BTEC FIRST

BTEC

ENGINEERING

ALWAYS LEARNING

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Contents

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About this book

This book is designed to help you through your BTEC First in Engineering, and covers nine units of the qualification.

About your BTEC First in Engineering

Choosing to study for a BTEC First Engineering qualification is a great decision to make for lots of reasons. This qualification will give you the opportunity to gain specific knowledge and understanding in engineering, and will help you to sharpen your skills for employment or further study.

About the authors

Simon Clarke has spent over 20 years delivering BTEC qualifications across First, National and Higher National Certificates and Diplomas. His lecturing experience in FE has led to his appointment as an Advanced Practitioner and Head of Department. He has contributed extensively to various published resources.

Alan Darbyshire has worked as an advisor for BTEC on their mechanical engineering programmes. Prior to this, he held the post of lecturer and senior lecturer in mechanical and plant engineering at the Blackpool and Fylde College. He also spent 12 years working in the motor industry. He has written and co-written several engineering textbooks and tutor support materials.

Simon Goulden has been a teacher for 16 years in secondary and further education at a number of establishments in the north west and Wales. He has been Head of Subject for Engineering in a medium-sized school in Bolton.

Chris Hallgarth left school at 16 and started an apprenticeship as a toolmaker. On completing his apprenticeship, he focused on machining and moved into the field of injection moulding. Via various other roles, including work on CNC machines, he ended up as a designer for injection mould tools. Over the last 10 years, he has moved into teaching. He loves the challenge and opportunities that engineering can offer and finds it very rewarding to find solutions to many problems and create new and existing products.

Neale Watkins began his career as a toolmaker in South Wales where he served a four-year apprenticeship. He is now Head of Faculty at Lewis School Pengam. As well as almost 20 years of teaching experience, he has assessed and managed various engineering programmes. Throughout this time he has also been involved in the development of engineering specifications.

How to use this book

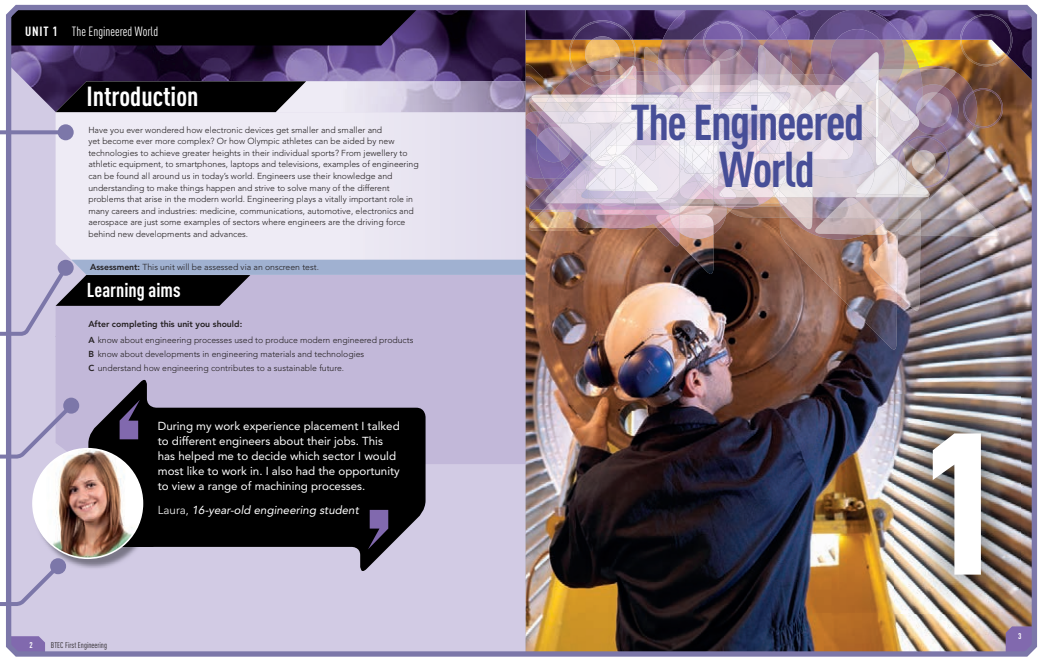
This book is designed to help you use your skills and knowledge in work-related situations, and assist you in getting the most from your course.

