PASSING LANE

MEM - Metal and Engineering

MEM10119 - Certificate I in Engineering

Unit

MEMPE006A

Undertake a basic engineering project

Trainer/Teacher Manual

SAMPLE ONLY

Passing Lane Pty Ltd
PO Box 975
COWES VICTORIA 3922

MATERIALS PUBLISHED IN AUSTRALIA

STUDENT/TRAINEE DETAILS

Student/Trainee Name

Student/Trainee Email

Teacher / Trainer Name

School / Institution / Training Organisation / Employer

PASSING LANE

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SAMPLE ONLY

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INTRODUCTION

This manual is developed to provide training content that addresses the specific ‘Unit of Competency’ as outlined on the following pages.

It provides the teacher and/or trainer with a document that includes all that the student and/or trainee manual content plus guidance notes as well as answers to the learning activities in the student/trainee manual.

This manual can be packaged with various manuals addressing other ‘Units of Competency’ in order to meet the ’Packaging Rules’ of a particular Australian Training Package Qualification.

This resource has been designed to be delivered in a form that is conducive to the learning environment including:

- Online delivery
- Classroom delivery
- On the job training

The documents are designed in a ‘landscape’ format in order to make reading on a computer screen easier as well as reduces the need to scroll down pages. Documents can be easily printed if the learning environment requires the student or trainee to have hard copies of the learning materials.

INTRODUCTION—CONT'D

LEARNING ACTIVITIES

The learning activities in the student and/or trainee manuals are 'Form Enabled' so that if the resources delivered online, the activities can be filled in using the computer keyboard.

Each learning activity is identified with the following icon.

Learning Activity

Learning activities come in the following forms.

- ☆ Questions
- ☆ Research
- ☆ Tasks
- ☆ Interviews

Questions

Questions would relate to the information presented on previous pages.

Research

This type of learning activity would require the student or trainee to locate information by using research methods. The information they would be require to locate would be in line and/or support the information that the manual had outlined in previous pages.

INTRODUCTION—CONT'D

Tasks

This learning activity type would require the student/trainee to actually do or undertake something and would be reinforcing the knowledge they have gained from reading the manual's previous pages.

Interviews

This learning activity type would require the student/trainee to interview person(s) in an actual workplace environment or a person(s) who are experienced in the industry sector which the student/trainee is currently undergoing training.

The student/trainee is made aware of the type of learning activity by noting the learning activity type displayed under the learning activity icon.

Learning Activity

Research

SELF ASSESSMENT

At the end of each manual is a series of questions that the student/trainee should review and answer.

This self assessment is to ensure in the student's or trainee's mind that they have reviewed and understood the information that was presented in their manual.

If they are unsure of their understanding in any of the topics reviewed, they are encouraged to go back and review the information again and/or seek the assistance of their teacher or trainer.

UNIT OF COMPETENCY OVERVIEW

The following pages are extracts from Training.gov.au website and outlines this specific ‘Unit of Competency’ including the ‘Elements’ and the ‘Performance Criteria’. The content within this manual has been developed to address this unit.

MEMPE006A - UNDERTAKE A BASIC ENGINEERING PROJECT

ELEMENT	PERFORMANCE CRITERIA
1. Research engineering materials and components	1.1. Determine the uses of **engineering materials** , such as types and forms of metals, polymers (thermo setting and thermo plastic) and fibres 1.2. Describe the advantages of the engineering materials when compared to each other 1.3. Determine commonly available **shapes of metal materials** , such as sheet, plate, bar, angle iron and other common shapes 1.4. Determine **methods used to join metal** pieces, such as, threads, pins, circlips, rivets, welding, folded joints and adhesives 1.5. Describe the advantages of the different metal joining methods 1.6. Determine the types of plain and anti-friction bearings, including type of materials, used in machines 1.7. Describe the advantages and disadvantages of the different types of bearings
2. Develop a metals-based project	2.1. Research and decide on a realistic project that can be completed in the institution in the available time 2.2. Determine the types of material required for the project 2.3. Determine the amount of material and components required 2.4. Gain approval for the project
3. Determine drawing requirements	3.1. Research engineering drawing practices 3.2. Decide how drawings will be produced, e.g. using a CAD systems and/or hand drawing equipment, and/or freehand sketches 3.3. Decide on appropriate dimensioning methods for the drawings produced 3.4. Decide on methods and conventions for naming and saving new or modified drawings

ELEMENT	PERFORMANCE CRITERIA
4. Create project drawings	4.1. Produce drawings of the completed project using either CAD systems, hand drawing equipment or freehand sketches 4.2. Produce drawings of the individual project components using either CAD systems, hand drawing equipment or freehand sketches 4.3. Review drawings with teacher/instructor and peers 4.4. Modify drawings as required 4.5. Produce an items and materials list using the either the CAD system or other computer software
5. Plan the manufacture of the product	5.1. Determine the machines, tools and equipment required 5.2. Determine the sequence of individual component manufacture and measures needed to protect manufactured components from damage 5.3. Develop a plan for the assembly of the project 5.4. Get advice and approval for the project and plan
6. ***Manufacture the product***	6.1. Use and wear appropriate personal protective equipment 6.2. Follow safe working practices and procedures 6.3. Manufacture and store components and acquire stock components according to the developed plan 6.4. Assemble product according to the developed and approved plan 6.5. Check for conformance to requirements throughout the manufacture and assembly process 6.6. Submit the project for final endorsement
7. Complete work requirements	7.1. Clear work area of waste and clean according to requirements 7.2. Maintain and/or store machines, tools and equipment according to instructions

Section One

Research Engineering Materials and Components

UNDERTAKE A BASIC ENGINEERING PROJECT

SECTION ONE—RESEARCH ENGINEERING MATERIALS AND COMPONENTS

Introduction

In engineering and manufacturing industries there is a wide range of materials, parts and fasteners used to make an endless number of products including consumer products, vehicles, aircraft, marine vessels and buildings.

In this section we look at a basic cross-section of steel and plastic materials, as well as the more common methods of fastening metal pieces and other common parts.

Section Learning Objectives

At the completion of this section you will learn information relating to:

- ☆ Determining the uses of engineering materials, such as types and forms of metals, polymers (thermo setting and thermo plastic) and fibres
- ☆ Describing the advantages of the engineering materials when compared to each other
- ☆ Determining commonly available shapes of metal materials, such as sheet, plate, bar, angle iron and other common shapes
- ☆ Determining methods used to join metal pieces, such as, threads, pins, circlips, rivets, welding, folded joints and adhesives
- ☆ Describing the advantages of the different metal joining methods
- ☆ Determining the types of plain and anti-friction bearings, including type of materials, used in machines
- ☆ Describing the advantages and disadvantages of the different types of bearings

Steel billets

Steel slabs

Determine the uses of engineering materials, such as types and forms of metals, polymers (thermo setting and thermo plastic) and fibres

and

Describe the advantages of the engineering materials when compared to each other

(Over the next few pages we cover two 'Performance Criteria' points at the same time to avoid repetition)

The most common metal used in the engineering industry sectors is steel. The two basic types of steel are:

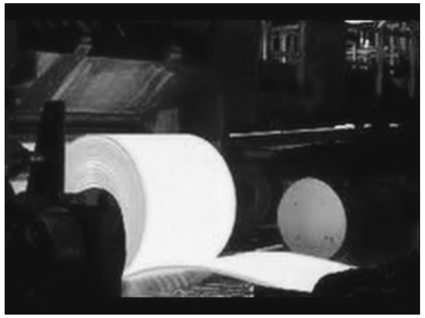
- ✰ Hot rolled
- ✰ Cold rolled

Hot rolled - semi-finished products called blooms, billets and slabs are transported from the steelmaking plant to the rolling mills.

Steel products can be classified into two basic types according to their shape: flat products and long products. Slabs are used to roll flat products, while blooms and billets are mostly used to roll long products. Billets are smaller than blooms and therefore are used for the smaller types of long product.

Semi-finished products are first heated in a re-heat furnace until they are red hot (around 12000 C). The reheated steel is passed through a collection of steel rolls (or drums) on which pressure can be applied to squeeze the hot steel passing through them, and arranged so as to form the steel into the required shape.

Plate mill



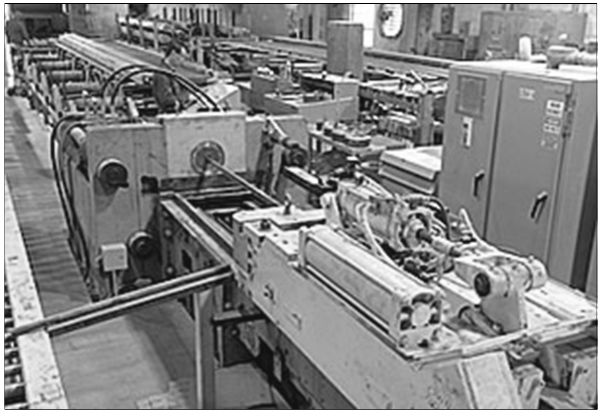
Strip mill

Long product mill

Hot rolled steel products are manufactured in three types of steel mills:

- ***Plate mill*** - as the terms suggests this mill manufacturers steel plates of varying thickness and grades using reheated slabs.
- ***Strip mill*** - slabs are also used to make 'hot rolled steel coils'. These are thin steel plates that are rolled into long length thin steel coils.
- ***Long product mill*** - blooms and billets are used to make long products. Long products include:
    - Angle bars
    - Flat bars
    - I-beams
    - Channels
    - H-beams
    - Rod

Cold rolling mill



Wire drawing mill

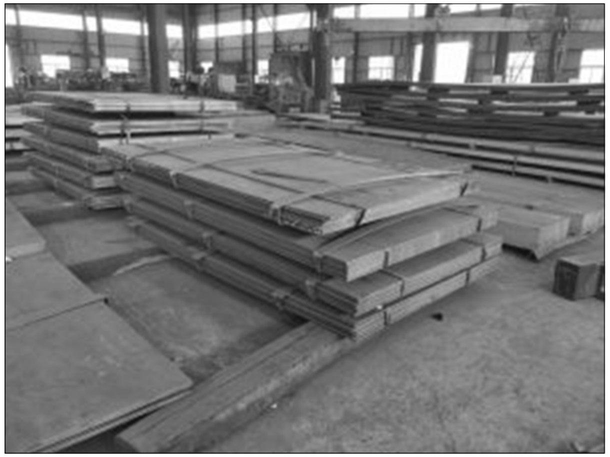
Cold rolling - after hot rolling, many steel products undergo a further processing in the cold state. This stage of processing does not alter the shape of the steel product, but it does reduce it in thickness and significantly improve its performance characteristics.

For example, hot rolled coil is commonly cold rolled next. The strip is first de-coiled (uncoiled) and then passes through a series of rolls which apply pressure to the strip and progressively reduce its thickness - down to as low as 0.15mm. The strip is then recoiled.

Cold rolling processes are also used to improve the surface quality of the steel. Cold rolling also has the effect of hardening steel, so cold reduced strip is subsequently ‘annealed’, which is a process of very carefully controlled heating and cooling to soften it.

Cold reduced strip and sheet is able to withstand subsequent forming and pressing operations without the steel cracking. The elaborate shapes used to make car bodies are pressed out of cold reduced sheets. Very thin cold reduced sheet, after coating with a thin layer of tin, is used to make food and drink cans.

Wire drawing - another form of cold processing is cold drawing. Steel rod is dragged at pressure (drawn) through a series of dies which progressively reduce the rod's circumference to produce wire. The drawing process substantially increases the steel's tensile strength - steel wires can be spun into huge ropes strong enough to support large suspension bridges.



Steel Grades

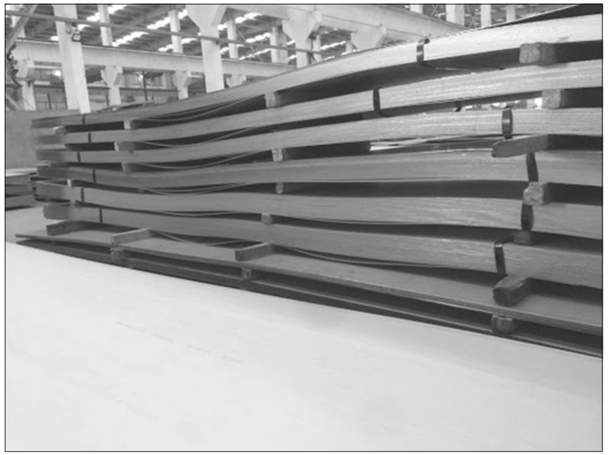
There are a wide range of steel grades all based on various mechanical properties of the steel and sometimes the additional alloys introduced into the steel.

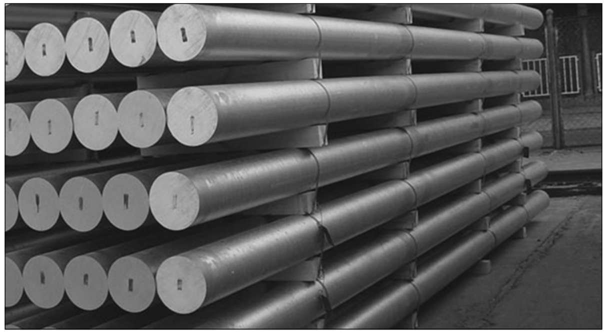
The standard common structural grade steel is known as Grade 250. The number 250 refers to the yield strength being 250 MPa (MPa being a scientific unit of pressure) of the steel based on a testing standard.

Depending on the application or use, the grades of structural steel increase when strength is an issue. Standard grades are:

- Grade 250
- Grade 300
- Grade 350
- Grade 400
- Grade 450

Structural sections such as universal beam and channels generally start at Grade 300 and up and welded and seamless pipe usually start at Grade 350.





Stainless Steel Grades

Stainless steel grades differ from carbon steel grades.

Stainless Steel is classified as a steel alloy. It has a small percentage of chromium alloy mixed in with the steel to make it less prone to rusting, staining and corrosion. There are numerous grades of stainless steel, however the most common grades are:

- ***Grade 304*** - a general purpose stainless steel which is suitable for both welding and cold forming. It is widely used in the food industry, chemical industry, and kitchenware.
  Grade 316 - 316 stainless steel has a very high corrosion resistance. It is generally used where 304 grade stainless steels corrosion resistance may be of doubtful suitability. 316 grade is used in a lot of marine applications, heat exchangers and the paper industry.

Both grades are common in several forms including plate, flat and round bar, tubing and angle.

Quench and Tempered Steels

Quench and tempered steels also known as QT steel is a medium carbon steel that has been heated and quickly cooled to increase both its hardness, as well as its strength.

Quench and tempered steels are widely used in applications that require a degree of abrasion resistance such as mining, construction and defence.

These steels are graded by their hardness level using the Brinell hardness scale (HB). In Australia the only manufacturer of QT steel plate is Bisalloy Pty Ltd. They have a range of QT plate that includes a hardness grading of:

- ☆ 60HB
- ☆ 70HB
- ☆ 80HB

Although these steel grades have a higher hardness rating than standard structural steel, they are chosen for their increased strength. Many are used in pressure vessel construction.

Where high wear resistant properties are required, then the following grades are usually chosen:

- ☆ 320HB
- ☆ 400HB
- ☆ 450HB
- ☆ 500HB

These grades have very high wear resistance and have high strength, however the trade off is that they can be somewhat brittle.

Low Alloy and Tool Steels

Low alloy steel is steel alloyed with other elements, usually molybdenum, manganese, chromium, vanadium, silicon, boron or nickel, in amounts of significance to improve the ‘hardenability’ of thick sections although it is available in thin wall sections.

