Delivery of Engineering Processes Safely as a Team

2

Getting to know your unit

Assessment
This unit will be assessed by a series of assignments set by your tutor.

Engineering processes, whether concerned with the manufacture of a product or the delivery of an engineering service, are the cornerstones of all modern industrial engineering. A single individual cannot carry out any complex industrial function effectively – often the coordinated efforts of hundreds or even thousands of people are required to manufacture a complex product such as a car or an aeroplane. This unit covers a range of practical and teamworking skills that are necessary when manufacturing a product or delivering a service safely as a team.

How you will be assessed

This unit will be assessed by a series of internally assessed tasks set by your tutor. Throughout this unit you will find assessment practice activities to help you work towards your assessment. Completing these activities will not mean that you have achieved a particular grade, but you will have carried out useful research or preparation that will be relevant when it comes to your final assignment.

In order for you to achieve the tasks in your assignment, it is important to check that you have met all of the assessment criteria. You can do this as you work your way through each assignment.

If you are hoping to gain a Merit or Distinction grade, you should also make sure that you present the information in your assignments in the style that is required by the relevant assessment criterion. For example, Merit criteria require you to analyse, and Distinction criteria require you to evaluate.

The assignments set by your tutor will consist of a number of tasks designed to meet the criteria in the table. They are likely to take the form of written reports, but may also include activities such as the following:

- Reviewing and analysing case studies based on the manufacture of an engineered product or delivery of a service in terms of the processes used and the influence of human factors.
- Creating engineering drawings using computer-aided design (CAD) software.
- Carrying out practical engineering processes both as a team leader and as a member of a team.

Assessment criteria

This table shows what you must do in order to achieve a **Pass**, **Merit** or **Distinction** grade, and where you can find activities to help you.

Pass	Merit	Distinction
Learning aim A Examine common engineering processes to create products or deliver services safely and effectively as a team		
A.P1 Explain how three engineering processes are used safely when manufacturing a given product or when delivering a given service. **Assessment practice 2.1**	**A.M1** Analyse why three engineering processes are used to manufacture a product or to deliver a service and how human factors, as an individual and as a team, affect the performance of engineering processes. **Assessment practice 2.1**	**A.D1** Evaluate, using high quality written language, the effectiveness of using different engineering processes to manufacture a product or to deliver a service and how human factors, as an individual and as a team, affect the performance of engineering processes. **Assessment practice 2.1**
A.P2 Explain how human factors, as an individual or as a team, affect the performance of engineering processes. **Assessment practice 2.1**		
Learning aim B Develop two-dimensional computer-aided drawings that can be used in engineering processes		
B.P3 Create an orthographic projection of a given component containing at least three different types of feature. **Assessment practice 2.2**	**B.M2** Produce, using layers, an accurate orthographic projection of a component containing at least three different types of feature and a circuit diagram containing at least six different component types that mainly meet an international standard. **Assessment practice 2.2**	**B.D2** Refine, using layers, an accurate orthographic projection of a component containing at least three different types of common feature and a circuit diagram containing at least six different component types to an international standard. **Assessment practice 2.2**
B.P4 Create a diagram of a given electrical circuit containing at least six different component types. **Assessment practice 2.2**		
Learning aim C Carry out engineering processes safely to manufacture a product or to deliver a service effectively as a team		
C.P5 Manage own contributions to set up and organise a team in order to manufacture a product or deliver a service. **Assessment practice 2.3**	**C.M3** Manage own contributions safely and effectively using feedback from peers, as a team member and a team leader, to manufacture a product or to deliver a service. **Assessment practice 2.3**	**C.D3** Consistently manage own contributions effectively using feedback from peers, as a team member and a team leader, to set up, organise and manufacture a product or deliver a service safely, demonstrating forward thinking, adaptability or initiative. **Assessment practice 2.3**
C.P6 Produce, as an individual team member, a risk assessment of at least one engineering process. **Assessment practice 2.3**		
C.P7 Set up, as an individual team member, at least one process safely by interpreting technical documentation. **Assessment practice 2.3**		
C.P8 Manage own contributions safely, as a team member and a team leader, to manufacture a batch of an engineered product or to deliver a batch of an engineering service. **Assessment practice 2.3**		

Getting started

In a small group, make a list of situations where you have had to work as part of a team. Think about how teamworking compares with working alone and make a list of the advantages and disadvantages of the two approaches to completing a task.

A Examine common engineering processes to create products or deliver services safely and effectively as a team

Engineering projects are usually large and complex, requiring a range of specialist skills to complete. Some of the great feats of engineering from history, such as Concorde or the Channel Tunnel, involved tens of thousands of people working together over decades to bring the project to fruition. The manufacture of everything, from condensing boilers to cars, depends on multi-skilled **teams** of engineers and technicians working together to manufacture products quickly, efficiently and in the necessary numbers to satisfy demand. After manufacture, similar multi-skilled teams are relied upon to deliver the services that help to maintain and repair these complex products.

Key terms

Team – a group containing three or more individuals who have a common objective or shared goal.

Batch – three or more products manufactured or services delivered together.

A1 Common engineering processes

Preparation before product manufacture or product delivery

Generally engineering products or services start life as ideas on how to solve a particular problem or satisfy some other demand from a customer or the wider marketplace. These ideas must be developed, evaluated and refined to achieve a viable solution. Once a solution is established, it must be communicated effectively to the people who will be asked to manufacture the product or deliver the service.

Preparation will include these documents:

- **Technical specifications** – define exactly what a product or service will do.
- **Engineering drawings** – define exactly what the individual components of a product will look like and how they should be assembled during manufacture to make the final product.
- **Scale of production** – defines the number of products that need to be manufactured or the number of times a service needs to be performed, hence dictating the approach to manufacture or service delivery; (see **Table 2.1**).
- **Work plans** – define a standard methodology that should be followed when manufacturing a product or delivering a service.
- **Quality control documents** – define the checks that should take place both during and after manufacturing a product or delivering a service.

Table 2.1 Characteristics of different scales of production

	One-off	Small batch	Mass or large batch	Continuous
Unit cost	high	medium	low	low
Tools and equipment	general	specialised	specialised and dedicated	dedicated
Initial investment	low	medium	high	high
Production efficiency	low	medium	high	very high
Labour type	skilled	skilled and semi-skilled	semi-skilled and unskilled	unskilled
Labour cost	high	medium	low	low

Standards and reference material

The importance of BS8888

The people who design a product and create its technical specifications are often not the same people who manufacture the product. In fact, they are increasingly likely to be thousands of miles apart in different countries and may not even share a common language.

It is vital, therefore, that the drawings and information that you generate comply with the widely adopted rules and conventions laid down in BS8888 for writing technical specifications. In this way you are adopting a common technical language that will be understood by engineering companies globally.

Reference charts

When preparing drawings and work plans it is often necessary to use information from reference charts or other sources of technical information. These can be found in engineering handbooks and are often displayed as posters in engineering workshops. The charts give information such as that in **Tables 2.2** and **2.3**.

Table 2.2 Metric (course) tapping drill sizes

Thread size	Tap drill (mm)
M3 × 0.5	2.50
M4 × 0.7	3.30
M5 × 0.8	4.20
M6 × 1	5.00
M8 × 1.25	6.80
M10 × 15	8.50

Table 2.3 Cutting speeds for commonly used engineering metals (using high-speed steel tooling)

Material type	Cutting speed (m/min)
Mild steel	30–38
Cast iron	18–24
Carbon steel	21–40
Stainless steel	23–40
Aluminium	75–105
Brass	90–210

Products and services

The main driver of economic activity through which wealth can be generated is the provision of products and services.

Products

Products are types of goods that are manufactured and then sold to customers. Upon purchase, customers take ownership of products, which can then be used when the customer needs them until they break down or wear out and have to be repaired or replaced. Products are physical items such as cars, washing machines and bicycles.

Services

A **service** can be described as a series of activities that provides benefit (value) to customers. Examples of services are the processing of a credit card transaction by a bank or an MOT inspection by a garage.

Key terms

Product – the final tangible outcome of a manufacturing process, often referred to in economics as 'goods' (e.g. a car, television or chair).

Service – activities that provide some intangible benefit to a customer (e.g. processing a credit card payment or performing an MOT inspection on a car).

PAUSE POINT Working in small groups, list some services that you might associate with the engineering sector.

Hint Such services might involve disassembly, maintenance activities or part replacement.

Extend Choose one of the engineering services you identified and break it down into the separate steps that would be involved in its delivery.

Common processes used to manufacture engineered products

Bench fitting

Bench fitting is the general term used for a wide range of engineering workshop activities carried out at a bench, which needs to be substantial and rigid and usually has a steel working surface. The fitter's vice (see **Figure 2.1**) is possibly the most important piece of equipment in bench fitting. It is used to secure a workpiece or assembly in place while the engineer uses hand tools such as files, saws or taps.

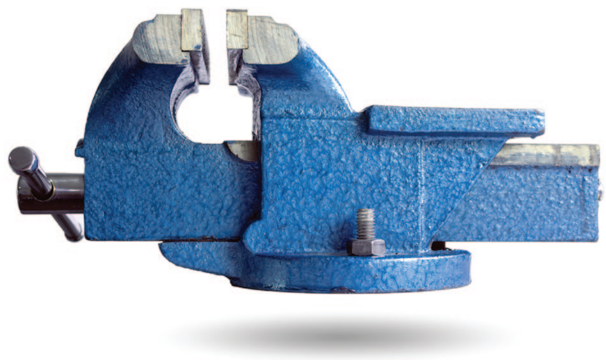


Figure 2.1 A fitter's vice

It is usually better to work on individual components or sub-assemblies from larger products at a bench where you can securely hold and orient them as necessary to access various parts. For example, a motor vehicle technician wouldn't disassemble a disc brake calliper while it was still on a vehicle.

Files

You would use a double-cut forged carbon steel file to shape metals such as brass, aluminium and steel.

Files come in many shapes and sizes, with different tooth pitches suited to different applications. Rough and bastard files with a large pitch between the rows of teeth are most suited to rapid metal removal with reduced clogging, but they give a poor surface finish. Smooth files with a small pitch between the teeth give an excellent surface finish but cannot remove material quickly.

The general-purpose choice of file in most workshops is the second-cut file (see **Figure 2.2**), which has a tooth pitch between those of the rough and smooth files. Second-cut files are capable of reasonable rates of stock removal and also give surface finishes that are acceptable in most circumstances.

Figure 2.2 A second-cut flat file

Filing techniques

Files can be used in different ways to give different finishes:

- cross filing – used for rapid material removal.
- draw filing – used for finishing to improve surface finish.
- straight filing – used to flatten surfaces (this is a highly skilled **operation** that can take years to master).

As the engineer files material from the workpiece, the spaces between the file teeth will become clogged. This is called 'pinning'. You can minimise pinning by rubbing chalk into the teeth periodically as you work. When pinning starts to affect the way in which the file cuts or begins to mark the surface being worked on, the teeth should be cleaned with a special wire brush called a file card.

Key term

Operation – a single step in a manufacturing process. For example, this could be marking out the position of a hole when manufacturing a product or removing an access panel when delivering an engineering service.

Cutting

You usually use a hacksaw (**Figure 2.3**) to cut metal. High-quality hacksaw blades are constructed from high-speed steel (HSS) that has been hardened to enable the teeth to cut soft metals like brass and aluminium, as well as most steels, accurately and with ease.

Figure 2.3 A hacksaw

HSS hacksaw blades are necessarily hard, but as a consequence they can also be brittle and have a tendency to snap when bent, twisted or used incorrectly. These problems can be overcome to an extent by using semi-flexible bi-metal blades. These have a strip of HSS teeth welded to a tougher and more flexible, but also softer, steel backing.

General-purpose carbon steel blades, which have been differentially hardened to make the teeth hard but leave the back tough and flexible, are also commonplace. Generally these are suitable only for occasional use or use with soft materials. They tend to wear quickly and become blunt when used with harder materials such as steel.

