Types of materials

Ferrous Metals	Ferrous metals which contain **iron**. They may have small amounts of other metals or other elements added, to give the required properties. They will corrode if unprotected	Iron, carbon steels, high speed steels
Non Ferrous metals	Non Ferrous metals which do not contain iron. Pure metals (have no other metal or element)	Copper, brass, bronze, aluminium, zinc, tin, lead, titanium
Polymers		
Thermo plastics	**Thermo Plastics** -usually a plastic polymer, which becomes more soft when heated and hard when cooled. **Thermoplastic** materials can be cooled and heated several times without any change in their chemistry or mechanical properties	ABS, Polyethylene, HIPS, PVS, polycarbonate, polypropylene
Thermoset plastics	polymer that irreversibly becomes rigid when heated.	Polyseter resin, urea – formaldehyde, epoxy resin, phenol- fromaldehyde.
Ceramics	A ceramic is an inorganic non-metallic solid made up of either metal or non-metal compounds that have been shaped and then hardened by heating to high temperatures.	Tungsten carbide, glass, ceramic bearing material
Composites	A composite material is a material made from two or more materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the original components	Glass reinforced plastic, Carbon fibre, concrete
Smart Materials	Smart materials, are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stress, moisture, electric or magnetic fields, light, temperature, pH, or chemical compounds	Shape memory alloys, thermochromic materials, Shape memory plastics, Quantum Tunnelling Composite.
Alloys	Alloying metals involves mixing two or more metals and other elements to improve their properties.	

High Carbon Steel

The hardest of the carbon steels. Less ductile, tough and malleable.
Uses - Chisels, hammers, drills, files, lathe tools, taps and dies

Medium Carbon Steels

Stronger and harder than mild steels. Less ductile, tough and malleable.
Uses - Metal ropes, wire, garden tools, springs.

Cast Iron

Hard, brittle, strong, cheap, self-lubricating.Whitecast iron, grey cast iron, malleable cast iron.
Uses - Heavy crushing machinery. Car cylinder blocks, vices, machine tool parts, brake drums, machine handle and gear wheels, plumbing fitments.

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Aluminium

Greyish-White, soft, malleable, conductive to heat and electricity, It is corrosion resistant. It can be welded but this is difficult.
Uses - Aircraft, boats, window frames, saucepans, packaging and insulation, pistons and cranks.

Copper

Red, tough, ductile, High electrical conductor, corrosion resistant, Can work hard or cold. Needs frequent annealing.
Uses - Electrical wire, cables and conductors, water and central heating pipes and cylinders. Printed circuit boards, roofs.

Aluminium alloys

Ductile, Malleable, Work Hardens.
Uses - Aircraft and vehicle parts.

Brass

Very corrosive, yellow in colour, tarnishes very easily. Harder than copper. Good electrical conductor.
Uses - Castings, ornaments, valves,forgings.

Mild Steel

Tough, high tensile strength, ductile. *Because of low carbon content it can not be hardened and tempered. It must be case hardened.*
Uses - Girders, Plates, nuts and bolts, general purpose.

High Speed Steel

Can be hardened and tempered. Can be brittle. Retains hardness at high temperatures.
Uses - Cutting tools for lathes.

High Tensile Steel

Very strong and very tough.
Uses - Gears, shafts, engine parts.

Stainless Steel

Corrosion resistant
Uses - Kitchen draining boards. Pipes, cutlery, aircraft.

Properties of materials

malleability	The ability of a material to permanently deform in all directions without cracking.
ductility	The ability of a material to deform, usually by stretching along its length.
conductivity/resistivity	The ability of a material to conduct heat or electrical energy. Opposite for resistivity
hardness	**Resistance of a material to deformation, indentation, or penetration by means such as abrasion, drilling, impact, scratching**
machinability	**Machinability is a characteristic of a material, such as a metal, that makes it easy to drill, shape, cut, grind**
corrosion resistance	**How well a substance (especially a metal) can withstand damage caused by oxidization or other chemical reactions**
elasticity/plasticity	The ability of a material to permanently change in shape.

Materials and uses

Ferous and non ferrous metals and alloys	**Used for cast iron machine bases, bronze for boat propellers, Copper used in wiring and circuit boards.**
Thermoplastics	**ABS for appliance casing**
Thermoset Plastics	**Phenol-formaldehyde for heat resistant saucepan handles.**
Ceramics	**Tungsten carbide for cutting tool tips)**
Composites	**Carbon fibre for bicycle frames**
Smart materials	**Shape memory alloy in alarm systems**

Destructive testing	is undertaken in order to understand a specimen's performance or material behaviour, these procedures are carried out to the test specimen's failure.	Tensile Testing, Hardness testing
Non Destructive Testing	is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part	Conductivity testing, Crack testing, Ultra Sonic Testing

(c) Describe, giving examples, **one** application of each of the following smart materials.