The common grades of low alloy steels include:

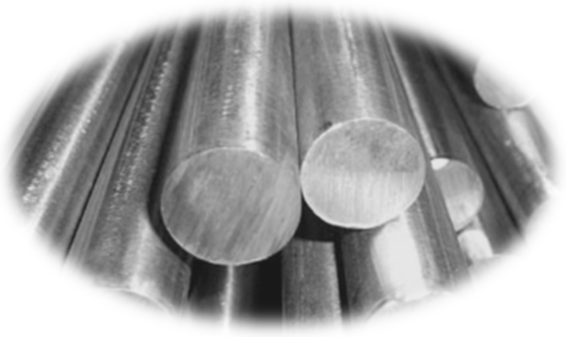
- 4130
- 4140
- 4340

Widely used for shafts, pins, spindles, gears and other parts that requires strength and wear resistance. Low alloy steels are often ‘induction hardened’. Induction hardening is a method of hardening steel surfaces without changing the deeper properties of the steel.

Tools steels are special alloy steels specifically developed to make metal working tools, cutting instruments (knives, etc.) and machinery parts that experience high impact conditions (gears, spindles, dies, etc)

- **O1** Cold work steel *(Oil hardened)*
- **O2** Cold work steel *(Oil hardened)*
- **A2** Cold work steel *(Air hardened)*
- **A3** Cold work steel *(Air hardened)*
- **A4** Cold work steel *(Air hardened)*
- **D2** Cold work steel *(High carbon and high chromium)*
- **D3** Cold work steel *(High carbon and high chromium)*
- **D4** Cold work steel *(High carbon and high chromium)*

Some of these steels are also known as ‘high speed’ steels, simply because they are used for drill bits, lathe bits, and saw tips.



Brass and Bronze

Many manufacturers use brass and bronze. They are used as gaskets, bushings, bearings, fasteners, and so on.

Both brass and bronze are copper alloys.

Brass is an alloy containing copper and a small percentage of zinc. Brass can be hard or soft depending on the amounts of the two alloys in the brass. The higher the zinc content, the harder the brass will be. Brass gets lighter in colour with additional zinc. Basic brass has approximately 67% copper and 33% zinc

Brass has a low melting point so it is often casted to make certain parts. Some grades of brass contain lead to make it easer to machine and form. Other grades have tin added to increase its corrosion resistance level. For hard brass some grades even contain a small amount of iron.

Brass comes in a wide range of shapes including, round and flat bars, plates, angles, channels and tubing. The common brass grades are:

- AS 260
- AS 360
- AS 380
- AS 385

Bronze is a metal alloy produced by blending copper and tin in various amounts, depending on the application. Additional elements such as manganese, lead and phosphorous are added to create bronze with specific properties. Bronze is much harder than brass.

Bronze has several properties that make it valuable in industrial applications. The first is that the metal causes minimal friction, making it highly useful for machine parts and other applications that involve metal on metal contact, such as gears. Bronze is also non-sparking, so it is often used to make tools for use in combustible environments.

Phosphor bronze contains a small amount of phosphorus, which further increases the hardness and wear resistance of the metal. In addition, it allows molten bronze to flow better, which enhances its casting quality.

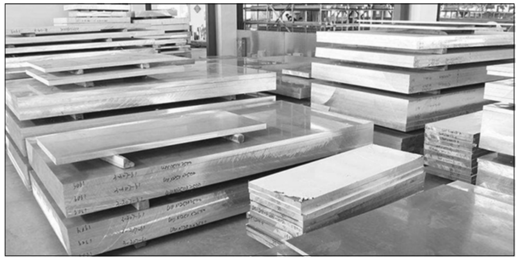
Leaded bronze has lead, usually in small amounts, mixed in to act as a lubricant. Such bronze is often used to make parts that must endure a lot of sliding action used in the manufacture of bearings and general castings.

Silicon bronze has small amounts of silicon, which makes it grow stronger when it is worked, such as by rolling. It is also particularly resistant to corrosion. It is used to make fastenings such as woodscrews and marine nails.

Higher strength bronzes such as aluminium bronze and manganese bronze are for applications where the strength is critical. Aluminium bronze is used for some tools and aircraft and automobile engine parts. Manganese bronze is actually a brass that contains manganese. It is often used to make ship propellers and shackles because it is strong, and resists corrosion by sea water.

The common bronze grades are:

- LG2 (leaded bronze) (also known as ‘gunmetal’)
- PB1 (phosphorous bronze)
- 954 (aluminium bronze)



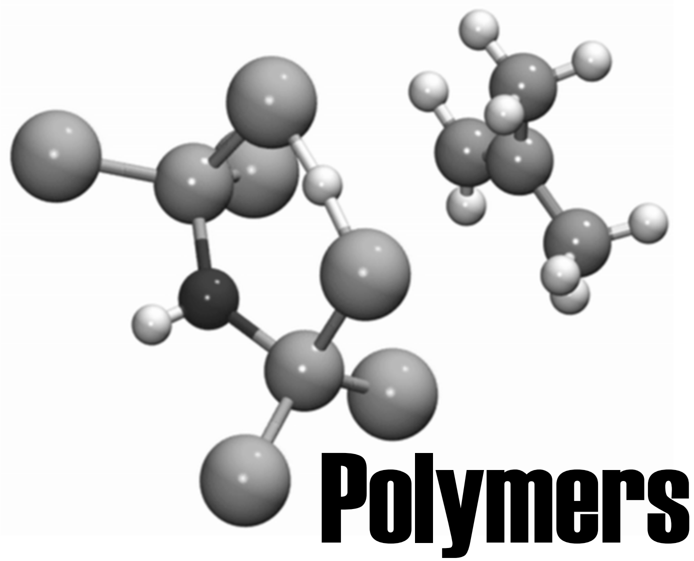
Aluminium

Next to steel, aluminium is the most commonly used and commercially available metal. It is light weight and its high strength-to-weight ratio make it a good choice for everything from aircraft, to furniture.

Pure aluminium primarily has little strength, but possesses high electrical conductivity, reflectivity, and corrosion resistance. For this reason, a wide variety of aluminium alloys have been developed.

The common alloy grades of aluminium are:

- ☆ ***2011 Aluminium*** - 2011 is the most machinable of the commonly available aluminium alloys however is not recommended if weldability, strength, and corrosion resistance is required. It is generally sold as round bar.
- ☆ ***2024 Aluminium*** - Copper is the main alloying ingredient in 2024. It is very strong compared to most aluminium alloys and has average machinability, but is susceptible to corrosion and is not considered to be weldable.
- ☆ ***3003/3004 Aluminium*** – this is the most common aluminium alloy used in sheet metal fabrications and for enclosures or containers, especially where chemicals are used.
- ☆ ***5052 Aluminium*** - is the alloy most suited to forming operations, with good workability and higher strength than that of the other alloys that are commercially available. It has very good corrosion resistance, and can be easily welded, but has a low machinability rating.
- ☆ ***5083 Aluminium*** - is the alloy most suited to marine applications.
- ☆ ***6061 Aluminium*** - 6061 is the most commonly used aluminium alloy in structural applications. It is specified in most any application due to its strength, heat treatability, comparatively easy machining, and weldability. The main alloy ingredients of 6061 aluminium are magnesium and silicon.
- ☆ ***6262 Aluminium*** – this alloy was as an aluminium alloy for operations where significant machining is required. It contains lead. It is generally regarded as having good strength and corrosion resistance. Finished parts can be produced with a high level of polishing.



Thermo Setting and Thermo Plastic Polymers

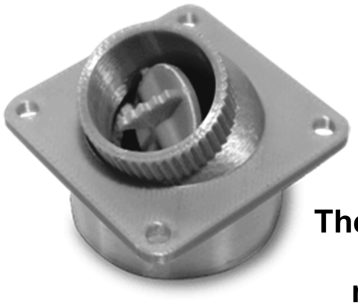
From a scientific point of view, polymers are large molecules made by bonding (chemically linking) a series of atoms.

There are two types of polymers, natural and synthetic.

Synthetic polymers include:

- ☆ Thermoplastic
- ☆ Thermoset
- ☆ Elastomers (such as synthetic rubber)
- ☆ Synthetic fabric fibres (such as rayon, nylon and polyester)
- ☆ Synthetic engineering fibres (such as fibreglass, aramid fibre, carbon fibre)

Over the next few pages we look closer at thermoset and thermoplastic polymers.



Thermoplastic injection moulding

Thermoplastic 3D printing

Thermoplastic vacuum moulding

Thermoplastic polymers - a thermoplastic is a plastic polymer, which becomes soft when heated and hard when cooled. Thermoplastic materials have low melting points. Thermoplastic polymers are a type of plastic that is known for its versatility and recyclability.

Thermoplastic based materials soften when heated and become more fluid as more heat is administered.

The curing process is 100% reversible because there is no chemical bonding that takes place as does with thermoset. This characteristic allows thermoplastics to be remoulded and recycled without negatively affecting the material's physical properties.

Beneficial properties of thermoplastic polymers are:

- Highly recyclable
- High impact resistance
- Chip resistance
- Chemical resistant
- Corrosion resistant
- Electrical insulating properties
- Extremely adhesive to metal
- Aesthetically-superior finishes
- Can be remoulded and reshaped

Common uses of thermoplastic polymers include:

- Drink bottles, plastic bags and other types of packaging
- PVC pipe
- Electrical cable insulation
- Construction materials
- High density thermoplastics used for machinery parts, bearings and gears
- 3D printing

Thermoset product examples

Thermoset polymers - thermoset components as implied by their name become set in their physical and chemical properties after an initial heat treatment and therefore are no longer affected by additional heat exposure. This is the main difference between thermoset polymers and thermoplastic polymers (which can be reheated and reformed)

After initial heat forming, thermoset products have the ability to resist heat, corrosion and can be further processed by machining, making them perfectly suitable for use in components that require tight tolerances and excellent strength-to-weight characteristics, while being exposed to elevated temperatures.

Beneficial properties of thermoset polymers are:

- ☆ Resistant to heat
- ☆ High strength to weight ratio
- ☆ Machinable
- ☆ Chemical resistant
- ☆ Corrosion resistant
- ☆ Electrical insulating properties
- ☆ Aesthetically-superior finishes

Thermoset components are used extensively in a wide range of industries.

Thermoset polymers are far more cost effective to use in manufacturing than thermoplastics, including tooling costs and fabrication costs compared to metal fabrication.

Thermoset injection moulding allows for a wide assortment of large and small parts. Huge volume requirements can be reached easily as well as complex, detailed geometric shapes that cannot be produced with metals or thermoplastics.

Polymers and Synthetic Fibres

Nylon parts

PET bottles

Acrylic display

As the term suggests, synthetic fibres are also known as polymers and the compounds used are generally petroleum based, where as natural fibres are plant or animal based such as cotton, hemp, wool and so on.

The most common types of synthetic fibres are;

- Nylon
- Polyester
- Acrylic

Many associate the above fibres as used in fabric making. However, these fibres are also used in other types of manufactured products other than fabrics.

Nylon - aside from clothing, nylon is also used in making rope, conveyor belts, seat belts, moulded small parts, fasteners, bearings and cookware. The benefits with nylon is that is has a low coefficient of friction and is used in high friction applications, it can bend and then bounces back, is abrasion resistant and chemical resistant.

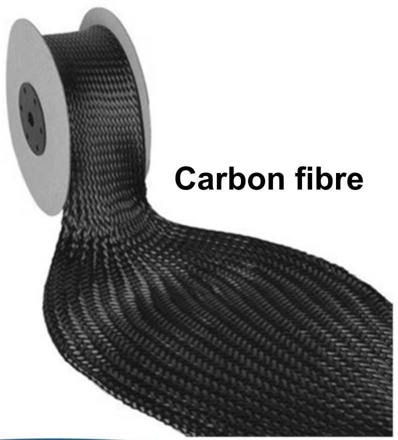
Polyester - aside from clothing, polyester is also used for making carpets, road building fabrics, paper and tape reinforcement, PET bottles, insulation, ropes and so on. The benefits of polyesters is that it is resistant to chemicals, flexible (especially as a fabric) and has high energy absorption qualities.

Acrylic - as a fabric, acrylic has heat insulation properties that makes acrylic fibre ideal for sweaters, socks, blankets, carpets and so on. Acrylic fibres resemble wool, so it is used predominantly to replace natural wool.

Acrylic itself is a type of thermoplastic polymer. As a 'plastic' it has 'clear' see through qualities so is used widely as airplane windows, display cases, signs and so on. Acrylic has outstanding strength, stiffness and optical clarity. Acrylic sheet is easy to fabricate, bonds well with adhesives and solvents, and is easy to thermoform. It has superior weathering properties compared to many other transparent plastics.

Aramid fibre

Fibreglass



Carbon fibre

Specialty Synthetic Fibres

Aside from those previously mentioned fibres there are the specialty fibres.

These include:

- ☆ Aramids
- ☆ Glass fibres
- ☆ Carbon fibre

Aramid fibre - aramid fibre is a man-made organic polymer (produced by spinning a solid fibre from a liquid chemical blend. The bright golden yellow filaments have high strength and low density giving very high specific strength. The fibres also offer good resistance to abrasion, are chemical resistant and withstand high temperatures. Aramid fibres are best known for their application in body armour and ballistic protection. An example of this is the well known Kevlar product.

Glass fibres - these are very small strands of extruded glass. They have a wide range of uses; the most common being fibreglass. Fibreglass cloth is mixed with a resin and use in the automotive industry for body panels, marine industry for hulls, sporting equipment industry and so on. Fibreglass has many benefits, some of which include:

- ☆ Mechanical strength
- ☆ Electrical insulator
- ☆ Incombustibility
- ☆ Easily shape and formed.
- ☆ Non-rotting
- ☆ Thermal conductivity

Carbon fibre - this fibre consists of very thin strands of the element carbon. These fibres have high tensile strength and are extremely strong for their size. In fact, one form of carbon fibre is considered the strongest material available. Carbon fibre applications include construction, engineering, aerospace, high-performance vehicles, sporting equipment and musical instruments. Similar to fibreglass, carbon fibre is woven into a cloth and then moulded into shapes using resin. The benefits of carbon fibre include:

- ☆ Extremely strong
- ☆ Very light weight
- ☆ Stiff
- ☆ Chemical resistant
- ☆ High resistance to heat

Learning Activity

Question

LEARNING ACTIVITY ONE

1) What are steel billets and steel slabs and what are they used for?

2) Why is steel cold rolled?

3) What are the five standard steel grades?

4) What are the two stainless steel grades and which one has the highest corrosion resistance?

5) What are the three common grades of low alloy steel?

6) What are the three methods used to make tool steel extremely hard?

7) What type of alloys are brass and bronze and what is the difference between the two?

8) Which aluminium grade is generally used for marine applications and which aluminium grade has the most copper?

TEACHER/TRAINER GUIDANCE NOTES

1) They are pre-processed steel from a steel mill and are used to make steel plate and other steel products in hot roll steel mills.
2) Steel is cold rolled to improve its surface features, reduce the thickness and also harden the steel.
3)
   1. Grade 250
   2. Grade 300
   3. Grade 350
   4. Grade 400
   5. Grade 450
4) Grade 304 and Grade 316. Grade 316 has the highest corrosion resistance.
5)
   1. 4130
   2. 4140
   3. 4340
6) Oil hardening, air hardening and adding carbon and chromium to the steel
7) Brass and bronze are both copper alloys. Bronze has additional elements such as manganese, lead and phosphorous.
8) 6061 is mainly used for marine applications and 2024 has copper added.

