31 Forces, Mechanisms and Structures

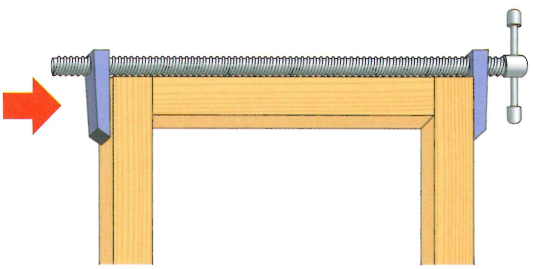
KEYWORDS

compression
fulcrum
gear train
pulleys
shear
tension
torsion

Forces

A simple force is something that is trying to move or change an object by pushing, pu bending or twisting it. There are a number of different types of force. Understanding these f will help you to plan your projects and to use the equipment in the workshop. It will alsc you to understand how joints work.

Compression force



A compression force acts on the frame

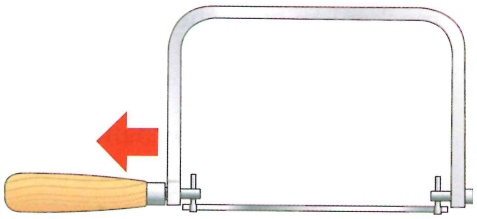
Compression

Compression is a pushing force. A frame is compressed by a cramp while the glue dries.

Tension

Tension is a pulling force. The chain of a swing is in tension when a person sits on the se tensile force is put on the blade of a coping saw by the frame.

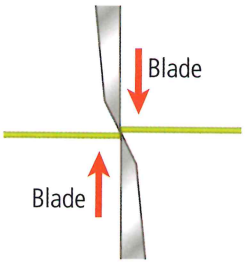
Tension force



Coping saw blade is in tension

Shear

Shear force tends to move two objects in different directions over each other. Scissors, or a metal snips, apply a shear force in order to cut paper or metal sheets. As we have already seen, nails are designed to work best under shear forces (stress).



Cutting with a shear force

Bending

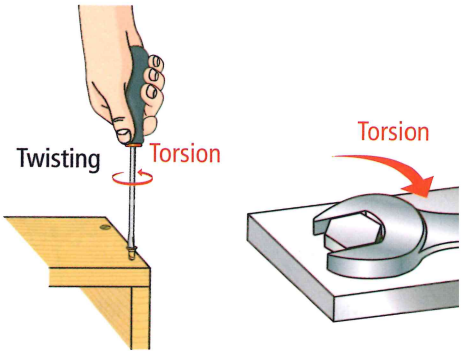
Understanding bending forces is important in the design of projects. If parts of a project are weak, they may bend if the weight (load) is too great.

We have already learned that a piece of solid wood or manufactured board will bend if it is not stacked properly.

Bending force

Torsion (twisting)

Torsion forces are twisting forces or turning forces. Torsion is applied to a screwdriver when driving a screw, or to a bradawl when making a pilot hole for a screw.



Torsion

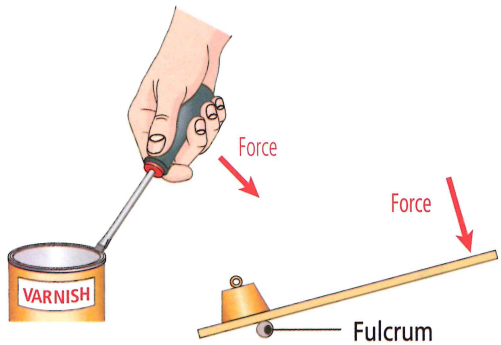
MECHANISMS

A mechanism is a simple mechanical device. We are familiar with mechanisms as we use them daily. Mechanisms are designed to make tasks easier. Without mechanisms, life would be very different.

A mechanism is powered by a force. For example, when you pull the brake lever of a bik mechanism grips the rim of the wheel and this slows the bike down.

Levers

A lever is a simple mechanism that allows work to be done more easily. A simple lever is a bar which pivots at a point called a **fulcrum**. There are many examples of levers in the work Levers allow us to lift weights more easily or to grip tightly.