Shape-memory alloy .....

.....

.....

.....[3]

Quantum Tunnelling Composite (QTC) .....

.....

.....

.....[3]

(b) Name **three** thermoplastic materials.

1 .....

2 .....

3 .....
[3]

(c) Give **two** reasons why saucepan handles are usually made from a thermosetting plastic material.

Reason 1 .....

.....

Reason 2 .....

.....
[2]

Ductility, elasticity and resistivity are three properties of engineering materials.

Describe what is meant by:

Ductility .....

.....

.....

.....

Elasticity .....

.....

.....

.....

Resistivity .....

.....

.....

.....

(d) Describe, using **one** example, the use of a non-destructive testing (NDT) procedure.

.....

.....

.....

..... [3

1 A list of engineering materials is given below.

ABS	**Copper**	**PVC**
Brass	**High speed steel**	**Stainless steel**
Cast iron	**HIPS**	**Tin**
Concrete	**Polycarbonate**	**Zinc**

(a) Complete the following statements by adding materials from the list.

(i) ..... and ..... are polymers. [2]

(ii) ..... is a composite material. [1]

(iii) ..... and ..... are non-ferrous metals. [2]

(iv) ..... is an alloy. [1]

(b) Describe what is meant by the term 'thermoplastic'.

.....

.....

.....[2]

(c) Explain why an alloy might be preferred to a pure metal for making an engineered product.

.....

.....

.....

.....[2]

(d) Describe **one** destructive testing process on an engineering material.

.....

.....

.....

.....[3]

1 Many different materials are used in the manufacture of engineered products.

(a) (i) Give **three** examples of non-ferrous metals.

1 .....

2 .....

3 .....
[3]

(ii) Describe what is meant by the term 'alloy'.

.....

.....

.....

.....[2]

(b) (i) Explain why thermoplastics are used for products more often than thermosetting plastics.

.....

.....

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.....

.....

.....[3]

(ii) Give **one** example of a **product** made using thermosetting plastic.

.....[1]

2 **(a)** Complete the table below by giving **one** typical use for each of the materials given.

One has been done for you.

Material	Typical use
Tungsten carbide	Cutting tool tips
Stainless steel	
Carbon fibre	
Cast iron	

[3]

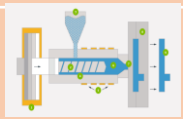
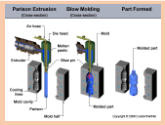
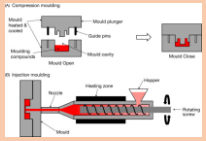
(b) Explain why sustainability is an important characteristic of engineering materials.

.....

.....

.....

.....[2]

Moulding	Video Support	
Vacuum forming		where a sheet of plastic is heated to a forming temperature, stretched onto a single-surface mold, and forced against the mold by a vacuum. This process can be used to form plastic into permanent objects
Injection moulding		lastic injection moulding is the process of melting plastic pellets (thermosetting/ thermoplastic polymers) that once malleable enough, are injected at pressure into a mould cavity, which fills and solidifies to produce the final product.
Blow moulding		Blow molding is the process of forming a molten tube of thermoplastic material and placed within a mold cavity and inflating the tube with compressed air, to take the shape of the cavity and cool the part before removing from the mold.
Rotational moulding		Rotational Molding involves a heated hollow mold which is filled with a charge or shot weight of material. It is then slowly rotated, causing the softened material to disperse and stick to the walls of the mold.
Compression moulding		Compression molding is the process of molding in which a preheated polymer is placed into an open, heated mold cavity. The mold is then closed with a top plug and compressed in order to have the material contact all areas of the mold.