Learning Activity

Question

LEARNING ACTIVITY TWO

1) What is the main difference between thermoplastic and thermoset polymers?

2) What were the nine benefits of thermoplastic polymers as we outlined in this Section?

3) What were the seven benefits of thermoset polymers as we outlined in this Section?

TEACHER/TRAINER GUIDANCE NOTES

1) Thermoplastic bases materials soften when heated and become more fluid as more heat is administered. The curing process is 100% reversible because there is no chemical bonding that takes place as does with thermoset. This means that once thermoset is moulded, it can not be recycled.

2)

1. Highly recyclable
2. High impact resistance
3. Chip resistance
4. Chemical resistant
5. Corrosion resistant
6. Electrical insulating properties
7. Extremely adhesive to metal
8. Aesthetically-superior finishes
9. Can be remoulded and reshaped

3)

1. Resistant to heat
2. High strength to weight ratio
3. Machinable
4. Chemical resistant
5. Corrosion resistant
6. Electrical insulating properties
7. Aesthetically-superior finishes

Learning Activity

Question

LEARNING ACTIVITY THREE

1) What were the three synthetic fibres we mentioned in this Section that are also polymers?

2) What are PET drink bottles made from?

3) What were the three specialty fibres that we mentioned in this Section and what is a common use for each?

TEACHER/TRAINER GUIDANCE NOTES

1) Nylon, polyester and acrylic
2) Polyester polymer
3)
    1. Aramids - body armour, such as Kevlar
    2. Glass fibres - fibreglass used in marine and automotive manufacturing
    3. Carbon fibre - aircraft and high performance vehicles

Determine commonly available shapes of metal materials, such as sheet, plate, bar, angle iron and other common shapes

Steel is produced in numerous shapes and sizes to meet a wide range of fabrication and manufacturing needs. Although we are concentrating on steel over the next few pages, other metals aside from steel also come in shapes common to steel.

The following shapes we will review are:

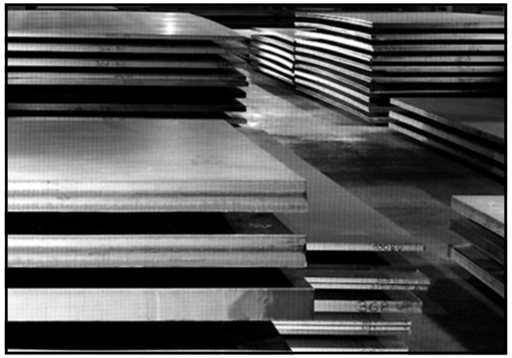
- ☆ Plate
- ☆ Sheet metal
- ☆ Bar
- ☆ Angles
- ☆ Columns
- ☆ Beams
- ☆ Channels
- ☆ Rolled hollow sections

Plate steel - plate steel comes in a wide range of lengths, widths and thicknesses.

The standard small size is 1200mm X 6 metres and the largest would be 3200mm X 12 metres.

Shipping and handling are the two main factors to consider when selecting steel plate sizes. Small fabrication facilities are also restricted by the capacity of their profile cutting machines (flame, plasma and laser cutters).

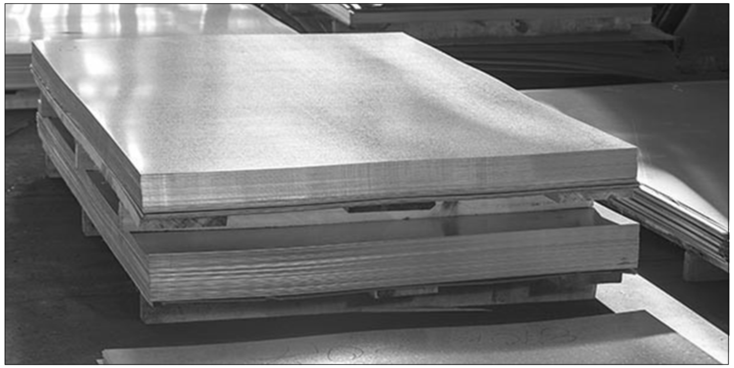
Standard thicknesses range from 5mm up to 150mm. Anything thinner than 5mm is normally classified as sheet metal.



Sheet metal - sheet metal is produced as a cold rolled product, or a hot rolled product.

Cold rolled sheet metal is a stronger material and therefore can be supplied in thinner thickness. Cold rolled sheet metal thicknesses range between .55mm through to 1.15mm. Standard sizes are 1200mm X 2400mm sheets.

Hot rolled sheet metal thicknesses range between 1.6mm through to 4mm and come also in 1200mm X 2400mm sheets.



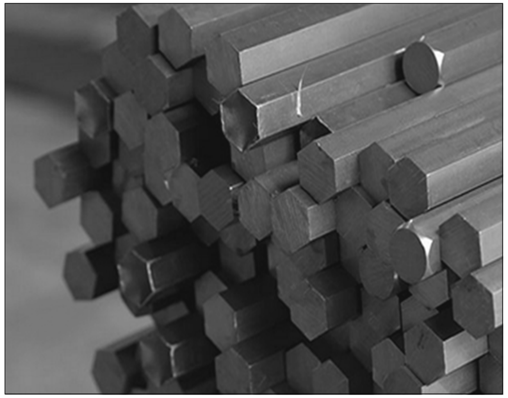
Bar steel - comes in flat, round, hexagonal and square shapes. Below are some of the common sizes of each.

- ***Flat bar***
  - Size range - width 20mm to 300mm
  - Thickness range - 5mm to 50mm

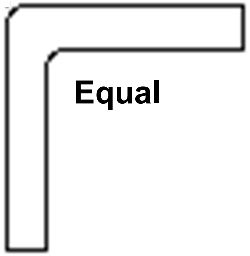
- ***Round bar***
  - Diameter - 10mm to 90mm
  - Standard length - 6.0m

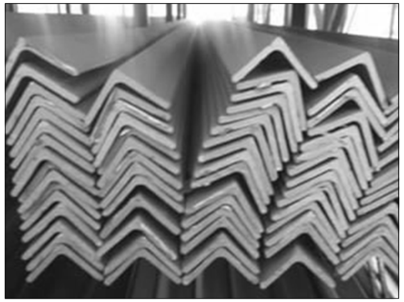
- ***Square bar***
  - Size range - 10mm to 40mm
  - Standard length - 6.0m

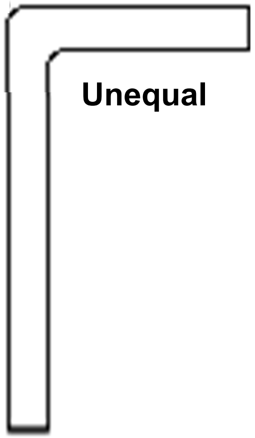
- ***Hexagonal bar***
  - Size range - 20mm to 63mm
  - Standard length - 6.0m



Angles - structural steel angles come in equal and unequal forms. Equal means both legs of the angle are the same, whereas if unequal they are different. Below are the common sizes for both cold formed and hot rolled steel angles.







☆ ***Cold formed structural*** (equal legs)
- Size range - 30x30 legs to 150x150 legs
- Thickness range - 2.5mm to 8.0mm
- Standard length - 6.0m, 9.0m, 12.0m

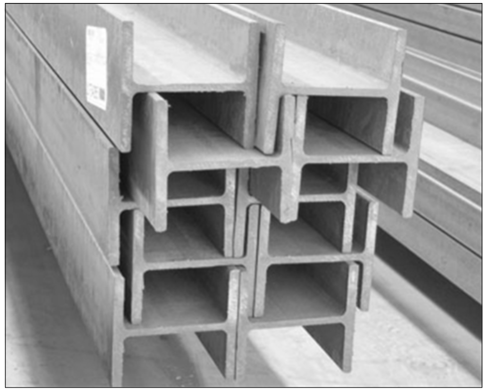
☆ ***Cold formed structural*** (unequal)
- Size range - 75x50 legs to 150x100 legs
- Thickness range - 4.0mm to 8.0mm
- Standard length - 9.0m, 12.0m

☆ ***Hot rolled structural*** (equal legs)
- Size range - 25x25 legs to 200x200 legs
- Thickness range - 3mm to 26mm
- Standard length - 7.5m, 9.0m, 10.5m, 12.0m, 13.5m, 15.0m

☆ ***Hot rolled structural*** (unequal)
- Size range - 65x50 legs to 150x100 legs
- Thickness range - 5mm to 16mm
- Standard length -7.5m, 9.0m, 10.5m, 12.0m, 13.5m, 15.0m

Columns - the most common column is known as the 'Universal column'. A universal column has a width generally the same as its height.

Hot rolled



Welded

Universal columns specifications are firstly by weight per metre and then by a 'rounded' depth measurement. For instance, a universal column spec of 150UC15 means a column that weighs 14.8 kilos per metre and that has a depth of 152mm.

- ☆ ***100UC15***
  - Weight – 14.8kg/m
  - Overall width – 99.0mm
  - Overall height – 97.0mm
- ☆ ***150UC30***
  - Weight –30kg/m
  - Overall width – 152.0mm
  - Overall height – 158.0mm
- ☆ ***200UC46***
  - Weight –46.2kg/m
  - Overall width – 203.0mm
  - Overall height – 203.0mm
- ☆ ***250UC90***
  - Weight – 89.5kg/m
  - Overall width – 256.0mm
  - Overall height – 259.0mm
- ☆ ***310UC97***
  - Weight – 96.8kg/m
  - Overall width – 305.0mm
  - Overall height – 308.0mm

The common lengths for universal columns are 9m, 10.5m, 12m, 13.5m, 15m, 16.5m, and 18m.

Beams - the most common beam is known as the 'Universal beam'.

Commonly referred to as 'I' beams because of the 'I' shaped appearance of the cross section. The vertical middle section of the beam is known as the 'web' and the horizontal components are called 'flanges'. The vertical 'web' of a Universal beam is significantly longer than the horizontal 'flange'.

Universal beam specifications are firstly by weight per metre and then by a 'rounded' height measurement. For instance a universal column spec of 150UB18 means a beam that weighs18 kilos per metre and that has a height of 155mm.

- ***150UB18***
  - Weight – 18kg/m
  - Overall width – 75.0mm
  - Overall height – 155.0mm
- ***200UB25***
  - Weight – 25kg/m
  - Overall width – 133.0mm
  - Overall height – 203.0mm
- ***250UB31***
  - Weight –31.4kg/m
  - Overall width – 146.0mm
  - Overall height – 252.0mm
- ***310UB46***
  - Weight – 46.2kg/m
  - Overall width – 166.0mm
  - Overall height – 307.0mm
- ***360UB57***
  - Weight – 56.7kg/m
  - Overall width – 172.0mm
  - Overall height – 359.0mm
- ***410UB60***
  - Weight – 59.8kg/m
  - Overall width – 178.0mm
  - Overall height – 406.0mm
- ***460UB74***
  - Weight – 74.6kg/m
  - Overall width – 190.0mm
  - Overall height – 457.0mm
- ***530UB92***
  - Weight – 92.4kg/m
  - Overall width – 209.0mm
  - Overall height – 533.0mm
- ***610UB125***
  - Weight – 125kg/m
  - Overall width – 229.0mm
  - Overall height – 612.0mm

Rolled Hollow Sections (Structural)

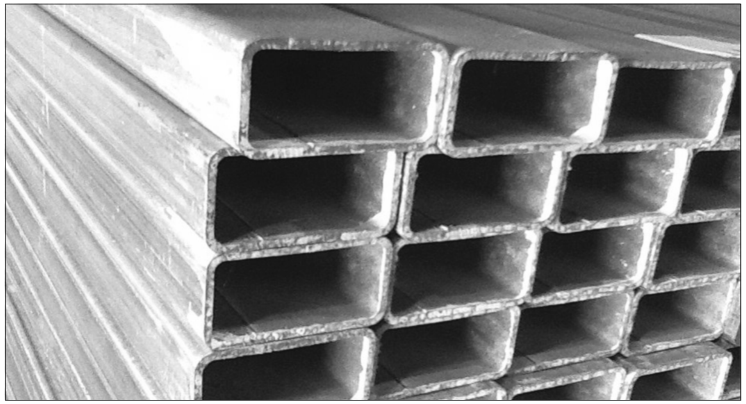
Rolled hollow sections include rectangular sections, square sections and circular sections. All rolled hollow sections are formed and then welded along the seam.

Square - these are commonly known as SHS or 'square hollow sections'. In square hollow sections they come in a variety of sizes starting at 13 X13mm square through to 250 X 250mm square.

Wall thickness range from 1.6mm thick through to 9mm thick. Common lengths are 6.5m, 8.0m and 12m.

Rectangular - these are commonly known as RHS or 'rectangular hollow sections'. Rectangular hollow sections come in a variety of sizes starting at 50 X 20mm square, through to 250 X 150mm shapes.

Wall thickness range from 1.6mm thick through to 9mm thick. Common lengths are 8.0m and 12m.



Circular tubing - circular hollow sections come in a variety of sizes starting at 21.3mm outside diameter, through to 457mm outside diameter.

Wall thickness range from 2mm thick through to 12.7mm thick.

Common lengths are 6.5m and 12m.

Hollow sections are defined as structural members and commonly called tubing.

Circular tubing is not pipe. Pipe is considered a 'vessel', in other words, pipe is delivering something, such as water, gas, oil and so on and therefore the inside diameter is important.

So pipe specification goes by the inside diameter, whereas circular hollow sections go by the outside diameter. The thickness of the wall is heavier on pipes than on tubing.

Learning Activity

Question

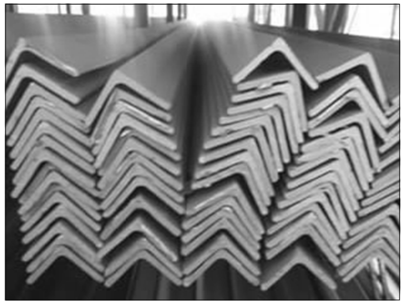
LEARNING ACTIVITY FOUR

1) What is the difference between plate steel and sheet metal?

2) Bar steel comes in what shapes?

3) There are two types of angle bars in the pictures below. What is each one called and why?

1


2

4) What does the specification code '***100UC15'*** stand for?

5) What are Universal beams are also known as, and why?

6) The specification code '530UB92' refers to a universal beam size and weight. How do you know it is for a universal beam?

7) SHS and RHS are acronyms for what?

8) How are all rolled hollow section structural steel made?

TEACHER/TRAINER GUIDANCE NOTES

1) Plate steel standard thicknesses range from 5mm up to 150mm. Anything thinner than 5mm is normally classified as sheet metal.
2) Flat bar, round bar, square bar and hexagonal bar
3) Picture 1 is ‘unequal angle bar’ and Picture two is ‘equal angle bar’. The names refer to the legs of the angles.
4) It is a specification code for a ‘Universal steel column’.
5) ‘I’ beams because of the ‘I’ shaped appearance of the cross section.
6) It is the ‘UB’ in the specification code ‘530UB92’ that tells you it is for a universal beam.
7) SHS stands for ‘Square Hollow Section’ and RHS stands for ‘Rectangle Hollow section’.
8) All rolled hollow sections are formed and then welded along the seam.

Learning Activity

Research

LEARNING ACTIVITY SIX

In this Section we reviewed steel products. In this activity we want you to do some research and locate a supplier of brass and bronze. Download their product catalogue, or copy it off their website.

Present your research findings to your teacher or trainer for review and discussion.

TEACHER/TRAINER GUIDANCE NOTES

This activity will expose the student or trainee to what is available for brass and bronze products.