Like other saws, hacksaw blades are available with different teeth pitches. These are usually defined in terms of the number of teeth per inch (TPI). For general-purpose work, a 24 TPI bi-metal blade is ideal.

Cutting internal threads

Internal threads are cut by hand with taps held in a tap wrench (**Figure 2.4**).

Figure 2.4 A thread-cutting tap held in a tap wrench

Before using the tap to cut a thread, you need to drill a hole with the appropriate diameter for the thread required. This diameter is known as the tapping drill size and can be obtained from appropriate engineering workshop reference tables (such as **Table 2.2**).

Taps are generally provided in sets of three with progressively shorter leads. The first-cut (or taper) tap has a long lead-in to enable you to start the thread in the plain hole. You must ensure that the thread is aligned with the axis of the hole. The second-cut tap has less of a lead-in and can be used to increase the depth of the thread. The third-cut (or plug) tap can be used to finish the thread-cutting through the full thickness of the material or to the bottom of a blind hole.

Cutting external threads

You cut external threads by hand using a split button die secured in a die holder (**Figure 2.5**).

Figure 2.5 A split button die in a die holder

First, you need to prepare a rod of material of the correct diameter for the thread required. This is the outside diameter of the thread, so for an M8 thread you will need rod of 8.0 mm diameter.

Like taps, split button dies also have a lead-in, so you must similarly orient them correctly in the die holder. To enable easy starting on the first cut, you can spread the split die a little using the central screw on the die holder. Again, you need to take great care at this stage to ensure that the die is aligned properly so that you don't end up with what is known as a drunken thread. You then make the second and third cuts by progressively closing the gap in the split die.

Secondary machining

Types of workshop machine include pillar drills, lathes and milling machines. You typically use these to make holes, slots or other features in a single workpiece by removing the material required by the component design.

Drilling using a pillar drill

You primarily use a pillar drill (**Figure 2.6**) to cut circular holes in a range of materials. The pillar drill has the advantage over hand drills in that the rotating chuck moves vertically up and down by means of an operating handle and the depth of cut can be controlled using adjustable stops.

Figure 2.6 Pillar drill

- Features – through holes, blind holes, countersinking, flat-bottomed holes, counterbored holes.
- Tooling – straight-shanked twist drill bits (1–13 mm diameter), taper-shank twist drills (>13 mm diameter), centre drills, countersinks, counterbores, flat-bottomed drills.
- Tool holding – keyed or keyless Jacobs chuck.
- Work holding – machine vice, clamps.
- Parameters –
  - the spindle speed (N) in revolutions per minute (rpm) must be selected before drilling. This will depend on a range of factors, but is generally found using the formula $N = \frac{1000S}{\pi D}$, where D is the diameter (in millimetres) of the hole being drilled and S is the recommended cutting speed (in m/min) of the material being drilled, which can be obtained from general workshop data tables and charts.
  - You can adjust the spindle speed by moving the spindle drive belt between pulleys. The machine must be isolated from its power source while this procedure is carried out.

Turning using a centre lathe

You use a centre lathe (**Figure 2.7**) to perform turning operations to produce round features on cylindrical components. Unlike other machining processes that involve turning, the tool remains stationary while the workpiece is rotated.

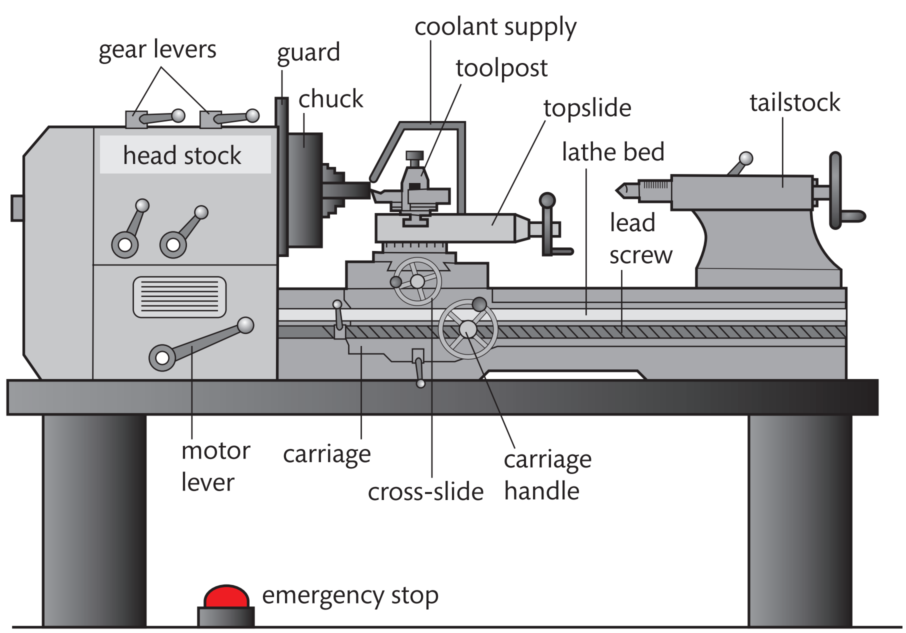


Figure 2.7 Schematic of centre lathe

- Features – flat faces, parallel diameters, stepped diameters, tapered diameters, chamfers, grooves, knurls, axial drilled holes.
- Tooling – turning tool, facing tool, parting tool, knurling tool, centre drills.
- Tool holding – turning tools are secured on an adjustable toolpost and must be set to the correct height and cutting angle when installed; a tailstock-mounted Jacobs chuck is used for drilling operations.
- Work holding – cylindrical workpieces are held in a three-jaw chuck; square or rectangular workpieces are held in a four-jaw chuck.

- Parameters –
  - The cutting speed (N) in revolutions per minute (rpm) must be selected before turning. This will depend on a range of factors, but is generally found using the formula $N = \frac{1000S}{\pi D}$, where D is the diameter (in millimetres) of the workpiece being turned and S is the recommended cutting speed (in m/min) of the material, which can be obtained from general workshop data tables and charts. You can change the cutting speed by setting the gear change levers as required.
  - The feed rate is the rate at which the carriage (and so the toolpost and tool) moves parallel to the workpiece. It is usually stated in millimetres moved per revolution (mm/rev). This will usually depend on the surface finish required because the lower the feed rate the better the finish. For deep roughing cuts, a high feed rate will enable lots of material to be removed quickly. When finishing a workpiece, shallow cuts at a low feed rate will give a good surface finish.

Milling using a vertical milling machine

Milling is a machining operation that uses a rotating cutter to remove material from a workpiece (**Figure 2.8**). During operation the position of the rotating cutter is fixed, and you move the machine bed to which the workpiece is clamped horizontally and vertically as required.

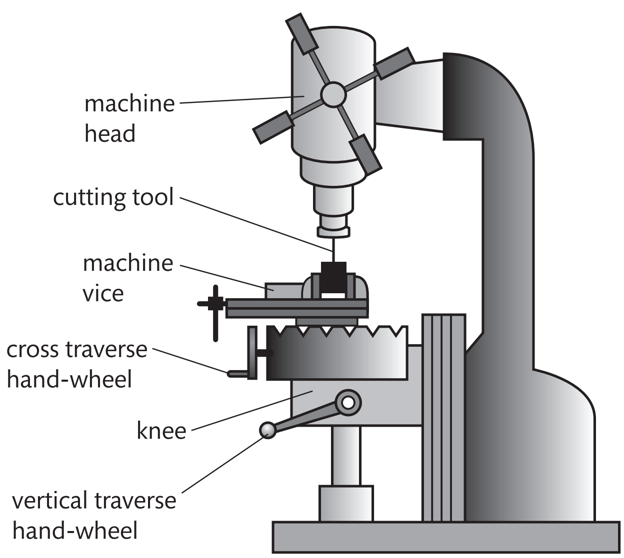


Figure 2.8 Schematic of vertical milling machine

- Features – flat surfaces, holes, grooves, slots, steps.
- Tooling – end mill, slot drill, face mill.
- Tool holding – milling tools have standard shank diameters and are held in an appropriate collet which grips over a large surface area to prevent any tool movement or slippage while in use.
- Work holding – machine vice, clamps.
- Parameters –
  - The spindle speed (N) in revolutions per minute (rpm) must be selected before milling. This will depend on a range of factors, but is generally found using the formula $N = \frac{1000S}{\pi D}$, where D is the diameter (in millimetres) of the milling cutter and S is the recommended cutting speed (in m/min) of the material, which can be obtained from general workshop data tables and charts.
  - The vertical and horizontal feed rates generally depend on the surface finish required. A low feed rate will give a better finish but only remove small amounts of material.

Fabrication

Instead of removing material from a solid workpiece as with machining processes, fabrication involves the forming and joining of sheet metal to components in order to manufacture thin-walled products such as a toolbox. Some common fabrication processes, such as shearing, rolling and welding, are described below.

Shearing

You can use hand shears (sometimes referred to as tin snips) to cut thin sheet metal. These are available with straight or curved blades and in a range of sizes. A guillotine or press shear can be used to make longer, straighter and more accurate cuts in a wider range of material thicknesses than you can with hand shears.

Forming

You usually making tight and uniform folds in sheet material using a press-mounted V-block and blade or a box press.

Rolling

Rolling allows you to bend sheet material uniformly into large-diameter curves or even tubes by using a series of adjustable rollers.

PAUSE POINT Calculate a suitable spindle speed for drilling a 10 mm diameter hole in a mild steel workpiece.

Hint You will need to refer to the cutting speeds for commonly used engineering materials given in **Table 2.3**.

Extend Investigate the range of spindle speeds available on a pillar drill in your workshops.

In a general-purpose workshop these machines are usually manually operated using long handles or foot pedals. **Figure 2.9** shows an example of a small, hand-operated combined shear, roll and V-block and blade machine that gives three-in-one functionality.

Figure 2.9 General-purpose combined shear, roll and V-block and blade machine for the small workshop

MIG welding

Metal inert gas (MIG) welding (**Figure 2.10**) is a form of electrical resistance welding where a consumable welding wire is fed from a reel to the welding gun during operation. A high electrical current is fed through this wire and the workpiece, and a high-temperature electrical arc at the point of contact provides the heat necessary to form the weld. To prevent oxidation of the molten materials as the weld is formed, air is excluded from around the weld as it is formed by using a shield of inert gas (usually argon) fed from a cylinder to the tip of the welding gun. MIG welding is suitable for a variety of material thicknesses, from car body panels to heavy beams, because both the supply current and the wire feed rate can be quickly and easily adjusted.

Figure 2.10 MIG welding

Spot welding

Spot welding is a form of electrical resistance welding suitable only for joining thin sheet metal components. It works by passing an electrical current through a small area as sheet components are pressed together by the welding electrodes. The temperature in the material between the electrodes is sufficient to melt and fuse the sheets together.

Electrical wiring

Engineered products often contain electrical components that need to be wired up and connected together. Before assembly into a product, you can make a wiring loom, where all the necessary wires are cut to length and fitted with the necessary connectors to join with switches and other components. This saves time during installation and is common practice in the automotive and aerospace industries.

Soldering

You can make reliable and permanent electrical connections by soldering. Solder is a low-melting-point metal alloy (commonly 60% tin and 40% lead) that can be melted safely and easily using a soldering iron (**Figure 2.11**). Molten solder adheres extremely well to the surface of copper wires (and many copper alloys such as brass) and can be used to make low-resistance electrical connections, while also providing good mechanical strength after it has cooled and solidified.

Figure 2.11 A soldering iron

You solder components on printed circuit boards (PCBs) by passing the board's underside through the surface of a bath of molten solder so that hundreds of soldered joints are made in a single operation.

Electrical connectors

There are many situations in which it is either inconvenient or too time-consuming to make individual soldered connections. Sometimes there is a need for temporary connections, which need to be easily disconnected. You can use many different types of electrical connectors in these cases, including screw terminal blocks, crimped spade connectors and bullet connectors (**Figure 2.12**), as well as plugs and sockets in hundreds of different styles and sizes.

