table which is adjustable for depth of cut and the rear table which is fixed at the same height as the blade (it can be adjusted if required).
- Cutter head: the section of the machine that houses the three (sometimes four) knives (Figure 10.19).
- Fence: used to guide the timber and is adjustable for width and angle of cut. The fence should be adjusted to expose *only the required amount of blade* when dressing a piece of timber.
- Guard: covers the cutting knives and swings out of the way when a piece of timber is passed over the knives.
- Table adjustment: a series of knobs, located under the table, that are used to raise and lower the table to achieve the depth of cut desired.
- Base: the supporting frame; also houses the motor.

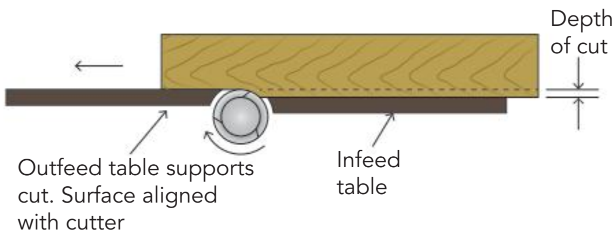


Figure 10.19 The blades on a cutter head are set level with the rear table

Planing faces, edges and ends

Always check the fence is tightened and the depth of cut is correct before using the machine. When planing a face, the general rule is to not take more than a 3 mm cut in a single pass. On extremely hard timber, an even smaller cut must be taken in a single pass. A piece of timber can be completely dressed on a jointer if the cutter knives can cut the entire width of the timber in a single pass. After checking the depth of cut, determine the grain direction. The timber should be passed over the cutter so the cutting action goes with the grain; this produces a smoother surface.

When dressing a piece of timber that is slightly bowed, either remove a small amount from each end or start dressing the timber from the middle to correct the bow on one face then make a full pass to finish. As the timber is passed over the cutter, transfer the pressure on the wood from the front table to the rear.

SAFETY

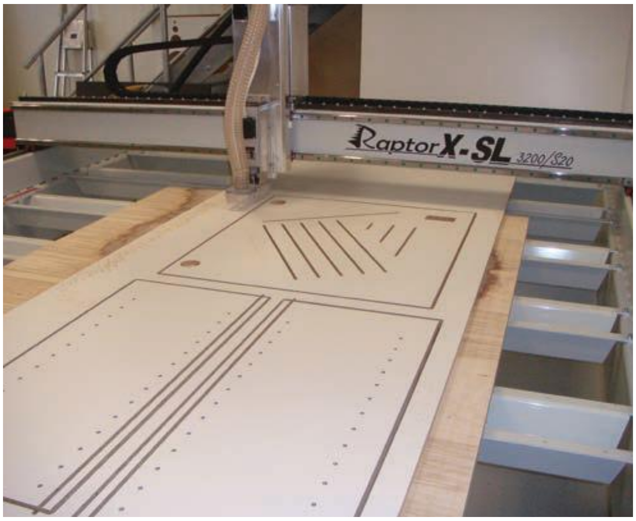
- Not for student or teacher use in NSW secondary schools.
- Always observe the general safety rules given at the beginning of this chapter.
- Make sure the safety guard is in place and ready for use at all times.
- Check that blades are sharp and firmly attached.
- Always stand to the left of the machine to avoid possible kickback.
- Use a push stick when surfacing timber. Do not attempt to plane boards less than 300 mm in length. Plane short boards by hand.
- Determine the direction of grain on the timber so that the cut aligns with the grain and leaves a smooth surface.
- Always surface the concave side of a board first. Twisted timber may require hand-planing before being dressed on the jointer.

CAD/CAM

Weblink: CAD/CAM in woodworking

Computers have become an essential part of life. The use of smart phones and tablets is common for communication of voice, text, photos and images. In industry, computer aided design (CAD) plays an essential role enabling products to be designed and displayed to the clients as solid models, then transferred to a computer numerical control (CNC) machine to cut out or shape the product. This process is known as **CAD/CAM** (CAM being computer aided manufacturing). Once the CAD drawing is completed, it is converted into a file recognised by CNC machines, such as a CNC router, **3D printer**, **laser cutting** machine or **water jet cutter**.

In order to remain competitive, the furniture and joinery industries utilise CNC **machining centres**; they are an essential component in modern factories. The machines have a large, flat bed that can hold a full sheet of manufactured board. Machining centres save manufacturing time by sensibly ordering different cutting operation; for example, all the holes are drilled in one go then the routing of the shapes are done together rather than completing each shape one at a time. The use of **nesting** software minimises waste while maximising the number of pieces that can be cut from a single sheet.



CNC-Step, www.cnc-step.de

Figure 10.20 An example of nesting in use for cutting out kitchen cabinet panels on a CNC router

Figure 10.21 An example of a CNC machining centre for nesting applications

Machining centres have multiple tools that are automatically changed to suit the task at hand. They are used to cut out the panels, route trenches and grooves, drill the holes for the hinges, screws and shelves (Figure 10.21).

CNC table saw

Another machine extensively used in the furniture and joinery industry is a CNC table saw. The saw uses the data from a CAD drawing to set the fence width and angle as well as blade height and angle (Figure 10.22). These allow the user to cut panels accurately and quickly with minimum waste.

Courtesy of Altendorf Asia Pacific Pty. Ltd.

Figure 10.22 A CNC table saw, note the computer interface on top of the saw

3D printing

3D printing is being used more and more in the design and development stages of products. It is often employed as part of the **rapid prototyping** process of product development. 3D printing is an additive process that builds up a 3D shape from a 3-dimensional digital model (CAD drawing), producing multiple layers of material. They can make a composite of wood and plastic making use of low-cost wood waste from traditional manufacturing that can churn out objects that look at least something like wood, including a grain pattern of sorts. At the moment 3D printers are too slow and expensive for large production runs but the process is improving quickly; even now you can download a 3D file from the internet for a product and print it off.

3D printing in woodworking

Weblink

iStockphoto.com/belekekin

Figure 10.23 An example of a 3D printer used in rapid prototyping

Recent advances in 3D printing of wood use a layered additive manufacturing process that prints small, uniformly cut wood pieces that are joined in layers to create larger objects (Figure 10.24). This could revolutionise furniture designing by making custom furniture more affordable for the consumer.

Stelios Moussaris

Figure 10.24 A 3D printed wood table

Laser cutter

A **laser cutter** is another CNC machine that is widely used in the woodworking industry. The machine works from a computer drawing which is either set to cut the lines or to engrave **raster** a pattern or image. This is a non-contact process that works by focusing a laser through a nozzle onto the work piece resulting in high quality, extremely accurate cuts and engravings. Its accuracy makes it a great machine for cutting out veneers for marquetry (Figure 5.32, page 86) and engraving a recess for inlaying timber or intarsia.

Trotec Laser Pty Ltd

Figure 10.25 An example of a laser cutting machine engraving several picture frames in one project setup (using a Trotec speedy 400 laser)

Water jet cutting

Water jet cutting is another CNC industrial process that is growing in popularity. This process is capable of cutting a variety of materials using a very high-pressure (210–620 MPa) jet of water, or a jet of water mixed with an abrasive (usually garnet).

One main advantage of using a water jet is its cold cutting quality. The materials are cut without being burned, melted, or split, effects which can be a problem with other cutting methods. It also has a very fine kerf so there is very little waste, making it great for nesting applications. This technology is currently being used for the production of wooden jigsaw puzzles, table tennis rackets and wooden furniture – with more to come.

Computer integrated manufacturing

Many larger production companies now use a process of manufacturing called **computer integrated manufacturing (CIM)**, which uses computers to manage the whole manufacturing process from marketing and factory management to CAD/CAM and **automated assembly**, **automated fabrication** and **automated warehousing**.

Alamy Stock Photo/Vladimir Nenezic

Figure 10.26 A water jet cutter in use

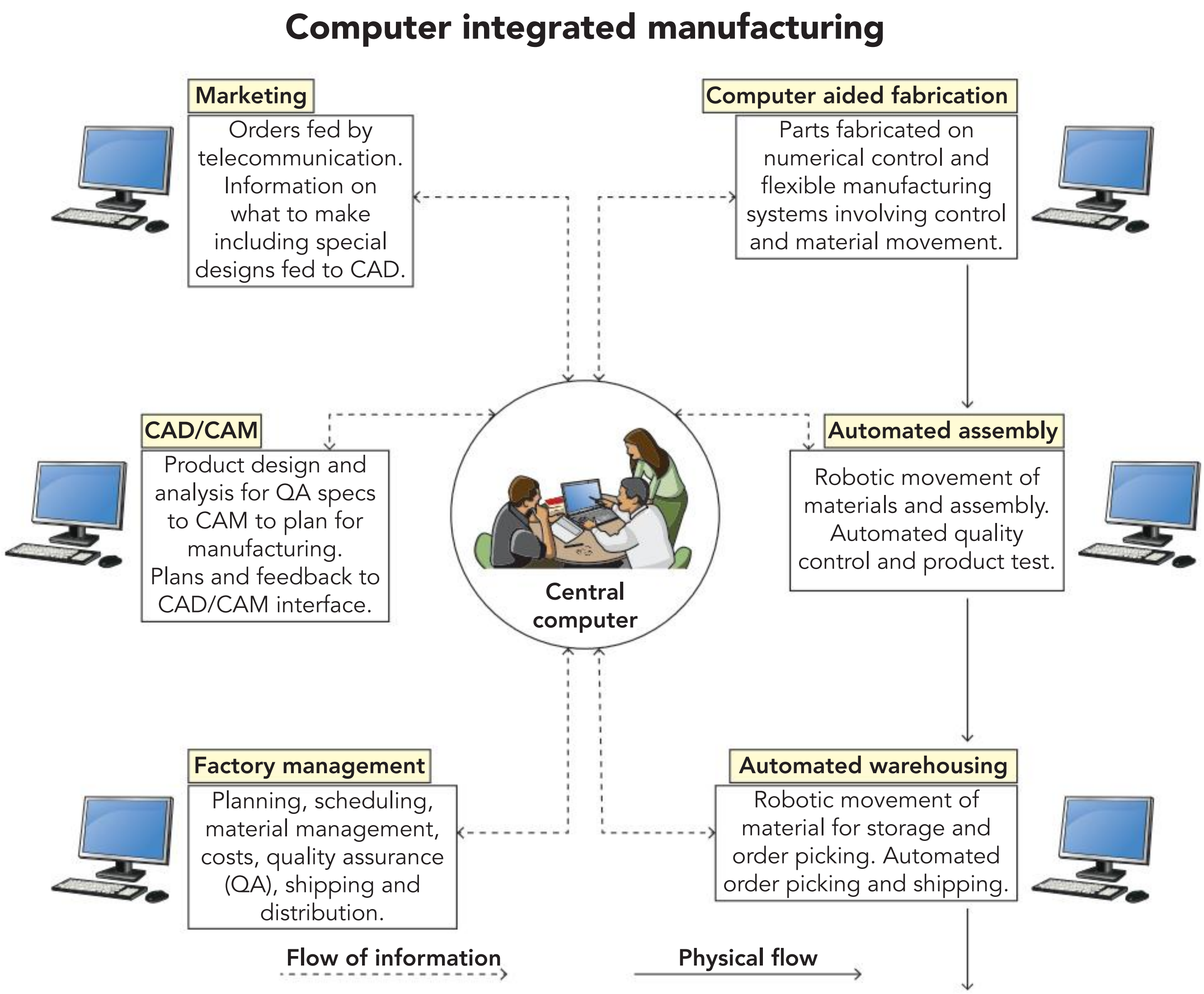


Figure 10.27 A diagram showing how CIM is used to control the whole manufacturing process

CHAPTER REVIEW QUESTIONS

1 A rotating disc sander has one half going up and the other down. Which is the correct half to use and why?

2 List two ways that an abrasive disc of a disc sander can become clogged.

3 How can you clean an abrasive disc?

4 What is the problem with disc sanding a project until the marked pencil line disappears?

5 Which direction does the blade of a scroll saw cut in? Why?

6 Why is it important not to cut round stock on a bandsaw?

7 List two reasons why the upper blade guide of a bandsaw must be adjusted to just above the height of the work piece.

8 How can you cut a reasonably accurate line on a bandsaw?

9 **a** Which of the two large wheels in a bandsaw is used to adjust blade tension?

b Outline the purpose of the other adjustment.

10 Why should you stop the bandsaw before reversing the saw blade out of an incomplete curved saw cut?

11 If you are using the bandsaw and you hear a clicking sound, what might it be and what should you do?

12 Which type of blades are better for curve cutting on a bandsaw?

13 What will happen when cutting thicker timber on a scroll saw? If you push harder, what is likely to happen?

14 What PPE would you use when operating a scroll saw?

15 How do you change speeds on a pedestal drill?

16 When setting up a hollow chisel mortising machine how far should the drill tip be set from the inside surface of the hollow chisel. Why?

17 Describe the procedure to be followed if a number of pieces are to be dressed to the same dimensions on a thicknesser.

18 How has technology played a role in enabling the Australian timber industry to be competitive on a global market?

19 How has the use of CAD helped in the kitchen design industry?

20 Why has the use of CAD/CAM become a necessary part of the furniture and joinery industry?

21 Why is nesting a good technology for the environment?

22 What processes can be carried out on a CNC machining centre?

23 What role do 3D printers play in the rapid prototyping process?

24 What does ‘raster’ refer to when using a laser-cutting machine?

25 What advantages does water jet cutting have over other cutting methods?

26 Apart from CAD/CAM, what other computer operations are used in CIM?

CHAPTER

11

Woodturning

Woodturning is far more than a simple machining process; at its best, it becomes an art form. Successful turning requires not only the mastery of specialist techniques but also an appreciation of what constitutes a pleasing shape with flowing lines.

The interest in woodturning and the rapid increase in the number of clubs around the world over recent years has led to many significant advances in the design of lathes, tools and accessories. This in turn has led to the recognition of woodturning as an art form.

9780170411516

Key terms

bead an external curve on a piece of wood; either turned or routed; moulding

bevel an angle, less than 90°, produced over a complete face of a material (e.g. wood), or the ground angle of a cutting tool

cabriole chair leg 18th century furniture leg with a shallow, graceful 's-shaped' curve

checking splits that can appear in the surface of timber during the drying-out process

chuck turning turning with the work held in a chuck attached to the headstock

concentric having a common centre

crotches the point where a branch divides into two smaller branches

face-plate turning turning with the work held on a face plate attached to the headstock

laminations several thin layers of material (e.g. plywood)

lopped cut down, as in a tree

maxims a statement of information generally accepted as true

microwave seasoning removing moisture from green timber by carefully cooking it in a microwave

parting cutting grooves, shoulders or cutting to length (parting off) in wood turning

polyethylene glycol (PEG) a substance used to seal and help season green timber by reducing checking

periphery the outer edge of an item

roughing in wood turning, the first stage of converting square stock into round stock

shoulder the squared part of a tenon or tongue that reverts back to full thickness

spigot a cylindrical peg or plug

spindle turning turning between centres, with the work held between the drive or 'live centre' in the headstock and a freewheeling or tailstock centre at the other end

Wood lathes

A wood turning lathe is one of the oldest pieces of equipment for fashioning articles from wood, dating back more than 3000 years. A two-man lathe was developed in Egypt as early as 1400 BCE. It has undergone centuries of improvements, culminating in the modern swing bed lathe (Figure 11.1b).

The backbone of a lathe is the bed, upon which are mounted the other components. Lathes are usually either bolted to a sturdy bench or feature their own stand. The headstock houses the pulleys, which govern speed changes, and the main bearings supporting the headstock spindle. Modern lathes sometimes include electronic speed control, which can maintain the torque necessary for turning. Equipment, like *face plates* or a *spur centre*, is attached to the spindle depending on the project. Along the bed may be sited a *tool rest holder* and a *tailstock*. A belt around the headstock pulley is connected to another stepped cone pulley, which is attached to an electric motor mounted in the stand. By taking the tension off the belt, which is achieved by lifting the motor, then moving the belt onto a different sized pulley (taking care to always keep the belt on the same positioned pulley above and below), speeds can be altered to suit requirements. For example, *sanding* would require a medium to fast speed, while turning a large or unbalanced piece of timber would be done using a very slow speed.

There are three basic operations performed on a lathe:

1. **Spindle turning**: turning between centres, with the work held between the drive or live centre in the headstock and a freewheeling or tailstock centre at the other end.
2. **Face-plate turning**: turning with the work held on a face plate attached to the headstock.
3. **Chuck turning**: turning with the work held by a chuck attached to the headstock.