Learning Activity

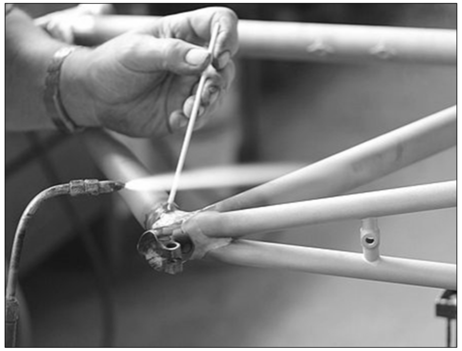
Research

LEARNING ACTIVITY FIVE

In this Section we reviewed steel products. In this activity we want you to do some research and tell us in what shapes aluminium is sold. List them below.

TEACHER/TRAINER GUIDANCE NOTES

The student or trainee will quickly learn that aluminium is basically sold in the same shapes as steel.



Determine methods used to join metal pieces, such as, threads, pins, circlips, rivets, welding, folded joints and adhesives
and
Describe the advantages of the different metal joining methods

(Over the next few pages we cover two 'Performance Criteria' points at the same time to avoid repetition)

The most commonly known method of joining metal pieces is welding.

The most common method of welding is electric welding, or arc welding, which uses electricity to create a high heat, hot enough to melt metal and fuse (or weld) two pieces of metal together. Arc welding is generally used to weld ferrous metals, such as steel and non-ferrous metals such as aluminium.

The two methods or electric arc welding are 'consumable' and 'non-consumable' welding'.

Over the next couple of pages we look at each type of welding.

Welding rods

Flux core wire

MIG wire

Types of Welding

Consumable type welding is when the welding process uses a filler material which could be a 'stick electrode', or 'welding wire'.

The three main types of this type of welding are:

- ☆ ***Shielded metal arc welding*** - this type of welding is better known as 'stick welding'. The welding electrode is known as the 'stick' or a 'welding rod', which is coated with a 'flux. An arch is struck with the stick electrode and both the rod and work piece surface melt to form a 'weld pool'. Simultaneously melting of the flux coating on the rod will form gas and flux slag, which protects the weld pool from the surrounding atmosphere.

- ☆ ***Flux cored arc welding*** - the welder uses a welding gun that feeds welding wire to the work piece. A trigger on the gun sends electricity to the tip of the wire that starts the welding process. The wire is hollow and has flux in the middle. There are two types of flux core welding wire, gas-shielded and self-shielded. Gas-shielded flux-cored wires require external shielding gas and the slag is easy to remove. The gas is generally carbon dioxide. Used mainly for heavy welding where the work pieces are thick material.

  Self-shielding flux-cored wire does not require external shielding gas because the weld pool is protected by gas generated when flux from the wire is burned. As a result, self-shielding flux-cored wire is more portable because it does not require an external gas tank. Used for outdoor welding and best in windy situations.

- ☆ ***MIG (Metal Inert Gas) welding*** - this is a welding process in which an electric arc forms between a consumable wire electrode and the work piece. This process uses inert gases or gas mixtures as the shielding gas. Argon and helium are typically used for the MIG welding of non-ferrous metals such as aluminium. Another type of MIG welding is ***MAG or Metal Active Gas*** welding. The main difference between MIG and MAG is the type of shielding gas used and the material being welded.

The other category refers to the non-consumable electrode methods.

The main type is:

- ***Tungsten Inert Gas (TIG) welding*** - in this welding process the arc is formed between a pointed 'tungsten electrode' and the workpiece using a shielding gas of argon or helium. The small intense arc provided by the pointed electrode is ideal for high quality and precision welding. The tungsten electrode is not consumed during welding. The arc creates a 'weld pool' that is what joins the work piece components. However, filler metal can be added separately to the weld pool using stick materials, or a small wire feeder.

TIG tungsten electrodes

TIG filler rods

TIG filler wire

Electric Welding Different Types of Materials

Each welding process is suited to different types of metals. Since every metal has various characteristics and melting points they have better compatibility with some welding methods than others.

- ***Steel and stainless steel*** - iron-based metals such as steel and stainless steel are weldable using a number of welding methods. Low carbon mild steel is one of the most weldable metals available. Its composition includes low amounts of elements that can decrease the risk of a failed weld. Stainless steel has a more complex chemical composition, but it can also work with several types of welding methods.

  Most suitable welding methods would include:

  - Shielded metal arc welding (Stick welding)
  - Gas metal arc welding (MIG)
  - Gas tungsten arc welding (DC-TIG, this uses a ‘direct current’ type welding machine)
  - Flux-cored arc welding (FCAW)

- ***Aluminium*** - this metal comes in a number of ‘grades’ starting a Grade 1xxx through to Grade 7xxx (which is known as aircraft grade aluminium). In many cases the aluminium work pieces are thin so temperature control is essential. Because of the composition of aluminium alloys, only ‘alternating current’ welding machines can be used.

  Most suitable welding methods would include:

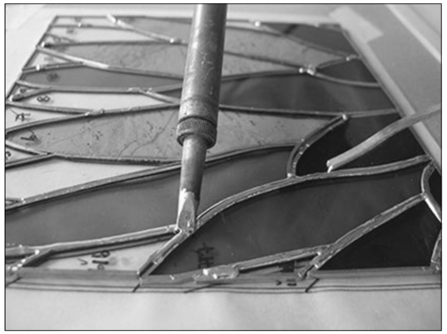
  - Shielded metal arc welding (Stick welding)
  - Gas tungsten arc welding AC-TIG, this uses an ‘alternating current’ type welding machine)

- ***Cast iron*** - cast iron is difficult to weld than metals, such as steel or aluminium. Its high carbon content requires careful preheating and heating methods as well as slow cooling down methods. Cast iron welding is often repair work and in most cases would use a nickel alloy as the filler material.

  Most suitable welding methods would include:

  - Shielded metal arc welding (Stick welding)

Brazing



Soldering

Brazing and Soldering

Two other types of welding are ‘brazing’ and ‘soldering’.

Both do not require the metal pieces to melt in order to make a welded joint.

Brazing is done by melting and flowing molten filler metal into the joint, the filler metal having a lower melting point than the adjoining metal. The filler metal is melted using in most cases a flame torch, such as an acetylene torch. Common filler metals are:

- ☆ Aluminium-silicon
- ☆ Copper
- ☆ Copper-silver
- ☆ Copper-zinc (brass)
- ☆ Copper-tin (bronze)

Soldering is similar to brazing since it uses ‘capillary’ action to flow the metal into the joint till it cools and hardens. The soldering filler metal has a far lower melting point.

Soldering is used when the pieces being welded could be damaged by high heat such as in electronic components. In soldering the filler metal is heated until melted instead of the base metal needing to be heated to melt the filler metal.

The soldering filler metal is generally melted using a ‘soldering’ iron’.

Soldering iron

Soldering filler metal

Threaded Fasteners

The most common threaded fasteners are the bolt.

Generally bolts are used to join two pieces of metal using nuts. Bolts are usually made from metal and comprised of a head at one end, a chamfer at the other and a threaded shaft.

The chamfer at the opposite end of the head provides a slightly bevelled edge which helps with inserting the bolt into holes and nuts.

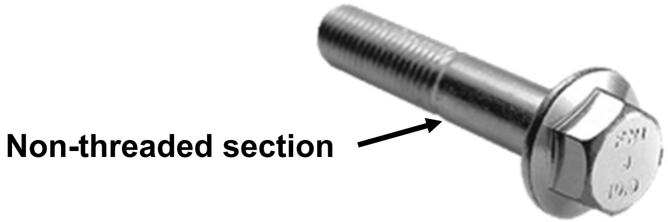
There are a number of different types of bolts and the more common types are:

Carriage bolt - this is a type of bolt used for fastening metal to wood. Carriage bolts are designed with a domed head, which can prevent loosening from one side, an enlarged head shape also prevents the bolt from being pulled through a wooden construction.

Elevator bolt - these bolts feature a wide, countersunk flat head, a shallow conical bearing surface, a square neck, and a unified thread pitch. They are commonly used in conveyor systems.

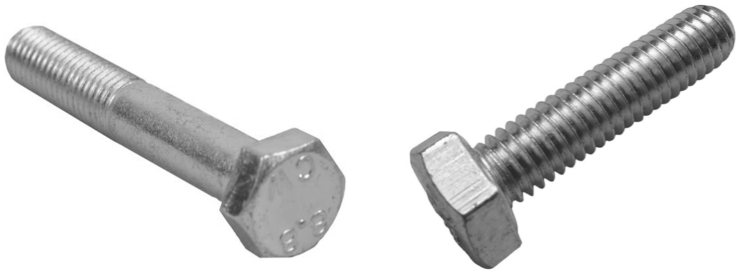
Flange bolt - these bolts have a circular flange under the head that acts like a washer to distribute the load.

Flange bolts that have a non-threaded section are called ***'frame bolts'***. Frame bolts are commonly used on truck frames, giving them their name. The flange eliminates the need for a washer and helps to compensate when holes are misaligned.



Hanger bolts - these bolts allow for permanent or removable connections in many applications. The wood screw thread provides a secure fixing point in soft and hard timbers, and the bolt thread allows for something to be joined using a nut.

Hexagon (Hex) bolt - these bolts are a very common choice when it comes to construction and repair. A hexagon bolt comprises a head that has six sides. Some will have the threading that begins part-way down the shank and others threaded the whole length.



Short hex bolts are often called ***'machine bolts'***. This bolt is intended for assembling metal components through predrilled holes.

Square head bolt - these bolts are similar to hex bolts but have a square head. Most are short and used as machine bolts.

To go with bolts are the nuts and washers. Each type is designed for a specific purpose. The more common nuts include:

Coupling nuts - a coupling nut is a longer, cylindrical nut that joins two male threads. This component can be used to add length to an installation.

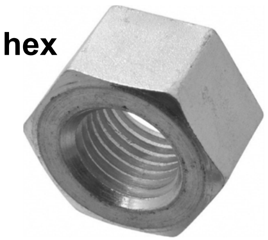
Flange nuts - Similarly to flange bolts, flange nuts feature a round flange that acts as an external washer and allowing for a more even load distribution. Most commonly known as hex flange nuts.

Hex nuts - hex nuts are hexagonally shaped. These nuts are extremely versatile but require a wrench for installation. The types of hex nuts include finished hex (machined surface), semi-finished hex and heavy duty (thicker in dimension) hex.

Finished hex

Semi finished hex

Heavy duty hex



Jam hex - They are used in pars. One is tightened after another so that the two prevent each from loosening.

Hex jam nuts

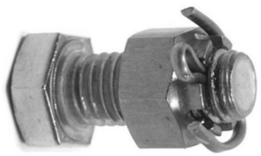
Lock nuts - Lock nuts are available in a range of shapes and are used to secure other nuts and prevent them from loosening.

In the 'all metal lock nut', metal at the end of the nut deforms as it is tightened and this locks the nut in place and prevents it from loosening under vibration.

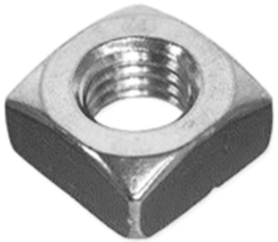
Other common lock nuts replace the deforming metal with a nylon insert.

There is the 'serrated flange lock nut' The serrated flange serves as a 'non-spinning washer'.

Slotted nuts - slotted nuts are designed and constructed such that they can form a locking mechanism with a cotter pin, or a safety wire.



Square nuts - as the name suggests, square nuts are characterised by their square shape. This head shape increases the surface area of the fastener and the amount of friction it experiences, reducing the risk of it loosening.



Along with bolts and nuts are washers. The common washers include:

***Bevelled washers* -** these washers are formed with a slightly angled surface, allowing them to join materials that are not parallel to one another. They can be round or square washers.

Flat washers - these washers are the most common type of washer. They provide a larger surface area for better load distribution. Different thicknesses are available for a variety of hold strengths.

Lock washers - Lock washers come in many shapes, such as serrated, toothed (internal/external), conical or spring, each designed to prevent slippage of fasteners in demanding applications. They are commonly used in environments that experience high levels of vibration.

Serrated

Toothed internal

Outside internal

Conical

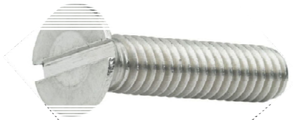
Spring

Machine Screws

Machine screws are essentially a type of bolt, however they are generally screwed into an existing threaded hole.

They come in many sizes and types. The types of machine screws are basically identified by the head of the screw. Some of the more common types are shown below.

Flat head - as the name suggests the screw has a flathead. The head can be a slotted head, Philips head, hex socket and slotted hex head.



Slotted

Phillips

Hex socket

Slotted hex head

Pan head - the other common style machine screw is the 'pan head' screw. The head of the screw is conical in shape and comes in the same styles as the flat head screws,

Sheet Metal Screws

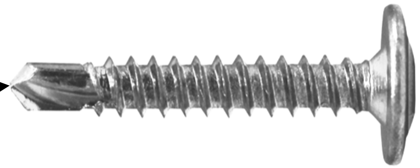
There are two basic types of sheet metal screws, self-tapping screws and self-drilling screws.

Self-tapping screws have a sharp tip that is designed to cut through metal, but the metal must be pre-drilled before these screws can be used.

Self tapping tip

Self-drilling screws (also known as TEK screws) have a drill point tip that can easily cut through metal without a pre-drilled hole.

Self drilling tip



The heads can be flat and commonly are Phillips drive, or hex nuts with washer

Flat head
Phillips drive

Hex head
With washer

Threaded Joints

Threaded joints are those that have had threads cut into the metal pieces. The most common method of creating threaded joints is using the ‘tap’ and ‘die’ tools.

The ‘tap’ creates the ‘female’ part of the threaded joint and the ‘die’ creates the ‘male’ part of the threaded joint.

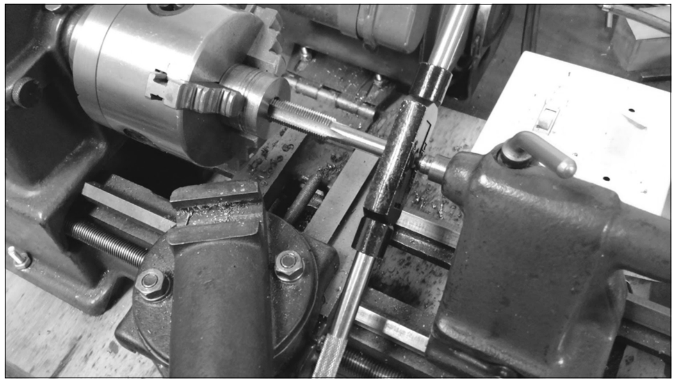
The ‘die’ is used to thread round stock, such as round bar or pipe. The ‘die’ comes in a number of sizes all the way up to very large pipe threaders.

Common die set

Pipe threaders

The ‘taps’ can be used as hand tools, or in some cases tapped thread holes are done using a drilling machine or lathe.

Hand tap set



Tapping using a lathe

There is a choice between standard thread and fine thread. Size for size, a fine thread is stronger than a coarse thread. Fine threads can be more easily tapped into hard materials and thin-walled tubes. Fine threads have less tendency to loosen.

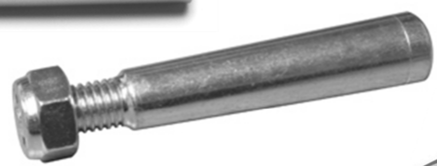
Pinned Joints

In engineering there are times when metal items are joined using pins. Pinned joints are classified as detachable joints, meaning the two or more parts pinned together can be detached and repaired, or replaced.

