Pulleys

Introduction

The output from power sources such as electric motors, car engines and wind generators is rotary motion of a drive shaft. The output rotary motion and force must be transmitted from the power source to a mechanism that will use the energy in some way. The usual ways of transmitting motion and force from the output drive shaft to a shaft in a mechanism is through:

- gears
- belt and pulleys
- chain and sprockets
- a crank
- couplings.

This section will explain how:

- motion and force is transmitted from the output shaft of a power source through a belt and pulleys to other parts of a mechanism
- pulleys are used to aid lifting and hauling loads
- belt and pulley systems are used as conveyors of people and products
- belt and pulley systems are the main elements in band saws.

Belt and Pulleys

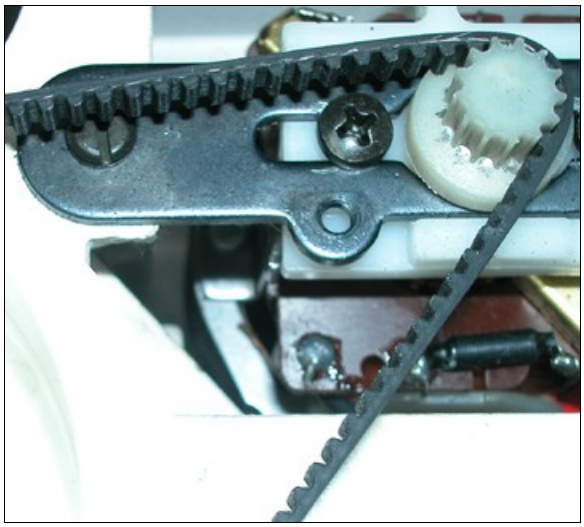
Pulleys are rollers that may be:

- plain cylinders
- cylinders or discs with one or more vee grooves
- cylinders or discs with teeth.

Each of these pulley types will be connected to another similar pulley by an appropriately shaped belt, e.g. a plain flat belt, a vee belt or a toothed belt.

Flat belts slip easily on pulleys so they are mainly used as conveyors of products and people. Vee belts grip the sides of the vee groove in pulleys fairly well when the belt is pulled tight, but will slip under heavy loads. Toothed belts are used to connect pulleys that require a positive non-slip drive. They are used in applications such as drives for belt sanders, sewing machines, computer printers and as the timing belt in internal combustion engines.

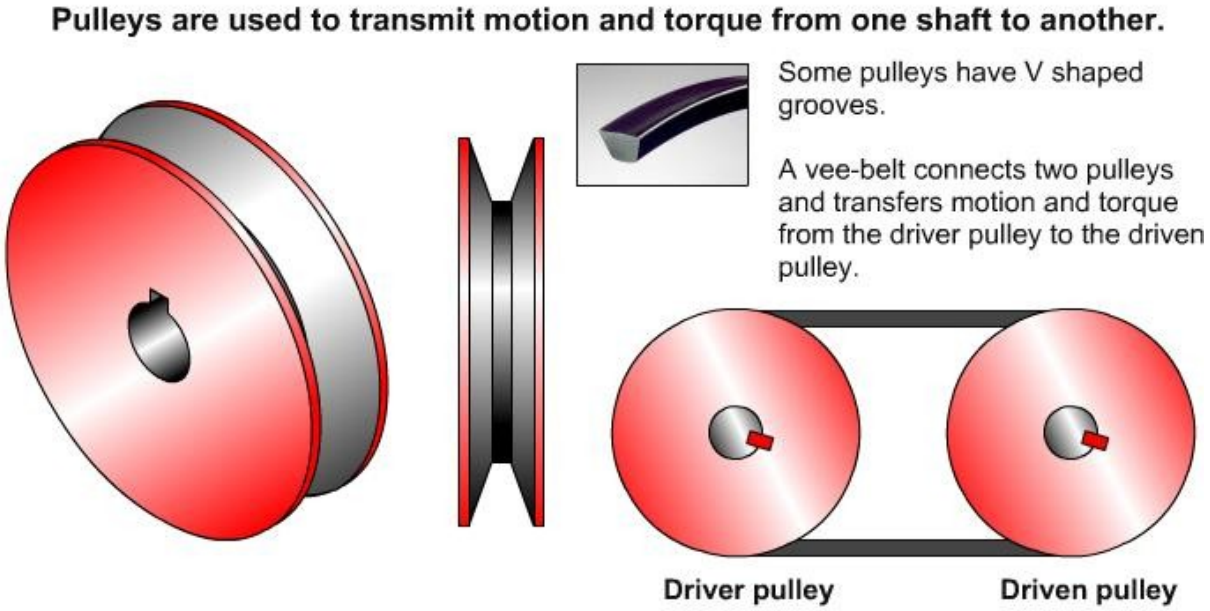
Toothed belt and pulleys used on a belt sander



Toothed belt and pulleys used on a swing machine

Belt and pulleys used to transmit motion and torque

A pulley used to transmit motion and torque is placed onto a shaft and prevented from slipping on the shaft by a key that fits into keyways in the shaft and pulley. There may also be a morse taper on the shaft and pulley and a locknut to prevent the pulley from falling off the shaft. The driver pulley and the driven pulley rotate in the same direction.