These introductions give you a snapshot of what to expect from each unit – and what you should be aiming for by the time you finish it.

How this unit is assessed

Learning aims describe what you will be doing in the unit.

A learner shares how working through the unit has helped them.



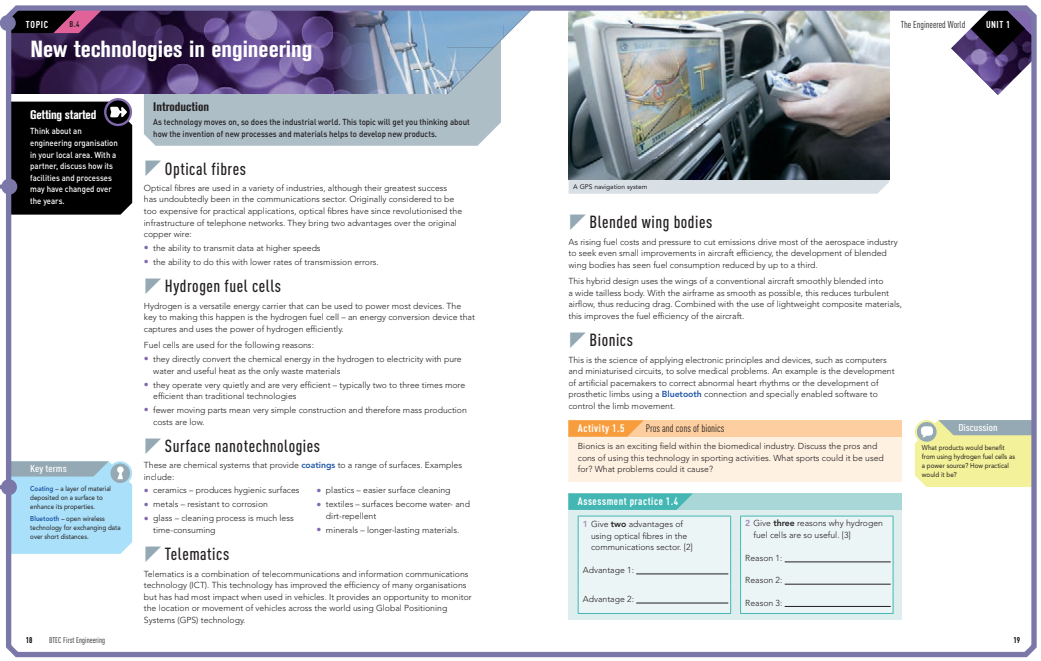
Features of this book

There are lots of features in this book to help you learn about the topics in each unit, and to have fun while learning!

Topic references show which parts of the BTEC you are covering.

Get started with a short activity or discussion about the topic.

Key terms appear in bold blue text and are defined in a key term box on the page. Also see the glossary for definitions of important words and phrases.



Activity 2.4 Injection moulding

Identify a product that has been moulded with a hole through it and see if you can work out how this is done. A good example is a plastic pencil sharpener.

Activities will help you learn about the topic. These can be completed in pairs or groups, or sometimes on your own.

Assessment practice 1.1

1 Identify three hazards associated with using workshop machinery [3]:

Hazard 1: _____

Hazard 2: _____

Hazard 3: _____

2 A small engineering company produces bespoke printed circuit boards for a range of products. Outline the five main stages in PCB manufacture.

3 Match the following processes with the correct description [3]:

Forging	Pouring/injecting liquid metal into a mould, which then cools in the shape of the desired product.
Casting	Heating a metal, then applying a force to change its shape or size permanently.
Welding	Applying heat to join two pieces of metal together.

A chance to practise answering the types of questions that you may come across in your test or exam. (For Unit 1 and Unit 9 only.) Answers can be found on page 275.

Assessment activity 5.2 Manufacturing children's toys

2B.P4 | 2B.P5 | 2B.M2 | 2B.M3 | 2B.D2

You are on a work placement with a firm that manufactures children's toys and have been asked by your supervisor to prepare a presentation on their use of sustainable materials. You must include information about:

- the environmental impact of the materials used in a children's toy
- appropriate forms of supply for the materials used, with reasons.