Pinned joints are also used when the joint is a 'hinged' joint. The pin acts like the 'hinge' pin.

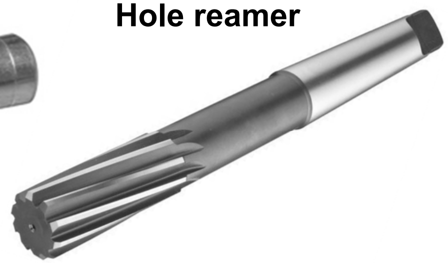
A common type of pin is the tapered pin. They are steel rods with one end having a slightly larger diameter than the other. Most taper pins are inserted into tapered holes to provide safe and firm pinning. Often used to attach pulleys, gears and other parts to shafts. The tapered holes are created using a 'tapered hole reamer'. Some tapered pins will have a thread end for a nut.

Plain tapered pin



Tapered pin with threaded end

Hole reamer



Another type of pin used for pinned joints is the 'grooved' pin. When the pin is driven into a drilled hole of suitable diameter, the material displaced by the grooving process is forced back to partially close up the grooves and lock the pin into place. A tight fit is obtained by the deformation of the edges along the grooves called 'swagged grooves'. Grooved pins can have one to three grooves of varying lengths on the pin.

Grooved pin

Another type of pin used for pinned joints is the 'dowel' pin. This pin is used to accurately align and secure metal parts. The main feature of the dowel pin is the tapered end that allows it to pull misaligned holes into alignment.

Many pins are secured into place using split cotter pins, or spring cotter pins that are inserted into the end of the pins through holes.

Split cotter pin

Spring cotter pin

Other pins are secured into place using 'circlips'. These are inserted at the end of the pins in a groove.

Circlips

Riveted Joints

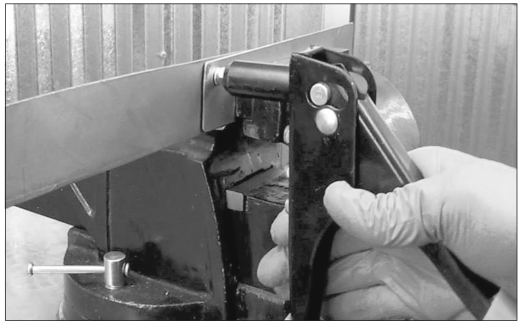
Another method of joining metal pieces is a mechanical joining process called ‘riveting’.

The ‘rivet’ is a metal pin with a head on one end. The pin may be hollow or solid depending on the application.

The rivet pin is inserted into a hole drilled between two pieces of metal. The head on one end prevents the pin from going through the hole. Then the other end is deformed by pressing, forging or smashing, creating a ’head’ that results in a riveted joint.

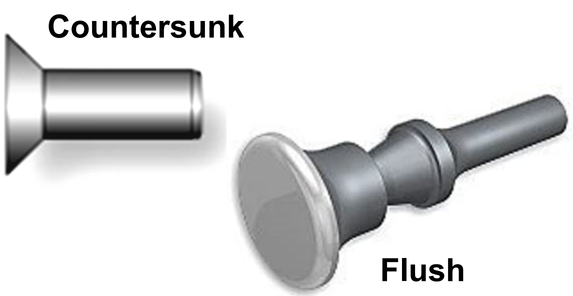
Some riveting applications are not commonly used today as the rivets have been replaced without types of joining, such as welding or bolts. Eight types of rivets include:

Blind rivets or pop rivets – these are used when it is impossible to see the other side of a joint. This type of riveting is very fast to apply and is used in a variety of sectors including aerospace, shipbuilding and electronics. Used mainly on sheet metals. The rivets are installed using a rivet gun.



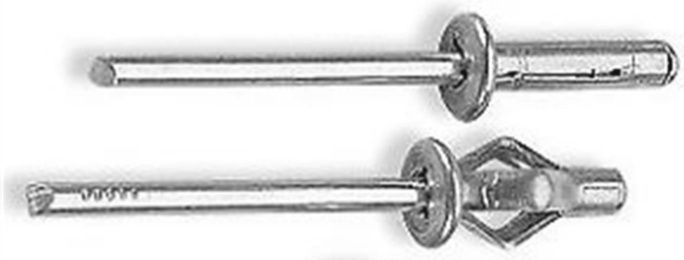
Drive rivets – this type of blind rivet has a short mandrel which protrudes from the head and is driven in with a hammer causing the end inserted into the hole to flare. Primarily use to join sheet metal. Tools needed are basically a hammer.

Flush rivet – used for external surfaces to provide a good appearance and eliminate aerodynamic drag, this type of rivet uses countersunk heads, as well as a countersunk hole and are also called countersunk rivets. The rivets are generally installed with rivet gun.



Friction-lock rivet – these are early forms of blind rivet and were the first to be widely used in aerospace applications. These rivets resemble an expanding bolt.

Trifold rivets – similar to blind rivets, trifold rivets have splits along the hollow shaft. These splits, which usually come in sets of three cause the shaft to bend and flare outwards as the mandrel is drawn into the rivet. The flare creates a wide surface which reduces the chance of the rivet being pulled out.

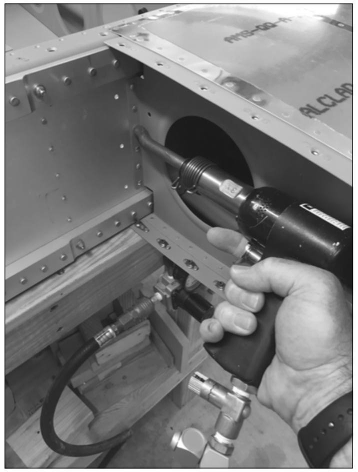


Self-piercing rivets – these rivets do not need a drill or punched hole as the end includes a chamfered poke to pierce materials to be joined. Self-piercing rivets go through the top sheet of material but do not fully pierce the bottom sheet, creating a water or gas-tight joint. Often used in vehicle body repairs. A self-piercing rivet gun is used to insert these rivets.

Solid rivets or round head rivets – a technique that goes back to the Bronze Age, making this one of the oldest and also one of the most reliable types of fasteners. As the term suggests the rivet shank is a solid material with a standard or countersunk head. The solid rivets are installed using a rivet gun.

Countersunk

Standard head



Structural steel rivets – this type of rivet was widely used to join structural steels, but has been largely replaced by the use of high-strength bolts as they do not require skilled workers to install and tighten these bolts.

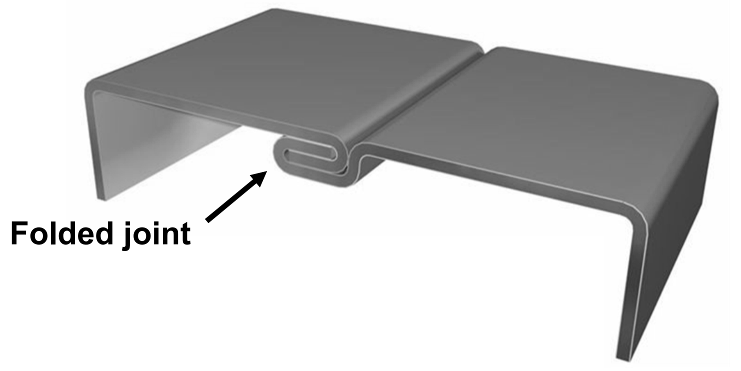
Structural rivets

Structural bolts

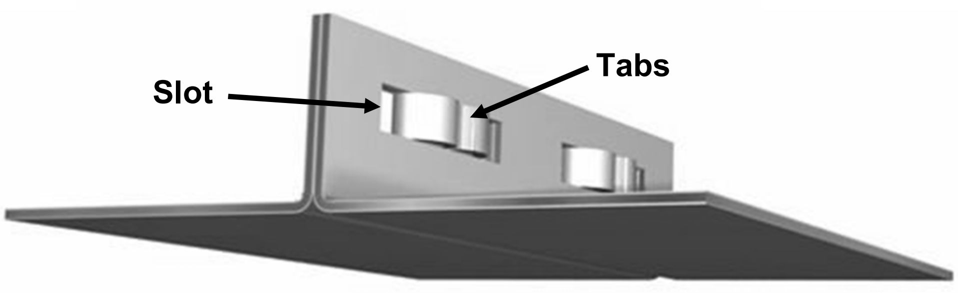
Folded Joints

Folded joints are widely used in sheet metal fabrication. Folding or bending tabs is an economical way for making permanent sheet metal joints. This process does not require additional fastening hardware.

This operation can be done on a sheet metal bending machine. Soft steel, aluminium, copper and brass can be joined using folded joints.



There is a type of folded joints in sheet metal called the 'TAB' joint. This is where one metal part has slots and the only metal part has 'tabs'. The 'tabs' are inserted into the slots and then bent over, thus joining the two parts.



Learning Activity

Question

LEARNING ACTIVITY SIX

1) What were the four types of welding we mentioned in this Section?

2) Based on the picture, what type of welding would use this filler material?

3) What type of welding uses tungsten electrodes?

4) What is the main difference between arc welding and brazing, or soldering?

5) What is the main difference between brazing filler material and soldering filler material?

6) What is each of the tools below called?

A


B


C


7) What is a 'hole reamer' used for?

8) What type of pin is the picture depicting?

TEACHER/TRAINER GUIDANCE NOTES

1)
    - Stick welding
    - Flux core welding
    - MIG
    - TIG
2) Stick welding
3) TIG
4) Brazing and soldering both do not require the metal pieces to melt in order to make a welded joint, whereas arc welding does.
5) Soldering filler material has a far lower melting point.
6) A - Die set, B-Tap set, C - Pipe threader
7) To ream out holes for tapered pins
8) A grooved pin

Learning Activity

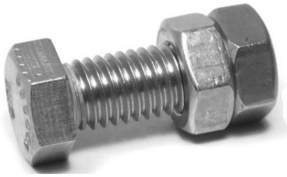
Task

LEARNING ACTIVITY SEVEN

Tell us what each picture below is depicting.

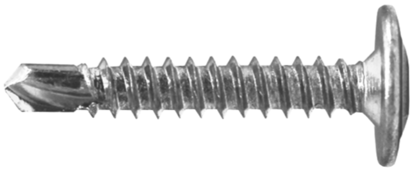
1

2

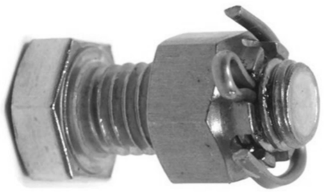


3

4



5



6

7

8

9

TEACHER/TRAINER GUIDANCE NOTES

1) Spring washer
2) Hex bolt with jam nuts
3) Carriage bolt
4) Self drilling sheet metal screw
5) Bolt with slotted nut
6) Flange nut
7) Machine screw with hex socket
8) Flange bolt
9) Self tapping sheet metal screw

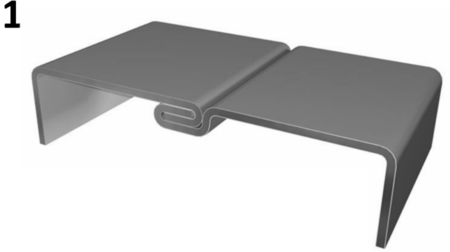
Learning Activity

Task

LEARNING ACTIVITY EIGHT

Tell us what each picture below is depicting.

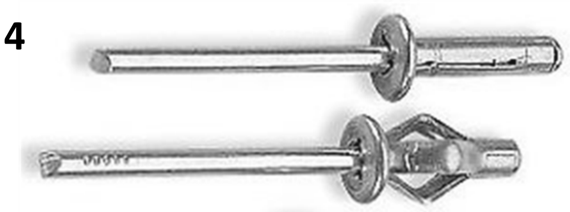
1



2

3

4



5

6

7

TEACHER/TRAINER GUIDANCE NOTES

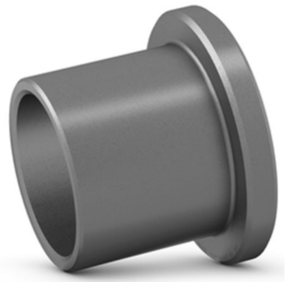
1) Folded joint
2) Circlips
3) Hole reamer
4) Trifold rivets
5) Self-piecing rivet gun
6) Tab fold joint
7) Spring cotter pin

Determine the types of plain and anti-friction bearings, including type of materials, used in machines
and
Describe the advantages and disadvantages of the different types of bearings

Cylindrical

Split

Split halves



Flanged

Grooved

(Over the next few pages we cover two 'Performance Criteria' points at the same time to avoid repetition)

Bearings are used to reduce friction associated with moving parts, which in turn creates better mechanical efficiency and reduces wear on metal parts.

There are two common classifications of bearings, 1) plain bearings and 2) antifriction bearings.

'Plain bearings' are the oldest and simplest type of bearings and the least expensive. A plain bearing provides a 'bearing surface'.

The name of plain bearings is also known as 'journal bearings' or bushings. They have a shaft that rotates freely in a supporting metal sleeve or shell, called the bearing or bushing.

There are no rolling or rotating elements in these bearings. The 'journal' is the surface of the shaft that makes contact with the bearing surface.

Journal bearing (bushings) can be made of a number of types of materials. They include:

- Metal such as brass, bronze, white alloy (tin and lead) or aluminium. Metal journal bearings generally require a lubricant, such as oil or grease.
- Nylon
- Polytetrafluoroethylene or PTEF (also known as Teflon)
- POM composite (high strength low friction thermoplastic)
- Filament wound bushings (glass fibres and polymer fibres in a resin)

Plain bearings come in a number of types which include:

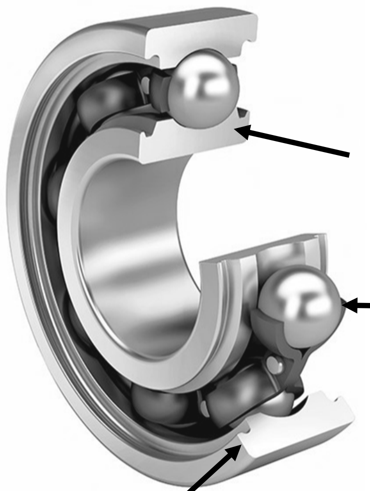
- ***Cylindrical*** - the most basic type
- ***Split*** - when inserted it compresses to retain position
- ***Split halves*** - commonly used on crankshafts
- ***Flanged*** - can be a plain flange or with bolt holes
- ***Grooved*** - this allows lubricant to be injected into the bearing surface

Anti-Friction Bearings

Antifriction bearings minimise friction by removing any possible sliding between bearing surfaces and replacing all contacts with rolling interfaces.

The most common anti-friction bearing is the 'ball bearing'.

In a ball bearing, the load is transmitted from the outer 'race' to the ball and from the ball to the inner 'race'. Since the ball is a sphere, it only contacts the inner and outer race at a very small point, which helps it spin very smoothly. This also means that ball bearings are only used where the load is relatively small.



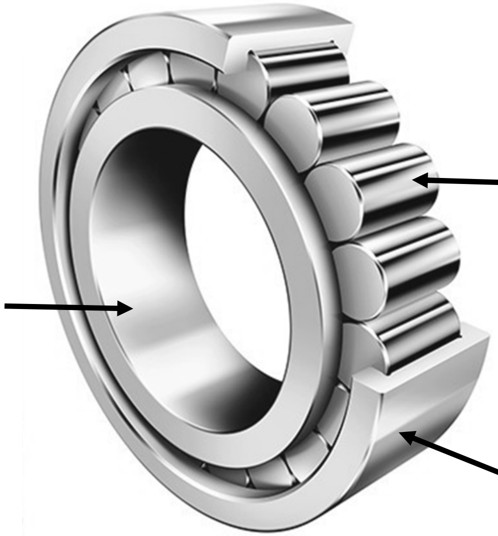
The other type of anti-friction bearing is the 'roller bearing'.