Figure 2.12 Crimp ring, bullet and spade terminal connectors

Primary forming

Primary forming is a term used to describe the reshaping of metals without the removal of material. Primary forming processes include casting, forging and moulding.

Casting

You use casting processes when large numbers of components are required or when the shape of a metal component is complex and difficult to machine. Processes take many forms, including sand casting (**Figure 2.13**), investment casting and die casting. All work on the basic principle of pouring molten metal into a die or mould that is pre-formed in the required shape. Once cooled, you can remove the cast component from the die or mould and either use it directly or use secondary machining processes to refine it.

Figure 2.13 Pouring molten iron in sand casting

Link

Casting and forging processes are covered in more detail in Unit 25: Mechanical Behaviour of Metallic Materials.

Forging

Forging does not involve melting the metal, and so the internal grain structure of the material is different from that of cast products that have undergone complete recrystallisation in their new shape. Forging deforms and stretches the internal structure of the material, leaving it considerably stronger and crucially tougher than cast components.

It is possible to cold forge some materials, but you usually need heating to soften the metal and make it malleable so that it can be reshaped.

Traditionally forging was carried out in a blacksmith's forge, and the reshaping was done with an anvil and hammer. More modern forms of forging include drop and press forging (**Figure 2.14**), where material is forced into a shaped die using a series of blows or the application of extremely high pressing forces.

PAUSE POINT What process is used in the manufacture of spanners?

Hint Inspect a spanner in your workshop.

Extend Why do you think this process is used for making a spanner in preference to alternative methods?

Figure 2.14 A freshly struck, and still hot, drop-forged component ready for removal from the die

Common processes used in engineering services

Disassembly, replacement and refitting

You will often need to disassemble an engineered product in order to maintain, service or repair it. You usually do this by using general tools such as screwdrivers, spanners or hexagon keys.

Make sure that you collect and label all the fixings (such as screws, clips and bolts) so that you can easily identify them during re-assembly.

Parts that have worn during normal operation (such as cam followers, push rods or bearings) should be replaced in the same position and orientations as they were in before removal, so you should also carefully record this information.

You will need specialist tools in certain disassembly and re-assembly operations. These might include security screw fasteners (which require a specific driver bit to remove), bearing pullers or specialist alignment tools.

Inspection

A visual inspection of the condition of certain components, such as those prone to wear like cutting edges on tools, lubricant levels or the condition of the coolant being used on a lathe, is often enough to prompt further investigation and component replacement, adjustment or repair.

Other signs which indicate that further investigation is required might be noisy operation, vibration, over-heating, a blown fuse or any other problem affecting the correct operation of the system.

Systems servicing

Most engineering systems require regular system servicing as part of a preventative maintenance plan. You are probably most familiar with this in relation to motor vehicles, which need to undergo regular oil and filter changes to help prevent premature engine wear. Waste engine oil has to be collected, safely disposed of and replaced with the correct grade and quantity of new oil.

There are hundreds of examples of industrial systems that require similar attention. Engineers in workshops or factories that use compressed air must regularly drain the water that accumulates in tanks and pipework to prevent corrosion. They need to top up lubrication fluids so that the compressed air feed to power tools carries sufficient oil to lubricate the working parts. To perform these procedures safely, you must depressurise the system, and isolate and lockout the compressor to prevent accidental operation while the system is being worked on.

Installation

The installation of new equipment or parts is often necessary in a range of circumstances. This might be the installation of a central heating boiler in a new house, a new machine, such as a laser cutter in a workshop, or a hydraulic winch on an off-road vehicle.

In all these circumstances, the manufacturer of the product to be installed will provide detailed installation instructions.

A2 Health and safety

It is both a legal and a moral responsibility of employers and their employees to take health and safety in the workplace seriously. There is a well-established legal and regulatory framework in the UK that helps to ensure the safety of workers. The following is a selection of some of the more important legislation and regulations that are commonly encountered in engineering.

Health and Safety at Work etc Act 1974

The Health and Safety at Work etc Act (HASAWA) is the cornerstone of British health and safety legislation. It establishes in law the legal responsibilities that an employer has towards their employees as well as visitors and members of the public while on their premises. As a consequence, if you are an employee, apprentice or on work experience in an engineering business, then the employer must provide you with:

- safe machinery and systems of work to help prevent accidental injury including the provision of appropriate personal protective equipment (PPE)
- a healthy workplace, which should include adequate lighting, heating (or air conditioning) and washing facilities
- a safe workplace with appropriate fire alarms, clearly defined exit routes and established emergency procedures
- safe methods of storing, transporting, handling, using and disposing of any substances or materials encountered as part of your employment
- appropriate training and instruction in how to carry out your duties safely.

Employees (and any other persons with permission to be on site) also have a legal responsibility to look after their own and their colleagues' health and safety, and to cooperate with their employer on health and safety issues.

Suppliers and manufacturers of materials and equipment used in the workplace also have a legal obligation under the Act to ensure these are safe. They must provide adequate information (e.g. data sheets, operating instructions) on the correct use of the products they supply.

HASAWA also established the Health and Safety Executive (HSE) that is responsible for developing national health and safety guidance and enforcing the provisions made in the Act. HSE inspectors have the right to enter any workplace where they believe dangerous working practices are being used. If a serious breach of health and safety law is discovered, notices can be served to halt dangerous work and/or prosecutions made against the company involved.

Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013

All accidents and incidents (including minor ones and near misses) in the workplace should be recorded in the company accident book. These records will be used when reviewing risk assessments, and they often prompt the introduction of additional control measures.

Under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), an employer has a legal duty to report certain types of serious accident, incident or dangerous occurrence directly to the Health and Safety Executive (HSE). These reports are used by the HSE to compile statistics on the numbers of different types of accidents. If the HSE suspects that a company has failed to meet its legal responsibilities with regard to the health and safety of its employees, the reports are also likely to prompt an investigation.

An accident or incident at work becomes reportable under RIDDOR if certain types of injury result. These include, but are not restricted to:

- death
- the fracture of any bone, except a digit or toe
- amputation of any part of the body
- permanent or temporary loss of sight
- any crush that has damaged internal organs in the head or torso
- serious burns
- scalping that requires hospital treatment
- loss of consciousness resulting from a head injury or suffocation
- certain injuries that have resulted from working in an enclosed space.

Some occupational diseases must also be notified if contracted while at work, such as occupational dermatitis caused by contact with cement dust, oils or waste materials.

Dangerous occurrences that must be notified to the HSE include:

- failure of any crane, lift, hoist or derrick
- failure of a pressurised container, such as a tank on a compressor
- a forklift truck tipping over.

Personal Protective Equipment at Work Regulations 1992

Employers have an obligation to provide appropriate PPE when its use is deemed necessary by a risk assessment.

PPE must be fit for purpose in order to provide the required level of protection. For example, a boiler suit provided for use by a welder should be manufactured from a flame-retardant material, and dust masks must be of an appropriate type and sufficient quality to provide effective protection against the inhalation of dust or particulates.

All PPE must be provided free of charge to relevant employees, and it must be cleaned and maintained by the employer. Worn or damaged equipment that is no longer fit for purpose must be replaced.

Control of Substances Hazardous to Health Regulations 2002

The Control of Substances Hazardous to Health (COSHH) Regulations are designed to ensure the safe use and handling of the potentially hazardous substances that are often encountered in engineering. For instance, frequent and prolonged skin contact with some common fluids, such as petrol and oil, can cause long-term skin problems, which is why you should use barrier creams and gloves to minimise your exposure.

Some chemicals, such as those used as solvents in paints and glue, can cause more immediate damage or even death if inhaled in sufficient quantities.

Potentially harmful fumes, dust, liquids and chemical vapours can enter your body through a number of mechanisms, including being absorbed directly through the skin or eyes, entering the bloodstream through a cut or broken skin, and being inhaled or even ingested in contaminated food or drink.

Very few substances commonly encountered in engineering will cause immediate acute symptoms, and even fewer have the potential to pose an immediate threat to life in normal circumstances. However, prolonged exposure to a range of substances has been shown to be severely detrimental to long-term health. For instance, exposure to coal dust over the working life of a miner is known to cause chronic lung diseases, and exposure to asbestos, used for years as a heat-proof insulation material, is directly linked to an aggressive and incurable form of lung cancer.

When using or working with potentially hazardous chemicals you should:

- ensure that they are stored securely in appropriate and labelled containers
- read and understand the labels and/or the manufacturer's data sheets on the safe use of the substances, and follow the recommendations
- always use the correct type of PPE to protect you from contact with hazardous substances
- investigate the availability of safer alternatives.

Appropriate warnings and labels should be displayed where hazardous materials are present. Examples of internationally recognised signs are shown in **Figure 2.15**.

Figure 2.15 Examples of COSHH warning symbols that can be found on product labels

Manual Handling Operations Regulations 1992

About a third of all reported injuries at work are the result of people using incorrect manual handling methods when lifting or moving heavy objects. In engineering there is often the need to move heavy tooling, equipment, components or products, so you must be familiar with safe ways in which this can be achieved.

Employers should ensure that their staff avoid moving any items in the workplace in a way that could cause them injury. Where repetitive movement of heavy objects is required, some mechanical aid should be employed to lessen the reliance on manual handling. For instance, on a vehicle production line, heavy sub-assemblies such as doors are picked up and supported in position by mechanical hoists while they are bolted into place.

Pallet trucks, trolleys and conveyors are all widely used to lift and move objects around factories and production lines. If manual handling cannot be avoided, then it is important that staff be trained in the safest methods and techniques to minimise any risk of injury.

Research

Carry out your own research to find out more details about employer and employee responsibilities under the health and safety requirements mentioned above.

PAUSE POINT Identify any substances in your workshop that are potentially hazardous.

Hint To comply with COSHH regulations, these substances will be locked away, so you'll need a technician or tutor to join your investigation.

Extend Investigate the availability of safer alternatives.

A3 Human factors

Human factors affecting productivity

The productivity of any organisation depends on the people carrying out the processes. Their skill level, training, experience, enthusiasm and conscientiousness all play a part.

Reliability

An important factor in maintaining productivity is that staff arrive at work on time and have a good attendance record. Absenteeism increases pressure on fellow workers as the absentee's duties need to be performed by others who perhaps lack the relevant knowledge and experience or who may become overloaded. This inevitably leads to a decrease in work output.

Quality

In modern factories, quality assurance systems go well beyond the traditional quality control checks carried out at the end of the manufacturing process. All staff are expected to perform continual quality checks as they work to ensure that any problems they encounter or perhaps even cause are not passed on to subsequent stages without being addressed. This requires a certain level of trust that is cultivated in a team-oriented environment where allocating blame is less important than addressing and solving problems together. It is vital that individuals are conscious of the importance of the quality of their own work and the work of their team and the potential effects on the wider organisation.

Safety

As noted in the 'Health and safety' section above, it is a legal requirement that all employees in an organisation manage their own health and safety and do nothing to jeopardise the safety of others. Safe working practices also help to maintain productivity. Stoppages while incidents and accidents are investigated or damage repaired can be significant and have a disastrous effect on productivity, so it is an employee's ethical duty to ensure that nothing harms their colleagues or equipment.

Human factors affecting the performance of individuals and teams

Professionalism

The regulatory body for the engineering profession in the UK is the Engineering Council. It is the role of such professional bodies both to set and to regulate the standards of technical competence, commitment and ethical behaviour of its members. These are laid out in the UK Standard for Professional Engineering Competence (UK-SPEC).

Some of the expectations of professional conduct for engineers are:

- to operate and act responsibly, avoiding negative environmental, social or economic impact when conducting work-related activities
- to accept responsibility for your own work and that of others
- to exercise personal responsibility – for example, managing a project through to completion to an agreed deadline
- to manage and apply safe systems of work – for example, carrying out risk assessments
- to take responsibility for identifying your own limitations and training requirements
- to carry out continuing professional development (CPD) activities to enhance operational knowledge and competence
- to act with due care, skill and diligence throughout your professional life.