Andrew Kay Photography

Figure 11.1a A typical long bed lathe

Photo by Bruce Leadbeatter

Figure 11.1b A modern swing bed lathe

Wood-turning chisels

Types

Two classes of chisel are used in turning:

1. *Cutting chisels* are designed mainly to achieve a cutting action, such as the gouge, skew chisel and parting tool.
2. *Scraping chisels* are used only for a scraping action, such as the round-nose, square-nose, spear-point and combination chisels.

Broadly speaking, a cutting action (with the chisel at a tangent to the work) is like ‘peeling a potato’ and is used during between-centre turning. A scraping action (with the chisel at right angles) is like ‘removing the mud from your boots with a boot scraper’ and is safer and more suitable for face-plate work (Figure 11.2).

Materials used to make chisels

Carbon steel chisels are generally cheaper than high speed steel (HSS) chisels but will blunt more quickly than harder materials. High speed steel produces a lasting edge but costs more. There are other alloys and materials being experimented with but, as yet, they are very expensive and difficult to market.

Cutting chisels

Each of the cutting tools in Figure 11.3 have different uses and are explained below.

Gouges

The square-ended gouge is used for **roughing** down stock when turning between centres.

HINT

Square stock corners can be planed off initially; this makes roughing down less noisy and bumpy.

For cylindrical cutting

- Convex side down, place the gouge on the tool rest near the middle of the cylinder, a little higher than you would think necessary.
- Lower the blade by raising the handle gently, so that the **bevel** (the angle that has been ground) rubs lightly on the rotating stock (but does not cut), then slowly lower the cutting edge onto the work surface until the cutting action begins.

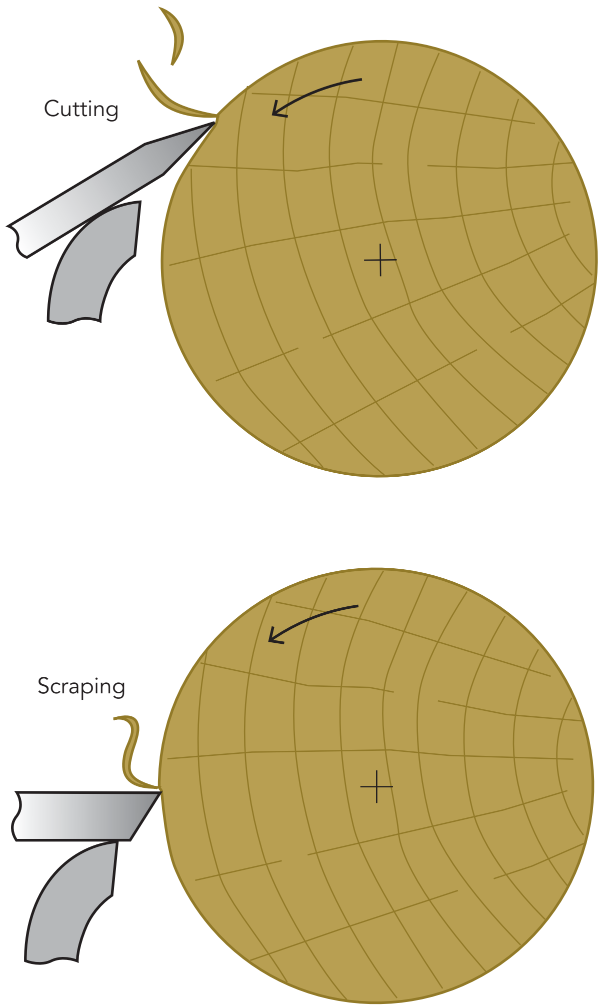


Figure 11.2 Scraping chisel in operation: Note burr left on cutting edge, which removes fine shaving; scraping chisels are normally sharpened by grinding one side, without honing, to an angle of 45–65°

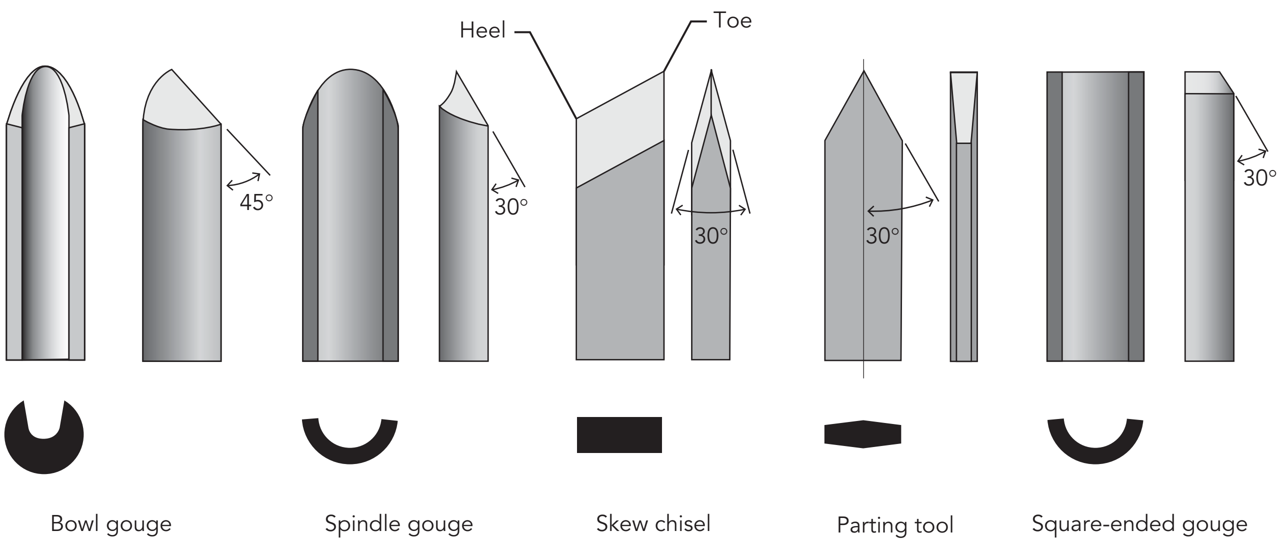


Figure 11.3 Cutting chisels

- Gently move along the cylinder, maintaining the same angle with the gouge, coming off the end of the work. Next, go back to the middle and repeat the process in the other direction. If you are turning from square, initial passes will feel very bumpy until a round form is nearly complete.

SAFETY

Do not start a cut from the end of a piece of work because the gouge may lift a splinter by digging in from the end grain.

Cutting hollows (coves) using a spindle gouge

- Use a pencil to mark the size of the hollow.
- Select a suitable size gouge (12 mm for general work).
- Place the gouge flat on the rest and push it gently into the stock to achieve a scraping action to remove most of the centre portion.
- Next, place the gouge on its side with the bevel at right angles to the axis of the stock, keeping the handle slightly raised (Figure 11.4a Position 1).
- Roll the gouge from the side to the horizontal position, moving the handle outwards and downwards, guiding the cutting edge to stop at the centre. Use the bevel to control the cut.

Note that each cutting stroke begins at the top or **shoulder** (largest diameter) and works down to the base of the hollow (smallest diameter) (Figure 11.4a Positions 2–3). The same operation occurs from the left and then the right sides of the hollow. You should swap the position of your hands to make the process easier.

Gouges can be used to form hollows, straight cylinders, general shaping and **beads** if a fine shallow gouge is used. They result in a very smooth finish, which needs little sanding.

A deep fluted bowl-turning gouge may be used for face-plate work and generally produces a better-quality finish than a scraper (but is more difficult to master).

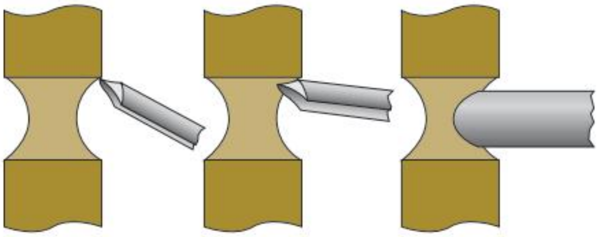


Figure 11.4a Turning hollows or coves with a fine gouge

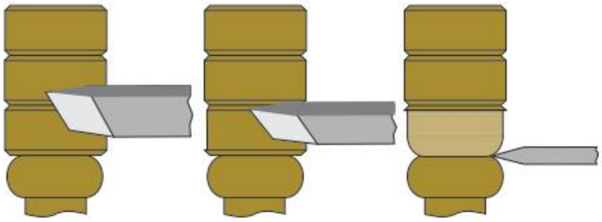


Figure 11.4b Turning beads with skew chisel

Skew chisels

Skew chisels are the best choice for finishing cuts on cylinders, vees, square shoulders and convex curves, and for turning beads. When skew chisels are sharp, and used correctly, they give an excellent finish, which needs virtually no sanding. They should not be used for scraping, because this quickly blunts the tool (Figure 11.5).

Andrew Kay Photography

Figure 11.5 Skew chisel in operation: Bevel must rub on work to support cutting edge and control depth of cut; cutting chisels are sharpened by grinding and honing to the same angle

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For finishing cuts

1. Hold the chisel on the rest with the cutting edge well in advance of the handle.
2. Lower the skew until the work contacts gently on the bevel (but not yet cutting).
3. Lower the cutting edge to the desired depth of the cut, controlled by the bevel, by raising the handle.
4. Push gently, allowing the chisel to cut in the direction in which it is being advanced. Be careful about taking too much off in a single cut.

HINT

Set the tool rest parallel to the work piece; this allows the skew chisel to be guided along it (Figure 11.6).

To turn a bead

1. Cut two vees at the outer edges of the bead to allow clearance for the final cuts.
2. In order to 'roll' the bead, hold the skew chisel flat on the rest at right angles to the axis of the stock at one side of the bead and with the cutting edge high. The point of the heel, responsible for all the cutting, must be very sharp, with the bevel ground flat.
3. Roll the chisel over from the horizontal position, gradually raising the handle to lower the cutting edge, at the same time swinging your arm to one side.
4. Turn the other side of the bead in a similar manner. Changing hands makes this task much easier.

SAFETY

Never use the upper part of the skew chisel cutting edge (especially the top point, because once it touches the rotating wood it will suddenly dig in).

For turning shoulders, after roughing out the work with a gouge, cut in with the toe of the skew, finishing along the axis with the heel of the skew chisel (Figures 11.6a and b).

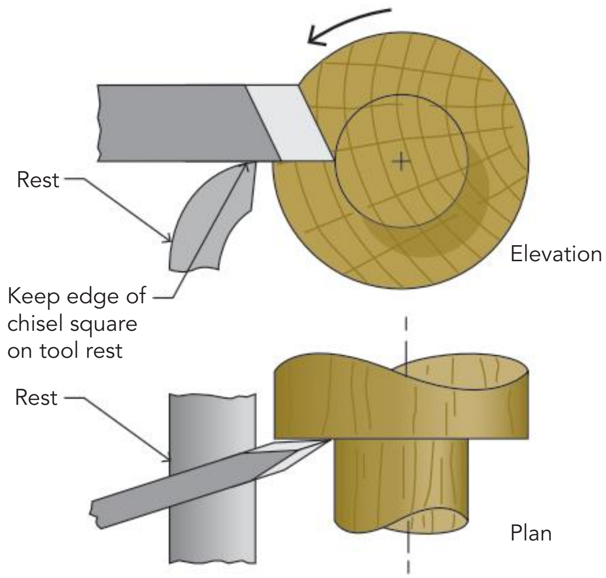

Figure 11.6a Top and side view of turning a shoulder with the toe of the skew chisel

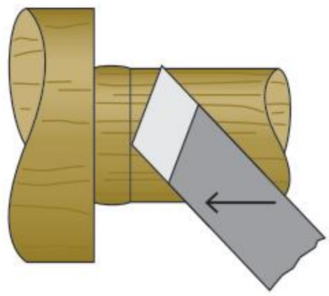

Figure 11.6b Heel finishes to the shoulder

Parting tools

A parting tool is a narrow tool that is designed to cut and produce its own clearance so that the edge will not be burnt (Figure 11.7). It is designed to cut grooves and shoulders straight into the stock to a desired depth, as well as **parting** off a finished project from waste.

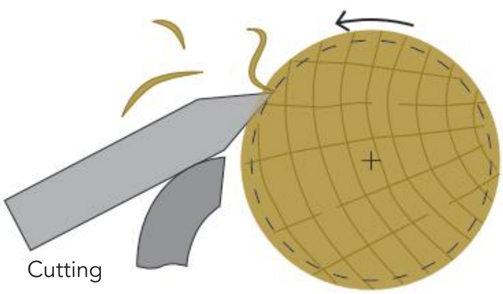

Figure 11.7 Correct angle for parting tool use

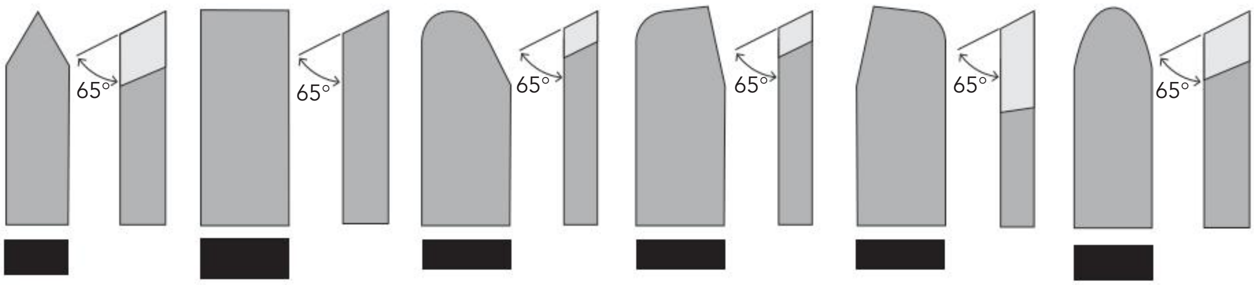

Figure 11.8 A variety of scrapers – ground angle may vary between 45–75°

Scraping tools

While scraping tools (Figure 11.8) are best used for face-plate work, they can also be applied to between-centre turning (Figure 11.9a and b).

Scraping, which produces a rougher surface, demands less skill and is easier to learn because it is a slower method of cutting than turning. Another reason it is recommended for patternmakers and beginners is the degree of accuracy that can be achieved.

Flat and convex surfaces are produced with flat, combination or spear-point scrapers; round-nose, combination or bowl-turning scrapers are best for turning hollows.

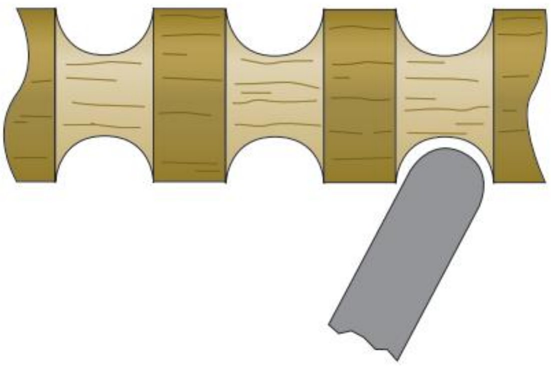

Figure 11.9a Scraping hollows with round-nose scraper

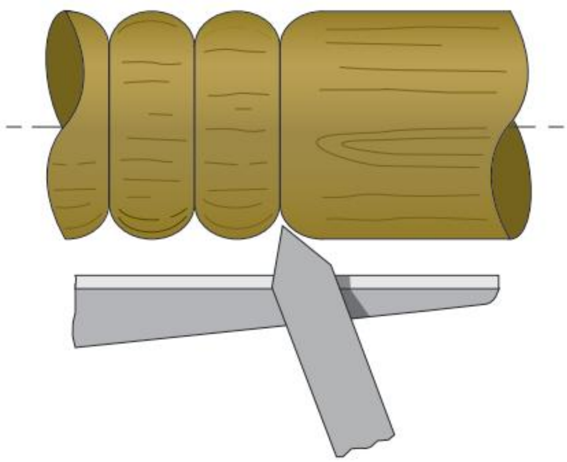

Figure 11.9b Scraping beads with spear-point scraper

General rules for scraping tools

- Set the tool rest so that the chisel can be held at the horizontal with its cutting edge close to centre height.
- Preserve a cutting edge by 'backing off' now and then to reduce overheating.
- Aim to make the tool take off fine shavings rather than dust; this is less abrasive for the cutting edge.
- When sharpening the tools, by grinding on a wheel, leave the burr to act as the cutting edge.
- Virtually any profile may be ground to suit a specific project. For example, a scraper that is ground to hook to the left is ideal for turning an inside lip at the top of a bowl.

Turning between centres

How to mount stock

- Mark diagonals on both ends of the stock to locate centres.
- Plane corners along the stock (for easier roughing to round).
- Cut saw kerfs roughly 3 mm deep on the diagonals on one end of the stock (Figure 11.10).