Tips

- Consider the environmental impact of each stage of the toy's life – including extraction and processing of its materials, manufacture and maintenance.
- Consider ways to make the product more sustainable.

Activities that relate to the unit's assessment critera. These activities will help you prepare for your assignments and contain tips to help you achieve your best results. (For all units **except** Unit 1 and Unit 9.)

Just checking

1 What are the letters used to define a 2D coordinate system?

2 What options are used to create and remove drawn lines?

3 What tools are used to define accurate geometry on-screen?

Use these to check your knowledge and understanding of the topic you have just covered.

Someone who works in the engineering industry explains how this unit of the BTEC First applies to the day-to-day work they do.

This section gives you the chance to think more about the role that this person does, and whether you would want to follow in their footsteps once you've completed your BTEC.

Workspace

Sarah Woodfine

Materials engineer

I work for a company that makes equipment for the nuclear industry. My job involves sampling and testing components that will be used in nuclear power stations. I also make regular visits to our suppliers to discuss material specifications and requirements. I work as part of a team in a well-equipped inspection laboratory where we carry out exhaustive tests to confirm material properties. Some of my time is spent writing test reports and attending meetings to discuss recommendations and changes.

Sometimes we have to investigate cases where a component has failed in service. It is vital that we find the cause of this and suggest design modifications or a change to an alternative material. I enjoy my work, especially when it involves problem-solving. I also enjoy meeting customers and suppliers to discuss material requirements and supplies.

Think about it

1 Why do you think it is important to find out why a component has failed in service?

2 Which of the topics that you have covered do you think would be the most important in Sarah's job?

3 What communication skills do you think Sarah needs to do her job?

BTEC Assessment Zone

You will be assessed in two different ways for your BTEC First Engineering qualification. For most units, your teacher/tutor will set assignments for you to complete. These may take the form of projects where you research, plan, prepare, andevaluate a piece of work or activity. The table in the BTEC Assessment Zone explains what you must do in order to achieve each of the assessment criteria. Each unit of this book contains a number of assessment activities to help you with these assessment criteria.

Assessment criteria		
Level 1	Level 2 **Pass**	Level 2 **Merit**
Learning aim A: Understand the performance requirements of an engineered product		
1A.1 Identify relevant basic specification criteria for an engineered product.	2A.P1 Outline relevant basic and advanced specification criteria for an engineered product. **See Assessment activity 2.1, page 37**	2A.M1 Explain the importance of basic and advanced specification criteria for an engineered product. **See Assessment activity 2.1, page 37**

This table in the BTEC Assessment Zone explains what you must do in order to achieve each of the assessment criteria, and signposts assessment activities in this book to help you to prepare for your assignments.

For Unit 1 of your BTEC, you will be assessed using an onscreen test. For Unit 9 you will be assessed by a paper examination. The BTEC Assessment Zone for these units helps you to prepare by showing you some of the different types of questions you will need to answer.

A Questions where the answers are available and you have to choose the answer(s) that fit. *Tip: Always read carefully to see how many answers are needed and how you can show the right answer.*

Examples:

Match the products to the most appropriate engineering sector. [1]

Product	Sector
Aircraft landing gear	Chemical
Smartphone	Aerospace
Washing up liquid	Automotive
Flat bed lorry	Communications

Answers:
Aircraft landing gear – Aerospace
Smartphone – Communications
Washing up liquid – Chemical
Flat bed lorry – Automotive

Which **one** of the following types of energy source is considered renewable? [1]

A Coal
B Gas
C Oil
D Solar

Answer: D

The BTEC Assessment Zone in Units 1 and 9 helps you to prepare for your test by showing you some of the different types of questions you will need to answer.

Study skills

Planning and getting organised

The first step in managing your time is to plan ahead and be well organised. Some people are naturally good at this. They think ahead, write down commitments in a diary or planner and store their notes and handouts neatly and carefully so they can find them quickly.

How good are your working habits?