Ethical principles

If an individual, team or larger organisation is seen to conduct themselves ethically with a strong sense of right and wrong, then they are perceived as trustworthy and reliable. Some of the qualities displayed by those considered to be acting ethically include:

- Rigour – approaching each task or project in a thorough and careful manner.
- Honesty – being truthful and straightforward in dealings with other people (and yourself).
- Integrity – able to recognise right from wrong and willing to do the right thing.
- Respect – displaying regard for the feelings and opinions of others, valuing their contribution.
- Responsibility – being accountable for your actions and, when things go wrong, willing to admit you were wrong and work to put things right.

Behaviours

Some personal characteristics and forms of behaviour can influence how individuals are perceived and affect their roles within a team. For instance:

- Strong values – maintaining your principles and standards of behaviour is important if you are to retain your self-respect and gain the respect of other people.
- Attitude – maintaining a positive outlook can help to bolster the morale of a team under pressure.
- Persuasion – getting people to embrace change or try something new is best achieved by encouragement, enthusiasm and reasonable argument. An individual who has given their support and agreement to a course of action through collaboration will be more committed and effective than if they were coerced.

- Coercion – an unacceptable form of forceful persuasion, which might include threats or emotional blackmail, that will cause long-term damage to relationships and morale.
- Rapport – establishing good relationships with groups or individuals by understanding their thought processes, cares and concerns and communicating clearly and effectively with them is a valuable skill.
- Authority – although the person in charge of a team or organisation has the right to make decisions and direct the activities of others, the way in which they choose to exercise their authority can be damaging if it is not done respectfully.

Limitations

There are both physical and mental limitations to the activities that can be undertaken by an individual or a team in a busy working environment. You must consider the following:

- Stress – a sense of mental and emotional strain or anxiety that can be brought about by the demands and pressure of work.
- Time pressure – having to complete tasks in a fixed time frame or at a defined rate.
- Fatigue – physical or mental tiredness.
- Memory – it is only possible to retain a limited number of facts and effectively process a limited amount of information at any one time.
- Capability – the extent of someone's ability to complete a task.
- Motivation – the reasons why people act in the ways they do; put simply, it is their desire to do certain things. People tend to be motivated by a variety of factors, and it shouldn't be assumed that all people are alike in what they find motivating.
- Knowledge – the depth of a person's technical knowledge must be sufficient for the task in hand.
- Experience – generally people become quicker and more effective at performing tasks or processes if they have done them before.
- Health – some physical tasks are unsuitable for those with particular health issues or physical limitations.

Other factors, such as the consumption of drugs or alcohol, can seriously affect an individual's ability to perform tasks safely.

PAUSE POINT Which ethical and behavioural characteristics do you believe you already possess?

Hint Go through the list one at a time and be honest about your assessment of yourself.

Extend Ask a colleague to carry out the same procedure, but to look for the characteristics they recognise in you. Do the two lists match?

Assessment practice 2.1

A.P1 A.P2 A.M1 A.D1

You are working in a small engineering company, and your manager has asked you to take a look at a prototype of a screwdriver and determine the best way to manufacture five more as samples for potential clients. Your recommendation should be fully justified and include a comparison with alternative processes.

If the screwdriver eventually goes into production, it will be required in large numbers. Your manager has explained that when demand reaches a certain level, a fully automated manufacturing system will be introduced that will eliminate human involvement in the process almost entirely.

This would require a significant investment, and your company is keen to establish how a range of human factors could actually benefit the performance of engineering processes involved in manufacturing.

Your manager has asked you to write a technical report that will address the issues that she will present to the operations director of the company. Care must be taken to ensure that a high standard of written language is used throughout.

Plan

- What is the task? What am I being asked to do?
- How confident do I feel in my own abilities to complete this task?
- Are there any areas I think I may struggle with?

Do

- I am confident in what I'm doing and know what I should be achieving.
- I can identify where I've gone wrong and adjust my thinking/approach to get myself back on course.

Review

- I can explain what the task was and how I approached its execution.
- I can identify the parts of the task that I found most challenging and seek ways that will help me to overcome any difficulties.

B Develop 2D computer-aided drawings that can be used in engineering processes

Link

Unit 10: Computer-Aided Design in Engineering covers many of the techniques and concepts required by this learning aim. Unit 10 also includes additional background material that you will find helpful when you practise using CAD software to produce your own drawings

B1 Principles of engineering drawing

Orthographic projections

An orthographic projection is a method of positioning the different views of an object when representing it in an engineering drawing, such as that in **Figure 2.16**. The rules that dictate where each view goes in an orthographic projection can be confusing, so you may find the following rules of thumb helpful.

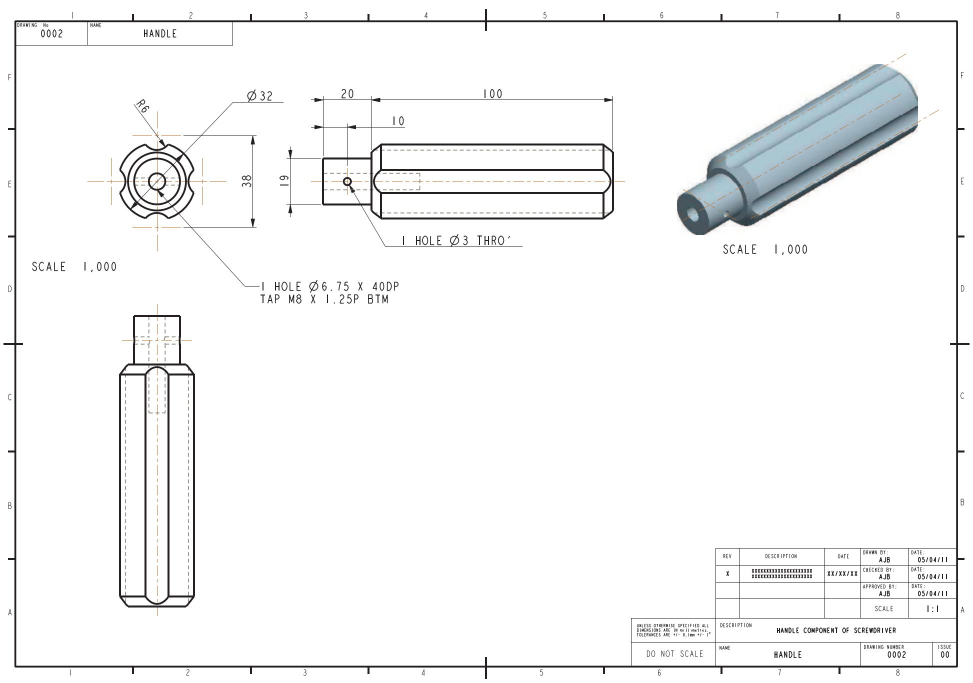


Figure 2.16 Third-angle orthographic projection of a screwdriver handle component

Third-angle orthographic projection

The standard symbol (**Figure 2.17**) that you will find on a drawing arranged in a third-angle projection looks very much like something that you are probably familiar with – a traffic cone. This will help remind you how to set out the drawing.

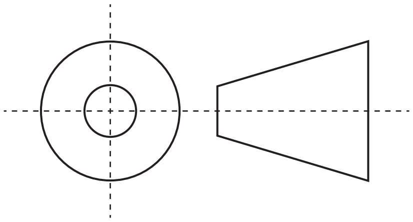
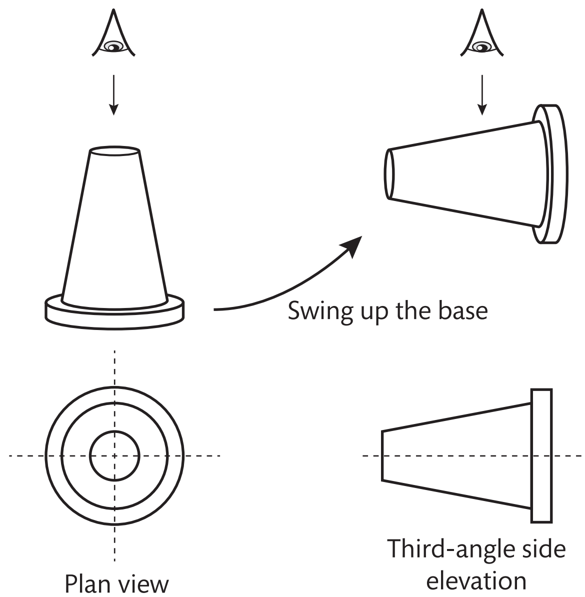


Figure 2.17 Symbol for third-angle projection

Worked Example

Draw a third-angle orthographic projection of a real traffic cone.

Solution



▶ **Figure 2.18** Rule of thumb to create a third-angle projected view

Step 1: Draw the plan first – this shows the view of the object from directly above. In this case the plan view consists of two concentric circles, representing the tapering section of the cone, inside the larger circular base (left-hand side of **Figure 2.18**).

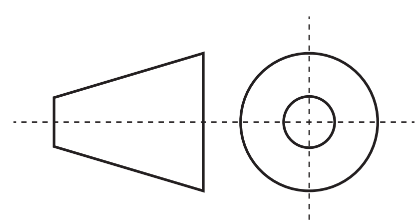
Once this has been drawn, all the other views in the drawing are projected from the plan.

Step 2: Now imagine picking up the traffic cone by its narrow pointed end and swinging the bottom of the cone out in the direction of the next projected view to be generated (a side elevation). What you now see from above is the way this side of the cone should be drawn as a third-angle projection (right-hand side of **Figure 2.18**).

Step 3: Repeat this process to create as many views as are necessary to show all the features on an object.

First-angle orthographic projection

The standard symbol for a first-angle orthographic projection is shown in **Figure 2.19**.

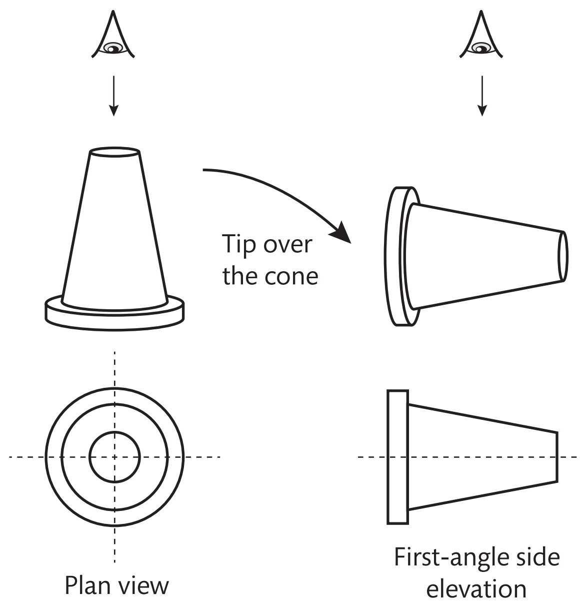


▶ **Figure 2.19** Symbol for first-angle projection

Worked Example

Draw a first-angle orthographic projection of a real traffic cone.

Solution



▶ **Figure 2.20** Rule of thumb to create a first-angle projected view

This follows a very similar method to that used above for a third-angle projection. The only difference lies in Step 2: instead of picking up the cone and swinging the base out, you just tip it over in the direction of the required projected view.