- Position the spur centre, which fits in the headstock spindle of the lathe, with prongs in the kerfs at the point where diagonals intersect (Figure 11.11). Secure it with a soft hammer or wooden mallet.
- Remove the spur centre and push the tapered end firmly into the headstock spindle of the lathe.

Andrew Kay Photography

Figure 11.10 Cutting kerfs to locate spur centre

Andrew Kay Photography

Figure 11.11 Seating spur centre

Andrew Kay Photography

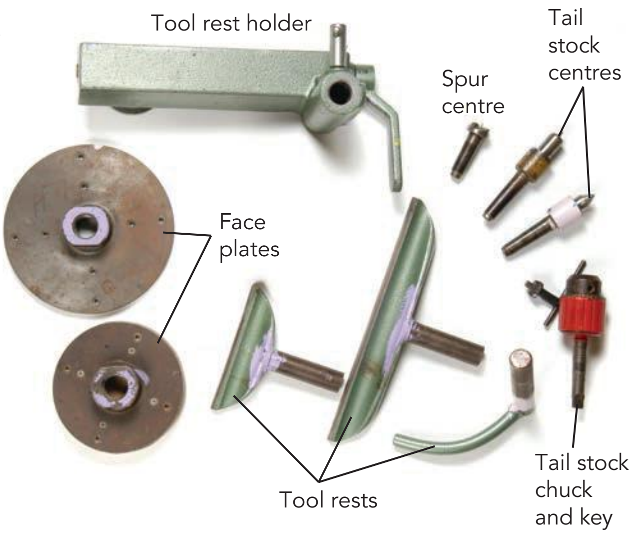

Figure 11.12 Lathe accessories

- Place the stock in position, wind the tailstock spindle in to about half of its travel, insert a centre with a ball bearing then advance the whole tailstock until the revolving centre point almost touches the end of the stock where the diagonals intersect, lock the tailstock to the bed.
- Wind the tailstock spindle in while slowly turning the work back and forth by hand until no free movement is felt. At this point the tailstock centre will be properly embedded in the wood. Lock the spindle.
- Select the appropriate tool rest and set it approximately halfway up the side of the wood (about level with the axis or point in the tailstock) and close to the wood.
- Make sure the work rotates easily by hand without catching on the rest.
- Allow your teacher to check the preparation prior to starting the motor.

Face-plate turning

The ideal introduction to turning is via small face-plate projects. Good results can be obtained with a minimum of skill and practice, and it is possible to turn some items with the use of a single tool, such as a round-nose scraper or bowl-turning scraper. Care must be exercised when locating the stock on the face plate. Various chucking methods may be used. Seven of these methods are detailed below. A tailstock may be used to add support to the project until it is turned concentric.

Methods of chucking

- There are various expanding-type face-plate chucks on the market. The development of microwave seasoning by Bruce Leadbeatter for woodturning highlighted the need for a special chuck for green-timber turning. Leady's chuck suited this (Figure 11.13a). This system requires a shallow insert to be drilled in the base of the work piece that just fits the chuck, which is then expanded to grip the work.
- There are chucks that are designed for gripping a turned **spigot** at the base of the work piece; for example, the Nova chuck. The spigot is removed when the bowl is turned and sanded (Figure 11.13b).

- By first screwing a wooden backing plate to a face plate, a seasoned work piece can be attached in two ways: using four blobs of quality hot glue or by gluing a piece of cartridge paper (with PVA glue) between the backing plate and the work piece, followed by clamping and waiting 24 hours for it to dry (Figure 11.13c). Both methods are carefully separated with a chisel later.
- Turn a recess at least 5 mm deep in the base of the stock then turn a wooden jamb chuck to fit (Figure 11.13d). The plug must be a tight fit with a true shoulder flush against the base. A similar method involves screwing the top of the stock to a face plate. The total outside surface (base and side) can be turned and a spigot formed on the base. A wooden plug is then turned that the base will fit in. Turning the inside then removes the screw holes.
- Use a screw centre – a woodturning accessory designed with a threaded point to hold small stock for turning; for example, drawer knobs (Figure 11.13e). The screw spigot chuck (Figure 11.13f) is used on medium diameter projects, and is an improvement on the traditional pin chuck because it provides a more secure drive.
- The cup chuck is used to support turnings, such as goblets, eggcups, mugs and vases, in which the end grain runs parallel to the axis of the lathe; therefore, requiring lateral stability (Figure 11.13g). Firstly, turn a taper on the end of the stock to correspond with the taper of the chuck then drive it firmly into the chuck with a mallet.
- The screw cup chuck (Figure 11.13h) needs a spigot to be turned on the work piece. A thread is cut onto the spigot while screwing the project into the chuck, prior to locking against the shoulder. This eliminates the traditional cup chuck problem of throwing the project out of true in response to excess pressure or when a tool digs-in. Also, incomplete projects can be quickly removed from the chuck and rechucked later for finishing, maintaining accuracy.


Bruce Leadbeatter

Figure 11.13a Leady keyless bowl chuck, no levers or keys required, no protruding jaws, designed to be self-tightening for safe use in schools


Nova

Figure 11.13b Typical scroll chuck by Nova

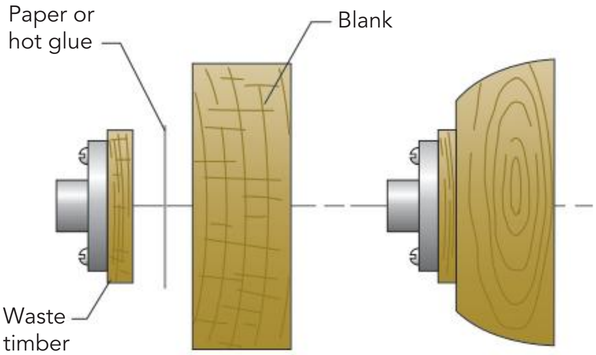

Figure 11.13c Paper or hot glue method

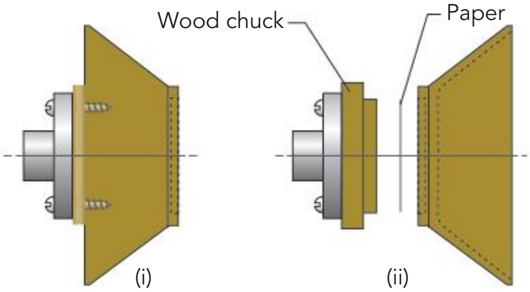

Figure 11.13d Turning a jamb chuck to fit in a recess. Paper may be used in the recess for a tight grip

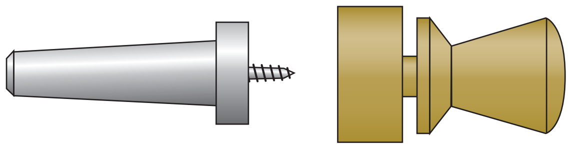

Figure 11.13e Screw centre with threaded point holds small stock for turning

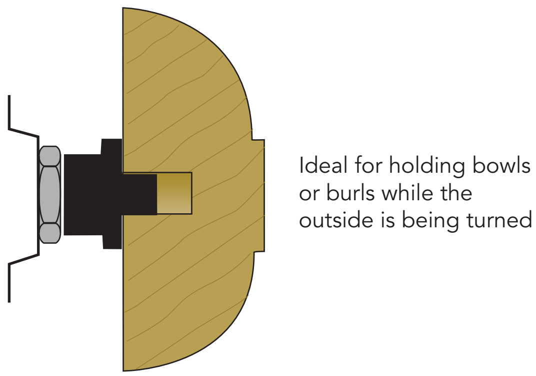

Figure 11.13f Screw spigot chuck

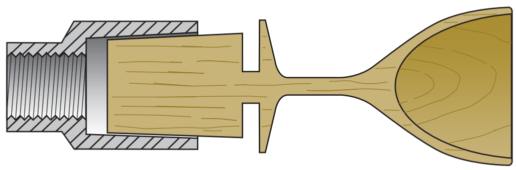

Figure 11.13g Cup chuck; note mating taper turned on end of stock

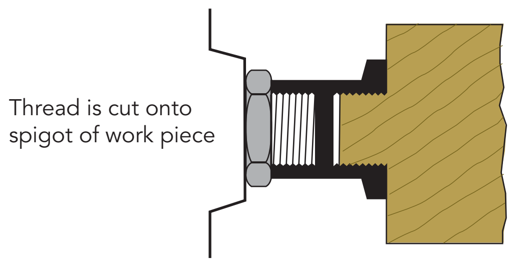

Figure 11.13h Screw cup chuck; note locating shoulder on chuck

Bruce Leadbeatter

Figure 11.13i Eccentric chuck used for off-set turning (Figure 11.19)

Other turning operations

Drilling and boring

When turning between centres (i.e. a lamp spindle) it is possible to drill the essential hole through the centre to take the power cord. A cup centre has a removable point which will allow a drill or long auger bit to be passed through the tailstock and centre. Care and slow feed is necessary. For a very long spindle, such as in a floor lamp, the spindle is normally made from two parts that are later joined together.

Sometimes it is useful to use a spade or Forstner bit in a Jacobs chuck mounted in the tailstock to drill out the waste timber in the top centre area of a bowl. There, it is revolving more slowly than the **periphery** of the bowl. Use care to avoid drilling too deeply!

FACT

The pedestal drill has a rotating bit and a stationary work piece while the wood lathe has a stationary drill bit and a rotating work piece. Both achieve the same result.

Green-timber turning

The ability to turn green-timber has much to offer. Aside from the cost savings to be gained from finding a local tree that needs to be **lopped** or has died, the wood turns more easily, there is a lack of dust irritation, tools require less frequent sharpening and there is a greater variety of species to choose from. Many fruit trees (such as mulberry, apricot and mango) and native trees (such as lemon-scented gum and silver wattle) provide attractive colour and figure patterns.

SAFETY

Be aware some wood-turners might have an allergic reaction to the moisture emitted by green timber. For example, camphor laurel may cause respiratory issues.

The parts of a tree that produce the most interesting figure, such as burls, knots and **crotches** are difficult to air season, taking from six months to one year per 25 mm of wood thickness to dry to EMC. The main disadvantage with rapid wood seasoning is that stresses can be set up in the timber that lead to shrinkage and cracks. Evolving methods are attempting to reduce this to a minimum; mainly by sealing the timber on or near its surface.

Microwave seasoning

Microwave seasoning is relatively simple; however, care is needed to ensure that the object is not overheated or the internal cell structure of the wood may collapse and, with thicker walls, splits may appear. Many wood-turners have differing ideas on seasoning but, as a general rule, the slow reduction of moisture and the avoidance of overheating are vital **maxims** to apply.

The advantages of microwave seasoning over other methods of drying timber include:

- Shorter seasoning times: minutes and hours (compared to weeks and months) is achievable, and with far fewer defects.
- The heating process softens, or plasticises, the wood (as in steam bending) because the lignin and cellulose soften. This relieves the majority of the stresses that are normally associated with knots or uneven grain structure. A certain amount of shaping or forming is possible, providing design possibilities as well as permitting correction of ovality, if required.
- The bark remains firmly attached which provides greater artistic possibilities.
- The applied heat kills any borers or fungi. Most commercially available timbers (such as pacific maple) have been treated with insecticides or chemicals, which create a potential health problem for the wood-turner.

Figure 11.14 An example of Microwave seasoned Jacaranda bowl with bark attached

- Many Australian eucalypts that were previously considered too difficult to turn and season can now be satisfactorily worked.

Using the microwave to season green-turned timber

This process uses a normal domestic-use microwave oven to quickly remove moisture from wood until it reaches EMC. The microwave creates uniform heat throughout the timber to a maximum depth of approximately 25 mm. However, the inside of the timber actually gets considerably hotter because wood is a good insulator. This forces the moisture to the outer layers of the timber, greatly reducing the stresses that cause cracking or **checking**. Green timber that is to be microwaved is best turned slightly thicker than is required in order to allow for final re-turning prior to finishing. For best results it is recommended to maintain a uniform wall and base thickness.

This process is similar in many respects to baking a cake – the larger the cake, the longer it takes to cook. Therefore, let us describe the steps in drying an average-sized wooden bowl (for example, 250 × 75 mm). Larger or smaller bowls will take more or less time, respectively.

1. A partly filled cup of water should be placed in one corner of the microwave to protect the magnetron.
2. Place the project in the microwave for 10 minutes on medium to high heat.
3. Remove the project and place it on a stand until it cools (approximately 20 minutes).
4. Place the project back in the microwave for 5 minutes. Look for knots or checks after you remove it. A damp cloth, applied immediately after the project is removed from the oven should be used to control end grain, knots or checking – these should close up in 30 seconds.
5. Repeat this heating, cooling and wetting process three or four more times, gradually reducing the length of time for each action depending on the type of timber and the thickness of the project.

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There are a number of ways to tell when the timber is dry.

- Weigh the wood at intervals. When it ceases to lose weight you only need to let it cool.
- Feel the project: wet wood is cooler than dry wood.
- Tap the project with your knuckles: dry wood produces a different sound compared to wet wood.
- Test for EMC if you have access to a moisture metre.

If timber checking appears in a number of places, stop the drying process; the wood is below EMC.

Other methods of drying green-turned timber

Detergent treatment involves soaking the wood to prevent potential checking as the wood dries. Use clear washing-up liquid diluted with six parts water and soak the roughed-out wood for four days.

Follow this with waxing, wrapping, freeze drying or dehumidifying.

Boiling the wood can also dry a rough turned piece quickly. Boil the wood for close to an hour, plunge it into cold water to kill any mould, then dry it using a method discussed below (or the microwave).

Another option for drying involves using standard air drying but covering the wood with **polyethylene glycol (PEG)** or other similar chemicals. The wood is then stacked in cool, shaded, ventilated conditions and wrapped in newspaper, its own shavings or shredded paper.

Refrigerators and dehumidifiers will dry wood faster than standard drying; however, they may increase surface checking.

Freeze drying entails placing the wood in a plastic bag in a freezer for two days. It is then unwrapped and thawed for a day in a cool place, away from sunlight. The unwrapped wood is then weighed and placed in the refrigerator. Check the weight every few days until no more weight is lost over a period of 3–10 weeks depending upon the thickness and density of the timber. Final weight should be 20–50 per cent less than when the process began.

After drying, the timber will probably be warped/distorted, so returning it to the lathe is necessary. Be careful to ensure it is remounted securely by your chosen method. Use a slow speed until you are sure all is secure and **concentric**.

HINT

Avoid storing green timber pieces in plastic bags because this promotes mildew and discolouration.

Laminating

This method uses smaller pieces of timber and glues them together to form a larger piece, which can then be turned. Very attractive effects can be achieved by placing different coloured woods together in the build-up of **laminations**. A similar effect can be achieved by cutting a solid piece of timber, possibly at an angle, then gluing in contrasting coloured veneers that give a sloping hoop effect to a bowl.

An original piece designed and created by Jim McConnachie

Figure 11.15 Laminated bowl by Jim McConnachie

Segmenting

Bowls and other projects that are turned from blocks built up of segmented timber rings, which are glued together, are attractive and offer the following advantages:

- Less risk of warping than in a solid block of equal dimensions.
- Minimum end grain exposure.
- There are savings in timber and time because scrap pieces are utilised to produce stock in which the shape is already 'roughed out'.

The steps for producing a built-up block for a fruit bowl are as follows:

1. Complete a full-size drawing to determine the size and shape of each segment so that suitable templates can be made for the segments to be used in each ring (Figure 11.16a).

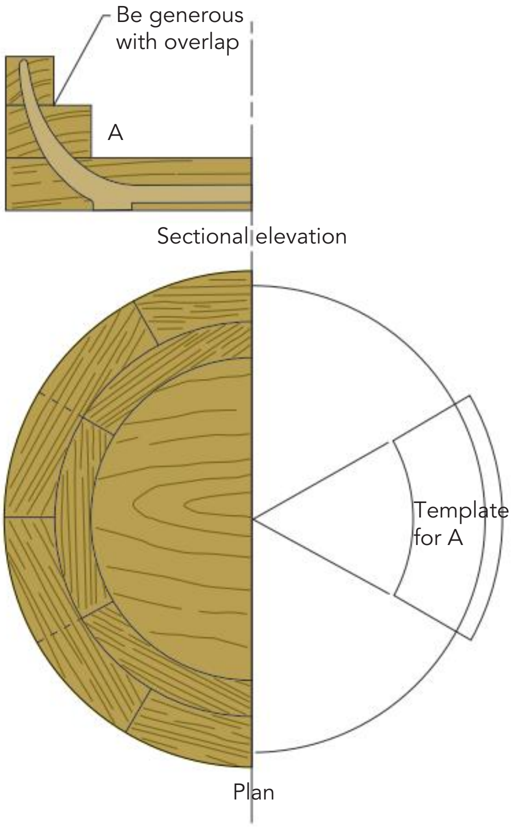

Figure 11.16a Setting out segments for rings in built-up fruit bowl

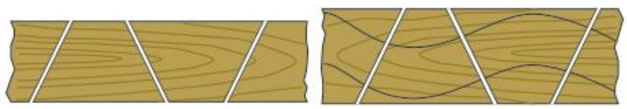

Figure 11.16b Mark and cut segments so that grain runs lengthwise and tangent

2 Mark out and cut segments so the grain runs lengthwise and forms a tangent to the circle (Figure 11.16b). Leave the edges straight. Number each set of segments to ensure they match.
3 Clamp each set on a jig, forming a ring and re-saw between mitres with a tenon saw for a more accurate fitting of joints (Figure 11.17).
4 Glue both surfaces of each mitre joint and clamp each ring with a heavy rubber band. Tip: place a sheet of paper underneath the ring to guard against the segments sticking to the clamping board.
5 Sand and glue the faces of the rings and assemble them concentrically with the base, ensuring the joints are staggered. Clamp the whole assembly in a press, taking care the rings do not move off-centre. Consider how you will hold the assembly on the lathe and add a layer of timber if necessary.