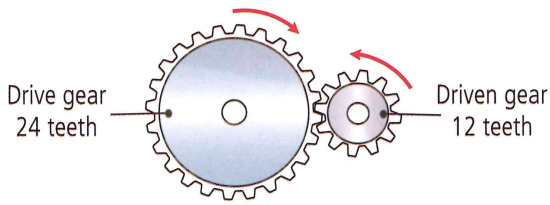


A screwdriver levers a tin lid

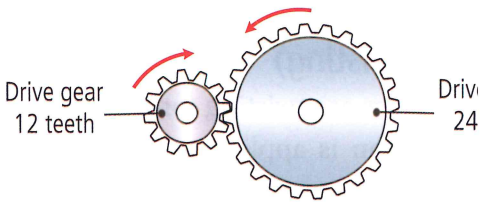
A claw hammer as a lever

Gears

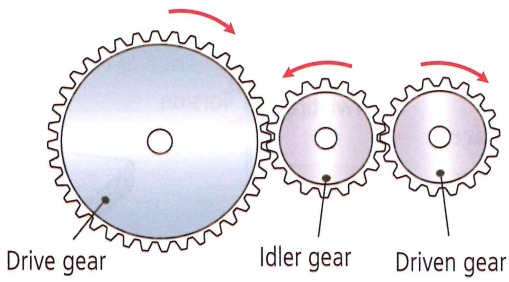
Gears are components that have teeth that mesh to transfer forces or motion. Different gears are also used to change the speed or direction of rotation in machinery. A number of connected together are called a **gear train**.



Speeded up 1:2



Slowed down 2:1



Gear trains

Drive gear bigger than driven gear – speeded up

Drive gear smaller than driven gear – slowed dow

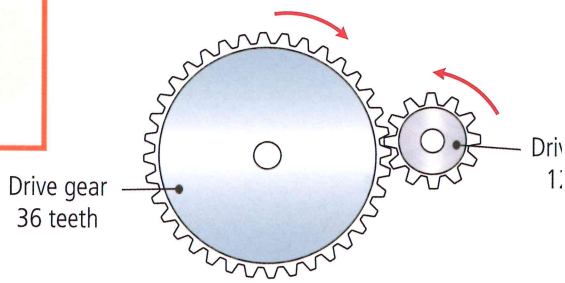
The rotation in the drive gear will reverse the rota of the driven gear.

VELOCITY RATIO

The velocity ratio of gears is the ratio between the speed of one gear wheel compared to a second. It can be calculated using a simple formula.

$$\text{Velocity ratio} = \frac{\text{Number of teeth on the driven gear}}{\text{Number of teeth on the drive gear}}$$

$$\text{Velocity ratio} = \frac{12}{36} = 1:3$$

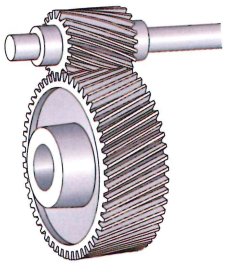


Velocity ratio

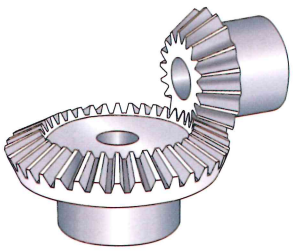
The velocity ratio of a gear train can also be calculated using this formula:

$$\text{VR (total)} = \text{VR1} \times \text{VR2}$$

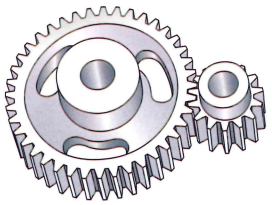
There is a variety of different types of gear used in different situations.



Helical gears



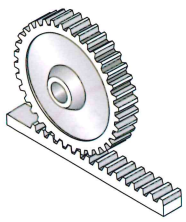
Bevelled gears



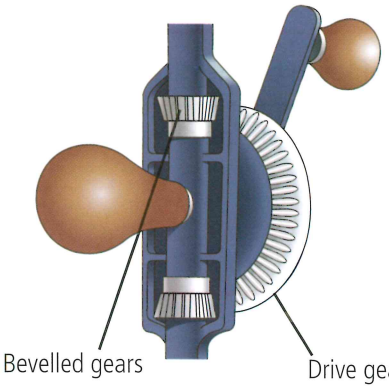
Spur gears

Types of gear

Bevelled gears are used in hand drills in the workshop. The mortising machine and the s drill press use rack and pinion gears.