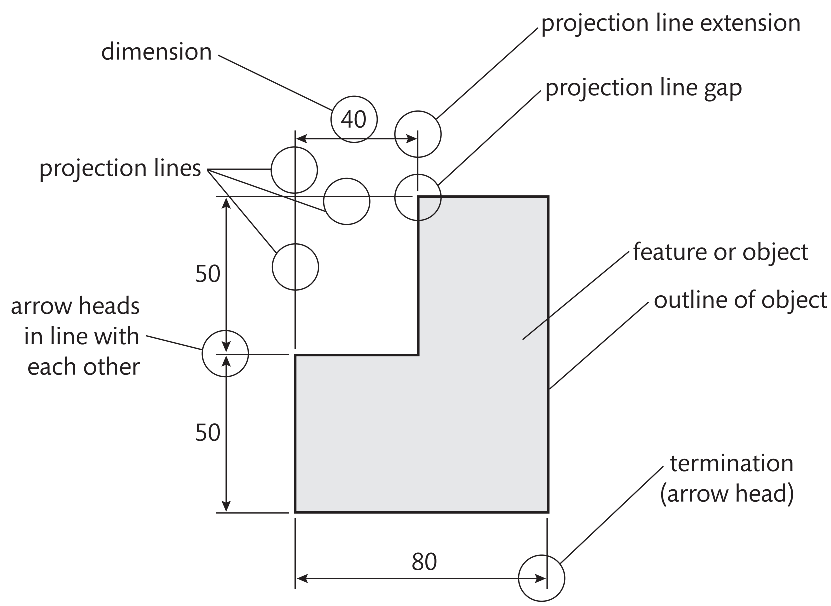
Dimensions

Dimensions are an essential element of any engineering drawing. It takes only one missing or poorly formatted dimension to cause unnecessary confusion and possible delays.

Dimensioning should:

- not interfere with the component drawing lines or any other features
- be neatly aligned and spaced out evenly
- be consistent in the use of font, text size and style
- be clear and easy to interpret
- comply with the requirements of an appropriate standard (such as BS8888).

Examples of good practice when drawing linear dimensions and the different terms used when referring to the features of dimensions are shown in **Figure 2.21**.



▶ **Figure 2.21** Examples of good practice and the terms used to identify the features of dimensions

Several acceptable methods can be used to dimension circles; these are shown in **Figure 2.22**. The actual method to use often comes down to personal preference, but the underlying principle here, as with all dimensioning, should be to choose the method that gives optimum clarity.

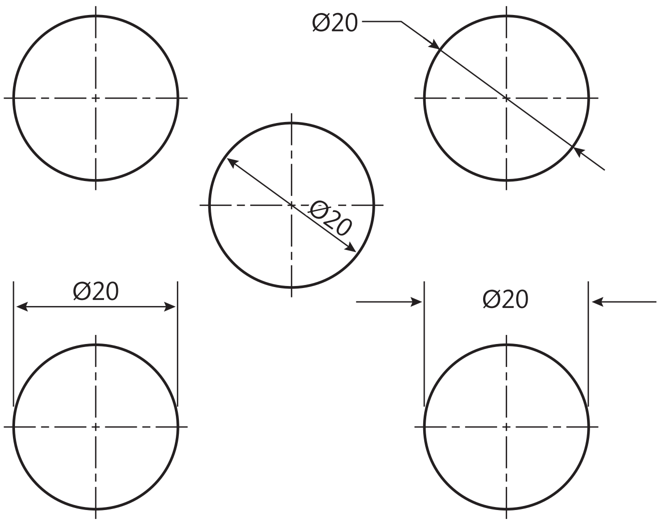


Figure 2.22 Examples of acceptable practice when dimensioning circles

Tolerances

Tolerances define the allowable variation between the measured dimensions of a completed product and the design dimensions stated on an engineering drawing.

Generally speaking, a reduction in tolerance means an increase in associated manufacturing cost. As tolerances become smaller, costs can rise because the machinery used in manufacturing needs to be capable of working to the required accuracy and precision.

The tolerances required will depend on the product being manufactured. For manufacturing a sheet metal wheelbarrow, the tolerances are likely to be large (of the order of ±2 mm), because this level of variation will not detrimentally affect the functioning of the product. At the other extreme, a jet engine turbine assembly will require manufacturing tolerances of the order of ±0.005 mm to prevent vibration when the assembly rotates at high speed.

Tolerances can be represented on engineering drawings in a number of ways. Again, personal preference plays a part in which method you use, but you should stick to the principle of the clearest method being the best.

Research

Search the internet to find different ways in which tolerances can be represented on engineering drawings.

Material

An engineering drawing generally states the material from which the component is made. This should be specified as a particular type, grade or alloy.

Surface finish

The roughness of a finished surface is defined in terms of its roughness average (Ra) measured in micrometres (μm), which is the arithmetic mean of the sizes of the peaks and troughs present on a surface when viewed under a microscope.

You should state the Ra value for each surface shown on an engineering drawing. For example, a cast iron engine block has a relatively rough cast finish (Ra ≈ 20 μm) over most of its surface, but on bearing or mating surfaces, such as the cylinder bores or where the head is mounted, the surfaces are ground to a much lower roughness (Ra ≈ 0.2 μm).

Figure 2.23 shows the standard symbol for surface roughness. In this case Ra = 3.0 μm is specified. This is typical of the finish left by turning and milling operations.

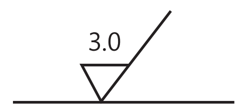


Figure 2.23 The standard symbol for surface roughness (indicating Ra = 3.0 μm)

Scale

It is important to select a suitable scale for any engineering drawing you are asked to complete. Few things will fit conveniently on a standard sheet of A4 or A3 paper. More often than not, objects are drawn either larger or smaller than life-size.

Small objects, such as the components of a mobile phone, would usually need to be drawn larger than in reality so that sufficient detail can be shown with the clarity necessary. When making small objects larger in a drawing, it is conventional to use one of the following scaling factors: 2 : 1, 5 : 1, 10 : 1, 20 : 1 or 50 : 1.

Large objects, such as a car door, would be too large to draw full size on a sheet of A3, so they should be drawn to a smaller scale. When making large objects smaller in a drawing, it is conventional to use one of the following scaling factors: 1 : 2, 1 : 5, 1 : 10, 1 : 50 or 1 : 100.

Drawing conventions

BS8888

The accepted conventions used in engineering drawings and other documentation for specifying a product are laid out in British Standard BS8888 *Technical Product Documentation and Specification.*

The topics covered in BS8888 relevant to this unit are: scales, dimensioning, tolerancing, surface finish, lines, arrows and lettering, projections and views, and symbols and abbreviations.

BS60617

A range of standard electrical and electronic symbols for use in wiring diagrams and circuit layouts are defined in BS60617.

General layout and title block

A standard layout should be used for all the drawings produced by any one organisation. Layouts will differ slightly between companies, but they should all be based on the conventions laid down in BS8888.

- A drawing's extent is defined by a border. This often includes vertical and horizontal divisions that form a coordinate system for identifying specific features in a drawing.
- The title block, usually positioned in the bottom right corner of a drawing, contains basic information about the drawing itself, including:
  - drawing number – a unique reference number that can be used to identify the drawing
  - projection symbol – a symbol that specifies whether the drawing views are arranged in first- or third-angle orthographic projection
  - scale – the scale applicable to the component drawn
  - units – the units in which the dimensions are stated
  - general tolerances – the tolerances that apply where no specific tolerance is stated on a dimension
  - name of author – provides traceability back to the person who created the drawing
  - date – specifies when the drawing was completed.
- Parts referencing – when the drawing depicts an assembly, it is common for each element to be labelled with a balloon note and referenced in a table that contains additional information such as part numbers and a description.

Views

The different views portrayed in engineering drawings are:

- **Plan** – the view of an object from directly above.
- **Elevations** – the front, back and side views of an object or component. Where only a single side view of an object is required, this is sometimes referred to as the end view.
- **Section** – sometimes it is necessary to provide details of a cross-sectional slice through a component to reveal internal or otherwise hidden details. This is provided in a section view.
- **Hatching** – used to define areas that have been sectioned.
- **Auxiliary view** – if a component cannot be fully represented by the standard orthographic plan view and front, back and side elevations, then an additional auxiliary view might be required. This allows features that are not aligned with standard orthographic views to be shown and clearly dimensioned.

Line types

There are several standard line types that can be used to represent the features on an engineering drawing. These are shown in **Table 2.4**.

Table 2.4 Standard line types used in engineering drawings

Line type	Usage	Example
Continuous thick line	Visible outlines and edges	
Continuous thin line	Dimension projection and leader lines, hatching	
Chain thin line	Centre lines of symmetry	
Dashed thin line	Hidden outlines and edges	

Link

Unit 10, Figure 10.2, shows some other standard line types used in engineering drawings.

Circuit diagram symbols and components

Commonly used electrical and electronic components are represented on circuit diagrams using standard symbols, which include those shown in **Table 2.5**.

Table 2.5 Some component symbols used in engineering drawings

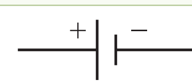
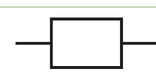
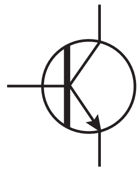
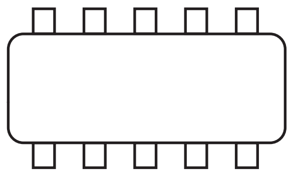
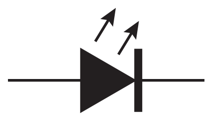
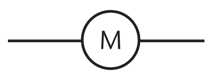
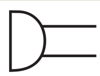
Component	Symbol
Cell	
Battery	
Switch – single pole single throw (SPST)	
Resistor	
Diode	
Capacitor (polarised)	

Table 2.5 Some component symbols used in engineering drawings – *continued*

Component	Symbol
Transistor (NPN)	
Integrated circuit	
Light emitting diode (LED)	
Motor	
Buzzer	

Link

More information can be found in Unit 19: Electronic Devices and Circuits.

Abbreviations

A number of standard abbreviations can be used in engineering drawings. **Table 2.6** lists some of these.

Table 2.6 Some abbreviations used in engineering drawings

Abbreviation	Meaning
A/F	across flats
CHAM	chamfer
DIA	diameter
R	radius
PCD	pitch circle diameter

Lettering

It is vital that the lettering used in the title block, notes and dimensions are of a size and type that ensures clarity and legibility. To facilitate this, all lettering should be in upper case and additional formatting such as underlining should be avoided.

On drawings sized A2, A3 and A4 the lettering used in the title block for important information such as the drawing number and title should have a minimum height of 3.5 mm. Lettering used in notes and annotations elsewhere on drawings of this size should have a minimum height of 2.5 mm.

General notes should be grouped together in one place on the drawing wherever sufficient space is available. However, notes relating directly to a specific view or feature may be located adjacent to that view or feature.

All notes should be aligned in the same direction, conventionally this will be parallel to the bottom of the drawing.

Common features

Often time and effort can be saved by using simplified representations of common features and components in engineering drawings, such as springs, threads and splines (see **Figure 2.24**).

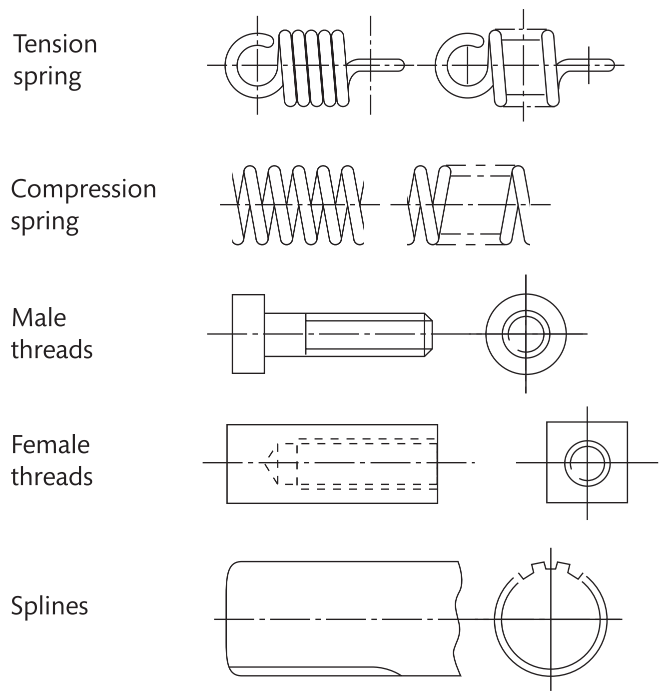


Figure 2.24 Simplified representations of springs, threads and splines used in engineering drawings

B2 Two-dimensional (2D) computer-aided drawing

Coordinates

A computer-aided design (CAD) package displays a system of coordinates on-screen. These coordinates allow you to navigate around a drawing and to specify accurately the positions of features such as the centre of a circle or the start and end points of a line.

