Relative clauses (defining)

Look at the following sentences:

(a) *Loads* cause tensile stresses.
(b) *The loads* tend to pull a body apart.

If the noun phrases in italics refer to the same thing, we can combine the two sentences into one by using a relative clause:

(c) Loads which tend to pull a body apart cause tensile stresses.

Write down a single sentence for each of the following pairs of sentences. Make the second sentence into a relative clause and insert it into the first sentence at the place marked by dots.

EXAMPLE

A lever . . . can be used to compare two masses.
Such a lever has the fulcrum placed between load and effort.
= A lever which has the fulcrum placed between load and effort can be used to compare two masses.

1. A strut is a member . . .
   The member resists a compressive force.
2. The beams . . . are welded together.
   They form the chassis of the truck.
3. Rust may attack certain metals. . . .
   These metals contain some proportion of iron.
4. We can combine information on the size of a force and the distance it moves, in a diagram . . . .
   The diagram is called a work diagram.
5. Sir Isaac Newton put forward a law . . .
   The law states that every action has an equal and opposite reaction.

Relative clauses (non-defining)

Compare the following sentences:

(a) The mill *which produces sheet steel* was made in Scotland but the mill *which produces tube steel* was made in Sweden.
(b) The mill, *which produces sheet steel*, was made in Scotland.

In sentence (a) the relative clauses tell us which mill we are talking about. In sentence (a) we have two *defining* relative clauses. In sentence (b) we already know which mill we are talking about. The clause simply adds some extra information about the mill. In sentence (b) we have a *non-defining* relative clause. Note the use of commas.

In Exercise D you made sentences with defining relative clauses. In this exercise, make the second sentence into a relative clause and insert it into the first sentence at the place marked by dots. You will write sentences with non-defining relative clauses.

EXAMPLE

Brass, . . . , is used to make bolts and screws.
Brass is an alloy of copper and zinc.
Brass, which is an alloy of copper and zinc, is used to make bolts and screws.

1. The rectangular block of steel, . . ., is fixed to the floor.
   The block measures 100 by 200 by 10 mm.
2. The electric motor, . . . , is linked to the driving shaft by a belt.
   The motor has a mass of 400 kg.
3. Polished steel, . . . , is in fact covered with tiny bumps.
   Polished steel is normally described as flat and smooth.
4. Friction, . . . , dissipates mechanical energy by converting it into heat energy.
   Friction is always present in a machine.
5. Stainless steel contains chromium, ...
   The chromium makes the steel corrosion-resistant.

Relative clauses (*defining and non-defining*)

Now join the following pairs of sentences and state whether the completed sentences contain defining or non-defining relative clauses.

EXAMPLE

The micrometer screw gauge, . . . , consists of a steel frame carrying a sleeve on which a thimble turns.
The micrometer screw gauge is used by engineers to obtain very accurate measurements.
= The micrometer screw gauge, which is used by engineers to obtain very accurate measurements, consists of a steel frame carrying a sleeve on which a thimble turns. (non-defining)

1. The body is just on the point of sliding at the angle . . . .
   The angle is known as the angle of friction.
2. A railway engine, . . . , draws a train of eight coaches, each of mass 17 tonnes, up a gradient of 1 in 40.
   The engine has a mass of 80 tonnes.
3. The screw-jack is basically a screw running through a fixed nut . . . .
   The nut is incorporated in the jack.
4. As the cord is wound off the wheel, the load cord, . . . , is wound on and thus overcomes the load.
   The load cord is attached to the axle.
5. The gear . . . rotates in an opposite direction to the first.
   The gear is last in an even series of gears in mesh.
6. Intermediate gears, . . . , are often referred to as idlers.
   Intermediate gears do not affect the ratio of the gear train.
7. Hoisting winches of the first group, . . . , are termed single purchase crab winches.
   These winches employ a simple gear train.
8. This diagram means that the tensile force . . . must exceed 3 kN.
   The tensile force will cause permanent distortion.
9. Complicated mechanisms . . . are machines just as simple levers are machines.
   These complicated mechanisms make up an aeroplane engine.
10. Malleable cast iron, ... , is tougher than grey cast iron.
    Malleable cast iron is a ferrous metal.
11. Steels . . . are called tool steels.
    These steels are used to make tools.
12. The Kariba dam, . . . , provides electric power for Zambia.
    The dam is situated on the Zambesi.

Noun modification (i)

If we want to describe an object in greater detail we may use an adjective:

water – *hot* water
metal – *ferrous* metal
lever – *simple* lever

We can also put a noun in front of a noun:

a cylinder – a *steel* cylinder
a bearing – a *brass* bearing
a filter – an *air* filter

Many grammatical relationships are possible in Noun+Noun constructions, or *noun compounds*. Look at the following examples:

(a) a diesel engine = an engine *which uses* diesel oil
(b) a brass bearing = a bearing *which is made of* brass
(c) carbon steel = steel *which contains* carbon
(d) a capstan lathe = a lathe *which has* a capstan

Find further examples of each type in the following list. Mark each phrase (a), (b), (c) or (d).