Rack and pinion gear



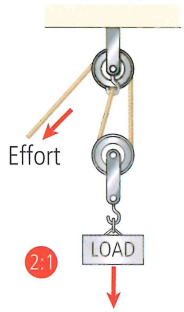
Gears

Pulleys

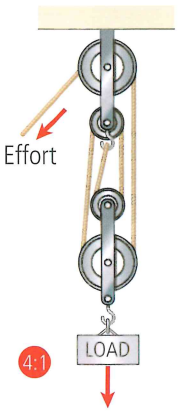
Pulleys are grooved wheels on which belts or ropes run. They are used to lift heavy weigh to change the drive speed of motors. Pulleys are also used to drive machinery. The lathe an drill press use pulleys to drive the spindle.

Changes in speed are achieved by using pulley wheels of different sizes. Pulleys generally in one direction only, but if the belt is crossed it can be used to reverse the direction of rotat

Pulleys used to drive a drill press and change the speed of the drill

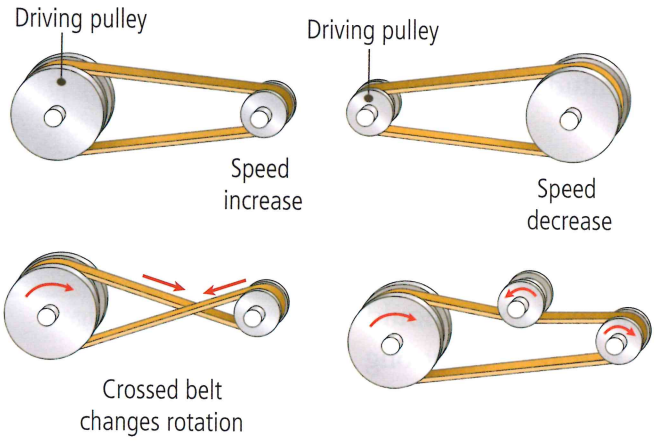


If you have 2 pulley wheels, the effort needed to lift the load is reduced by 2



If you have 4,it will reduce the load by 4

Pulleys in a block and tackle can help to lift weights



Pulleys

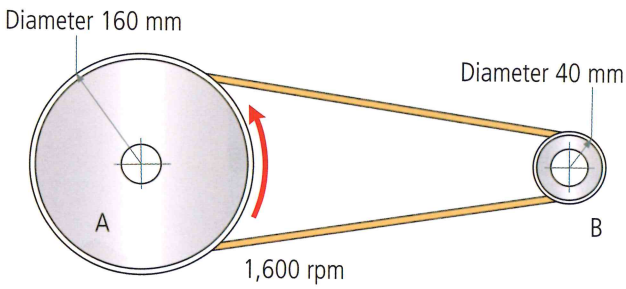
You can use a simple formula to calculate the velocity ratio for a pulley.

$$\text{Velocity ratio} = \frac{\text{Diameter of driven wheel}}{\text{Diameter of drive wheel}}$$

$$\text{The output speed (OS)} = \frac{\text{Input speed}}{\text{Velocity ratio (VR)}}$$

Example

The diagram shows a pulley system. The drive wheel A has a diameter of 160 mm and the driven wheel B has a diameter of 40 mm. Calculate the output speed of wheel B if the speed of A is 1,600 rpm.



$$\text{VR} = \frac{40}{160} = \frac{1}{4} = 1{:}4$$

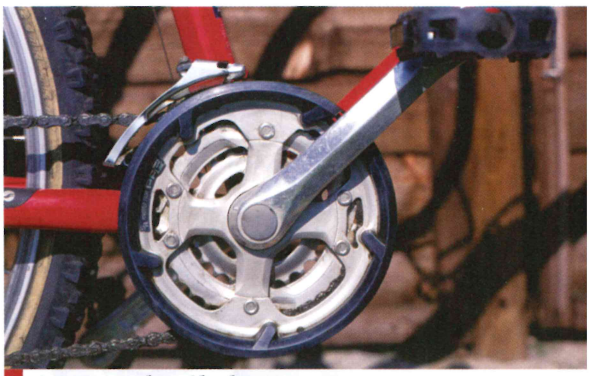
$$\text{OS} = \frac{1{,}600}{1{:}4} = 1{,}600 \times \frac{4}{1}$$

$$= 4{,}800 \text{ rpm}$$

Output speed of a pulley

Linkages

When levers are connected together, they are known as linkages. They allow us to change a force in magnitude, direction or both.