There are three coordinate systems available for use in most CAD packages:

- **Absolute coordinates** – these define your position in the drawing using X and Y Cartesian coordinates with reference to a fixed datum point or origin, often the bottom left corner of the drawing.
- **Relative coordinates** – these let you choose a position as the origin of a Cartesian coordinate system. This is useful when you are drawing a number of different features on the same diagram. For example, if you define the starting point of a line as the origin of the coordinate system, then the end of the line can be specified more easily using X and Y coordinates.
- **Polar coordinates** – these are a type of relative coordinate system that is particular useful when positioning features in circular arrays. Instead of using distances along two perpendicular (X and Y) directions, polar coordinates use an angle and a distance from the origin to specify a position.

Templates

The starting point for most CAD drawings will be a basic template, which already contains a border and a partially completed title block. Using a standard template saves time and helps to ensure that all the drawings an organisation produces look similar and contain all the required information in the title block.

A template will probably be the first thing you create in CAD and will be used in all your subsequent drawings, so it is important to get it right.

Layers

Layers in a CAD drawing can be used to overlay different information on a common drawing outline. Each feature you add to a drawing will belong to a specified layer and can be moved to a different layer if needed. You can specify any number of layers in a drawing. You can give the layers names and colours and control them in different ways. For instance, if the drawing outline and dimensions are on separate layers, then you have the option to hide the dimension layer so that only the drawing outline is visible.

Common commands in CAD

- Line – you create straight lines by specifying a start and an end position. You can do this by using a mouse to click between grid snaps or by clicking with the mouse to start a line and entering the relative coordinates of its end point.
- Circle – you can define circles in a number of ways. A common method is to define the centre of the circle (in the same way as you define the starting point of a line) and then input its diameter.
- Arc – this is part of the circumference of a circle. A common method of drawing an arc is to define the centre of the circle and the start and end points of the arc.
- Polygon – regular polygons include shapes such as squares, rectangles and hexagons, which are all commonly required in engineering drawings.
- Chamfer – this describes the replacement of a sharp (90°) corner with an edge of a specified angle.
- Fillet – this describes the replacement of a sharp (90°) corner with a curve of a specified radius.
- Grid – a system of on-screen dots that help you lay out the drawing. You can specify different grid spacings appropriate to the size and scale of the drawing you are producing.
- Snap – this allows you to use the mouse pointer to specify an exact position in a drawing. In its simplest form, when you click the mouse button, a snap will jump to the grid point nearest to the mouse pointer. Snapping is useful when you want to make a seamless join with the end point or midpoint of a line, or with intersections and numerous other entities on your drawing.
- Copy – replicating an **entity** or group of entities that make up a component on a drawing.

Key term

Entity – a discrete element of a drawing, such as a line or circle.

- Rotate – turning an entity or group of entities around a given centre by a specified angle.
- Erase – deleting an entity or group of entities from the drawing.
- Stretch – resizing an entity or group of entities by specified amounts in the X and Y directions.
- Trim – removing specified sections of overlapping lines.
- Scale – establishes the scale of the engineering drawing being produced, letting you use the actual dimensions of an object when creating the drawing.
- Dimensioning – methods of dimensioning the features of your drawing will vary depending on the particular CAD package being used. Default dimension styles and formats are generally pre-set in the program preferences so that they will be used consistently. The actual value for a dimension is usually generated automatically according to the exact size of the drawing you have produced, but positioning will be up to you.
- Text – text boxes are frequently used in drawings to provide additional information about a component. Again, the default style and format used will generally be pre-set in the program preferences so that the text will have a consistent appearance.

- Pan – moving a particular area of a drawing so that it is more conveniently positioned on the screen. It is often used in conjunction with the zoom function.
- Zoom – you zoom in to enlarge a particular area of a drawing and zoom out to display more of the drawing.
- Cross-hatching – most CAD packages will have a number of pre-defined hatch patterns that are usually used to denote areas of cross-sectioning. Methods of applying cross-hatching differ between CAD packages, but generally cross-hatching can be applied only to an area that is fully bounded by a continuous line.
- Importing standard components or symbols – one of the advantages of CAD is that there are libraries containing thousands of standard pre-drawn components or symbols that can be imported into your drawings. This can save a great deal of time and effort when producing circuit diagrams.

Link

See Unit 10 for more details on computer-aided design in engineering.

PAUSE POINT Experiment by exploring the capabilities and commands available in the 2D CAD package you will be using.

Hint Start by drawing simple entities such as lines and circles before attempting to join them together.

Extend Find different ways of drawing similar features. How many ways can you draw a circle in the CAD package you're using?

Assessment practice 2.2

B.P3 B.P4 B.M2 B.D2

A colleague in technical sales has been working with a client on a new product and has brought in some hand sketches they have drawn up during a recent meeting.

The first sketch is of a stepped drive shaft with a milled keyway cut in one end.

The second is of an electronic circuit that monitors the temperature of the oil in the gearbox that drives the shaft.

Your colleague has asked you to use the information in the sketches to produce an engineering drawing for the shaft and a circuit diagram for the temperature sensor. Use a 2D CAD package to complete these drawings, ensuring that they both comply with appropriate international standards.

Plan

- What is the task? What am I being asked to do?
- What tools will I need in order to complete the task?
- How confident do I feel in my own abilities in using the tools? Are there any areas I think I may struggle with?

Do

- I know what I'm doing and what I am aiming to achieve.
- I can identify the parts of the task that I find most difficult and devise strategies to overcome those difficulties.

Review

- I can explain what the task involved and how I approached the work.
- I can explain how I would deal with the hard elements differently next time.

C Carry out engineering processes safely to manufacture a product or to deliver a service effectively as a team

C1 Principles of effective teams

If teams are going to work together to achieve a common goal, then every member of the team needs to understand what that goal is, what it will look like when it is achieved, the part they are expected to play and how this fits with the activities of other members of the team.

Good communication

Clear communication within teams and by team members to external stakeholders and interested parties is vital if the project is to be effective. Communication skills are important and can take many forms:

- Verbal – The language you use and the clarity with which you are able to get your message across are extremely important when talking to people. You are likely to need to enunciate your words carefully and talk more loudly during a formal presentation. You should always remain conscious of the reaction of your audience – they will usually make you aware if they are unable to hear or understand you properly.
- Written – The quality and clarity of written communications must always be high and should be tailored to suit different readers. A technical report will use appropriate technical terms, impersonal objective language and a structure appropriate to its readership. In contrast, a letter requesting a meeting to introduce a new product to a potential customer will be formal but friendly, because it seeks to persuade the reader to consider using your services. Use of correct spelling and grammar may not be sufficient to make a good impression, but repeated mistakes in a letter or report will always leave a poor one.
- Effective listening – Other team members can only make effective contributions if they are encouraged to express their thoughts during meetings and discussions. This means giving them the opportunity to contribute. You must listen carefully to what they have to say without curtailment or interruption. Ask questions to make sure you really understand what they are saying – it could be crucial to the success of your project. Maintain eye contact and provide encouragement by using non-verbal cues such as nodding as people speak.
- Respect for others' opinions – Although you may not agree with all that someone else brings to a discussion, it is important that they have the opportunity to express themselves and are treated with respect. This will encourage them to keep contributing their ideas, some of which might prove valuable.
- Negotiation – Negotiation is a process used to reconcile differences between parties. This could mean haggling over the price of a contract or trying to agree how the workload should be distributed within a team. Negotiation should be carried out in a reasonable and fair way, with the aim of establishing a compromise that is acceptable to all parties. Nobody should walk away from a negotiated settlement feeling that they have been treated unfairly or unreasonably.
- Assertiveness – A team leader must have a certain level of assertiveness to establish and maintain the direction in which the team should proceed. But don't confuse assertiveness with being dictatorial. Being assertive can help to build loyalty and maintain the focus of the team as they move forward with you. Being dictatorial and imposing your opinions without establishing a general consensus breeds resentment and disquiet within a team.
- Body language (non-verbal actions) – How you present yourself can often have an unconscious effect on how others perceive you. Maintain eye contact when you are talking to people; smile and shake hands when being introduced to colleagues; use your arms to help emphasise what you are saying; and definitely keep your hands out of your pockets!

Planning

The following are important when planning a project:

- Setting targets – A team needs to have a clearly defined target that they are working together to attain. It is important that all members of the team understand what the final outcome of their activities should be and the consequences to the organisation of missing the deadline for their target.
- Considering alternative approaches – The full team should meet early in the project to brainstorm ways by which their target might be reached. If everyone is involved in this way from the very start, team members will feel more involved in the project and are more likely to buy in to the decisions reached and the processes chosen.
- Organisation – see Section C2 'Team set-up and organisation'.

PAUSE POINT In small groups, take it in turns to express your mood using body language only.

Hint Try the easy ones first, such as happiness, sadness and excitement.

Extend Try to express more complex emotions, such as boredom, frustration or disbelief, and see if your colleagues interpret them correctly.

Motivation

Maintaining the motivation of individuals and teams is essential if they are to function effectively. There are many factors that can influence motivation.

- Shared goals – A sense of shared enterprise towards established and achievable goals will help to sustain the motivation of individuals in a team.
- Collaboration – People generally enjoy working collaboratively with their colleagues in situations where their opinions and suggestions are valued and they feel they are making a valuable contribution to a larger process.
- Reaching agreements – Effective negotiation will leave all parties feeling fairy treated when agreeing workloads or allocating responsibilities within a team. People generally resent having decisions imposed upon them without consultation or discussion. Change is best implemented by reaching mutual agreement where possible.
- Fairness – A team leader must act impartially in all matters. Any hint of favouritism should be avoided because it will have a negative impact on the morale of other team members.
- Opportunities to take responsibility – Encourage team members who are unused to managerial roles or positions of responsibility to take charge of parts of a project in which they have valuable experience or specialist knowledge. For instance, the setter who has worked with and maintained a specialist machine will have important knowledge to organise its transfer and re-installation.
- Constructive feedback – Comments relating to the work carried out by members of a team should be both timely and constructive. When things go wrong, other members of the team need to know quickly. Any issues raised should be worked on and resolved collaboratively with colleagues that have been affected by the problem.

In general, the allocation of blame will neither help solve a problem nor improve the performance of a team or individual. Working together to solve issues will help to cement relationships and demonstrate to those involved the importance of their part in the bigger picture and the potential effects their actions can have on the work of others.

Remember the rule of thumb that ninety per cent of feedback should be positive. The motivating effect of thanking someone for a job well done and confirming that you appreciate the efforts being made by others is invaluable in raising morale and maintaining motivation – but be careful not to give false praise because this can mislead.

Working with others

There are several aspects of being able to work successfully as a team.

- Being a team player – To work successfully in a team, you need to open up to the idea that your colleagues might actually have some useful input, which could improve your way of working. In a multi-disciplinary team, for example, some of the tasks you currently perform might be done more effectively or efficiently by a colleague. Sometimes being part of a team means putting your feelings and opinions to one side and doing what is best for the team as a whole.
- Flexibility/adaptability – Your willingness and ability to carry out multiple roles within a team will make you a valuable asset to any organisation. Working together is often about concentrating greatest effort where it is needed most at any one time. This might be in an area that is outside your core competency or specialism but in which you could effectively contribute if you are prepared to adapt.
- Social skills – It is important to remember that you must practise good language and behavioural skills at all times in the workplace so that you don't cause embarrassment or offence. Some colleagues or team members might become close personal friends over time.
- Supporting others – You will work closely with others in a team. A sense of loyalty and camaraderie among team members is important. Mentoring and supporting colleagues through difficulties both inside and outside of work help to cement these relationships.