Improving your planning and organisational skills

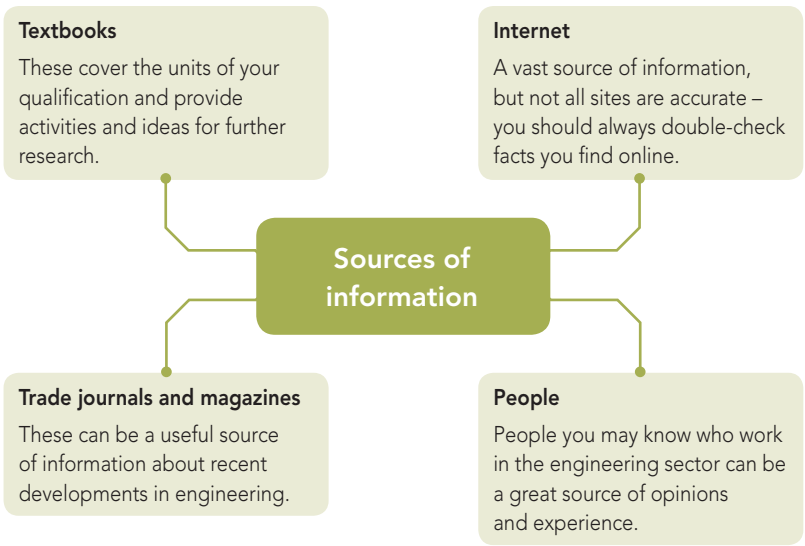
1 Use a diary to schedule working times into your weekdays and weekends.
2 Also use the diary to write down exactly what work you have to do. You could use this as a 'to do' list and tick off each task as you go.
3 Divide up long or complex tasks into manageable chunks and put each 'chunk' in your diary with a deadline of its own.
4 Always allow more time than you think you need for a task.

Take it further

If you become distracted by social networking sites or texts when you're working, set yourself a time limit of 10 minutes or so to indulge yourself. You could even use this as a reward for completing a certain amount of work.

Sources of information

You will need to use research to complete your BTEC First assignments, so it's important to know what sources of information are available to you. These are likely to include the following:



Remember!

Store relevant information when you find it – keep a folder on your computer specifically for research – so you don't have to worry about finding it again at a later date.

Organising and selecting information

Organising your information

Once you have used a range of sources of information for research, you will need to organise the information so it's easy to use.

- Make sure your written notes are neat and have a clear heading – it's often useful to date them, too.
- Always keep a note of where the information came from (the title of a book, the title and date of a newspaper or magazine and the web address of a website) and, if relevant, which pages.

Selecting your information

Once you have completed your research, re-read the assignment brief or instructions you were given to remind yourself of the exact wording of the question(s) and divide your information into three groups:

1. Information that is totally relevant.
2. Information that is not as good, but which could come in useful.
3. Information that doesn't match the questions or assignment brief very much, but that you kept because you couldn't find anything better!

Check that there are no obvious gaps in your information against the questions or assignment brief. If there are, make a note of them so that you know exactly what you still have to find.

Presenting your work

Before handing in any assignments, make sure:

- you have addressed each part of the question and that your work is as complete as possible
- all spelling and grammar is correct
- you have referenced all sources of information you used for your research
- that all work is your own – otherwise you could be committing **plagiarism**
- you have saved a copy of your work.

Key terms

Plagiarism – If you are including other people's views, comments or opinions, or copying a diagram or table from another publication, you must state the source by including the name of the author or publication, or the web address. Failure to do this (so you are really pretending other people's work is your own) is known as plagiarism. Check your school's policy on plagiarism and copying.

Introduction

Have you ever wondered how electronic devices get smaller and smaller and yet become ever more complex? Or how Olympic athletes can be aided by new technologies to achieve greater heights in their individual sports? From jewellery to athletic equipment, to smartphones, laptops and televisions, examples of engineering can be found all around us in today's world. Engineers use their knowledge and understanding to make things happen and strive to solve many of the different problems that arise in the modern world. Engineering plays a vitally important role in many careers and industries: medicine, communications, automotive, electronics and aerospace are just some examples of sectors where engineers are the driving force behind new developments and advances.

Assessment: This unit will be assessed using an onscreen test lasting one hour.

Learning aims

After completing this unit you should:

A know about engineering processes used to produce modern engineered products

B know about developments in engineering materials and technologies

C understand how engineering contributes to a sustainable future.