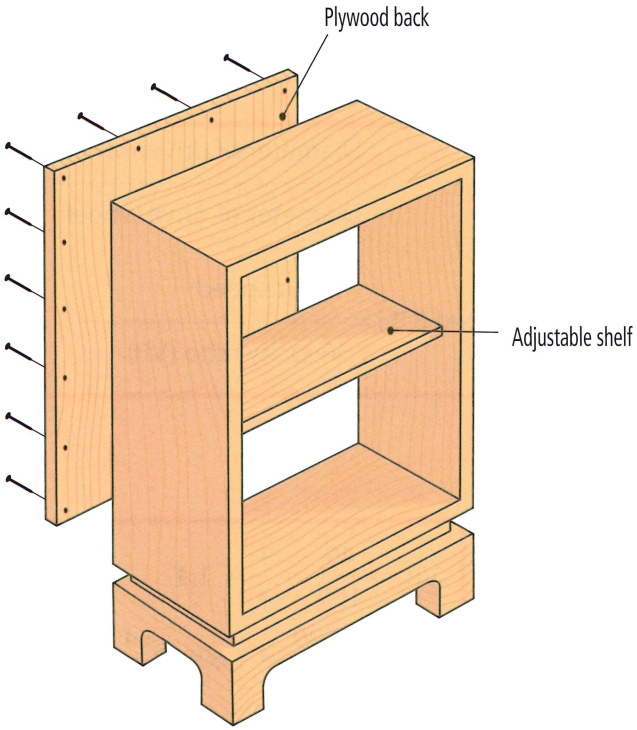
An example of linkage

STRUCTURES

Just like bridges and buildings, the projects that you make in the workshop should have a good structure to make them strong enough to stand up to everyday use. A simple frame or carcase can be strengthened by secu a back piece on to it as shown below.

A frame is a strong structure and most g work will include one or more frames to gi stability and strength.

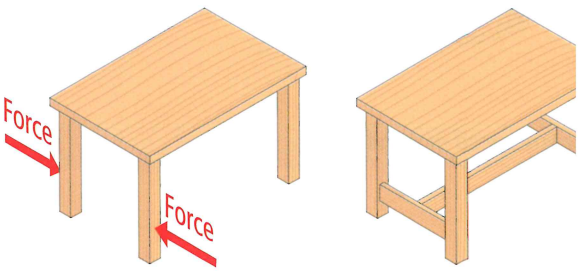
Triangles are the simplest and stron frames and this is why electricity pylons roofs use triangulation in their structures.



Applying a back to a carcase will give it strength

An electricity pylon

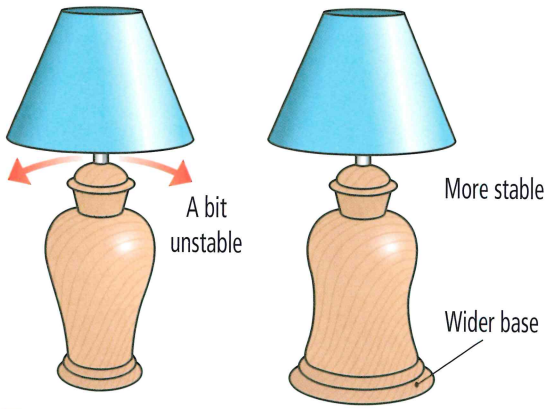
Frames can be used to strengthen items such as tables and chairs. Adding rails on a table or chair can give it much greater strength. Rails can also be a decorative feature on tables and other items.