PAUSE POINT What are the main benefits of working in a team?

Hint Try to think of an example from your own personal experience.

Extend What, if any, are the potential pitfalls of being part of a team and working closely with others?

The working environment

Here are some attributes of a working environment that are conducive to successful outcomes.

- Safe – Health and safety at work is vitally important to you and your team members, and everybody should take responsibility to ensure that safe working practices are rigidly adhered to, even if this means that a particular process might take a little longer to complete.
- Supportive – A supportive working environment might mean more than just the friendship of your colleagues. Your workplace might provide on-site childcare facilities to support working parents or agree to you working from home or becoming a part-time employee if you need to establish a better work–life balance. Treating employees as real people and appreciating that an employee's life outside work can and will affect their contribution inside is likely to increase staff loyalty and the long-term retention of staff.
- Challenging – Working within your comfort zone on the same kind of work day after day can lead to boredom, complacency and a lack of fulfilment. Most people need a little challenge in their working lives. Boring, unfulfilling jobs lead to bored and unfulfilled employees, and this will in turn harm productivity and the effectiveness of an organisation.
- Opportunities to show initiative and leadership – Providing opportunities for employees to show initiative and leadership encourages them to push themselves, develop and achieve their full potential. Effective leaders are rarely born, but are developed in organisations that provide sufficient training, challenge and progression opportunities to their staff.

Case study

The Toyota Production System (TPS)

Figure 2.25 Car being manufactured on a production line

The Toyota Production System developed by the Japanese car manufacturing giant is the forerunner of what has come to be known as the 'lean philosophy'. Since its development in the latter part of the twentieth century, the lean philosophy has been applied to everything from the delivery of services in hospitals to the manufacture of aircraft.

A cornerstone of TPS is the empowerment of the employees who actually carry out manufacturing operations. Any one of them can stop the production line in order to address a quality problem they have encountered. The changes needed to solve the problem can be made by the team itself immediately, without having to seek further guidance – this minimises delay. Taking collaborative ownership of a process in this way and exercising both individual and joint responsibility for the quality of the work leaving their production cell has meant that TPS provides an environment where near-perfect quality is the norm.

Check your knowledge

How do you think that the TPS approach benefits the employees and the company as a whole?

C2 Team set-up and organisation

Team competencies and development

When establishing a team it is vital to recruit team members who have the correct mix of skills to complete a project successfully.

Professional team members will have a diverse mix of experience that can be passed on to other members to develop their abilities and effectiveness. These development activities help to enhance the flexibility and capability of individuals and of the team as a whole.

Constructive peer feedback

Most multi-disciplinary teams have a fairly flat hierarchical structure, often with a single project manager responsible for coordinating the efforts of the whole team. As such, most opportunities for receiving feedback on your work will come from your colleagues, who might be affected by issues that will benefit from your improvement. Peer feedback can be a very valuable and powerful developmental tool to ensure the smooth running of a project. Problems tend to be exposed quickly and can be addressed immediately.

Roles and responsibilities

The allocation of roles within a team is often a matter of common sense because team members will usually be selected on the basis of their skills or expertise in a specific area. It is important to ensure that sufficient staff are allocated to each task. Core responsibilities will be clearly laid out for each member of the team, but there is usually some flexibility.

Timescales and planning

The project manager usually plans a project and coordinates the efforts of the team involved in its delivery. The schedule can be extremely complex for a large project.

In practice, planning the delivery of projects often moves backwards from a required completion date, and staff and resources are determined so that the project can be completed on time and within budget.

At the heart of the plan is a detailed list of all the activities that need to take place to complete the project and the order in which they should be carried out. Some activities can be performed concurrently, with different parts of the team working on different elements of the project at the same time. Other activities cannot be started until the completion of some previous task or tasks.

You can use flow charts, tabulated data, Gantt charts and/or network diagrams to visualise project planning activities.

Objectives and target setting

It is important that the scope of any project is properly established and its success criteria are well defined. In other words, you must state exactly what it is you are trying to achieve and define clearly how you will know when you have achieved it.

For example, suppose the scope of a project is described as:

'Change the coolant on a centre lathe.'

This is not sufficiently clear – will the project include cleaning out the coolant tank after it has been drained or safe disposal of the old fluid? When is the coolant change going to take place? What will define completion of the project?

A better description might be:

'Change the coolant on a centre lathe. Machine to be taken out of service and handed over to maintenance team at 17.00 on 04/05/16. Maintenance team to complete the following: drain old fluid, clean out storage tank, flush pipework, transfer waste to waste fluid drums (in preparation for collection), refill system with new coolant to equipment manufacturer's specification, test operation of coolant pump and delivery system. Machine to be returned to service and handed back to manufacturing team at 19.00 on 04/05/16.'

During a project or process, a number of milestones or gateways may also be established in the plan to enable the project manager to measure the progress of the project. At these key points in the project, the team might be gathered together to review the work completed so far and suggest any improvements or changes that might be required in the next phase of the project.

C3 Health and safety risk assessment

Risk assessment in an engineering workshop

The Health and Safety Executive (HSE) gives clear guidance (www.hse.gov.uk/pubns/indg163.pdf) on how to conduct a risk assessment in five steps:

1. Identify the hazards.
2. Decide who might be harmed and how.
3. Evaluate the risks and decide on precautions.
4. Record your significant findings.
5. Review your assessment and update if necessary.

Identifying hazards

Hazards are best described as anything that has the potential to cause harm. You can identify hazards by inspecting your working environment and the equipment available to you. In an engineering environment, hazards might include things such as:

- having an untidy workshop
- using hand tools, such as a hacksaw
- using machine tools, such as pillar drill
- exposure to chemical substances, such as lathe coolant
- using hot processes, such as welding.

Deciding who might be harmed and how

For each of the hazards identified, you need to determine how an injury might happen and who might be injured. For example, if you consider the hazard of 'having an untidy workshop', someone might be injured by tripping over or slipping on something left on the floor. The consequences of a fall can be serious and could lead to head or back injury, cuts or broken bones. Those at risk of the hazard include anyone who has access to the workshop, such as technicians, supervisors, managers and site visitors.

Evaluating risk and adopting control measures

Risk is related to the likelihood of a hazard actually causing an injury and the likely severity of that injury. It is sometimes useful to establish a rating for each risk so that the risks can be compared and categorised as trivial, acceptable, or unacceptable and requiring immediate action.

A risk rating is the product of a likelihood score, which represents how likely it is that an injury will occur, and a severity score, which represents the potential seriousness of any injury. The calculated risk ratings can be displayed in a matrix as shown in **Figure 2.26**.

Likelihood		Severity: Minor injury (First aid) **1**	Moderate injury (lost time) **2**	Serious injury (RIDDOR reportable) **3**	Major injury (RIDDOR reportable) **4**	Fatality (RIDDOR reportable) **5**
Extremely unlikely	**1**	1	2	3	4	5
Unlikely	**2**	2	4	6	8	10
Likely	**3**	3	6	9	12	15
Extremely likely	**4**	4	8	12	16	20
Almost certain	**5**	5	10	15	20	25

Figure 2.26 Example of a risk rating matrix

In this example, where a risk rating is 4 or less (the green cells in **Figure 2.26**), the risk is considered trivial and no additional control measures need to be put in place. Risks with a rating of 5–10 (amber cells in **Figure 2.26**) are accepted, but any measures put in place to limit the risk should be reviewed regularly and efforts should be made to reduce the risk rating further. Immediate action must be taken to reduce the risk if its rating is 12 or above (red cells in **Figure 2.26**).

You can use a variety of techniques to control risk – each has a different level of effectiveness (see **Table 2.7**).

Table 2.7 A hierarchy of effectiveness for control measures

Control measure (in order of decreasing effectiveness)	Examples and comments
Eliminate the hazard	This might mean stopping use of a particular process, material or piece of equipment because it is unacceptably dangerous. For example, exposure to lead fumes during soldering operations in the electronics industry was extremely difficult to control effectively. As a consequence manufacturers changed the type of solder used to one which no longer contained lead, thus eliminating the problem.
Reduce the severity of the hazard	Building sites use electrical tools that operate on a reduced, and therefore safer, voltage of 110 V instead of the UK standard supply voltage of 240 V.
Isolate personnel from the hazard	Computer numerical control (CNC) machine tools, such as lathes and milling machines, are completely enclosed during operation.
Limit the extent of exposure or contact with the hazard	A residual current device (RCD) will limit exposure to electric current if an electrical device develops a fault. Welding curtains are used to limit the exposure to UV radiation of workers near where welding operations are being carried out.
Personal protective equipment	Goggles provide eye protection from flying debris that might otherwise cause eye damage.
Discipline and safe working practices	Instruction and training on safe working practices are important but rely on good discipline, concentration and responsible behaviour, which cannot always be guaranteed.

Other means of reducing risk in the workplace include:

- good design – for example, improving the operational safety of equipment; designating exit routes from workplaces.
- permit-to-work system and guards – allowing only designated personnel to work in hazardous areas or on hazardous jobs; physical barriers to keep visitors or unauthorised people away from dangerous equipment.
- testing and maintenance – checking that equipment is in good working order and safe; revealing potentially dangerous faults.

Recording significant findings

Carrying out a risk assessment and putting in place the necessary control measures are insufficient on their own. Keeping proper records is also extremely important because these prove that you have carried out your legal obligations to provide a safe place of work.

HSE provides pro forma documentation to enable record-keeping to be done effectively. Prompts are provided to ensure that important steps are not missed (see **Figure 2.27**).

Company name:						
What are the hazards?	Who might be harmed and how?	What are you already doing?	What further action is necessary?	Action by who?	Action by when?	Done
Slips and trips	*Staff and visitors may be injured if they trip over objects or slip on spillages.*	• *General good housekeepoing.* • *All areas well lit, including stairs.* • *No trailing leads or cables.* • *Staff keep work areas clear, e.g. no boxes left in walkways, deliveries stored immediately, offices cleared each evening.*	• *Better housekeeping in staff kitchen needed, e.g. on spills.* • *Arrange for loose carpet tile on second floor to be repaired/replaced.*	*All staff, supervisor to monitor* *Manager*	*From now on* *01/10/10*	*01/10/10* *01/10/10*

Figure 2.27 Example of an HSE-approved risk assessment template

Reviewing the assessment

Work methods, tools and machinery tend to change over time, so it very important that risk assessments are reviewed periodically to ensure that they are still relevant and effective.

PAUSE POINT Working with a small group of colleagues, carry out a risk assessment on the use of a pillar drill.

Hint Follow the procedures laid out in the five steps to risk assessment.

Extend How does your risk assessment compare with the work carried out by other groups?

Case study

Slippery workshop floors

An employee slipped on the dusty concrete floors of a workshop during a routine visit; luckily he wasn't hurt. However, this incident did spur the company into action to investigate methods of making the workshop safer.

The nature of the work being carried out meant that graphite dust was constantly being produced, and despite using an extraction system, some of this dust found its way onto the floor.

The company decided to take a two-pronged approach to reducing the risk of slipping by both upgrading the extraction and filtration system to capture more dust and installing textured resin flooring in the workshop.

Check your knowledge

What might have been the consequences for the company if the employee had slipped and been seriously injured?

C4 Preparation activities for batch manufacture or batch service delivery

Health and safety factors

In all branches of engineering, health and safety needs to be considered during the planning and preparation for any new manufacturing or process task.

In both manufacturing and service processes, risk assessments and safe working prractices need to be eastablished prior to the commencement of any work.

On completion of the planning and preparation activities, a comprehensive risk assessment on the manufacturing or service delivery plan you have developed is required. This should be carried out according to the approach explained in Section C3.

Defining the required outcomes

When planning the manufacture of a product, you will need a materials list, relevant engineering drawings for the manufactured components and a general assembly drawing detailing how the finished product is put together (if necessary). These documents will contain a complete definition of the product being manufactured and all of its component parts.