During my work experience placement I talked to different engineers about their jobs. This has helped me to decide which sector I would most like to work in. I also had the opportunity to view a range of machining processes.

Laura, *16-year-old engineering student*

The Engineered World

1

Engineering sectors and products

Getting started

Think about the different products that you use or see in everyday life. With a partner, produce a list linking each one to a particular engineering sector.

Introduction

This topic will introduce you to some of the key **engineering** sectors, as well as a variety of products associated with them. You will need an understanding of these when you are choosing your career.

Types of products

You are probably already familiar with some of the main engineering sectors and products.

Engineered products are used in all walks of life. Here a journalist wears a helmet and bulletproof vest to make his job safer.

Table 1.1 Engineering sectors and products

Engineering sector	Description	Typical products
Aerospace	The design, development and manufacture of products through flight	Military aircraft, passenger jets, helicopters and rockets
Automotive	The design, development and manufacture of vehicles	Cars, motorbikes, commercial vans and lorries
Communications	The way information is used around the globe	Mobile phones, routers, satellites and computers
Electrical/electronic	The design, development and manufacture of electrical/electronic products	Televisions, Blu-ray players, calculators and microwaves
Mechanical	This is a branch of engineering that can be found in many different sectors and is associated with the design, manufacture and testing of machines and other mechanical devices	Engines, robots, lifts and machine tools
Biomedical	This is a sector that specialises in developing devices/procedures that solve medical problems using science and engineering knowledge	Artificial limbs, medical instruments, magnetic resonance imaging (MRI) systems and bulletproof vests
Chemical	The design and processing of equipment for the chemical industry as well as the manufacture of chemical products	Petroleum, medicines, cleaning fluids and a range of foods

Key terms

Engineering – a profession that involves applying scientific and mathematical principles to design, develop and manufacture products and systems.

Discussion

Think about the different businesses in your local area that might employ engineers. Which sector do you think each business falls into?

WorkSpace

Matthew Carlick

Aircraft Engineer

I work as part of a team of engineers that assembles aircraft engines in a busy aircraft maintenance facility. There are four engineers working on each engine at any one time. We work around the clock to assemble the various parts, taking it in turn to lead the team.

The engine itself comprises a number of sub-assemblies or modules: three gearboxes, a low pressure turbine, a compressor, a fan and booster and, finally, a series of bearings. My job is to help assemble these modules to produce a complete engine unit.

Other very important tasks I perform during assembly are 'stack measurement checks'. Each module should be a certain dimension, and it is my job to ensure that all the dimensions of the module 'stack up' when the engine is fully assembled. Once completed, the engine is transported to the test bed where I am on hand to fix any problems prior to, or during, the engine test. On numerous occasions I have had the opportunity to perform 'on wing' maintenance. This means I will fix engine problems at airports around the world.

I love my job because I enjoy working with my hands and I am fascinated by how an engine is assembled. I also really value working as part of a team, and have found that I am a natural team leader. It always gives me a sense of pride once the engine has been assembled and tested, and when I fly I am confident in the knowledge that trained engineers have serviced the engines that keep me in the air.

Think about it

1. Why are team-working skills so important in Matthew's job?
2. What are your strengths when it comes to teamwork? What areas would you like to improve?
3. If you were in charge of a team, how would you ensure that others carried out their tasks effectively?

Mechanical and electrical/ electronic engineering processes

Getting started

Consider an engineering product that you are familiar with, such as a hand vice or centre punch. Make a list of its important features. Think about its shape, size and how it helps you with an activity.

Introduction

In today's society, engineers need to have an understanding of the range of processes that will help them produce products or parts that perform a required function. This topic will introduce you to some of the main processes used to make or assemble products that meet the needs of customers and manufacturers, and will also outline important health and safety considerations.

Machining processes

The manufacture of engineered products or parts often requires the removal of material and some form of shape change. This is known as 'secondary machining' or 'forming'. Traditional secondary machining processes and the machines that perform them fall into three groups – turning, milling and drilling.

Link

For more information see *Unit 7 Machining Techniques.*

Turning

Turning involves the use of a lathe to produce a given shape, usually cylindrical. Lathes have one thing in common: the workpiece is held in a chuck and rotated while being machined to shape and size using a cutting tool.