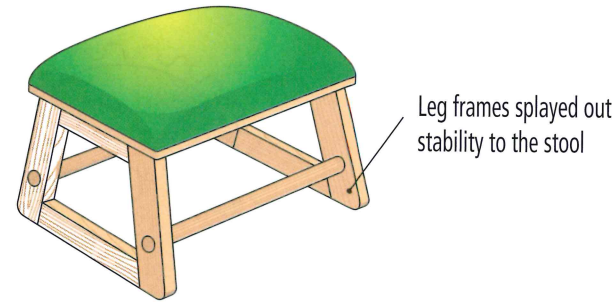
Rails add strength

Stability

Stability is also important when designing. An object should not topple over. An object is made stable by keeping the weight of the object low and increasing the size of the base to keep the centre of gravity low.



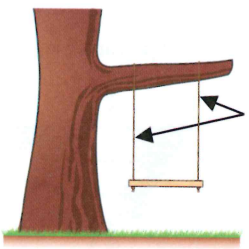
Lamps



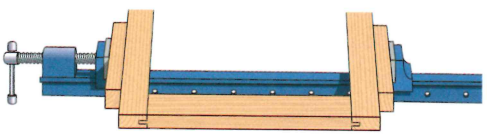
Stool

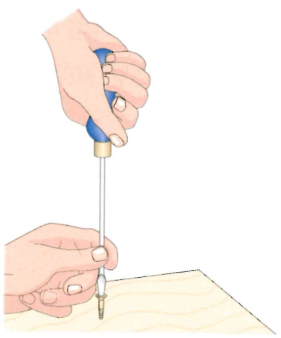
Exercises

1 Name the force acting on the ropes of the swing in the diagram.



2 Name the force involved in each of the situations below.



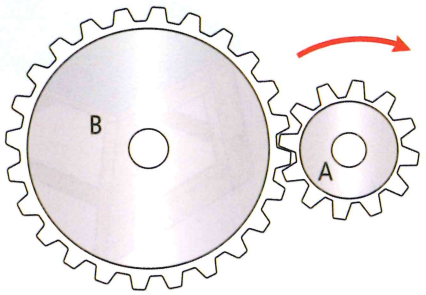


Exercises

3 Draw a simple sketch of the following gears:

- Rack and pinion gear
- Spur gears

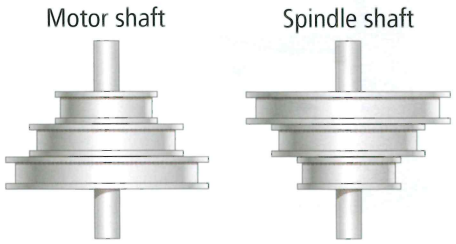
4 The diagram below shows two gears.



(a) Indicate the direction of the gear labelled B above.

(b) If the gear wheel labelled A is the drive gear, will gear B turn at a faster or slower rate?

5 The diagram below shows the pulley system of a lathe. Show, by means of a diagram, t position of the belt when the lathe is at its slowest speed.



6 Name the force acting on the pin of a sash cramp when it is in use.

7 When cutting sheet metal with a snips, what kind of force is being used?

Exam Questions

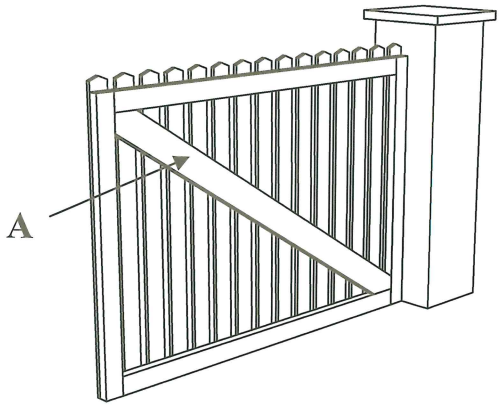
1 The diagram shows a bookshelf unit made from wood.

Identify one design defect and describe a possible remedy.
(JC, HL, 2009)

2 The diagram shows a gate. What is the correct name for the force acting in member A?

- Torsion
- Compression
- Tension

(JC, HL, 2007)



Web Links

www.flying-pig.co.uk/mechanisms/index.html
www.technologystudent.com/cams/camdex.htm
www.btinternet.com/~hognosesam/gcse/page55.html
www.enchantedlearning.com/physics/machines/Levers.shtml
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