When planning to provide an engineering service, you will need a full description of the required outcomes that must be achieved. For instance, to perform the renewal of the coolant in a centre lathe, the outcomes might be defined as: supply and renewal of coolant; removal and safe disposal of the used fluid; cleaning out the tank; testing the fluid flow.

Determining the processes required

For manufacturing a product, this phase of planning and preparation will require careful inspection of the specification and component drawings in order to determine suitable and efficient methods of manufacturing. This will help you select appropriate manufacturing processes for each step. A single product may require an understanding of several different process types. For example, the manufacture of a light fitting might require: mechanical processes to create formed metal components, assembly processes to fix components together, electrical processes to install wiring and connect electrical components, and testing processes to ensure the product is electrically safe and functioning properly.

For an engineering service, you need to take a close look at the requirements of the service being planned and determine the best way to achieve each of the required outcomes. This will require research into the equipment you will be working on (where necessary), and might involve consideration of a number of disassembly, replacement and test processes. This will help you select appropriate engineering servicing processes for each step. A service may require an understanding of several different process types. For example, changing the coolant on a lathe will require: effective use of safe working practices such as electrical isolation of the lathe to prevent accidental activation, safe material handling and disposal, disassembly processes using hand tools to gain access to the coolant tank, safe cleaning and fluid replacement processes, and testing processes on the coolant pump, coolant flow and checking for leaks or blockages.

Sequence of operations

As part of the preparation, define the sequence of operations that need to be carried out. Identify the operations that must be performed sequentially and those that can be carried out concurrently. This will form the basis of your manufacturing plan (for a product) or delivery plan (for a service), which defines what must be done, how, when and by whom.

Equipment

Determine the equipment that will be needed to complete each operation in the manufacturing plan or service delivery plan.

Quality control

Define when and how checks will be carried out to ensure that the product has been manufactured or the service delivered as originally specified. For a product, this might include taking measurements, assessing the fit and finish, and testing the finished product. For a service, this might include functional testing and ensuring that all fixings have been replaced and tightened to the required torque.

Materials and parts

For a product, gather together the materials and parts, such as screws or washers, that will be required to complete all the manufactured components and assemble a finished product. For a service, gather together the materials and replacement parts that will be required to complete the engineering service.

C5 Delivery of manufacturing or service engineering processes

Manufacturing engineered products

Many manufactured products are suitable for consideration in this unit – for example, a screwdriver, a toolmaker's clamp, a sheet metal toolbox, callipers, a ball joint splitter and a wiring loom.

You need to consider a number of basic workshop processes when manufacturing an engineered product.

- Marking-out processes are used to indicate the positions of features on a workpiece clearly so that they can be created accurately. This might mean using a rule, square and scriber to mark the position of a saw cut or using a centre punch to mark the position of a drilled hole. This stage must be done precisely, and there are a range of specialist tools that will help you achieve the required accuracy – for example, a scriber, rule/tape, punch, square, vernier height gauge or marking-out medium.
- Manual processes are usually used for one-off production because they are versatile. The down side is that they are time-consuming and usually require a high degree of skill to use proficiently and achieve a good finish. Tools used in manual processes might include shears, punch, guillotine, bender, saw, tap, die or file.

- Machining processes tend to be used for the quick and accurate removal of larger amounts of material than would be practicable with hand tools. Typically these might include a pillar drill, lathe or milling machine.
- Assembly processes complete the final product once all its component parts have been manufactured. There are numerous joining methods used in assembly, which might include the use of adhesives, mechanical fasteners such as screws, rivets or clips, and cable ties or wiring connectors such as bullets, spades or terminal blocks.
- Quantity production techniques are used to semi-automate processes that need to be repeated on a large number of products. Manufacturing aids, which help to cut down production times, might include bespoke form tools, templates, jigs, moulds, fixtures or stops.
- Measuring processes must be employed to ensure that work is marked out and manufactured accurately. This is likely to require the use of specialised engineering measuring devices such as micrometers, vernier or digital callipers and comparators.

Engineering services

Many engineering services are suitable for consideration in this unit – for example, refurbishing an alternator (including worn part replacement and testing), modification of pipework (including the connection of valves and operational checks), modifying and rewiring electrical switch panels, and performing a service on a centre lathe (including coolant renewal).

Delivering engineering services

Engineering services will not usually require the use of heavy workshop machine tools. Instead, they concentrate not on the manufacture of new parts but on the refurbishment or repair of existing products. Again, there are a number of workshop processes that will need to be considered when carrying out engineering services.

- Disassembly, removal and strip processes all involve the removal of parts. You will usually do this because the parts need to be checked or they are simply in the way and preventing the removal of other components that need to be checked. You will need a range of tools to remove the fasteners that hold a product together, such as screwdrivers, wrenches, spanners, sockets, pliers/grips and hexagon keys.
- A manual process may be needed in removing, repairing, refurbishing or refitting components, such as when removing burrs, cleaning, trimming pipes to length or cutting gasket material. You may need to use other hand tools such as snips, cutters, knives, punches, saws, files or hammers.
- Assembly processes are those required to reinstate the product into working condition. It is fundamentally the opposite of disassembly, but some of the electrical connections or mechanical fixings may need to be totally replaced. These processes might include using a soldering iron to connect wiring, refitting or replacing mechanical fasteners, using a torque wrench to ensure that machine screws are correctly tightened, fitting new wiring crimp connectors, and using pneumatic tools or clamps to hold components in place while fixings are refitted.
- You will use inspection/testing processes to verify the function of the product once it has undergone a service and to ensure that components have been assembled correctly. This might mean using a multimeter to check continuity of electrical connections, flow meters to verify that fluid input and output are as required, or a pressure sensor/gauge to ensure that appropriate system pressures are maintained and there are no leaks.

Assessment practice 2.3

C.P5 C.P6 C.P7 C.P8 C.M3 C.D3

In your role as a shop floor supervisor in a small engineering company, you have been tasked with setting up, leading and working alongside a small team of two manufacturing technicians to make a batch of five sample screwdrivers for approval by a client.

- Discuss your role as an effective team leader in manufacturing the screwdrivers.
- Discuss the requirements in setting up the manufacturing process.

Ensure that you include safety, efficiency and quality aspects in your answers. You will be expected to produce a risk assessment for at least one engineering process and discuss any necessary set-up activities.

Plan

- What is the task? What am I being asked to do?
- What issues do I need to consider and what research should I undertake in completing this task?
- Are there any areas I think I may struggle with?

Do

- I know what I'm doing and am confident that I can achieve my goals.
- I can identify the challenging aspects of the task and refine my thinking/approach to overcome these difficulties.

Review

- I can explain what the task involved and the steps I took to complete it.
- I can identify the parts of my knowledge and understanding that require further development.

THINK FUTURE

Patrick Makin

Apprentice engineering technician

I'm now in my third year as an apprentice engineering technician with a multinational manufacturing company. At school I completed a BTEC National in Engineering, and as part of the course we did some project work with my current employer and worked with them to solve some real-world engineering problems. Well, I must have done something right because they encouraged me to apply for one of their apprenticeships. At the start of Year 13 I did just that and sent off my application. After an interview I was accepted! I joined the programme immediately after leaving school (with a Distinction in my engineering course) and couldn't wait to get stuck in.

I am now settled in and really enjoying myself. I have been supported in loads of different ways by the company and am considered as part of the team by my work colleagues who I really enjoy working alongside.

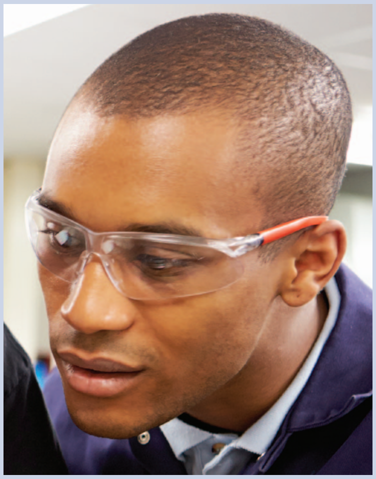
Focusing your skills

Becoming established in a new environment

It can be tough when you start a new job or join an unfamiliar team. Here are a few tips to help with the transition:

- Listen – starting a new role will mean having to absorb of information. You need to pay attention to what you are told. People will generally cut you a bit of slack in the first few weeks, but don't expect that to last.
- Take a few notes – note down important information such as start, finish and break times.
- Address people by name – this helps to establish working relationships more quickly. Try to remember names. You could even make a note of people's names as you are introduced to them.
- Be aware of what your body language is saying – you might be intently listening to a presentation, but if you're leaning back in your chair with your eyes closed it will look like you are not.
- Stay safe – during your induction and initial tour of the facilities make sure you pay attention to the emergency procedures, where to find the exits, how to contact a first-aider and all that stuff you hope you'll never need.
- Ask questions – don't be afraid to ask questions, but make sure that you don't keep asking the same ones of the same people.
- Learn how the equipment works – you need to know how the equipment you will be using works and if there are any dos and don'ts that do not appear in the manuals. Obviously don't use a piece of equipment unless you have been trained to do so and are familiar with any relevant safety requirements.
- Ask for help – if you are lost (this can happen in a big facility!), confused about something or simply need direction to the nearest toilet, then don't be afraid to ask. Take the opportunity to introduce yourself at the same time.
- Be punctual – be on time in the morning, don't be late back from breaks and don't be the first to rush out of the door at the end of the day.
- Be friendly – if you are friendly towards your colleagues, then they will usually reciprocate. If you're in a bad mood then bite your lip and don't take it out on your colleagues.
- Maintain your sense of humour – smile!

Getting ready for assessment



Hazeem is working towards a BTEC National in Engineering. He was given an assignment for Learning aim A that asked him to evaluate the manufacturing processes used to make a screwdriver and the impact that human factors have on manufacturing operations.

His findings had to be written in a technical report that would be passed on to the operations director of the company in the assessment scenario.

The report had to:

- justify the use of at least three manufacturing processes used to manufacture the screwdriver, comparing them with possible alternatives
- evaluate how human factors and characteristics affect the performance of individuals and teams when carrying out manufacturing processes.

Hazeem shares his experience below.

How I got started

First, I had a really good look at the screwdriver we were given to use as the basis of the assignment. From my notes on manufacturing processes I was able to recognise the tools and techniques that could be used to make the different parts. What really helped was drawing pictures of the different components on A3 sheets of plain paper and then adding annotations to record my thoughts on the different ways each feature could be made. The assessment criteria said I had to consider at least three different processes, but I made sure I had plenty to choose from.

The second part of the assignment on the effects of human factors on individual and team performance was harder to get my head around. I started by reviewing my notes and making a mind map of all the factors that I thought were most important. This helped me visualise what I should write about and helped me to structure my written report.

How I brought it all together

I wanted my report to look professional because it was going to be read by a senior business manager, so I used a simple Arial font and included a footer on each sheet containing my name and page numbers. I added a title page, which included a photograph of the screwdriver, and then wrote a short introduction. I included lots of relevant photographs to support what I was saying in the text and to add some visual interest.

While I was writing the report, I ticked off the points I had covered on the annotated sketches and mind maps I had created previously in my preparation for the assignment.

What I learned from the experience

I think my assignment went really well on the whole. Keeping good notes of the things we covered in class really helped later on. I am going to buy a notebook to keep all my class notes together though. Trying to keep all my loose sheets of paper in order is a pain.

If I were going to do this again, I would make sure that I got hold of a copy of the unit specification so I could look at the 'Essential information for assessment decisions' page while I was writing the assignment. This would have been really useful because it explains what the assessment criteria actually mean in practice, and tutors use this when assessing the work.

Think about it

- Have you planned what you need to do in the time available for completing the assignment to make sure that you meet the submission date?
- Do you have your class notes on manufacturing processes and the influence that human factors can have?
- Is your information written in your own words and referenced clearly where you have used quotations or information from a book or website?