Figure 11.17 Resaw between segments to make a more accurate joint

Bruce leadbeatter

Figure 11.18 An Australian red cedar segmented bowl by Bruce Leadbeatter

Turning thin items

Long, thin spindles, such as standard lamp stems, are usually turned in two sections, then assembled with a pin-and-socket joint. However, each section may be so long that it will cause ‘whipping’ and ‘chattering’ in the lathe unless supported by a steady rest.

1 Position the steady rest near the centre of the spindle against a pre-turned portion that has been left at least 3 mm oversize for final finishing.
2 Complete the turning with the lathe at a lower speed than normal. Remove the steady and finish the point of contact with the lathe at lowest speed, and work longitudinally with the lathe stationary, then sand and burnish with wood shavings at higher speed.

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Off-set turning

This type of turning between centres is achieved by first partially turning about three-quarters of the timber's length then off-setting the tailstock end of the timber so it creates a new support position for the tailstock centre; for example, a **cabriole chair leg** (Figure 11.19). An alternative to moving the tailstock is to use an eccentric chuck on the headstock (Figure 11.13i).

Figure 11.19 Cabriole leg made by off-set turning

Figure 11.21 A camphor laurel bowl. Note: 'Bowl Miser' parting tool was used to turn out centre waste. Waste was then used to turn the matching base.

Burnishing arrises

An attractive effect can be achieved by burnishing a sharp arris on a turned item, such as a jar with a lid (Figure 11.20).

1. Set the speed of the lathe to fast.
2. Press and hold a small firm pad of an appropriate material, such as nylon cloth or compressed cork, against the arris.

The friction and consequential heat serves to burn the surface black and produces the desired aesthetic effect.

Figure 11.20 A burnished arris around a container

Bowl blank saving

There is a curved type of parting tool that, in experienced hands, can remove most of the waste from the inside of a bowl as a single piece rather than as shavings. This blank can then be used to produce another, smaller bowl with a matching colour and grain flow; therefore, saving natural resources and making the most of a single piece of timber.

Nail templates for marking

For repetitive work, a small offcut of wood can have nails inserted at measured positions, which are then ground or filed from both sides to produce a series of sharp chisel-like blades. The wood is held with the nails against the tool rest and gently pushed into the turning timber to produce marks which help position beads, hollows and shoulders, etc (Figure 11.22).

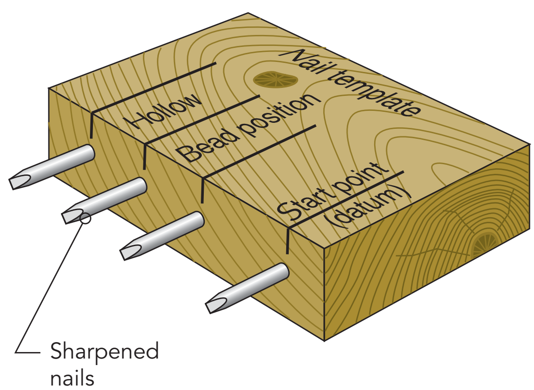

Figure 11.22 Nail template for marking repetition work when turning between centres, as in fancy chair legs

SAFETY

- Keep small, chucked objects short to prevent leverage of the tool pushing them out of the chuck.
- Always rub the bevel first before turning with a cutting tool.
- When scraping always have the cutting edge of the tool set at centre (axis) height.
- Avoid having too much of a scraper cutting edge touching the wood at one time because it may 'snatch'.
- Never slow the rotating work down using your hand; it can trap your fingers.
- If a tool is not cutting well, talk to your teacher; it may be blunt or your method may be incorrect.
- Lathe rotation speeds are adjusted to suit the work and conditions. Your teacher will explain and advise but, generally, if the project is large, heavy or not perfectly concentric, the speed must be slow. If you are sanding or turning a thin work piece then a medium to fast speed works best.
- Remember, when turning from square to round, the gap between the work and the tool rest will increase rapidly – readjust often (with the machine stopped) to maintain a small gap. This will help considerably with tool snatching by reducing the distance from the tool rest to the work piece. Having long handles on the tools also helps prevent this because you have better leverage; therefore, grip the tools at the end of the handle.
- When sanding on the lathe, always remove the tool rest and sand under the rotating work piece in case something catches.

Ideas for turning

Here are some ideas for turning projects you could decide to undertake.

- Honey dipper
- Laminated bowls
- Mallets
- Toy wheels
- Dip and chips bowl
- Candle holder
- Tool handle
- Vase
- Paper towel holder
- Drum sticks
- Container with lid
- Rolling pin
- Cricket stumps
- Yo-yos
- Segmented bowls
- Table legs
- Pen/pencil set (fine)
- Goblet
- Banister rails
- Back massager rollers
- Lamp base
- Salt/pepper mills
- Business card holder
- Bowl with bark on

Woodturning ideas

Project sheets

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CHAPTER REVIEW QUESTIONS

1 Sketch and fully label a typical wood lathe.

2 List three safety measures to be observed before starting a lathe.

3 When turning between centres, what object actually turns the piece of timber?

4 What is the purpose of a hollow tailstock centre?

5 Using labelled sketches, show how a piece of wood is prepared for turning between centres.

6 Why do wood-turning tools have very long handles?

7 Describe the headstock of the lathe and what it is connected to.

8 List three turning chisels, state the use of each and sketch the cutting end of each chisel.

9 Describe one method of attaching a piece of wood to the lathe for turning a bowl. Draw and label all parts of a side view of the wood attached to the headstock.

10 Explain the difference between cutting and scraping when using the lathe.

11 What are the advantages of microwave seasoning over normal air drying?

12 How can you tell when a piece of wood has reached EMC when using microwave seasoning?

13 Use the internet to research the methods that were used to turn a lathe before electricity was discovered. Sketch or print a picture and briefly explain how each type of lathe was turned.

CHAPTER

12

Finishing timber

Many advances in materials and techniques used for wood finishing have occurred in recent years, particularly for furniture and cabinetwork. However, decorative and protective coatings date all the way back to prehistory when people used animal fat to preserve and strengthen wooden weapons and implements. The ancient Egyptians made water-thinned paints from casein and egg-whites, and varnishes from fossilised resins. Chinese and Japanese craftspeople were using lacquer made from tree sap more than 2000 years ago. Shellac, a basic ingredient of French polish, came to Europe from India, where the secretions left by sap-sucking insects on trees had been gathered and used as a wood preservative since before the time of Julius Caesar.

Today we use more synthetic finishes, which, in industry at least, have largely replaced French polish because of their ease of application and their greater resistance to heat, moisture and abrasion.

Often a well-made project is let down by poor or incomplete finishing. It is often said you should spend as much time finishing the project as you did in making it.

This chapter describes some proven methods of surface preparation and outlines many of the finishes available to help you choose and apply the most suitable finish for your project.

Key terms

backing materials include paper and cloth to which abrasives are attached

carcinogenic any substance that tends to produce cancer

coke the solid product resulting from the distillation of coal in an oven or closed chamber, or by imperfect combustion

cure the process where a chemical reaction (such as polymerisation) or physical action (such as evaporation) takes place, causing a harder, tougher, or more stable linkage (such as an adhesive bond) or substance (such as concrete)

filling as part of filling the grain – a paste wood filler is rubbed onto the timber surface to fill the pores to give a smooth texture for a gloss finish to be applied

key the grip a substance has so it can remain attached (a rough rather than smooth surface)

laying off the final act of applying a brush finish; consists of very light strokes along the grain to remove brush marks and air bubbles

oxidation when a substance combines with oxygen and undergoes a chemical reaction

polymerisation a chemical reaction when molecules join together to make very long molecules called polymers. Generally, to form a plastic

raise the grain after sanding, this is the action of damping the surface of the timber and letting it dry, which lifts loose grain prior to re-sanding

semiprecious stone a stone that has value as a gem but not classified as precious

solvent a liquid that can dissolve another substance

stains a liquid used to change the colour of timber

stopping (putty) substance used to fill nail holes or imperfections in a timber surface. It may be coloured to match the timber being used

Surface preparation

Patience and skill in preparing the surface are essential to producing a good finish. This is especially important where a high polish is required because the reflected light will accentuate imperfections, such as plane marks, sanding scratches, bruises and rounded edges.

Careful surface preparation involves the following steps.

1. When necessary, clean off the surface with a smoothing plane, sharpened super-keen and set to produce extremely fine shavings.
2. Remove plane marks and tears by scraping the entire surface with a hand or cabinet scraper (see below).
3. If the surface is to be coated with a material likely to **raise the grain** damp down with hot water and allow to dry overnight.
4. Fill holes or breaks with stopping (putty).
5. Sand along the grain. For most cabinet timbers begin with 80–100 grade paper, follow with 120 grade then finish with 180 grade.

There is a step between planing and sanding that is sometimes omitted. This step involves removing plane marks or tears around knots by using a *hand* or *cabinet scraper*. Scrapers are normally rectangular, but curved scrapers are available for different shapes or removing a mark in an isolated spot. The cutting edge of a scraper is a 'burr' along the base that, when flexed, tilted forward and pushed on acts like a mini plane, smoothing the surface. It is not recommended that you use abrasive papers and then return to a scraper because loose grit may blunt the scraper edge. If only dust is produced, it means the scraper needs resharpening.

Sanding is the process of cutting wood fibres with abrasives to prepare the surface for a finish. You will often hear sheet abrasive materials loosely referred to as 'sandpaper', even though these days most abrasives are not generally made of sand.

Abrasives

Garnet

Garnet, a natural, reddish-brown **semiprecious stone**, is the most widely used wood abrasive. It is of medium hardness and toughness, and, due to its tendency to fracture, it forms new cutting edges while being used.

Silicon carbide

This shiny, dark grey to black synthetic material is made of **coke** and sand fused together in an electric furnace and then ground. Due to its brittleness, it fractures into sharp, wedge-shaped slivers. Almost as hard as diamond, it is generally used on wet-or-dry (waterproof) papers and, increasingly, on dry self-lubricating papers (those coated with zinc stearate to prevent clogging).

Aluminium oxide

This is extremely tough and resistant to wear and typically light grey in colour, although other colours are available. It will penetrate almost any surface and is particularly suitable for heavy-duty machine sanding. It is also an electric furnace product, made from bauxite, coke and iron filings.

Glasspaper (sand)

Basically, glasspaper is pale yellow, crushed glass that is glued to stiff brown paper. This type of abrasive is centuries old and is still used for hand sanding.

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Figure 12.1 A variety of abrasive papers

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Table 12.1 Comparative grading chart

General grading	Aluminium oxide and silicon carbide	Garnet	Glasspaper
Extra fine	600		
	500		
	400		
	360		
	320		
	280	280 – 8/0	
	240	240 – 7/0	
	220	220 – 6/0	00
Fine	180	180 – 5/0	0
	150	150 – 4/0	1
	120	120 – 3/0	1½
	100	100 – 2/0	F2
Medium	80	80 – 1/0	
	60	60 – ½	M2
	50	50 – 1	S2
Coarse	40	40 – 1½	2½
	36	36 – 2	
	30	30 – 2½	3
Extra coarse	24	3	
	20		
	16		

Backing and bonding materials

Faster cutting, both by hand and machine, has been made possible with the introduction of harder and tougher natural and synthetic abrasives and a variety of backing and bonding materials.

Backing materials include paper and cloth (the latter being easy to tear into strips). These backing materials result in sanding strips that are useful for curved work. Bonding materials include various combinations of animal glues and resins, to attach the grit to the backing.

Mineral grading

Abrasives are crushed, then sieved through finely woven silk screens. The mesh of the screen is classified according to the number of openings per 25 mm, which is also the number used to designate the grit size of the abrasive. Thus, a 100 grit abrasive would be sieved through a screen having 10 000 openings in 625 mm^2 (25 mm × 25 mm).

In woodwork, 60–80 grit is considered rough, 100–120 grit is medium, 180 grit is fine and 240 grit is very fine.

Types of coating

Coated abrasives are available in two basic types: closed coat and open coat.

Closed-coat abrasives have no voids or spaces between the grains; the backing is completely covered with grain particles. This type is used for heavy sanding operations, such as with power machines.

Open-coat abrasives have the grains spaced at a predetermined distance apart covering 50–70 per cent of the backing surface. It is especially suitable for use on resinous wood, such as radiata pine, because it allows the cuttings to drop free and not clog the paper.

Using abrasives by hand

- Sanding is a careful, precise operation aimed at creating a fine finish.
- The sheets sized 280 × 230 mm, are cut into conveniently sized pieces (about six to a sheet), which are used on a soft block of cork, rubber or a soft board glued to a wooden block.
- For clear finishes, sanding must be along the grain. Working across the grain leaves tiny scratches. Even with fine abrasives these will show if a clear finish is applied, particularly if the work is to be stained. For this reason, disc sanders should not be used.
- The normal procedure is to use several grades of abrasives, finishing with a fine one.
- Care should be taken to keep the surface flat and to avoid rubbing off corners.
- For shaped work, a contour block is used to bring all of the abrasive in contact with the wood.
- Sanding sticks, abrasive paper files or strips of emery cloth are useful for intricate and rounded shapes.
- Small items are best sanded by rubbing them on a sheet of abrasive placed and secured on a smooth, flat surface.
- Individual parts, especially their inside surfaces, are always sanded before assembly and given a final touch up later.
- For painted finishes, sanding may sometimes be completed across the grain direction so the paint will fill the grain.
- Do not exert undue pressure on the block because this exerts excessive wear on the abrasive and tends to cause scratching, even working with the grain. Dust off the work frequently with a soft brush and knock the abrasive against your hand occasionally to free the dust.

HINT

If you are sanding without a block (i.e. just using your hands), folding the abrasive paper into three sections stops it from slipping from your grip. Alter the order of the fold-overs to allow all of the paper to be used.

HINT

If there is an accidental bruise (dent) in a project, possibly resulting from storage, most of it can often be restored by steam ironing. Dampen a clean cloth or paper towel (not dripping), place it over the bruise and press a hot iron over it until the paper towel/cloth is dry. Remember to keep the iron still. Repeat this process two or three times, if necessary, and allow the area to dry before re-sanding the raised grain.

Note: Be careful to avoid the steam and the hot iron base because they could cause burns.

Sanding machines

The four types of sanding machines for hand use are disc, orbital, belt and drum sanders. The disc type of sander does not produce a satisfactory finish because of its circular action, but is useful for shaping and reducing surfaces quickly. Orbital sanders produce a good finish. Disc and orbital sanders are also available as drill attachments, while drum sanders are easily made with a spindle for use in a drill. Drum sanders may also be used between centres in a lathe.

In industrial environments, where sanding is a highly developed finishing process, single and multiple drum, belt and disc type sanders are used in specially made machines capable of sanding over one metre in width.

Finishes

Preparation

If the surface is to be coated with a water stain or any other substance likely to raise the grain, damp down the surface with hot water and allow to dry overnight before final sanding. This will remove the raised wood fibres and lead to a smoother finish.