Roller bearings are used in applications where they must hold heavy 'radial loads'.

Radial loads are loads that place downwards pressure on the bearing.

In these bearings, the roller is a cylinder, so the contact between the inner and outer rings is not a point, but a line.

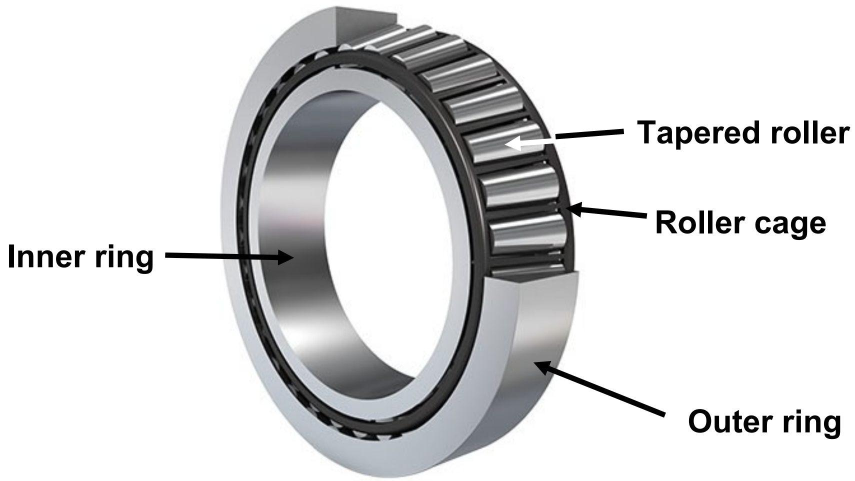
This spreads the load out over a larger area, allowing the bearing to handle much greater loads than a ball bearing. However, this type of bearing is not designed to handle much thrust loading.



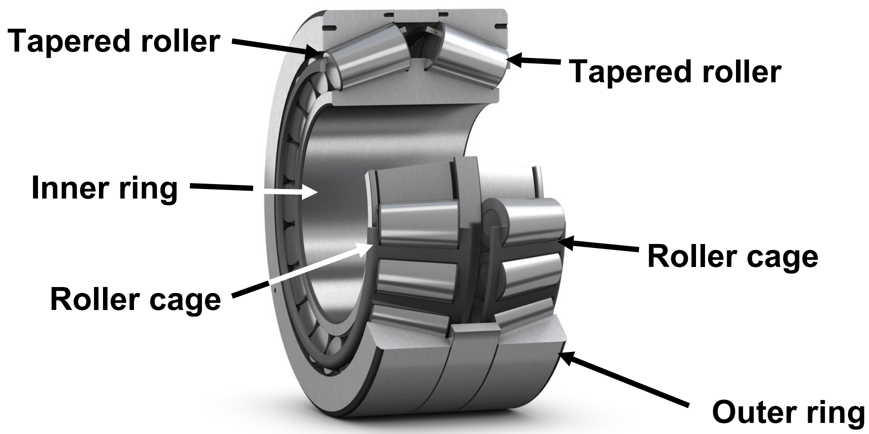
Another type of roller bearing is the ‘tapered roller bearing’.

The tapered roller bearings are designed to handle radial loads, as well as ‘axial loads’. Axial loads are loads that are created by a shaft pushing forward known as ‘horizontal thrust forces’. An example of this is a vehicle axle.

In these bearings, the roller is a tapered cylinder that is encased in a ‘cage’ and the assembly includes an outer ring and an inner ring.



There are also ‘double row’ tapered roller bearings. These are designed to take the thrust loads in both direction



Learning Activity

Question

LEARNING ACTIVITY NINE

1) What are the two other names for 'plain bearings'?

2) What are the four common types of metals that plain bearings are made of?

3) Aside from metals, what other four common materials are plain bearings made of?

4) What are the five common types of bushings?

TEACHER/TRAINER GUIDANCE NOTES

1) Journal bearings and bushings
2)
    1. Brass
    2. Bronze
    3. White alloy
    4. Aluminium
3)
    1. Nylon
    2. Polytetrafluoroethylene or PTEF
    3. POM composite
    4. Filament wound bushings
5)
    1. Cylindrical
    2. Split
    3. Split halves
    4. Flanged
    5. Grooved

Learning Activity

Task

LEARNING ACTIVITY TEN

Below are pictures of different types of bearings (both plain and ani-friction). Tell us the name of each type.

1

2

3

4

5

6

TEACHER/TRAINER GUIDANCE NOTES

1) Grooved bushing
2) Double row tapered roller bearing
3) Split halves bushing
4) Ball bearing
5) Roller bearing
6) Flanged bushing

Section Two

Develop a Metals-Based Project

UNDERTAKE A BASIC ENGINEERING PROJECT

SECTION TWO—DEVELOP A METALS-BASED PROJECT

Introduction

This section is where you are to choose a basic engineering project to complete as part of this ‘Unit of Competency's’ assessment requirements.

It will require you to determine the type and amount of materials, as well as determine how long it will likely take to complete the project.

Section Learning Objectives

At the completion of this section you will learn information relating to:

- ☆ Researching and deciding on a realistic project that can be completed in the institution in the available time
- ☆ Determining the types of material required for the project
- ☆ Determining the amount of material and components required
- ☆ Gaining approval for the project

Research and decide on a realistic project that can be completed in the institution in the available time

The assessment requirements for this unit of training requires you to complete an engineering project at the place of your training.

Your teacher or trainer will inform you the student or trainee how much time has been allocated to this project.

What you choose for your project will be dependant on the following:

- ☆ As we mentioned earlier time allocation for completion
- ☆ Tools and equipment available
- ☆ Your skill in using some of those tools and equipment
- ☆ Materials and other items required to complete the project

Some project categories you may want to consider could be:

- ☆ Functional items such as metal table and chairs, wine racks, toolboxes and so on
- ☆ Decorative such as outdoor sculptures, decorative gates and so on.
- ☆ Cooking and heating such as barbeques, smokers, wood fired stoves, fire pits and so on
- ☆ Repurposing such as creating something from old steel drums, old farm equipment parts, old car parts and so on.

There are many websites that will offer ideas. Roaming around old collectable shops and scrap yards can provide ideas, including access to some materials.

Learning Activity

Task

LEARNING ACTIVITY ONE

In this activity we want you to tell us what research methods you will be using to get some project ideas, as well as telling us what sources you will be going to for some project ideas.

Methods

Sources

TEACHER/TRAINER GUIDANCE NOTES

This activity is to have the student or trainee put some thought into researching methods and sources so that he or she can develop some project ideas.

Determine the types of material required for the project *and* Determine the amount of material and components required

(Over the next few pages we cover two 'Performance Criteria' points at the same time to avoid repetition)

At this point, you will have decided on what you are going to do for your basic engineering project.

It will be easy at this point to see what types of materials and other items such as fasteners and hardware your project will need.

You will need to be confident that the materials and other items will be available to you when you have made this decision.

Although it may be somewhat difficult to determine the exact amount of materials you will need until you make drawings or sketches of your project and work out in detail material requirements, as well as other components needed.

You can make some estimates or if you have a sample in which you will be replicating, then it may be easier to estimate your material requirements.

Learning Activity

Task

LEARNING ACTIVITY TWO

Describe to us what your basic engineering project will be and why you chose this project. Then tell us what materials and other items will be required to complete this project.

Project chosen and why

Materials and other items required

TEACHER/TRAINER GUIDANCE NOTES

This activity has the student or the trainee think about his or her project a bit more so that when they get approval, they will be confident they made the right choice.

SAMPLE ONLY

Gain approval for the project

It is at this point where you will need to get approval to do your project.

This approval will likely be from your teacher or trainer.

If you have been interacting with your teacher or trainer up to this point, then the approval will be a simple formality.

However, if your teacher or trainer is seeing your project idea for the first time, you will need to be prepared to answer questions about your project, the materials needed and the required tools and equipment.

SAMPLE ONLY

Learning Activity

Task

LEARNING ACTIVITY THREE

This unit requires you as the student or trainee to gain approval for your project before proceeding with it.

This activity requires you to do just that.

TEACHER/TRAINER GUIDANCE NOTES

You the teacher or trainer will likely have approval criteria and this criteria should have been communicated to the student or trainee earlier.

It will be up to you as the teacher or trainer to determine whether the approval criteria has been met, such as the time to complete seems reasonable, materials and other items available and the tools and equipment available.

Section Three

Determine Drawing Requirements

UNDERTAKE A BASIC ENGINEERING PROJECT

SECTION THREE—DETERMINE DRAWING REQUIREMENTS

Introduction

Working in the various engineering industry sectors you will quickly learn that drawings play a significant part in engineering processes.

There are a number of different types of drawings and each has a specific purpose such as manufacturing drawings, assembly drawings and sub assembly drawings; just to name a few.

In this section we will go through some of the basics of drawings and how each plays a part in engineering processes.

Section Learning Objectives

At the completion of this section you will learn information relating to:

- ☆ Researching engineering drawing practices
- ☆ Deciding how drawings will be produced, e.g. using a CAD systems and/or hand drawing equipment, and/or freehand sketches
- ☆ Deciding on appropriate dimensioning methods for the drawings produced
- ☆ Deciding on methods and conventions for naming and saving new or modified drawings

Research engineering drawing practices

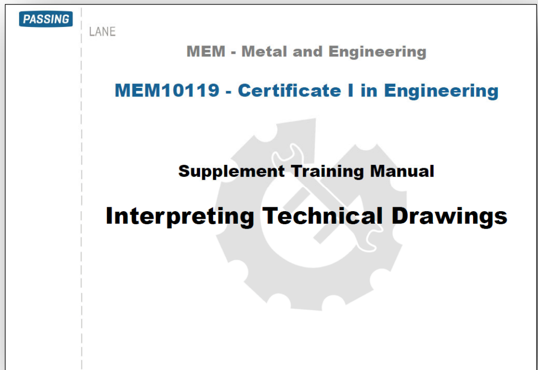
The engineering drawing is the fundamental means of conveying information from the designer to the manufacturer and/or assembly plant. It should provide all the details of how a part is to be made, or assembled.

The person designing and producing the drawing must be able to give the information clearly and in such a way that its meaning cannot be misunderstood.

Fundamental engineering drawing practices include:

- ☆ Scales
- ☆ Drawing elements, title boxes and layout
- ☆ Drawing sizes
- ☆ Line conventions and lettering
- ☆ Numbering conventions
- ☆ Single, multiple and sectional view drawings
- ☆ Isometric and pictorial Views
- ☆ Dimensioning and tolerancing
- ☆ Symbols
- ☆ Changes made to the drawings (revisions)
- ☆ Identifying revisions on drawings
- ☆ Identifying replacement drawings

More information on engineering drawing practices is provided in a supplementary training manual called 'Interpreting Technical Drawings'. Your teacher or trainer may refer you to this supplementary training manual for additional information and learning activities.



Learning Activity

Task

LEARNING ACTIVITY ONE

In this Section we mentioned a supplementary training manual called 'Interpreting Technical Drawings'. In this supplementary training manual it was mentioned that technical drawings are created using what is known as the Australian Standard AS1100.

It outlined that the standard AS1100 is broken down into nine specific areas. Take the time to go to this supplementary training manual and locate this information. Then tell us those nine areas are.

TEACHER/TRAINER GUIDANCE NOTES

TEACHER/TRAINER GUIDANCE NOTES

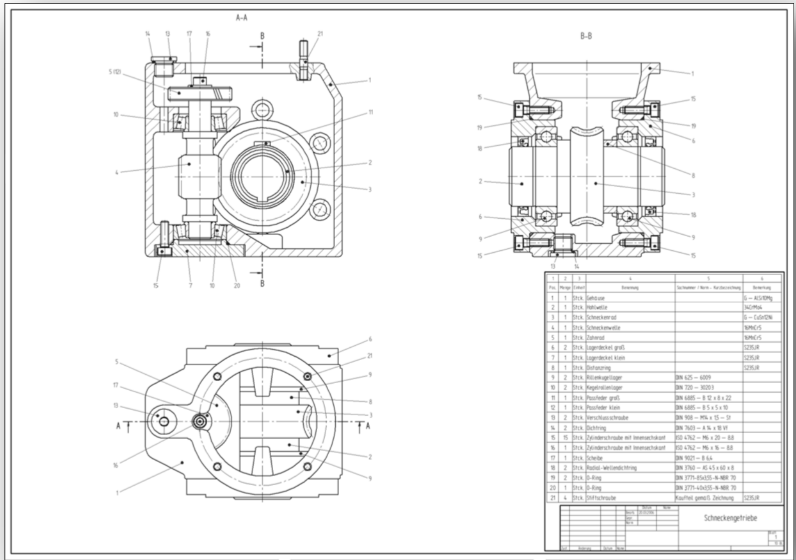
1) the use of abbreviations
2) materials, sizes and layout of drawing sheets
3) the types and minimum thicknesses of lines to be used
4) the requirements for distinct uniform letters, numerals and symbols
5) recommended scales and their application
6) methods of projection and of indicating the various views of an object
7) methods of sectioning
8) recommendations for dimensioning, including size and geometrical tolerancing
9) conventions used for the representation of components and repetitive features of components

Decide how drawings will be produced, e.g. using a CAD systems and/or hand drawing equipment, and/or freehand sketches

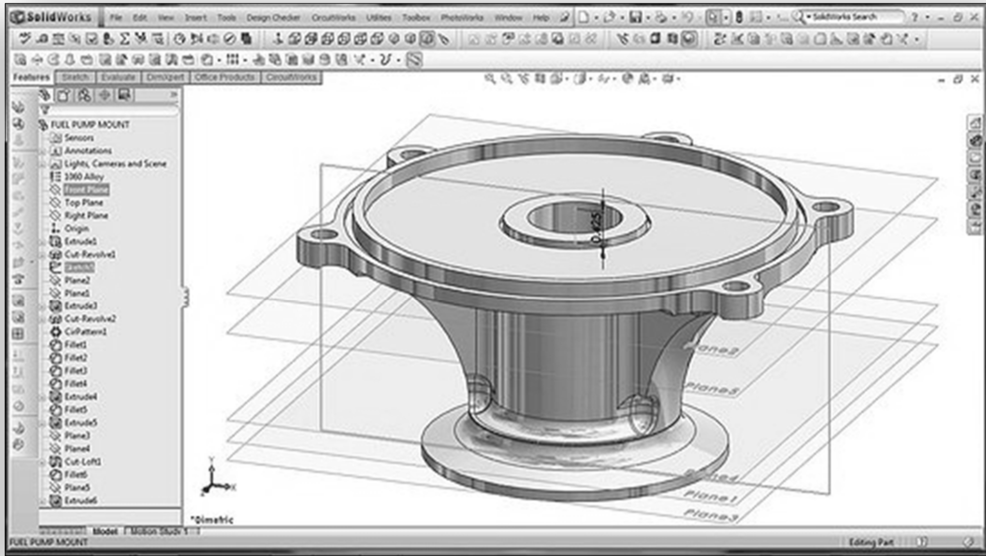
Engineering drawings are produced in a number of ways and how they are produced depends on the item being manufactured as well as the complexity of the manufacturing and assembly processes.

For complex manufacturing and assembly processes, drawing would be produced by engineers and designers using a drawing method called ‘Computer Aided Design’, or better known as CAD.