EXAMPLE

phosphor bronze (c)

air motor
turret lathe
chromium steel
steel plate
wing nut
electric drill
metal casting
concrete bridge
heat engine
aluminium alloy

Short-form relative clauses (i)

We have seen (Unit 3) that if two sentences each contain a noun phrase, and the noun phrases refer to the same thing, then the sentences can be joined together by a relative pronoun like *which.*

EXAMPLE

The block is resting on a plane.
The plane is inclined at an angle of 30° to the horizontal.
= The block is resting on a plane *which is inclined at an angle of 30° to the horizontal.*

We can make this sentence shorter by omitting *which is*:

The block is resting on a plane *inclined at an angle of 30° to the horizontal.*

In the same way we can omit *which is* from the following sentence:

The plane *which is flying at an altitude of 2,140 metres* is subjected to pressures of 80 kilonewtons per square metre.
= The plane *flying at an altitude of 2,140 metres* is subjected to pressures of 80 kilonewtons per square metre.

Now join the following sentence pairs omitting *which* wherever possible. In each case indicate whether the relative clause is a defining or a non-defining clause.

1. Steels . . . are known as alloy steels.
   These steels are mixed with one or more metallic elements.
2. Tests . . . are of two kinds – tests to destruction and tests within the elastic limit.
   These tests are applied to materials.
3. The power developed by the generator . . . is 20 kW.
   The generator is revolving at 1,000 rev/min.
4. A dockside crane, . . . , has a safe working load of 3×10^3 kg.
   The crane is mounted on a set of rails.
5. The distance . . . is plotted on a graph against time taken.
   The distance is travelled by a moving load.
6. These forces constitute a tensile stress, . . . , which acts around the circumference of the cylinder.
   This stress is known as hoop stress.
7. The force . . . was found to be 1,200 N.
   The force was exerted on the clamps.
8. Bridges, roof trusses and cranes are structures . . . .
   Such structures are designed to resist forces.

Short-form relative clauses (ii)

Look at this example:

The steel beams are welded together.
The beams form the chassis of the truck.

We can join these two sentences in two ways:

(a) The steel beams *which form the chassis of the truck* are welded together.
or (b) The steel beams *forming the chassis of the truck* are welded together.

In sentence (b) we have made the relative clause shorter by omitting *which* and changing the verb to its *-ing* form. What kind of relative clause does sentence (a) contain – defining or non-defining?

If the relative clause contains *which*+a verb in the simple present we can omit *which* and change the verb to its *-ing* form. This rule can be applied if

(a) the clause is a defining one
or (b) the verb is a verb of state

Verbs of state describe states not actions like 'work' or 'run'. The most common verbs of state in engineering are

measure	contain
weigh	hold
consist of	form

Now join the following sentence pairs omitting *which* wherever possible. In each case indicate whether the relative clause is defining or non-defining and underline verbs of state.

1. XY is a steel shaft . . . .
   It carries a 300 mm diameter eccentric gear.
2. A flywheel, . . . , has a diameter of 1·6 m.
   The flywheel consists of a cast iron rim which is connected to a boss by spokes.
3. The driving belt, . . . , is 9 mm thick.
   It transmits power to the pulleys.
4. The towers, . . . , support the main section of the bridge.
   The towers weigh a thousand tonnes each.
5. The tapping head has a spring clutch, ...
   The clutch allows the tap to slip without breaking when the load becomes excessive.
6. Grooving tools, . . . , are made of high-speed steel.
   Grooving tools cut slots or keyways.
7. The main shaft of the lathe drives the lubricant pump, ...
   The pump supplies cooling fluid at the tool cutting tip.
8. Bronze . . . is called phosphor bronze.
   This bronze contains 0·8 % phosphorus.

Short-form relative clauses (iii)

When the relative clause contains *which+have* we can shorten it in two ways. Look at the following examples:

Two steel sheets *which have a thickness of 3 mm each* are joined by rivets.

= (a) Two steel sheets *having a thickness of 3 mm each* are joined by rivets.

or (b) Two steel sheets *with a thickness of 3 mm each* are joined by rivets.

Now join these sentence pairs and omit *which* where possible:

1. Grey cast iron is a soft close-grained cast iron . . . .
   This cast iron has a relatively low melting point.
2. A diesel engine . . . is called a slow-speed diesel.
   This engine has a running speed of 75 to 250 rev/min.
3. A dockside crane . . . is mounted on a set of rails.
   The crane has a safe working load of 2,000 kg.
4. A milling machine . . . is known as a universal milling machine.
   This machine has a swivelling table.

Relative clauses with prepositions

In books about engineering we find many relative clauses with a preposition before *which*. Such clauses are formed in the following way:

The shaft runs in brass bushes.
The pulley is mounted *on the shaft*.
= The shaft *on which* the pulley is mounted runs in brass bushes.

Combine each of the following pairs of sentences into one sentence containing a relative clause beginning with a preposition+*which*:

1. The main bearings consist of steel shells lined with aluminium.
   The shaft runs in the bearings.
2. The point is called the fulcrum.
   The body is free to rotate about the point.
3. The piers resist the load by a reaction of 5,000 N each.
   The bridge rests on the piers.
4. The points are 600 mm apart.
   The one kilogramme masses are suspended from the points.