Stopping (putty) is used for filling holes made by nails or natural cracks and splits. There is a variety of stoppings including button shellac, water putty, plastic wood and wax. Shallow dents do not keep putty in place because there is very little **key**. If a dent cannot be steam ironed out, an alternative, if it must be filled, is to make a few small dents with a marking

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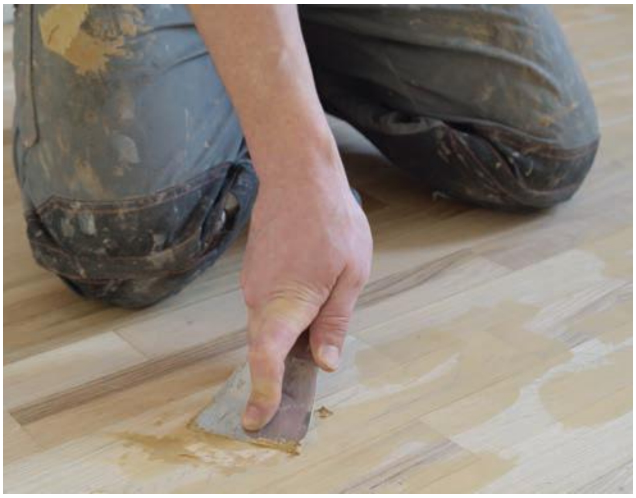
knife point, which will supply the necessary key to hold the putty. The two most common types of putty are water- and oil-based putty and both types come in pre-mixed form. Water-based putty has become more common, can be coloured with water-soluble colours and is suitable under most types of finish.



Shutterstock.com/welzevoul

Figure 12.2 Applying putty (stopping) to nail holes in a timber floor

To apply putty, use a flat-bladed knife and smear it, at a low angle, over the hole so that it is just a little above the surface, let it dry and sand it off with 180 grit along the grain.

Optional processes

Staining

A stain may be used to:

1. change the colour of the fibres to produce a more pleasing colour (aesthetics)
2. make the timber resemble more expensive ones, such as walnut, cedar and teak
3. create an even colour tone over the whole piece, especially when different varieties of the same timber have been used
4. match or harmonise the piece with surrounding furnishings.

Stains, and their application, have advanced a great deal. The instructions on stain containers have simplified the process and enabled it to be available to DIY craftspeople.

Types of stains

Stains are classified according to the solvents (bases) that are used in them. There are three main types in general use: oil-based pigment stains, water-based stains and spirit-based stains.

SAFETY

Gloves and proper ventilation are mandatory when working with wood stains, solvents and other toxic solutions. If using powder stains, cartridge masks may be necessary. It is essential to read all instructions and Safety Data Sheets (SDS) before using them. Aniline dyes are **carcinogenic** and banned from school use.

Oil-based stains

The main base or solvent in oil-based stains is turpentine, so brushes must be cleaned with this rather than water. Shake the container thoroughly because the pigment tends to fall out of suspension. Test the colour first for a preview of the end result – use a scrap of the same wood or apply where it will not be noticable.

iStockphoto.com/vitranc

Figure 12.3 Apply stain with a brush

Stain should be applied quickly and evenly, either with a brush (watch out for flicking the stain off an edge) or a small pad made from wrapping a little cotton wool/waste tightly into a piece of smooth cotton fabric and dipping into the stain. This will soak up and offer a reservoir, which is slower to apply than a brush but tends to be more even. It is difficult to reach corners with this method and a brush or pointed pad will have to be used. Wait for about seven minutes (see instructions) then vigorously wipe off any excess with a clean rag. Leave to dry before applying a finish or the two will start mixing and cause the stain to lift.

HINT

With this type of stain, if you discover a glue mark (normally it will show as a light patch) you can sand it out and re-stain that area without undue colour change.

Water-based stains

These dyes produce rich colours and possess excellent fade resistance qualities. Results will vary depending on the selected wood and the light source: natural, fluorescent or incandescent (normal light bulbs), so testing on a spare piece of the same timber is very helpful. Read all instructions on the container because they may vary. Stir the can periodically to ensure a consistent colour.

With an oily timber, better stain penetration results using a weak mix of warm water and washing-up liquid to break down surface tension. Using a soft cloth or fine brush, apply the stain along the grain, allow it to soak in for up to 10 minutes then wipe off the excess with a clean cloth. When the area is completely dry, a second coat can be applied for a darker result. Once the timber is totally dry, an energetic rub with a clean cloth will compress any raised grain and burnish (smooth) the surface ready for the top coat. Wash out brushes with water and a little soap.

Alamy Stock Photo/Robert Smith

Figure 12.4 Testing the stain on a similar piece of timber

Spirit-based stains

Methylated spirits or alcohol are typically used in spirit-based stains. These stains are best suited to open-pored timbers, such as maple, teak, rosewood and red cedar. They are not satisfactory on fine-textured timbers, such as coachwood and pines. While less penetrating than water-based stains, spirit-based stains are also less fade-resistant; however, spirit-based stains do not generally raise the grain. These stains can produce patchy results so an initial thin coat of shellac reduces absorption but requires two hours for drying before staining. This stain is applied in the same way as the other types and can be lightly sanded after about four hours of drying. A finish is then applied.

Filling the grain

Filling the pores of the grain provides a level surface or 'platform' upon which to apply the finish. Although the modern trend in woodworking is to show off the natural, open grain of a piece of timber (almost as if to prove it is not synthetic), filling becomes necessary if one is French polishing antiques or matching existing smooth-filled furniture.

Courtesy of Canadian Woodworking and Home Improvement

Figure 12.5 Filling the grain using a circular motion

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Fillers come in two groups: linseed-oil based and one- or two-pot plastic varieties. Colours are added to match the various timbers, and fillers normally come as a paste that is thinned, as necessary, with mineral turpentine. Drying is by evaporation of the **solvent**, and a little sinkage may occur. Two days drying time is required. There may be problems with adhesion of polyurethane finishes due to the oil content in the filler.

There is little shrinking after plastic fillers dry (i.e., set and **cure**). They are available in the usual timber colour range, dry in as little as six hours and are designed to take nitrocellulose or plastic finishes.

When applying both types of filler, follow these steps:

- Seal the end grain of very porous wood with a wash coat of shellac to control absorption.
- Mix the filler thoroughly to a smooth paste and thin with turpentine to produce the correct consistency.
- Use a thick mix for wood with large pores.
- Rub the filler freely and vigorously into the pores with a hessian pad. Use a circular action, leaving a skin of filler on the surface to allow for initial sinkage. Fillers may be applied by brush if desired.
- When this coat dries (in about 10 minutes), use a clean hessian cloth to wipe off any excess across the grain and check that the pores are filled.
- Wipe the surface lightly along the grain with a soft, clean cloth to remove cross-grain marks. Take care to avoid marking the surface with your hands and allow 24 hours for the filler to dry before further finishing. This is necessary because the filler leaves a sealing skin that must remain intact. Note: A shellac solution may be used as a sealer over oil-based fillers.

Bleaching timber

Wood may be bleached for three reasons:

- to lighten its natural colour
- to remove dark spots and streaks
- to obtain a uniform finish on several pieces of timber of the same, or a different species, whose natural colours vary.

Due to their structure and colouring, maple, ash, oak, mahogany and walnut timbers bleach more readily than pine, rosewood and gums. Always test a small section or off-cut of your work with bleach first to preview the end result.

a Shutterstock.com/Otophoto, b Shutterstock.com/Andrey_Kuzmin

Figure 12.6 A piece of timber before (top) and after (bottom) bleaching

SAFETY

Bleaches are composed of strong chemicals and must be used with the utmost care. Work in a well ventilated area, wear rubber gloves and protect your eyes. If bleach contacts your skin, wash the area immediately with soap and water.

There are two chemicals that may be used: ammonia and hydrogen peroxide, or oxalic acid and sodium hypochlorite. Details of their use should be researched if required; this is generally outside the scope of the school syllabus.

Types of finishing materials

Finish coatings can be classified in three groups:

1. those that dry by evaporation of the solvents
2. those that dry by **oxidation** of oils following evaporation of the solvents
3. those that dry by chemical change.

Water-based finishes

Due to environmental concerns and the simplicity of application, water-based finishes are the most popular type of finish used, especially in paints. Water-based finishes are easy to remove from brushes, there is a relatively low odour, the drying/recoat time is quick, and it is available in a true clear finish, which is good for using on pine. However, at the moment, water-based finishes are less durable than oil finishes. Dries by evaporation of solvents.

Turpentine-based finishes

Polyurethane is the best known turpentine-based finish. When using polyurethane, be careful as it may react badly if used over certain stains or fillers. Generally, turpentine-based finishes have a slight, brown tint when applied. These are one of the most protective finishes available. This level of protection increases with additional layers. The primary disadvantage of varnishes is that they are slow drying, which can allow time for dust and dirt to settle and damage the finish. Dries by oxidation of oils following evaporation of the solvents.

Nitrocellulose lacquer finish

These are generally for industrial use because of their rapid drying time (dries in minutes). However, they require respirators due to the fumes of the solvent. They are also highly flammable (check the SDS before use). Normally, these are applied using a spray gun rather than a brush – unless a slower cure brush type is used. Dries by evaporation of solvents.

French polish

One of the few natural resins still in use, French polish (made from shellac) is a typical methylated spirit-based finish. It is quick drying and imparts a red/brown colour.

Shellac comes from the *resinous secretions* produced by the female lac bug.

The tiny insects secrete this lac 'resin' while feeding on tree sap. It builds up on the tree branches, which is then harvested, processed and sold as dry flakes (Figure 12.7). Dries by evaporation of solvents.

Shellac, although capable of a superb gloss finish, is not the best finish for tabletops, chairs and kitchen cabinets because of the high level of use of these items (and the results of this use, such as heat and marking).

Figure 12.7 Orange shellac flakes before dissolving in methylated spirits to make French polish

Oil finishes

Oil is a natural product used for centuries to treat and preserve wood. Some oils, such as linseed and tung oil, turn from a liquid to a solid when exposed to oxygen, so they make perfect finishes. Oils are different from most other finishes because they seep into the wood and penetrate the fibres. Due of this, oil finishes cannot be built up to a thick coat and offer less protection; however, their primary advantage is ease of application. Another advantage is that simply wiping on more oil is often enough to repair minor scratches. Linseed oil is the most common, possessing an added metallic drying agent that helps the finish dry in a day. Without this additive, linseed oil can take over a week to dry. Tung oil, unlike linseed oil, does not require drying additives and cures in several days. Scandinavian oil (originally for use on teak) provides similar protection to other types of oil finishes.

Blends of oil and varnish are available that give a little more protection than oil alone; however, these are still only meant for one-coat applications. Dries by oxidation of oils following evaporation of the solvents.

Wax finishes

There are soft, hard and aerosol waxes. The two waxes that form polish bases are beeswax and carnauba (from the waxy leaves of a palm from Brazil), which include additives to soften and make application easier. Solid waxes can be melted onto wood, which gives a slightly darker effect, or rubbed on dry. When dry, the wood's surface is buffed hard and fast to produce a shine. It is

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recommended to seal the wood first and then finely rub back to provide a smooth surface for the wax. This provides an effective but simple satin finish for projects. Dries by evaporation of solvents.

Finishes that dry by chemical action

These are based wholly on synthetic resins of the thermo-setting type, such as urea formaldehyde, polyurethane, epoxy and acrylic polyester resins, and present an exceptionally hard film that can be cut back and burnished without impairing its protective properties. Hard enamels, for such applications as kitchen cupboards and table tops, are produced by adding pigments.

Synthetic resin finishes are sometimes supplied in two-pot form, with a plastic in one container and a catalyst, or hardener, in the other. When the two are mixed, an irreversible chemical change takes place by which the film eventually solidifies. Mixing must be done strictly in accordance with manufacturers' directions and special thinners are needed.

Loss of volume is very slight and film-building properties are high because these finishes dry by **polymerisation** (the linking of adjacent molecules of resin) rather than by solvent evaporation. For example, one coat of polyurethane is equivalent in thickness to five coats of nitrocellulose lacquer.

Types of reflective sheen

There are three types of reflective sheen, and most can be purchased in any of the following: gloss or high gloss, semi-gloss, satin or silk, and flat or matte.

Gloss or high gloss

This produces the shiniest surface and requires care to generate. A gloss, or high gloss, finish needs at least two well-prepared coats (the first to seal), which are applied in a dust-free environment and need fine rubbing back, except for the top coat.

Semi-gloss, satin or silk

This type of sheen gives the surface a shine that is similar to satin or silk. It is probably the most popular sheen because of its natural look and the ease with which it can be maintained (when compared with a gloss finish). Furniture polish, when applied over this sheen, retains the satin sheen, and it does not show wear or marks as easily as a gloss finish.

Flat or matte

This type of sheen is used when the craftsperson is seeking the 'natural look', as if no finish has been added at all, yet the protection is still there. Adding a polish to this type of sheen will make the surface look semi-glossy.

Basic brush finishing

- Ensure that your project, and the work area around it are dust free, and that you have a clean, soft brush and jar of clean turpentine or solvent.
- Spread newspapers in the 'drop zone'. Do not leave the project on the paper to dry because it will stick to it.
- Make a tripod of 12 mm scrap MDF (do not waste real wood on this) with three 30 mm nails suitably spaced (four or more nails will allow the project to wobble). Knock the nails right through the MDF (just off the edge of the workbench) so that the project can rest on the points rather than on the nail heads. This will make it almost impossible to detect the marks later. Use care to not bump or push the project across them.
- Plan your working pattern. Generally, the harder parts and the undersides are coated first, followed by the larger, easier parts. Thin edges should be done when the brush is not drenched in finish – to prevent a run. Large areas are best completed in strips about 50–60 mm wide. Each strip should be followed with the next strip overlapping it a little to reduce the brush marks. Always use the brush off an edge (never on it because this will result in a run). If this does happen, use the empty brush and lightly run it along an arris covering both sides to pick up any loose lacquer.

HINT

When lacquering large areas with a brush, slight thinning of the lacquer with solvent will prevent quick drying and allow more effective laying off.

- If the tin is new, or has not been used for a while, ensure that the lid is firmly on and shake it thoroughly for a minute (with your hands holding the lid on as a precaution). This will mix the contents but may introduce bubbles into the contents. Some say these bubbles are then transferred to the project – but we will see if this is a problem below!

- Open the chosen tin with an appropriate lever-opener or flat-bladed screwdriver. From this point on disposable gloves are recommended. Dip the brush in approximately one-quarter to one-third of the way up the brush hairs (maximum). Carefully and gently wipe the brush once on the inside of the tin to get rid of the excess. This also helps prevent drips, flicks and runs. Follow this process on both sides of the brush.
- Brush along the grain using long even strokes (Figure 12.8). Once a large area is completed, do not immediately refill the brush; balance the brush evenly between your finger and thumb, hold it at a lower angle and stroke it softly along the grain. This is called **laying off** and will even out the surface, get rid of any air bubbles (you might have to repeat two or three times) and allow it to settle without leaving brush marks. Always go off each end and come inwards from any blind corners. The next area must be completed in the same way and, when laying off, blend the lacquer in with the last area, and so on.
- When the project is completed, the tripod can be carefully lifted like a tray and taken into a dust-free room for overnight drying.
- When dry, you can choose between a second coat, waxing or oiling. This can be undertaken after a light sanding to flatten dust particles and raised grain, and after dusting off. Do not sand the final coat because this will introduce scratches.

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Figure 12.8 Brush finish on with long even strokes along the grain

- When you have finished with the tin, use the brush to sweep round the rim and pick up the excess fluid. Scrape it back into the tin so that the lid will fit on. Note: If the lacquer is allowed to dry in the rim, the lid will not give an airtight seal and the remaining lacquer will start to dry out and form a skin. The lid can then be seated using a scrap of MDF (or something similar) that fits across the lid and is tapped with a mallet until the lid is firmly fitted.
- Very few brushes are thrown out because they are worn out. They are usually discarded because they have been made useless by poor cleaning. Normally, at school, there will be a jar of the appropriate solvent to place the brush in. This will keep brushes soft and pliable ready for the next user. If there is no jar of solvent available, the brush must be washed (preferably twice) in the specific solvent – as per information on the side of the tin. The brush is finally washed in soapy water and wrapped in plastic (like cling film).

Wipe on/wipe off polyurethane

With wipe on/wipe off polyurethane you can achieve a run-free, brush-mark-free, air-bubble-free and almost dust-free finish, which after several coats is very protective against moisture penetration, and resistant to scratches, heat and solvents. You can do this with no more effort than wiping or brushing on the finish, and either leaving it, or wiping off some or all of the excess.

Wipe on/wipe off polyurethane is simply common oil-based polyurethane that is thinned enough with thinner so it is easy to wipe on wood.

Spray finishing

Many of the quick-drying finishing materials for woodwork are best applied by spraying. Aerosol finishes certainly warrant consideration for small projects because they give a professional finish when used correctly. Simply follow the directions printed on the can.

Spray-gun equipment can be used to apply stains, toners and fillers as well as clear and opaque finishes.

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Spraying equipment

Sophisticated computer-controlled equipment is used in industry for curtain coating and electrostatic spraying.

Curtain coating

This is usually used for large flat objects such as doors. The objects are placed on conveyor belts arranged end to end with a gap between. Above this gap is a paint trough with a slit the full width of the conveyor, below this is a second trough to catch the overflow paint, which is re-circulated. Paint is allowed to fall through the slit as a continuous curtain, through which the items to be painted are fed.