CAD is used to create precision drawings or technical illustrations. CAD software can be used to create two-dimensional (2-D) drawings or three-dimensional (3-D) models.



2D CAD drawing

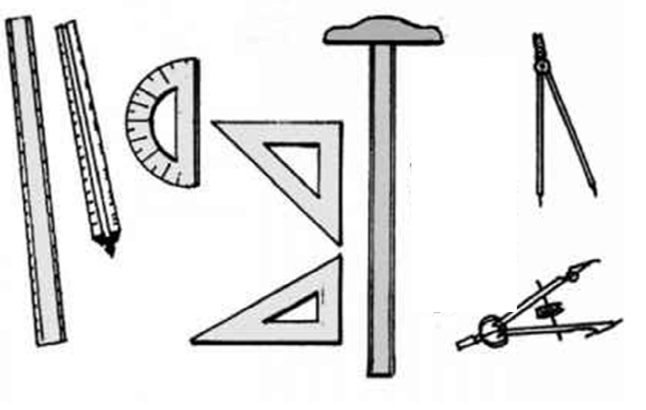


3D CAD model drawing

There are a number of CAD software applications on the market. The most popular is called ‘AutoCAD’. This and other software applications require a significant amount of training and practice to be skilled enough to use in complex manufacturing and assembly processes.

Hand Drawing

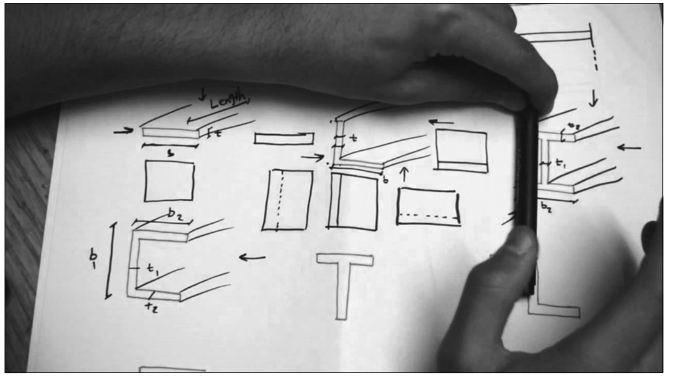
Still used today is the basic drafting board and drawing tools. These are common in small engineering shops where jobs are simple and basic and do not require the complex detail of some engineering projects.



Basic drafting tools generally include:

- T-square
- Triangles and protractor
- Rules and scales
- Protractor and dividers
- Pencils and pens

There is also the 'sketching' method of drawing. This is basically freehand drawing, providing the very basic of information.



Learning Activity

Task

LEARNING ACTIVITY TWO

Based on your chosen and approved engineering project, tell us below what drawing method you have chosen, as well as why.

TEACHER/TRAINER GUIDANCE NOTES

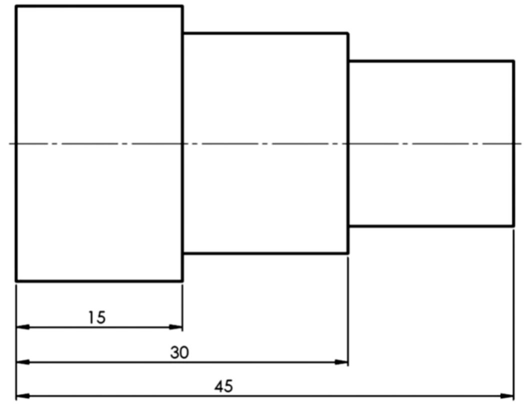
This activity is to have the student or trainee think about drawing methods, as well as what drawing skills they may have. This could include using a basic drawing software application not as sophisticated as AutoCAD.

Decide on appropriate dimensioning methods for the drawings produced

Dimensioning a drawing is about adding dimensions, notes and lines to a drawing.

There are four types: parallel, running, chain and combined dimensioning.

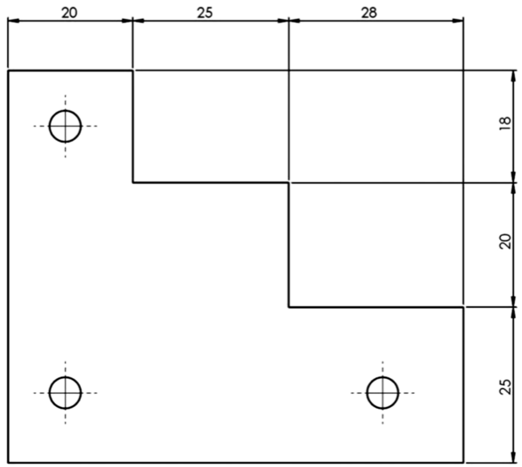
***Parallel dimensioning* -** when numbers of dimensions are measured in the same direction from a common feature, such as the surface of the part, then method of indicating all the dimensions from the same feature is called 'parallel dimensioning'. The dimension lines are parallel to each other and equally spaced.



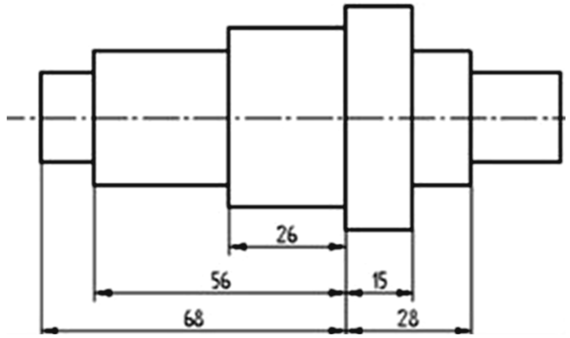
Parallel dimensioning

***Chain dimensioning* -** chain dimensioning is when each single dimension is placed directly adjacent to the next dimension without any gap between dimensions line.

Chain dimensioning



***Combined dimensioning* -** combined dimensioning is when chain and parallel dimensioning is used on the same drawing.

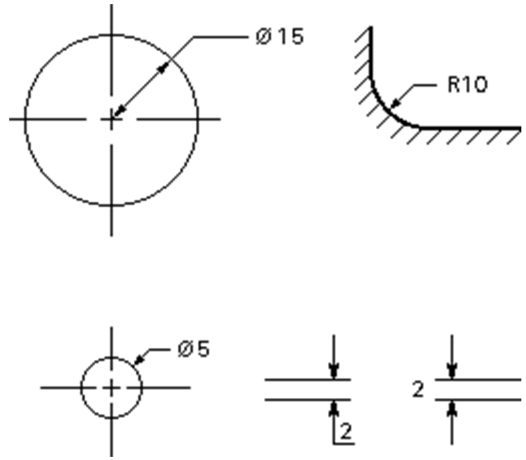


Combined dimensioning

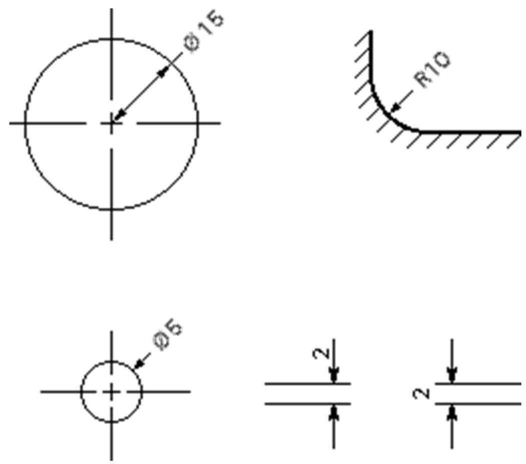
Dimensioning Methods

Two methods of dimensioning are in common use.

***Unidirectional* -** the dimensions are written horizontally.



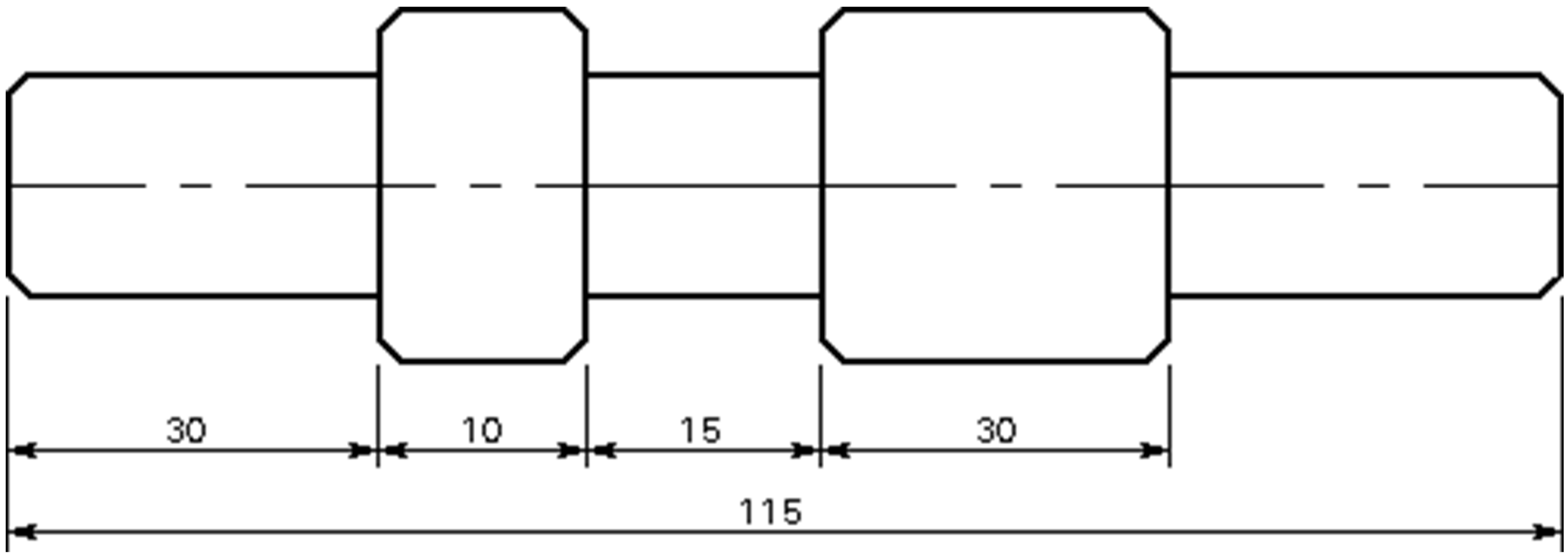
***Aligned* -** the dimensions are written parallel to their dimension line. Aligned dimensions should always be readable from the bottom or the right of the drawing.



Overall Dimensions

When several dimensions make up an overall length, the overall dimension can be shown outside these component dimensions.

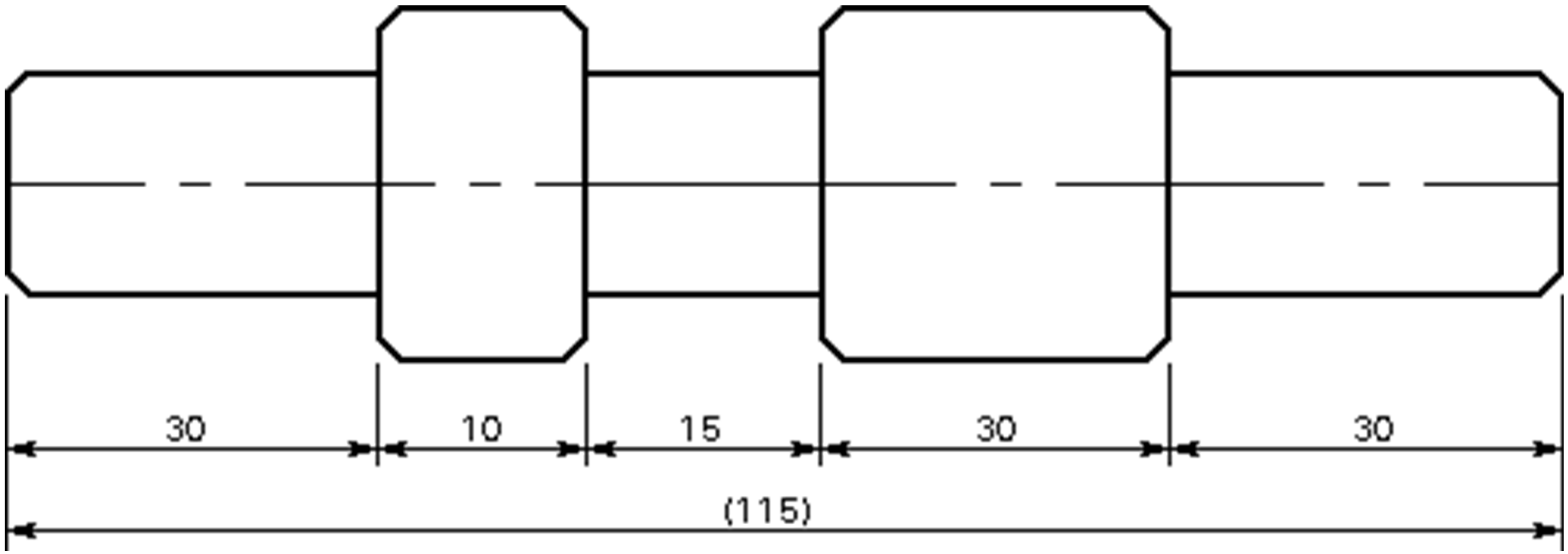
When specifying an overall dimension, one or more non-critical component dimensions must be omitted.



Auxiliary Dimensions

When all of the component dimensions must be specified, an overall length may still be specified as an ‘auxiliary dimension’.

Auxiliary dimensions are never toleranced and are shown in brackets.



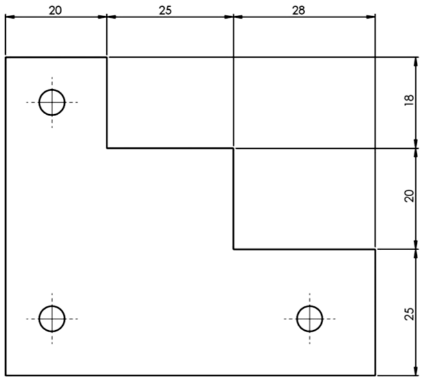
Learning Activity

Task

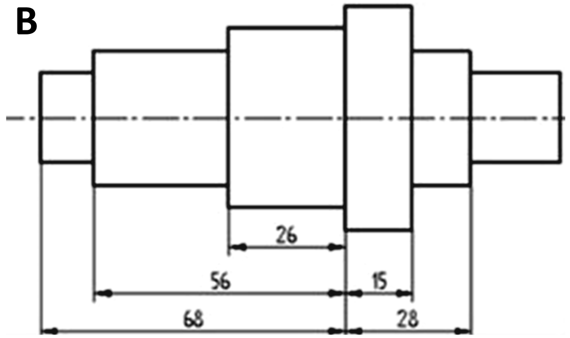
LEARNING ACTIVITY THREE

Tell us the types of dimensioning that is depicted by each illustration below.