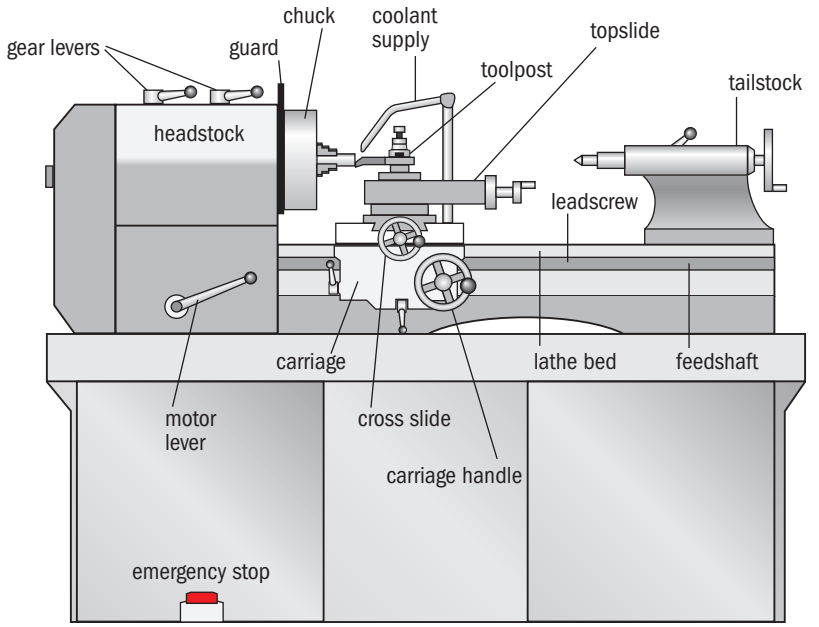


Figure 1.1 A centre lathe

Table 1.2 Machining operations

Operation	Description
Facing off	Removing material from the end of a workpiece to leave a flat or square surface
Drilling	Removing material from the inside of a workpiece using a drill bit
Parallel turning	Removing material from the outer diameter of the workpiece while maintaining the same size along its length
Taper turning	A process used to create a conical shape by feeding a tool at an angle to the length of the workpiece
Parting off	A process used to cut off the workpiece to the required length

Milling

This is a process used to shape products by removing excess material to produce a range of simple and complex shapes. A milling machine has a spindle that holds a rotating cutter in place. The workpiece will be clamped to a table or held in a vice and fed under the cutter to form the desired shape. There are two main types of milling machine – horizontal and vertical. In many cases, a universal milling machine combines both horizontal and vertical processes.

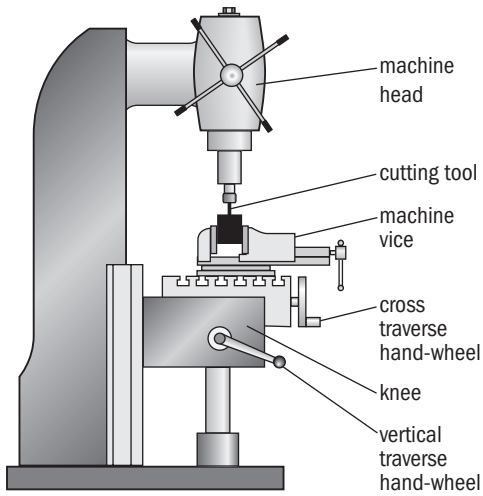


Figure 1.2 The cutter can move up and down in a vertical milling machine.

Drilling

Drilling is a process that creates circular holes in a workpiece. The cutting device is called a drill bit. It usually has a shank that allows it to be held in a drilling machine. To drill a satisfactory hole in any material, the correct type of drill bit must be used.

This is probably the most common machining operation you will perform and it is important that you do it correctly. Good-quality drill bits can be expensive but the key to good drilling is keeping the cutting edge sharp.

Safety

Accidents during secondary machining processes are usually caused by:

- loose clothing snagging on a revolving part
- flying pieces of material entering the eye
- the hand or arm coming into contact with revolving surfaces/parts
- minor burns from hot material surfaces.