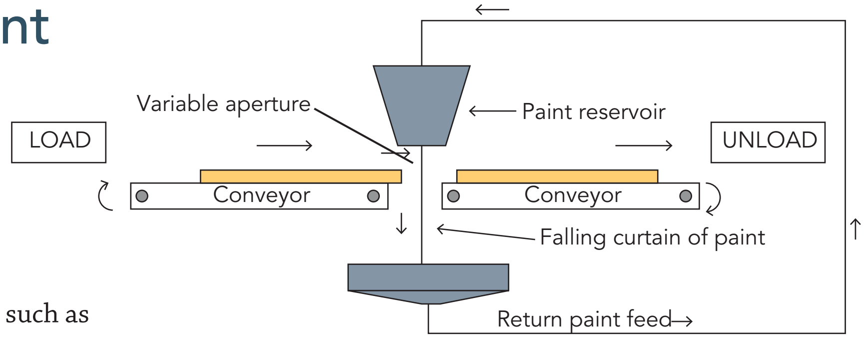


Figure 12.9 Curtain coating equipment used in industry to paint larger items

Electrostatic spraying

This method is used in the mass automated production of objects with complex shapes. A disk is charged with an electrostatic charge, which will concentrate at the disk. When the disk is spun centrifugal force ejects the paint from the disk edge and the electrostatic charge will cause disruption into very small, charged particles. These particles are attracted to the nearest earthed object, i.e. the item to be painted. Even films can be applied with far more control and accuracy than regular spray operations.

However, this chapter is designed to cover conventional low- and high-pressure spraying equipment and its use.

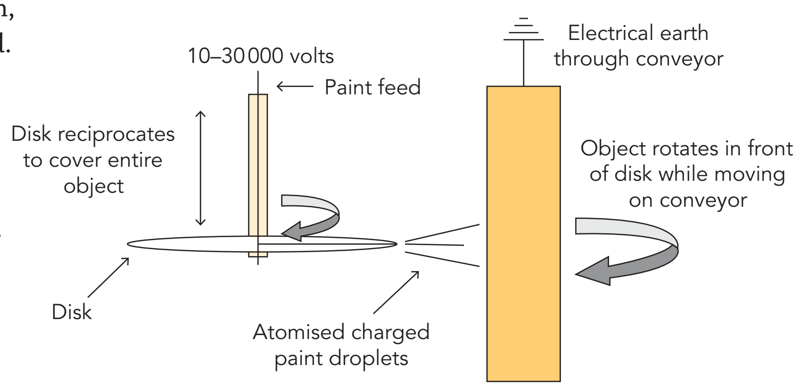


Figure 12.10 Electrostatic spraying process

Compressors

The compressor takes air from the atmosphere, compresses it, and supplies the air pressure needed to operate a spray-gun.

Low-pressure air compressors are usually small portable units. A diaphragm or small piston-type pump delivers compressed air directly to the airline without the use of a tank. This type of compressor is designed to be used with a pressure-feed spray-gun.

Compressors for high-pressure or siphon-type spray-guns need to supply a continuous high volume of air. Most larger-capacity air compressors have multiple pistons and a large reserve tank. They need to be able to supply at least 0.20–0.25 m^3/min at 200–280 kPa (Figure 12.11).

Figure 12.11 An air compressor

Spray guns

The low-pressure or pressure-feed spray-gun allows air to pass through the gun at all times. It uses a high volume of air at low pressure (Figure 12.12).

The material being sprayed is forced from the cup or container by direct air pressure. This type of gun is used for spraying thicker, high-viscosity materials, such as polyurethane varnishes and enamels. The trigger controls finish flow. The principal advantage of the low-pressure gun is that less thinning of material is required. This in turn reduces loss of material through overspray and reduces sagging and runs.

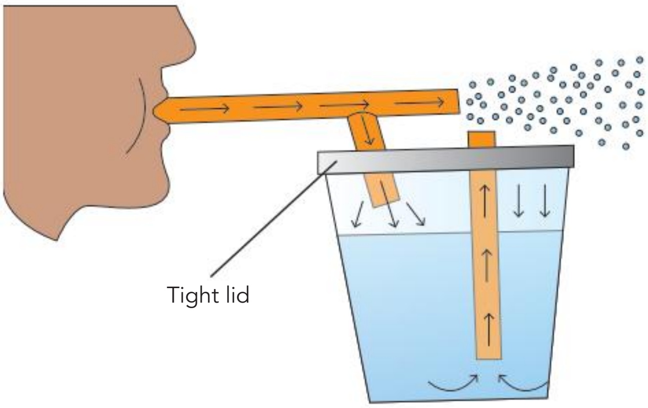


Figure 12.12 How a low pressure spray gun works

The high-pressure or siphon feed gun is probably the most widely used gun in industry (Figure 12.14). It uses a smaller volume of air at a higher pressure. The material is sucked from the cup through a siphoning action and then atomised by the airstream outside the nozzle.

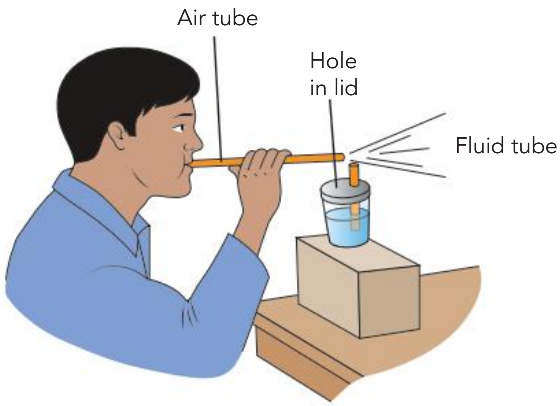
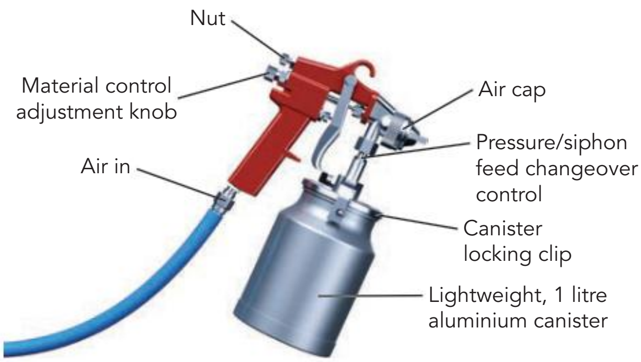


Figure 12.13 How a high-pressure or siphon feed spray gun works



Shutterstock.com/jules2000

Figure 12.14 High-pressure or siphon feed spray gun

Spraying procedure

Small projects can be safely sprayed outdoors, if there is no wind, or in large well-ventilated indoor areas. However, a spray booth is the best alternative where consistent quality and safety is required.

Before spray finishing can begin, all pieces of furniture should be completely sanded. Allowances should be made for the thickness of material to be applied so that drawers and doors will still fit after finishing. The actual spray application of finishing coats can be done with the furniture basically assembled. Bits and pieces, such as drawers, loose shelves and handles, are best supported on a fixture, such as a rotating table. Small objects, such as handles, should be fixed to a board so they are not blown away by the force of the sprayer.

Table top spray booths by Spray Tech / Junair, www.spraytech.com

Figure 12.15 A small bench top spray booth

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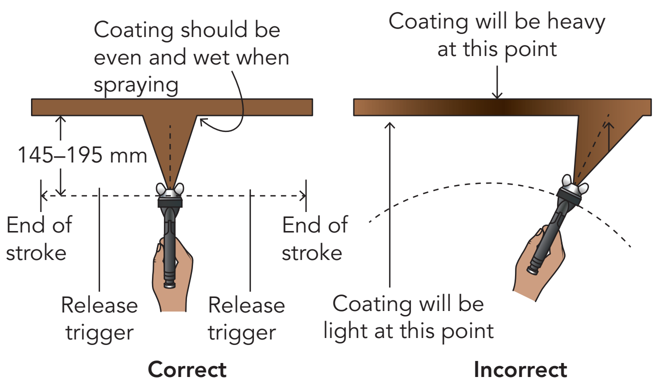

Figure 12.16 Keep spray parallel to the surface to maintain even coating

Always pour finishes into the cup or container through a straining fabric, such as an old nylon stocking, to remove particles that could clog the gun. Thin the material being sprayed to the manufacturer's specifications and test the spray pattern on a piece of waste material.

Start to spray in exactly the same place every time. Always lap the same distance, move the gun at the same rate of speed and keep it at 90° to and at the same distance from the surface to be sprayed at all times. Following these points will ensure you make the same number of passes each time.

The spray gun stroke is made by moving the gun parallel to the work and at a right angle to the surface. The distance from the gun to work should be from 150–200 mm for most paints (Figure 12.16). Work with straight, uniform strokes, moving the gun across the surface in such a way that the spray pattern overlaps the previous stroke by 50 per cent.

Sags or runs may occur if the gun is moved too slowly or held too close to the work, or if the material has been thinned too much. A dry, sandy finish or orange peel effect is invariably caused by insufficient thinner or holding the gun too far away from the project; the material atomises and too much finish is wasted in the form of mist. A steady, deliberate pass that leaves a full, wet coat gives the best result.

The corners of objects should be sprayed first. When spraying flat surfaces each coat should be applied at right angles to the preceding one to ensure a uniform streak-free finish. Round objects, such as table legs, are best sprayed using a round rather than fan-type pattern.

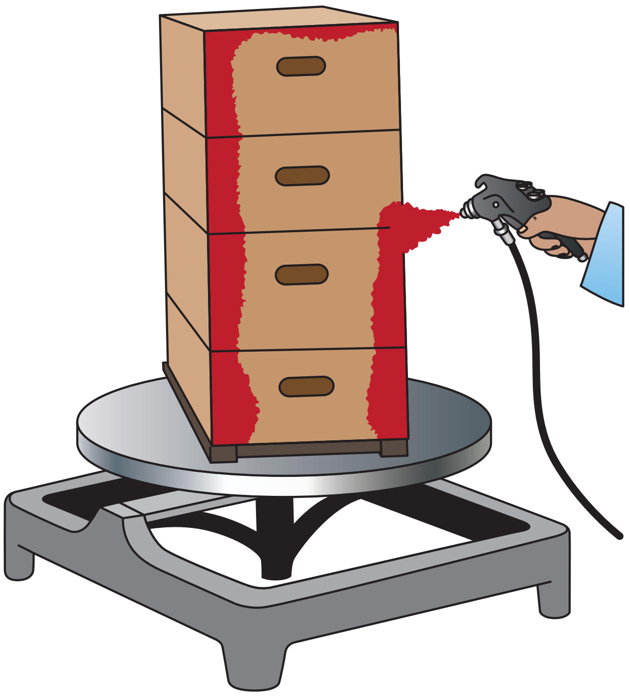

Figure 12.17 Corners of objects should be sprayed first. Note the rotating stand to allow the operator to make best use of the available light

If the trigger is pulled at the start of each pass and released at the finish, over-spraying is reduced and the operator has more control.

Cleaning the spray gun

Careful handling, cleaning and regular maintenance of the spray-gun are important aspects of successful spray finishing. If the gun is not cleaned correctly after being used it may ruin the gun.

After finishing your spraying project empty the canister and wash it out with the correct solvent. Partly fill the canister with solvent and spray some through the gun to clean the nozzle and passageways. Remove the cap and wash in the correct solvent using a small paint brush to help clean. Reassemble the gun ready to use or store.

Safety

The fumes from lacquers and epoxy finishes can be extremely hazardous. They are often both toxic and highly flammable. The vapour of most solvents should never be inhaled for any length of time because they can injure the respiratory system.

iStockphoto.com/ARTYuSTUDIO

Figure 12.18 Using the proper respirator provides protection against toxic fumes

- Never spray without using a proper respirator (Figure 12.18).
- Do not spray in confined spaces unless suitable extraction fans are used. The finishing area should have proper lighting, ventilation and exhaust systems.
- Containers of solvents and finishing materials should be securely sealed in fireproof metal containers and stored in a fireproof cabinet or room.
- Oily paint or solvent rags are highly flammable and should be stored in a fireproof container until they can be disposed of.
- Proper firefighting equipment should be readily available including a fireproof blanket to cover the fire at its source and water, foam, dry chemical or soda-acid extinguishers.

CHAPTER REVIEW QUESTIONS

1 a Why is correct surface preparation so important for producing a good finish when a high polish is required?
  b Describe the method of producing a good surface finish.

2 a Define 'stopping'.
  b Identify four stopping materials and state how each is used.

3 Identify three common faults in timber surfaces and outline how they can be cured.

4 a List three reasons for staining timber.
  b Identify three types of stains and describe how each is applied.

5 a What is the purpose of filling timber?
  b Name the two main groups of fillers and state the advantages and disadvantages of each.

6 a State three reasons why timber is bleached.
  b Name two bleaching solutions and describe how each is used.

7 a Identify the three classifications of finish coatings.
  b Describe the preparation and use of one of the three classifications.

8 Describe the application of Scandinavian oil finish.

9 Outline the care and use of brushes.

10 Set out the steps in applying a mirror finish with a two-pot plastic.

11 What information does the number on the back of garnet paper provide?

12 Define 'open coat'.

13 List the grades of backing used for abrasives, and the use of each type.

14 What is the use of wet or dry abrasives?

15 List three types of grit.

16 How are the various grades of abrasives listed?

17 What does '120 grit' mean?

18 Why must a soft block, such as cork, be used with abrasive paper?

19 Explain how a siphon feed gun mixes and atomises the finishing material.

20 Explain the importance of storing oily or paint saturated rags in a covered metal container.

21 Why is it important to hold the spray gun perpendicular to the surface being sprayed?

22 The spray gun is a precision tool. List the steps necessary to clean and maintain it in proper working order.

CHAPTER

13

Societal and environmental impacts

The world we live in is turning out to be a lot more fragile and less resilient than once assumed.

Every day we are becoming more aware of the environmental impacts caused by the disregard and overuse of non-sustainable resources and the effect upon climate change. Thankfully, we are growing to recognise the need for a more responsible attitude towards looking after the environment. We are also realising that old habits need to change to make sure our planet has a positive future.

This chapter focuses on the societal and environmental impacts the use of our natural resources is having, and shows how the responsible use of timber and timber products can reduce or even reverse damage done to our environment.

Key terms

carbon footprint the amount of carbon dioxide emitted into the atmosphere by an industry or individual

copyright the exclusive right, granted by law for a set number of years, to make and dispose copies, and otherwise control movies, books, music, advertisements, drawings, maps and artistic works. Symbol: ©

ecological balance natural systems in a state of equilibrium, in which disturbing one element disturbs the entire system

emerging technologies technologies that have only recently been discovered and are still in development

fuel cell a battery that produces electricity through a chemical action, such as combining hydrogen and oxygen

gender masculine and feminine aspects of a species

global warming the gradual increase in the temperature of Earth's atmosphere and oceans

innovations a better solution that meets new requirements

intellectual property (IP) anything that refers to the creation of the mind such as inventions, artist work, designs, symbols, names and images may be protected by copyright, trademarks, patents, etc

landfill a site where solid waste is buried under layers of dirt

life cycle analysis (or assessment) the technique for measuring the environmental impact of a product over its life, from designing to disposal

ozone layer a region of the outer stratosphere, where atmospheric ozone is concentrated. It absorbs a major portion of the Sun's ultraviolet (UV) radiation

patents government grants given to an inventor allowing them the sole right to use, make or sell their invention for a set period of time

photovoltaic cell cells that convert energy from the sun into a flow of electrons (electricity). Also known as solar cells

prefabricated assembly of a number of parts in a factory then transported to the site

recycling preparing something for a second use without changing the essential form or nature of the material

reuse using something again, either for its original purpose or for something completely different

sustainable designed or developed to have the capacity to continue perpetually without depletion

trademark serves to identify a business as the source of the goods. The use of a registered trademark gives a company a range of protections and opportunities

wind farms an array of wind generators set up together to produce electricity

Environmental impacts

The growth of industry and an increasing world population call for more and more energy, which is upsetting Earth's **ecological balance**.

Depletion of the **ozone layer**, which protects us from deadly ultraviolet rays, is occurring faster than it is being naturally formed (sunlight on oxygen). This is contributing to global warming. The side effect of **global warming** is the melting of polar ice caps which, if continued, will cause a rise in world sea levels. Many low-lying countries, such as the Maldives, will be adversely affected, causing periodic flooding from storm surges and a scarcity of freshwater for drinking and other purposes. Researchers have estimated that if the melting of the ice caps continues at the present rate, 77 per cent of the Maldives land will be underwater by 2100.