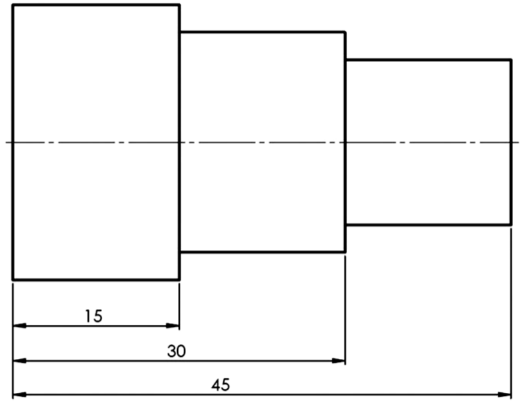
A



B



C



TEACHER/TRAINER GUIDANCE NOTES

A - Chain
B - Combined
C - Parallel

SAMPLE ONLY

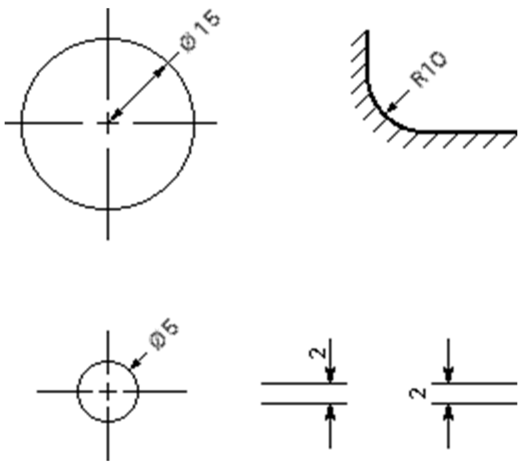
Learning Activity

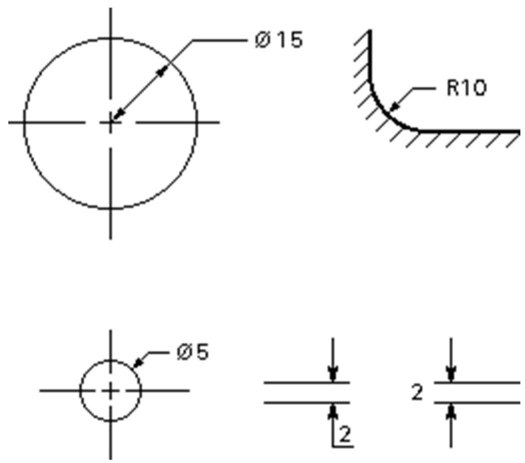
Task

LEARNING ACTIVITY FOUR

Two methods of dimensioning are in common use. One is '***Unidirectional'*** and the other is '***Aligned'***. In the examples below tell us which one is which.

A





B

TEACHER/TRAINER GUIDANCE NOTES

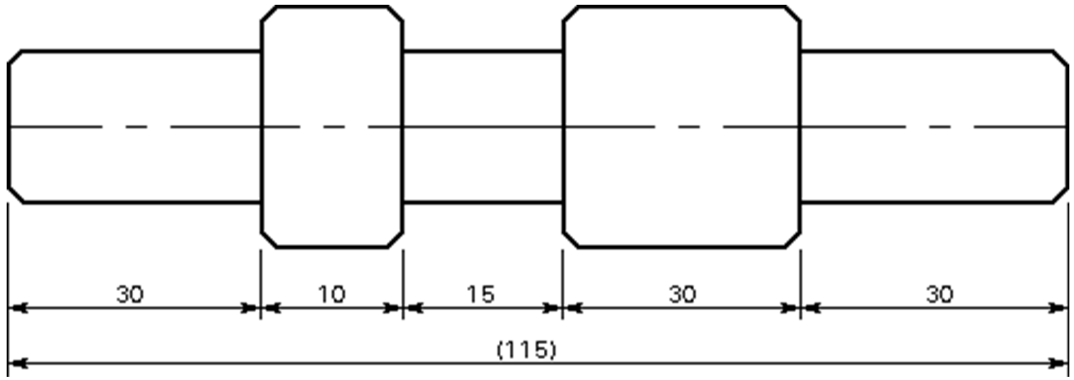
A—Aligned
B—Unidirectional

Learning Activity

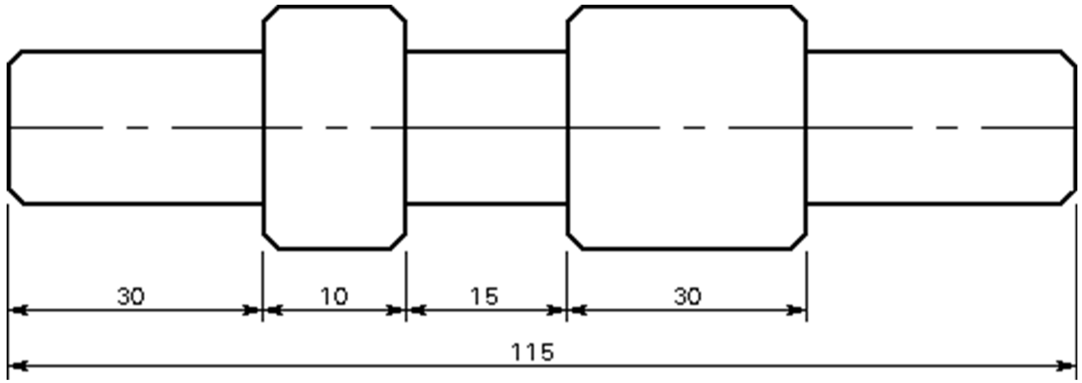
Task

LEARNING ACTIVITY FIVE

We looked at ‘overall’ dimensioning and ‘auxiliary’ dimensioning. Tell us which is which below.



A

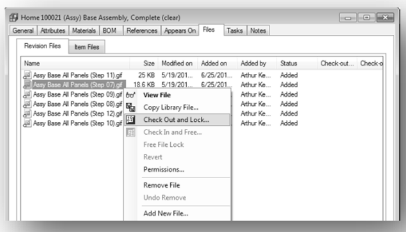


B

TEACHER/TRAINER GUIDANCE NOTES

A—Auxiliary
B—Overall

Decide on methods and conventions for naming and saving new or modified drawings



Conventions are a widely used practice, or procedure.

Convention used for engineering drawings is the use of ‘title blocks’.

The title blocks hold a significant amount of information that includes the:

- ☆ Name of the person the drawing belongs to
- ☆ Date the drawing was completed
- ☆ Number of the drawing (if there are more than one for the same project)
- ☆ Scale at which it was drawn

The title block is usually placed at the bottom right of the drawing. However, it may occupy the full width of the top or bottom of the paper in order to allow the drawing to fit within the size of the drawing paper.

An important piece of information is about the ‘revisions’. The convention and method of recording revisions is to have a ‘Revision Table’. This table will is most often separated from the title box. It will have a ‘Revision Number’, the date the drawing was revised, who made the revision and who approved the revision.

The actual name of the drawing is often the item, part or assembly name.

With regards saving drawings, the methods can vary, depending on the organisational conventions or requirements.

The methods of saving drawing could be:

- ☆ Under a part number system
- ☆ Under a product code
- ☆ Under a project name

These methods would apply to both hardcopy drawings and electronic versions of drawings.

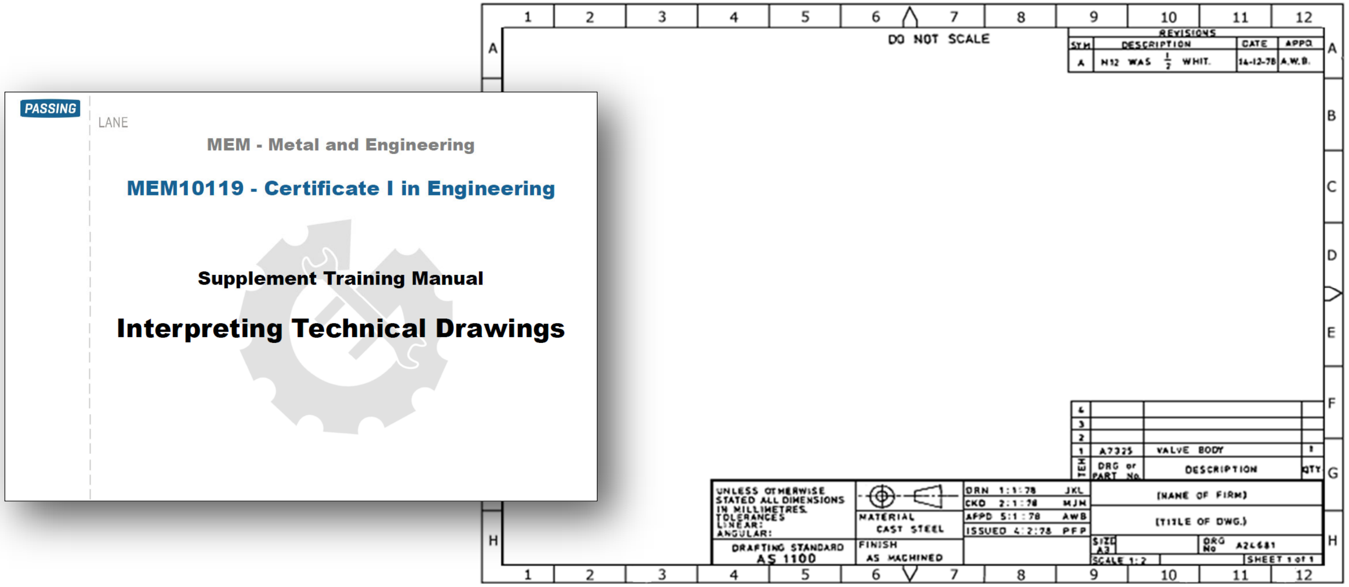
Learning Activity

Task

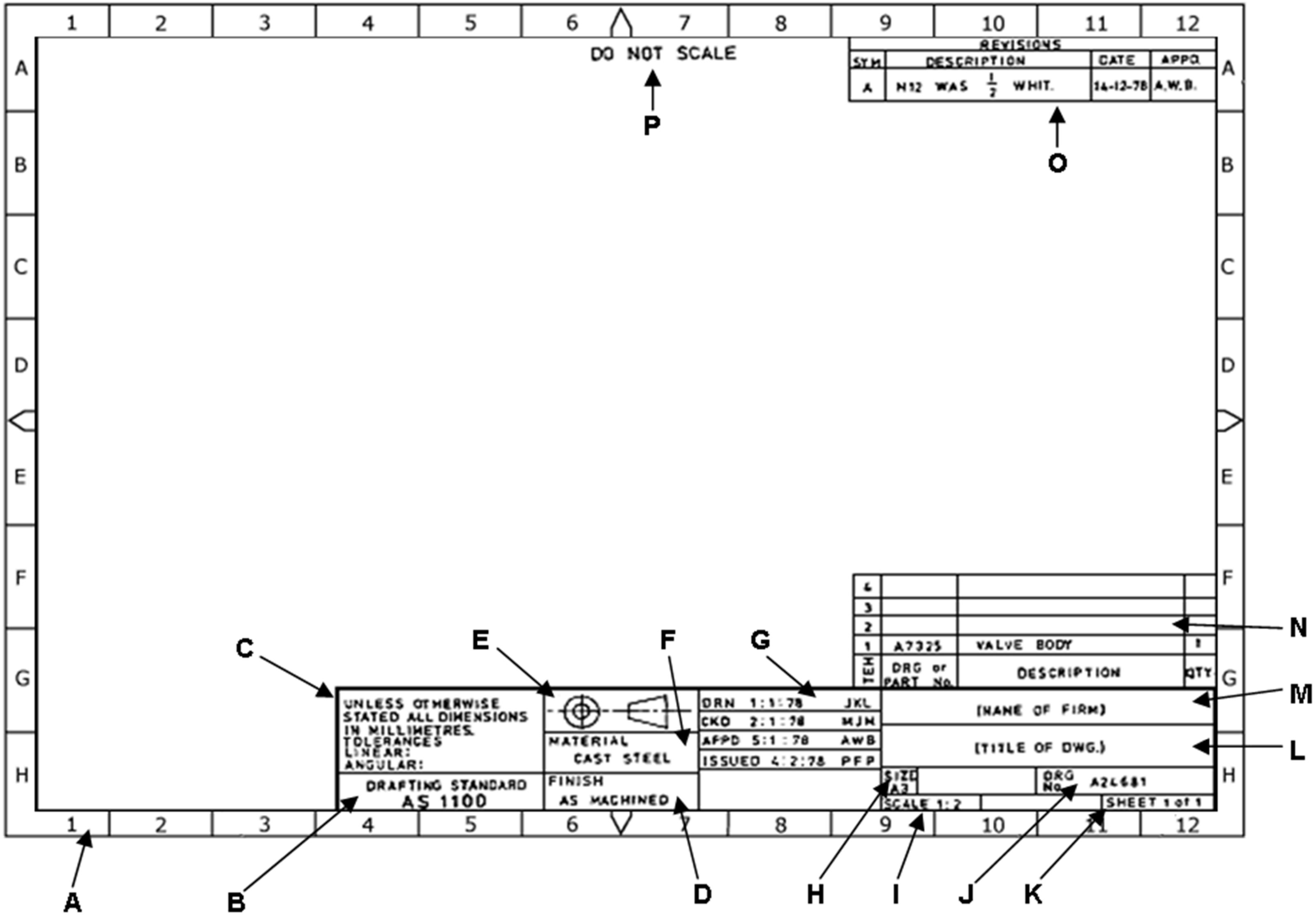
LEARNING ACTIVITY SIX

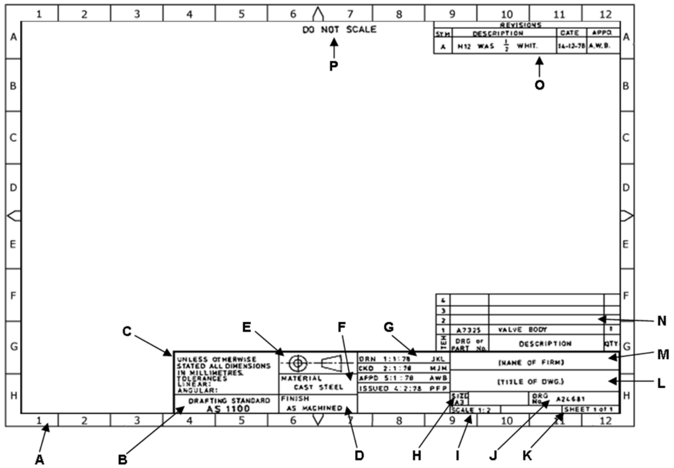
We mentioned earlier about a supplementary training manual called ‘Interpreting Technical Drawings’. To learn more about a standard engineering drawing layout we want you to go to this supplementary training manual and review the information about the standard drawing layout.

Then on the next page we want you to complete this activity.



Below is the standard layout of a technical drawing with each element identified by a letter. In the space provided on the next page tell us the name of the drawing element (name only).





A ______________________________

B ______________________________

C ______________________________

D ______________________________

E ______________________________

F ______________________________

G ______________________________

H ______________________________

I ______________________________

J ______________________________

K ______________________________

L ______________________________

M ______________________________

N ______________________________

O ______________________________

P ______________________________

TEACHER/TRAINER GUIDANCE NOTES

A- Zones

B- Standards Notification

C – Tolerances

D – Finish

E – Angle of Projection

F – Material

G – Person Identifier

H – Sheet Size

I – Scale

J – Drawing Number

K – Sheet Number

L – Title of Drawing

M – Name of Company

N – Part Numbers

O – Revision Table

P – Do Not Scale

Section Four

Create Project Drawings

UNDERTAKE A BASIC ENGINEERING PROJECT

SECTION FOUR—CREATE PROJECT DRAWINGS

Introduction

In the previous section you will have learned the basics of engineering drawings and you would have chosen your method of creating drawings for your project.

This section goes through the step of creating your project drawings.

Section Learning Objectives

At the completion of this section you will learn information relating to:

- ☆ Producing drawings of the completed project using either CAD systems, hand drawing equipment or freehand sketches
- ☆ Producing drawings of the individual project components using either CAD systems, hand drawing equipment or freehand sketches
- ☆ Reviewing drawings with teacher/instructor and peers
- ☆ Modifying drawings as required
- ☆ Producing an items and materials list using the either the CAD system or other computer software

End of Sample Document