Make sure that you follow the correct procedures and wear the right personal protective equipment for each process (e.g. goggles and overalls/aprons), and ensure guards are in the correct position prior to any machining operation. Above all, listen to your teacher when they are demonstrating the correct use of a piece of equipment.

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Forming processes

Sometimes complex shapes such as engine blocks, tools and equipment cannot be achieved through traditional secondary machining processes. The two main forming processes that allow these parts to be made are casting and forging.

Casting

Casting is a process that usually involves pouring or injecting a liquid metal into a mould. The mould contains a cavity that takes the shape of the desired object where the metal is allowed to cool and solidify. The casting is removed from the mould and may require secondary machining to create the finished product, depending on the type of casting process used.

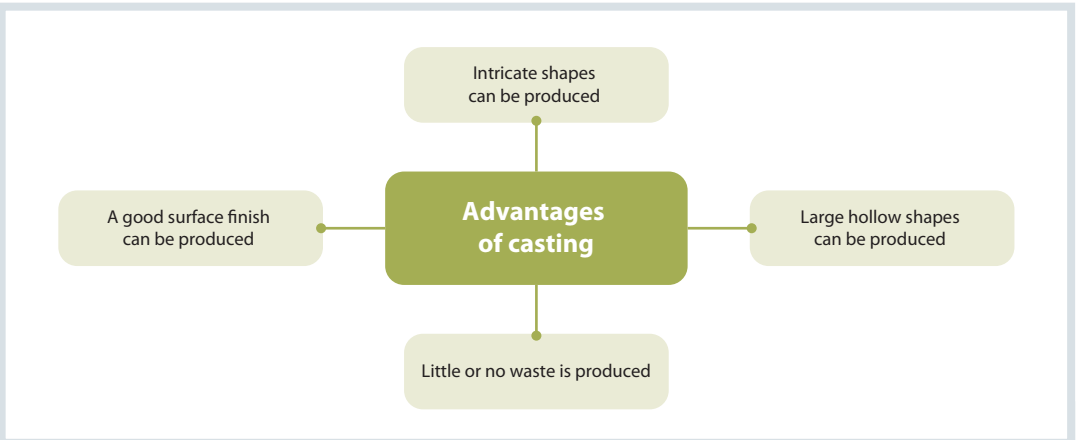

Figure 1.3 There are a number of advantages to casting.

Manufacturers use a range of different casting processes. The most common are:

- sand casting – used for large parts where dimensional accuracy is not as important as other features, e.g. manhole covers
- semi-permanent and permanent mould casting – used for products that require use with water pressure and in larger quantities than sand casting as tooling costs are relatively high, e.g. pressure valves
- investment casting – used for parts that require close dimensional tolerances and complex shapes such as compressor wheels for automotive turbochargers
- die casting – used for large quantities of parts that require close tolerances as tooling costs are quite high, e.g. toy cars.

Key terms

Plastic deformation – when a force is applied to a material, it changes its shape or size permanently, even after the force has been removed.

Forging

Forging is a process that involves a metal being heated up and shaped by **plastic deformation**. It is usually achieved by applying some kind of squeezing force (compression) such as hammer blows using a large power press. Forging improves the physical properties of a metal by changing the direction of the grain flow to improve strength, toughness and ductility.

As with casting, forging can be achieved in a number of ways:

- drop forging – produces a range of small to medium-size shapes with good dimensional accuracy and high production rates through hammering in a closed die, e.g. engine camshafts
- press forging – uses a slow squeezing action to form the metal that penetrates the whole object making it suitable for forging large objects, e.g. aircraft landing gear
- upset forging – uses bar stock where usually one end needs to be forged. This is achieved by heating the end and gripping it in a fixed die so that the end that needs to be forged is projecting out. A moving die then delivers the hammer blow to create the simple shape, e.g. the head of a bolt.

Did you know?

The word 'engineer' comes from the Latin word 'ingenium', meaning 'cleverness'.

Fabrication processes

Welding

More often than not, engineered products or parts need to be joined together in some way. Sometimes the solution is a simple nut, bolt and washer, but on other occasions a more permanent method is required. Welding is one of the most efficient methods of permanently joining two pieces of metal together. It can be done in many different ways but most methods use intense heat to fuse the metal together. A number of energy sources – a gas or electric arc, laser or ultrasound – can be used.