From situations like these, we are learning to think first and consider the consequences of our actions. This is reflected in **innovations** and **emerging technologies** that, while benefiting mankind, also serve to protect and preserve.

The depletion of non-renewable resources, such as coal and oil, is forcing the world to look at more sustainable alternatives. The improved performance of solar power for heating and electricity (**photovoltaic cell**) is providing a viable alternative for both industry and domestic users.

Solar energy use in Australia

Weblink

Australia is leading the world in domestic acceptance of solar energy use according to the Australian Bureau of Statistics (ABS). In 2015, 16.5 per cent of households were using solar energy (Figure 13.1).

Other alternative energy sources under consideration include hydrogen, wind and ocean waves. Some are still in the development stages and not seen as viable alternatives.

Hydrogen in Australia

Weblink

iStockphoto.com/Lighthousebay

Figure 13.1 A modern solar powered house with a single span photovoltaic-cell covered roof

Hydrogen powered cars

Even though hydrogen gas is very flammable, its best use is when it is combined with oxygen in a **fuel cell** to generate an electric current. The electricity is used to power electric motors which drive the wheels. Despite producing almost zero levels of pollution it faces challenges as a viable energy source. The current methods of extracting hydrogen are not efficient; therefore, it is not yet cost effective.

Wind

Wind currents are used to drive a propeller which in turn drives turbines to produce electricity. These wind-powered generators are generally grouped together in **wind farms** which are connected to the electrical grid.

Wind energy in Australia

Weblink

Shutterstock.com/David Steele

Figure 13.2 A wind farm in Australia

9780170411516

In Australia wind energy is one of the fastest growing renewable energy sources for electricity generation. The Australian Renewable Energy Agency has reported that its share of total Australian primary energy consumption is currently almost 4 per cent.

Despite wind being a growing source of energy it is still only suitable for areas that are consistently windy. Detractors of wind farms find them visually unappealing (turbines need to be large to make them efficient) and too noisy.

Wave

This is a method that captures energy directly from the surface of the waves produced in the oceans. This movement drives a turbine that generates electricity.

CHECK YOURSELF

1 Explain how the depletion of the ozone layer has led to far-reaching and adverse impacts on our environment.

2 Name two alternative energy sources and explain why they are not widely used.

3 Why is the use of sustainable material helping our environment?

The main issue with the use of wave energy is that it is expensive to set up. Also, water conditions are not the same in every part of the world.

Environmental and societal impacts of timber products

The measurement of greenhouse gases produced in a **carbon footprint** are generally expressed in equivalent tons of carbon dioxide (CO_2). An industry's carbon footprint gives an indication of its individual impact in relation to global climate change.

The **sustainable** use of timber for building materials is a catch-cry recognised as helping reduce global warming and producing a much smaller carbon footprint than more traditional materials.

Weblink: Timber's carbon footprint

Research by the Cooperative Research Centre for Greenhouse Accounting has shown that the amount of greenhouse gas emissions generated by the manufacture of timber products to build a family home is 25 tonnes less than the amount generated by the manufacture of common alternatives, such as concrete, brick, ceramic tiles, aluminium and steel. Therefore, it follows that when you build your home, wherever you choose to use timber and timber products over the common alternatives, you will produce a smaller carbon footprint (Figure 13.3).

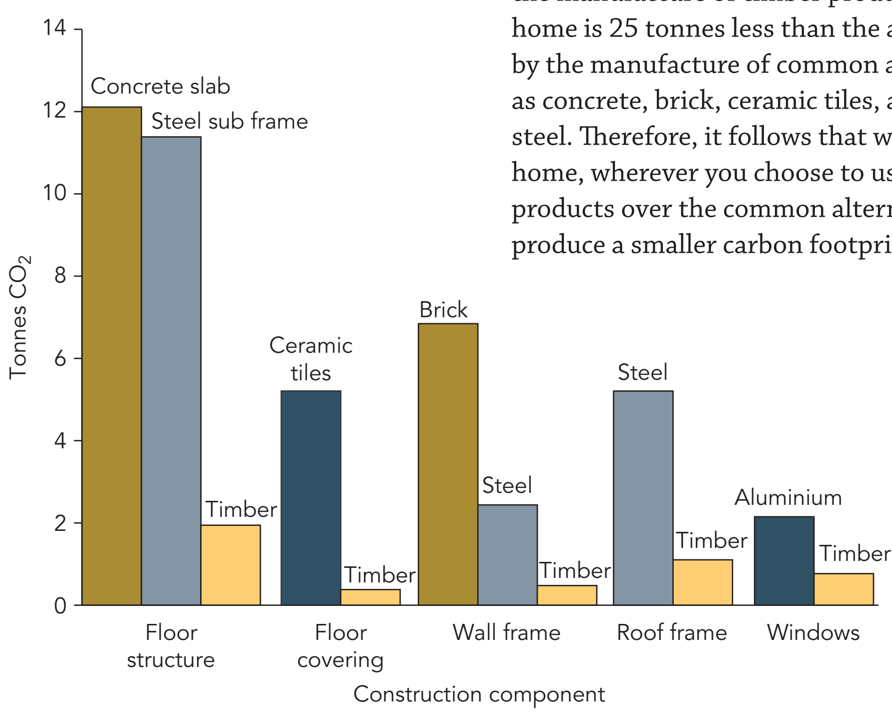

Figure 13.3 Greenhouse gas emissions from the manufacture of different building components commonly used in a family home

> **FACT**
>
> Using more timber in the production of building materials also makes a positive contribution to reducing carbon emissions because the trees absorb carbon dioxide from the air, releasing oxygen and storing the carbon in the wood.

Life cycle analysis

The impact a product has on the environment and society can be measured in terms of **life cycle analysis (LCA)**, reflecting the total effect, starting with collection of the raw materials through to processing, transport, use, maintenance, **reuse**, **recycling** or disposal. In each stage, the impact is measured in terms of the resources used and environmental and societal impacts caused.

LCA is a powerful tool that can help a business identify improvements than can be made in terms of environmental impacts and use of resources. Consumers can also use LCA to compare the environmental and societal impacts of similar products and services.

Waste and recycling

The problem of waste disposal is affecting the entire planet. Our garbage tips and **landfill** areas are filling up, especially with materials that are not easily recycled or reused. Action needs to be taken to reduce the amount of waste.

Wood is such a versatile material that at the end of its first life in a building or as part of a project, it can be recycled or reused, reducing the environmental impact.

Methods of reducing waste

A better way of dealing with waste is to accurately plan the projects to reduce waste on-site to next to nothing! In building projects, **prefabricated** plantation pine frames and trusses present little or no waste. Accurate timber and material orders contribute to reducing waste and will save you time and money. Modern frame and truss manufacturers are now using computer programs that reduce off cuts and reuse to a minimum. Over 95 per cent of timber is converted into frames and trusses.

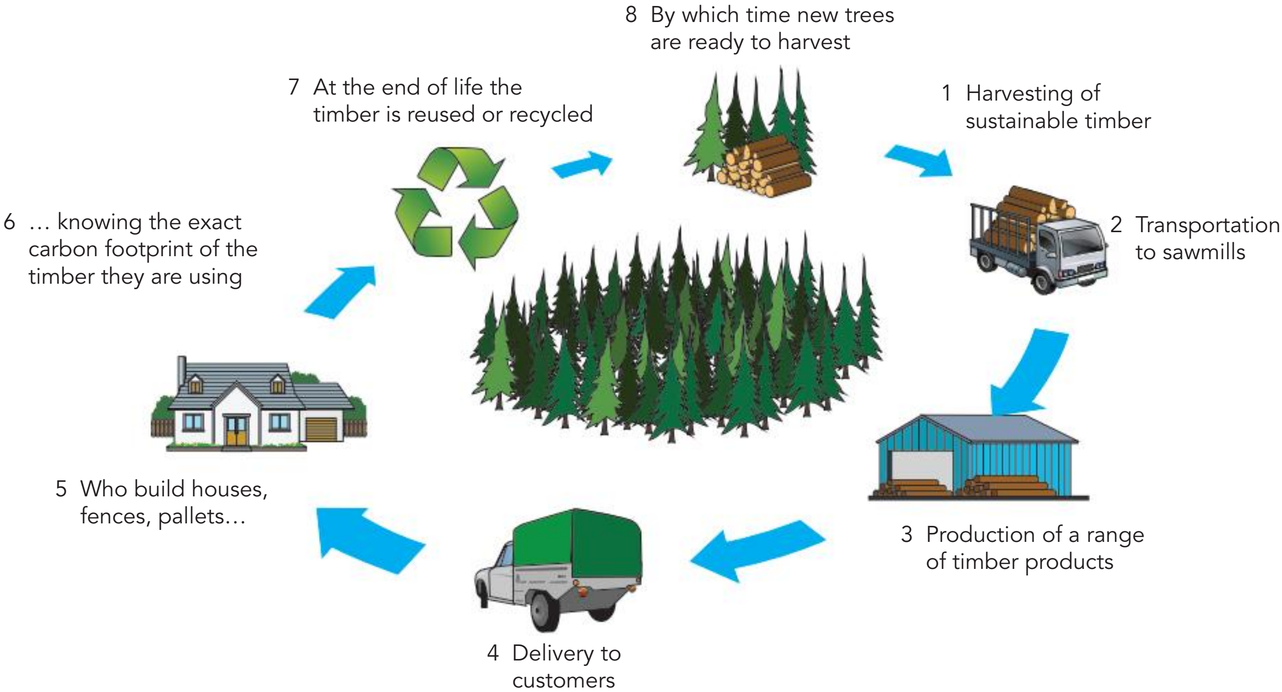

Figure 13.4 The life cycle of a sustainable business

The societal impact of design

Ethical considerations in design

A particular society's customs, values or religious beliefs must be taken into consideration and accepted when designing items. These considerations may differ from other cultures and locations, but they are still meaningful to a particular group of people; and therefore, should be respected. For example, the use of animals in research is an ongoing ethical issue.

Genetic engineering

There are environmental and religious issues related to genetically altering fruit and crops. These issues also relate to stem cell research and cloning.

Exploitation

Children, especially in low-income countries, need to be protected from being used as cheap labour – especially when the end product is providing large profits for a company in another country.

Social considerations in design

Many issues that occur within our society must be considered by the designer if they are to create a successful product. Below are some considerations.

Safety issues when designing

Every year, toys are checked and rejected from the retail market because they are badly designed and deemed unsafe, such as small parts that can be swallowed, flammable nightwear, sharp objects breaking easily and insufficient electrical protection.

Gender issues when designing

When designing an item, allowances should be made for physical differences between the sexes (i.e. their **gender**). A classic example of this is the differences in male and female bicycle design.

The protection of intellectual property

Intellectual property (IP) is anything that refers to the creation of the mind such as inventions, artist work, designs, symbols, names and images. Under international property law owners are given rights that include patents, copyright and trademarks.

Patents

A **patent** is a government grant given to an inventor allowing them the sole right to use, make or sell their invention for a set period of time. It provides the registered owner the right to prevent others from copying, manufacturing or selling their invention without their permission. Patents protect a number of IPs not only physical but manufacturing processes, software, materials development and even methods of business.

Copyright

Copyright is a mechanism to protect authors and artists. It is recognised by the symbol ©. Works include movies, books, music, advertisements, drawings, maps, photographs etc.

Trademarks

Trademarks serve to identify a business as the source of goods. The use of a registered trademark gives the company a range of protections and opportunities. It is recognised by ™ for an unregistered trademark and ® for a **registered trademark**.

Disability and age issues when designing

Design considerations are necessary for facilities, such as wheelchair access in public places such as libraries, purpose-designed toilets for people with disabilities and new tactile bank notes to assist visually impaired people with identifying different denominations (Figure 13.5). The rights of people with disabilities are protected by law.

Reserve Bank of Australia

Figure 13.5 A tactile bank note

Table 13.1 The impact of technology on society

Positives	Cheaper travel and communication
	Improved quality of life
	Less work
	Living longer and in better health
	Easier and faster access to information
	Surgery and diagnostic improvements
	Improved educational scope
Negatives	Robotics can lead to job losses
	Possible loss of personal privacy
	Less human interaction due to electronic communication
	Cyber-crimes increased
	Development of tools of war
	The paperless society has not happened
	Lack of job security

Table 13.2 The impact of technology on the environment

Positives	More global knowledge
	Better application of recycling
	Less resources used to run electronics
	Less space needed with electronics
	Awareness of impact reduction methods
	Better detection of impending natural disasters
Negatives	Pollution increase through production
	More radioactive and toxic waste
	More depletion of natural resources
	Holes in the ozone layer
	More large scale accidents, such as oil spills
	Animal species/habitats disappear

CHAPTER REVIEW QUESTIONS

1 Outline how the use of timber products makes a positive contribution to reducing carbon emissions.

2 Describe three methods of reducing waste on a building site.

3 Explain how recycling helps the environment.

4 What does LCA stand for and how does it help understand how products impact on the environment and society?

5 Define 'ethical considerations', using a different example to the ones mentioned in this chapter.

6 List three different examples of instances where gender has to be considered when designing a product.

7 State two positive and two negative effects of technology in our society.

8 Why are plantation timbers a better choice than rainforest timbers for projects?

9 Explain why intellectual property needs to protected by inventors or creators.

GLOSSARY

A

aesthetics how our brains interpret something to be beautiful or ugly, is the object pleasing to our senses, mainly sight and hearing (but can include smell and taste); the science that deduces from nature and taste the rules and principles of beauty

air seasoning a method of seasoning timber that relies on natural drying in the open air

alloy a mixture of two or more metals or a metal and a non-metal

amp hours (Ah) a unit of measurement for battery capacity; it is the amount of charge in a battery that will allow one ampere of current to flow for one hour

analysing examining something critically to determine its essential elements or features

anthropometrics the study and measurement of the size and proportions of the human body

arc part of a circle, as drawn by a pair of compasses

architectural referring to the art or science of buildings

arris where two surfaces meet at a sharp edge to form a sharp corner

automated assembly robotic movement of materials and assembly. Automated quality control and product testing

automated fabrication parts fabricated on numerical control and flexible manufacturing systems involving control and movement of material

automated warehousing robotic movement of material for storage and order picking. Automated order picking and shipping

axes plural of axis

axis an imaginary line of symmetry representing the centre of an object

B

back sawing a method of converting timber (tangential cut) that produces boards whose faces are, in general, tangential to the growth rings

backing materials include paper and cloth to which abrasives are attached

back-saw a saw with a stiffening 'backbone' to prevent flexing

bastard intermediate grade of file

bead an external curve on a piece of wood; either turned or routed; moulding

bevel an angle, less than 90°, produced over a complete face of a material (e.g. wood); the ground angle of a cutting tool

bevelled a chisel with angled sides

biscuits oval shaped pieces of compressed timber used to secure biscuit joints

brace a thin strip of timber temporarily pinned across a joint to hold it rigid until the adhesive sets

brief a concise statement clarifying the project task and defining the need or opportunity to be resolved

brushless technology a DC electric power supply is directed through a circuit that produces an AC electric signal to drive a motor

burls or burrs wart-like growths on the side of a tree, which can be turned as a bowl or sliced as a veneer

burnishing polishing (a surface) by friction

burr a small sharp turned edge on a cabinet scraper that acts like a tiny plane

C

cabriole chair leg 18th century furniture leg with a shallow, graceful 's-shaped' curve