Material Removal		
Sawing		A saw is a tool consisting of a tough blade, wire, or chain with a hard toothed edge. It is used to cut through material,
Filing		Filing is a material removal process in manufacturing.
Threading		Threading is the process of creating a screw thread

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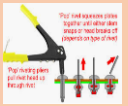
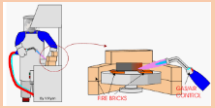
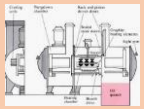
Joining Methods	Video Clip Support	
Welding		Welding is a joining process whereby two or more parts are united by means of heat or pressure or both.
Riveting		When installed the rivet is either drilled, placed or punched into a hole, afterwards the tail is then deformed, holding the rivet in place. The rivet is deformed by of the tail, which makes the material flatter and usually causes the tail to be expanded by about one and a half times the size of the stem's original diameter.
Soldering		Soldering is a process in which two or more items are joined together by melting and putting a filler metal into the joint,
Brazing		Brazing is a metal-joining process in which two or more metal items are joined together by melting and flowing a filler metal into the joint,
Threaded Fasteners		A threaded fastener is a discrete piece of hardware that has internal or external screw threads. hey are usually used for the assembly of multiple parts and facilitate disassembly. The most common types are the screw, nut and bolt.
Self Tapping Screws		A self-tapping screw is a screw that can tap its own hole as it is driven into the material

Hand Forming		
Forging		Forging is a manufacturing process involving the shaping of a metal through hammering, pressing, or rolling. These compressive forces are delivered with a hammer or die.
Casting		liquid metal is poured into a mold that contains a hollow shape. The metal and mold are then cooled, and the metal part (the casting) is extracted.
Bending		Bending is a metal forming process in which a force is applied to a piece of sheet metal, causing it to bend at an angle and form the desired shape.

Heat Treatment		Video clip Support
Hardening and Tempering		Hardening is the process of increasing the hardness of the material by heating and then quickly cooling. Tempering is the heating process to a temperature below is critical range, holding and then cooling
Case Hardening		Case-hardening or surface hardening is the process of hardening the surface of a metal object while allowing the metal deeper underneath to remain soft
Normalising		Normalising is the process of heating a material to a temperature above a critical limit and then cooling in open air.
Nitriding		Nitriding is a heat treating process that diffuses nitrogen into the surface of a metal to create a case-hardened surface. These processes are most commonly used on low-carbon, low-alloy steels.

(a) (i) Name the engineering component shown in Fig. 1 below.

Fig. 1

.....[1]

(ii) Explain how this engineering component would be used to join two sheet metal parts together.

.....

.....

.....

.....[3]

Give **two** other methods of joining sheet metal parts.

1 .....

2 .....[2]

Forging is a metal forming process.

Describe **two** benefits of using forging to make metal parts.

1 .....

.....[2]

2 .....

.....[2]

Fig. 2 is a line diagram of an injection moulding machine.

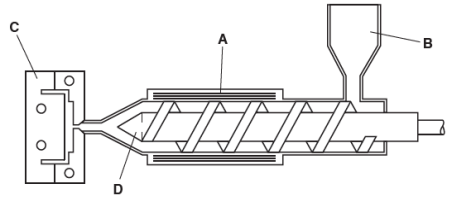


Fig. 2

(a) (i) Name the **four** parts of the injection moulding machine that have been labelled in Fig. 2.

A .....

B .....

C .....

D .....[4]

(ii) Name **three** other plastics moulding processes.

1 .....

2 .....

3 .....[3]

Fig. 1 shows a support bracket made in two parts.
Both parts are made from 3 mm thick mild steel.

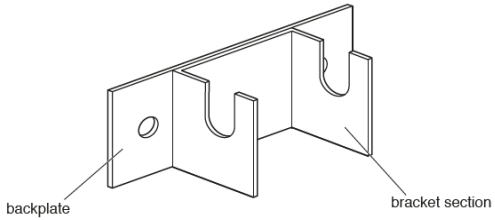


Fig. 1

(a) The bracket section is joined to the backplate by brazing.

Complete the table below by giving the stages needed to braze the two parts together.
The first and last stages have been done for you.

	Process
Stage 1	Clean the surface of both parts where the joint is going to be
Stage 2	
Stage 3	
Stage 4	
Stage 5	
Stage 6	
Stage 7	Remove scale and excess braze where necessary and clean finished piece

(b) Riveting is a joining process that does not involve the use of heat.

(i) Describe how two sheet metal parts would be joined using 3 mm countersunk rivets.

.....

.....

.....

.....

.....

.....[3]

(ii) Name **one** other joining process that does not involve the use of heat.

.....[1]

Engineered products often have surface finishes applied to them after manufacture.

(a) Give **three** surface finishing processes suitable for use on mild steel parts.

1 .....

2 .....

3 .....[3]

(a) The table below shows a number of threaded components.

Complete the table by giving the correct name for each of the components shown.

Component	Name
	
	
	
	
	

Grinding is a machine process used for material removal.

(a) (i) Name **three** other machine processes used for material removal.

1 .....

2 .....

3 .....[3]