Discussion

What processes do you use at your school/college? Consider the different machines that are available in your workshop and identify some of the processes that you have performed on them. Which did you enjoy doing the most and why?

Table 1.3 Welding processes

Welding process	Description	Advantages
MIG welding	This is probably the most common industrial welding process. It uses electricity to generate the heat required to weld materials. MIG stands for Metal Inert Gas.	• Suitable for large-scale production • Varying thicknesses of materials can be joined • Reduced cost because the production of neat and clean metal deposits on the workpiece means there is no need for extra cleaning
Oxy-acetylene	A gas welding process where a flame is produced using a mixture of oxygen and acetylene. No pressure on the product is required – the heat is there to control the welding of the parts.	• Ease of controlling the low and high temperatures needed for welding, brazing and soldering as the gas can be mixed manually • Relatively inexpensive in comparison with other welding processes and commonly found in school or college workshops
Spot welding	A type of electrical resistance welding generally used to join sheet material together. The basic principle uses a transformer with a primary winding and a secondary winding connected to copper electrodes. When the two electrodes trap the sheet material they generate enough heat to fuse the two together.	• The process is free from fumes or spatter • Requires little or no maintenance • Cost effective

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Shearing

This is a process used to cut straight lines on a range of materials from sheet metal to angle and bar stock. An upper blade and a lower blade are forced past each other with a space between them determined by a required offset. Usually, one of the blades is stationary.

Materials that are commonly sheared include aluminium, brass, mild steel and stainless steel.

Electrical/electronic processes

Circuit board manufacturing is a massive worldwide industry and circuit boards feature in all the high-tech gadgets we use every day.

Printed circuit board (PCB) manufacture

Printed circuit boards come in all shapes and sizes. Some are very simple, others extremely complex. To manufacture a circuit board you will need to work through some, or all, of the following basic steps:

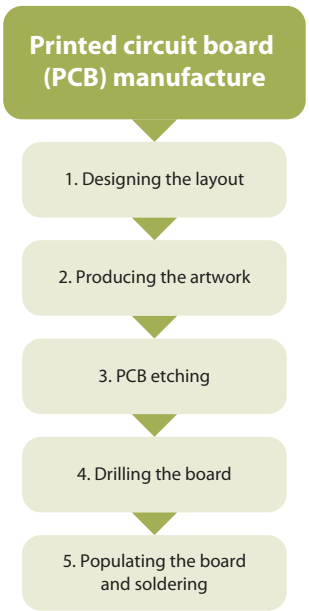

Figure 1.4 The steps of PCB manufacture

1 Designing the layout

Usually, circuit boards are designed using computer software. Many packages allow you to construct circuits and position components. Alternatively, layouts can be drawn on paper or directly on to your board to ensure components will fit correctly.

2 Producing the artwork

If you are using computer software, your circuit diagram can be converted to a black and white image showing the component positions and the connecting tracks. This is known as 'artwork' and needs to be printed onto clear acetate material. Check that your printer supports the use of clear acetate first as it can damage some machines.

3 PCB etching

You then need to transfer the track and component layout to the copper-covered board. If you are making the PCB yourself you can draw the tracks straight on to the board using an etch-resistant pen. If you are using printed clear acetate you will need a photo etch board and an ultraviolet (UV) lightbox. Peel the protective covering from the board to expose the sensitive surface, place the artwork on it and put the board in the UV lightbox with the clear acetate between the board and the light. The artwork must be the correct way up or your circuit will be produced the wrong way around. Close the lid and switch the machine on to expose the board to the UV light for around 2½ minutes. From this point on, you will need to use plastic tongs as you are dealing with chemical solutions. Place the board in a developer solution and remove it after 10 seconds. Then place it in a solution of ferric chloride (an etching solution) until all the exposed copper is etched away. After **PCB etching** you are left with the copper tracks and component positions that make up your circuit.

4 Drilling the board

After etching, carefully drill the circuit board at the points indicated to mount your components. Accuracy is vital – an incorrectly drilled hole may cause your circuit to fail.

Key terms

PCB etching – removing unwanted conductive material from the surface of a circuit board through a chemical process.