CAD/CAM software used for designing and manufacturing of products

calibrated marked out using a scale of measurement

carbon footprint the amount of carbon dioxide emitted into the atmosphere by an industry or individual

carcase the main body of a woodworking project (e.g. a cabinet)

carcinogenic any substance that tends to produce cancer

carving in the round shapes are carved on all sides, figures may be abstract, stylised, or natural

cast iron an alloy of carbon, iron and other elements, cast either as soft and strong or hard and brittle iron

chamfer a 45° angle produced on an arris

checking splits that can appear in the surface of timber during the drying process

chuck turning turning with the work held in a chuck attached to the headstock

cloud online internet file storage

coke the solid product resulting from the distillation of coal in an oven or closed chamber, or by imperfect combustion

collet chuck a chuck that forms a collar around the shank of a cutting tool to be held and exerts a strong clamping force when tightened

computer integrated manufacturing (CIM) the use of computer-controlled machines and automation systems in manufacturing

concave curving inwards (e.g. a hollow)

concentric having a common centre

conversion the action of cutting up logs into rectangular pieces of timber for the retail market

convex curving outwards (e.g. a moulding)

copy and paste computing term for copying information and placing it elsewhere

copyright the exclusive right, granted by law for a set number of years, to make and dispose copies, and otherwise control movies, books, music, advertisements, drawings, maps and artistic works. Symbol: ©

cordless no cord connected to mains power; a battery-powered tool

coreboard (or blockboard) a plywood with a solid timber core, mainly used in furniture construction, for table tops and cupboard doors

corestock timber in the middle of coreboard, generally pine

cross-banding where the grain of the veneer is at right angles to the grain of the adjacent wood

crosscutting sawing across the grain in timber

cross-sectional sizes when looking at the end of a piece of timber – its width and thickness

crotches the point where a branch divides into two smaller branches

cup a piece of timber that bends across its grain due to shrinkage; normally in tangential cut timber

cure the process where a chemical reaction (such as polymerisation) or physical action (such as evaporation) takes place, causing a harder, tougher, or more stable linkage (such as an adhesive bond) or substance (such as concrete)

cursive writing in flowing strokes with joined letters

D

deciduous trees or shrubs that shed its leaves annually (usually in autumn)

density the mass per unit of volume. It depends on the size of the cells, the thickness of the cell walls and the amount of lignin, gums and resins present. Density is typically quoted as 'light', 'medium', or 'heavy' and in kilograms per cubic metre (kg/m^3)

design process an activity that starts with the identification of a need or a problem through to the evaluation of the solution

digitally of or relating to the use of computer technology

dominos timber plate that serves as the loose tenon in a domino joint

drag 'n' drop computing term for highlighting information and dragging it to release it in another position

dressed all round (DAR) a rough-sawn piece of timber that has been machine planed on all four faces

dressed timber that has been planed to size

driving the act of inserting a screw with a screw driver or a nail with a hammer

dust extraction removal of solid particles suspended in the air and deposited in a capture bag or bin for disposal

E

ecological balance natural systems in a state of equilibrium, in which disturbing one element disturbs the entire system

electrolytic action an electrical action between two different metals with differing reactions (e.g. a battery)

emerging technologies technologies that have only recently been discovered and are still in development

end grain the exposed view of a piece of wood that has been cut across the grain

equilibrium moisture content (EMC) the moisture content at which wood is neither gaining nor losing moisture; however, this changes with relative humidity and temperature

ergonomics the design of objects to take into account the bodily needs of a worker in the workplace (e.g. the shape of an office chair)

evaluation assess if the project has achieved what the brief intended

eye level at the same level as the eyes

F

face edge an edge that is accurately planed to 90°, used for marking out

face side a side from which all other measurement can be taken (datum surface)

face-plate turning turning with the work held on a face plate attached to the headstock

false front an extra front attached to a drawer, which thickens it to allow for curving, carving, etc

feathers thin slivers of timber, or plywood, that are glued and slotted into corner joints to increase their strength and beauty

ferrule a metal cast or ring on the end of a handle for protection (i.e. to prevent splitting)

figure another name for the grain pattern in a piece of timber

filling as part of filling the grain – a paste wood filler is rubbed onto the timber surface to fill the pores to give a smooth texture for a gloss finish to be applied

flat packing items, such as furniture, that are sold unassembled to save on storage space and assembly labour

flitches slabs of timber cut from a sawn tree trunk from which finished boards are cut. Flitches are typically <100 mm thick and <150 mm wide

flush two surfaces that are level with each other

flutes the spirals in a drill bit that allow waste material to escape while drilling

former a shaped mould used to hold layers of glued material in place until the glue dries

fuel cell a battery that produces electricity through a chemical action, such as combining hydrogen and oxygen

function how an item operates or fulfils its purpose

G

gender masculine and feminine aspects of a species

global warming the gradual increase in the temperature of Earth's atmosphere and oceans

glulam a structural engineered wood product consisting of a number of layers of timber glued together

grain the arrangement or pattern of wood fibres in a piece of timber

green timber unseasoned timber that still contains its natural moisture

grinding removal of metal using an abrasive wheel

grit-size paper the abrasive grade on abrasive paper; the lower the number the courser the abrasive

grooves (or hollows) a recess cut along the length of timber with the grain

H

hardwood wood cut from broad-leafed deciduous trees with the botanical name *Angiospermae*

hazard a cause of danger or harm; a risk, particularly to safety

head the screws arranging the slots in screw heads so that they all line up with the grain of the timber

health the general wellbeing of people in the workplace

heartwood the hard central wood of the trunk of a tree that consists of mature timber

high-carbon steel hard wearing steel with 0.6–1.0 per cent carbon included; may be heat-treated

hone the fine finishing in the blade sharpening process that produces a keen (sharp) edge

I

impact driver a tool that delivers sudden rotational and downward force. Used for driving in wood screws

induction electric current runs through a coil, generating a fluctuating magnetic field which induces many smaller electric currents in the connecting material

inlay imbedding pieces of material into a surface to create decorations or patterns

innovations a better solution that meets new requirements

intarsia a form of inlaying similar to marquetry that uses varied shapes, sizes, and types of wood fitted together to create a picture, a bit like a puzzle

intellectual property (IP) anything that refers to the creation of the mind such as inventions, artist work, designs, symbols, names and images may be protected by copyright, trademarks, patents, etc

interlocked grain fibres on each layer spirally inclined in opposite directions

isometric drawing a scaled drawing with one vertical axis and two axes at 30° to the horizontal

K

kerf the gap created in timber by the thickness and set of saw blade teeth

kerfing the process of cutting several slots, at specific points, in material to weaken it, allowing it to be bent and formed

key the grip a substance has so it can remain attached (a rough rather than smooth surface)

kiln seasoning seasoning with the use of an oven to speed up the drying time (unlike air drying)

L

hardboard (also known as masonite) an engineered board made from compressed and treated wood pulp, from hardwood chips

laminated veneer lumber (LVL) an engineered wood that is similar to plywood but has no cross banding; each layer has the grain running in the same direction

laminated wood relatively thin pieces of timber that can be glued together to form a stronger and thicker component (may be shaped)

laminations several thin layers of material (e.g. plywood)

landfill a site where solid waste is buried under layers of dirt

laser cutting a non-contact process that works by focusing a laser through a nozzle onto the work piece resulting in high quality and extremely accurate cuts

latewood the wood growth that occurs late in the yearly cycle; generally has slower growth with a denser structure

laying off the final act of applying a brush finish; consists of very light strokes along the grain to remove brush marks and air bubbles

life cycle analysis (or assessment) the technique for measuring the environmental impact of a product over its life, from designing to disposal

linisher a belt sander

live sawing a method of converting timber that is the simplest and quickest way to saw a log resulting in the central planks being radial cut (quarter-sawn) and the two outer areas of the converted log being tangential cut (back-sawn)

lopped cut down, as in a tree

M

machining centres A CNC machine that includes an automatic tool changer and a table to clamp the material being machined

marquetry the process of applying pieces of veneer to a surface to form decorative patterns, designs or pictures

masonry refers to stone, brick, or concrete

material lists also known as cutting lists, are translated from a drawing or drawings of a project, extracting all the necessary detail to cut the parts out to exact sizes

maxims a statement of information generally accepted as true

medium density fibre board (MDF) an engineered wood product typically made by breaking down softwood into fibres which are mixed with wax and glue and pressed into a board

metal fatigue weakening of the metal due to repeatedly applied loads

microwave seasoning removing moisture from green timber by carefully cooking it in a microwave

mitre shooting board a device that allows a plane to sit on it at exactly 45° in order to chamfer an edge of timber

mortice and tenon a hole cut in a piece of timber that pairs with a close fitting tongue on another piece creating a very strong joint

mortising cutting a hole in a piece of wood – normally to fit a tenon into it

moulding a decorative contour or outline given to architraves, skirting boards, cornices, etc

multi-toothed having many teeth, such as a surform or rasp

N

nesting arranging shapes to be cut in such a way as to minimize waste and maximise the number of items that can be cut from one sheet

nominal the size of rough-sawn timber prior to DAR

O

oblique drawing a scaled drawing with one vertical axis, one horizontal axis (basically a front view) and the other axis projecting 45° to the left or right

offcuts the timber that is left after a required part is cut from it

on the skew holding the tool at an angle to the work

orbits per minute (OPM) how rapidly a sander vibrates

oriented strand board (OSB) a type of engineered wood similar to particle board, made by gluing layers of wood strands (flakes) in specific orientations under pressure

orthogonal drawing a way of representing a three-dimensional object in two dimensions, used in working drawings

oscillating travelling back and forth in a regular pattern

oxidation when a substance combines with oxygen and undergoes a chemical reaction

ozone layer a region of the outer stratosphere, where atmospheric ozone is concentrated. It absorbs a major portion of the Sun's ultraviolet (UV) radiation

P

panelling square or rectangular pieces of wood that fit together to cover a wall or ceiling

parallel two or more lines equidistant from each other at all points

parameters limits or guidelines that control a design

paring lightly chiselling to level off or remove a small amount of wood

parquetry decorative patterns and geometric shapes produced using blocks of timber glued to a backing material

particle board an engineered wood product manufactured from gluing wood chips together

parting cutting grooves, shoulders or cutting to length (parting off) in wood turning

patents government grants given to an inventor allowing them the sole right to use, make or sell their invention for a set period of time

patternmaking making accurate shapes which are used as moulds from which to cast items

periphery the outer edge of an item

perspective a pictorial drawing where the object seems to converge together at some point in the distance

philips head a screwdriver tightening system resembling a tapering cross; originally invented for faster car assembly line work

photosynthesis the process by which green plants create energy from carbon dioxide and water using light as an energy source

photovoltaic cell cells that convert energy from the sun into a flow of electrons (electricity). Also known as solar cells

pilot hole a small drilled hole that helps guide an item, like a larger drill bit, or makes it easier to insert a wood screw

pilot-tipped bearing the bearing on a router bit that rests against the timber and runs along it, thereby maintaining a faithful shape

planes flat surface areas that are normally horizontal or vertical

plant machinery or equipment used in the workplace

plunge push down into; a plunge router allows the cutter to be pushed down into the project

plywood three or more thin sheets of wood or veneer plies glued together with the grain at right angles in adjacent layers

polyethylene glycol (PEG) a substance used to seal and help season green timber by reducing checking

polymerisation a chemical reaction when molecules join together to make very long molecules called polymers. Generally, to form a plastic

Pozidriv a screwdriver tightening system, similar to the Phillips system, designed not to slip. It has four additional points of contact

pre-drilling to drill the holes in advance

prefabricated assembly of a number of parts in a factory then transported to the site

prescriptive a problem with many parameters (constraints) allowing less freedom in a design process

project sequencing the process of placing the stages of producing a design in a viable order

proofread re-read a completed passage to check for mistakes in spelling, grammar and content

push board a length of material used to push timber (generally thinner than the stock being machined) through a thicknesser

push stick a notched piece of wood used to feed timber into a machine to prevent the operator's hands getting too near the machinery

pyrography the art of decorating wood with burn marks, historically added using a hot poker

Q

quarter sawn a method of converting timber (radial cut) that produces boards whose faces are generally parallel to the medullary rays and at right angles to the growth rings and has less tendency to cup

R

raise the grain after sanding, this is the action of damping the surface of the timber and letting it dry, which lifts loose grain prior to re-sanding

rapid prototyping the fabrication of a scale model of an object using CAD data usually achieved using 3D printing

rasp a course file used to shape wood

raster closely spaced rows of dots that form an image used for etching or engraving with a laser

recycling preparing something for a second use without changing the essential form or nature of the material

regenerate to be formed or regrow again

relief carving creating a three dimensional effect in carving by removing the background

repealed withdrawn or revoked officially, such as a piece of government legislation that is overturned so it is no longer

resaw cut a board to thickness. This allows you to get a number of thin boards out of one larger, thicker piece of wood

resawn sawing flitches into smaller pieces

reuse using something again, either for its original purpose or for something completely different

ripping sawing along the grain

rivet a metal pin with a head on one end, inserted through aligned holes and then hammered on the plain end so as to form a second head

roughing in wood turning, the first stage of converting square stock into round stock

S

safety awareness/prevention of, and removal/reduction of potential hazards during practical activities

sapwood (or xylem) the newer timber that is formed outside the heartwood; more attractive to borers

scale in drawing, the process of reducing or increasing the sizes of an article by a set ratio in order to maintain proportion

scratch stock an 'L-shaped' piece of timber that holds a shaped metal blade, which is scraped along a timber edge to form a shape

scribe to mark or write with an implement or tool (e.g. a pair of compasses)

search engine a means of looking for information on the internet, such as Google or Bing

seasoning drying timber to reduce its moisture content

second cut a grade of file used for cutting hard metals (a grade finer than a bastard file)

semiprecious stone a stone that has value as a gem but not classified as precious

set mitre similar to a try square except that the blade is set at 45° rather than 90°

set on a saw blade, the alternate bending of teeth to the left and right to prevent binding of the saw

shank the straight, unthreaded part of a screw

shearing the action of cutting or breaking something sideways

shooting a method of planing the end grain of timber

short end grain an unusual situation in which the direction along the grain of a piece of wood is structurally weak

shoulder the squared part of a tenon or tongue that reverts back to full thickness

silviculture the deliberate cultivation of forests; forestry

slip (loose) tongue like a 'feather' or 'tongue', a slip is usually placed in grooves for strengthening a joint between two pieces of timber

smooth a fine grade of file (a grade finer than a second cut file)

softwood wood cut from fir and pine trees (needle-bearing evergreen trees with the botanical name *Gymnospermae*)

solvent a liquid that can dissolve another substance

spigot a cylindrical peg or plug

spindle turning turning between centres, with the work held between the drive or 'live centre' in the headstock and a freewheeling or tailstock centre at the other end

splay an edge created at any angle except 45°

spring the curvature of the edge of a piece of timber, with the face remaining flat.

springwood (earlywood) the wood growth that occurs early in the yearly cycle; generally has faster growth with a less dense structure

spur sharp points on a marking or mortice gauge that scribe the timber

square a right angle; 90°

squaring marking a line perpendicular (90°) to an edge using a try square

stains a liquid used to change the colour of timber

stay a device used to support an open lid during uncontrolled closure or excessive opening

steam bending the process of steaming susceptible timbers and permanently bending them, such as Thonet's bentwood chair

steel a metal alloy that is a mixture of iron and carbon (up to 2.1 per cent)

stem the long narrow part of a marking/mortice gauge that has the spur or spurs attached

stock the wooden part of a try square that the blade is fixed to at 90°; a block of wood, generally that which is being worked on

stopping (putty) substance used to fill nail holes or imperfections in a timber surface. It may be coloured to match the timber being used

substance the material, or matter, of which something is made

super foot a method of measurement used on exotic and rare timbers; its volume is 300 × 300 × 25 mm (1 foot × 1 foot × 1 inch)

sustainable designed or developed to have the capacity to continue perpetually without depletion

sustainable yield producing at least as much of a resource as is being used

T

2B a particular hardness of graphite within pencils; 2B grade is a softer pencil best used for marking out

3D printing an additive process that builds up a 3D shape from a three-dimensional digital model (CAD drawing) by laying down multiple layers of material

tang the pointed end of the file or chisel that fits into a handle

teeth per inch (TPI) is now teeth per 25 mm but still referred to as TPI

tensile strength the maximum ability of a material to be stretched prior to failure (breaking)

texture the size and arrangement of wood cells is referred to as texture, often classified as 'fine', 'medium' or 'coarse', 'uneven' or 'uniform'

time management organising one's time in the most efficient way possible

tourniquet a loop of material (such as thin rope) with a stick that is inserted and twisted, which results in tightening

toxicological of a poisonous nature or effect

trademark serves to identify a business as the source of the goods. The use of a registered trademark gives a company a range of protections and opportunities

trench a recess cut across the grain of timber

true accurate or correct

try square an accurate tool for measuring or marking 90° in woodwork

tungsten-tipped (tungsten carbide) a hard and brittle metallic compound used on the tips of cutting tools

twist or 'wind' is a spiral warp along the length of a piece of timber

U

urea formaldehyde a thermosetting resin used in adhesives, finishes, particle board, MDF, and moulded objects

V

vanishing point (VP) the point at which parallel lines receding from an observer converge to a point (e.g. as with a long straight road)

Velcro two thin pieces of material sheet, one covered by tiny hooks and the other with tiny loops, which stick to each other when pressed together

veneer a thin piece or sheet of wood that is typically used for decorative purposes by gluing over an inferior board

W

waney edge a piece of timber that has its edge missing showing the bark or sapwood

warping the broad term that is used to describe any distortion from the straight cut that may occur during or after seasoning (e.g. bow, spring, cup or twist)

water jet cutting cutting using a very high-pressure jet of water, or a jet of water mixed with an abrasive (usually garnet)

wind farms an array of wind generators set up together to produce electricity

wireless charging charging batteries without a wired electrical connection

working drawings orthogonal drawings used for construction of a project

working rod (or measuring rod) a full size working drawing of a project where the sizes and joints can be marked

workplace where events take place, such as a school workshop, a cabinet manufacturing factory or a hardware retail outlet

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