Velocity Ratio

The velocity ration between the driver pulley and the driven pulley can be calculated in a similar way to the way that velocity ration would be calculated for gears and for chain and sprocket drives.

$$\text{Velocity ratio} = \frac{\text{distance moved by the effort (rotary velocity of the driver pulley)}}{\text{distance moved by load (rotary velocity of the driven pulley)}}$$

or

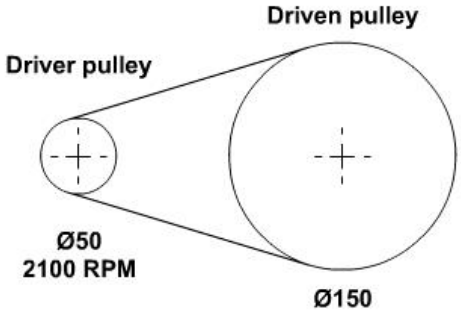
$$\text{Velocity ratio} = \frac{\text{diameter of the driven pulley}}{\text{diameter of the driver pulley}}$$

Example

The driver pulley has a diameter of 50mm (Ø50mm) and a rotary velocity of 2100 revolutions per minute (RPM).

The driven pulley has a diameter of 150mm (Ø150mm).

What is the rotary velocity of the driven pulley?



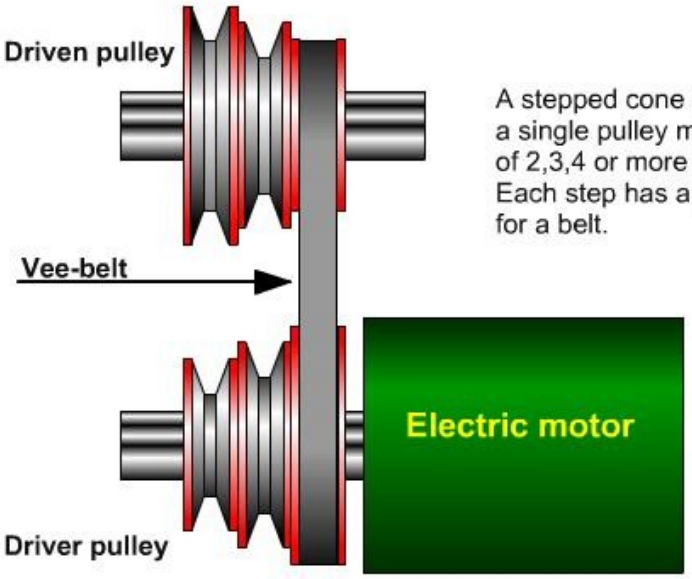
$$\text{Velocity ratio} = \frac{\text{diameter of the driven pulley}}{\text{diameter of the driver pulley}} = \frac{150}{50} = \frac{3}{1}$$

$$\text{Velocity ratio} = \frac{\text{rotary velocity of the driver pulley} = 2100}{\text{rotary velocity of the driven pulley} = x} = \frac{3}{1}$$

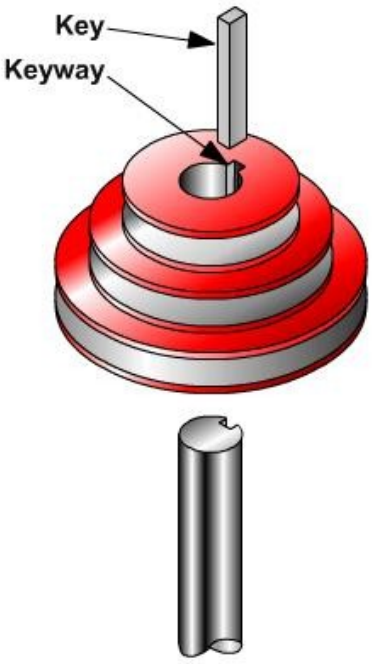
Therefore the rotary velocity of the driven pulley is 700 RPM.
As the driven pulley is keyed into the driven shaft, the rotary velocity of the driven shaft is also 700 RPM.

Stepped Cone Pulleys

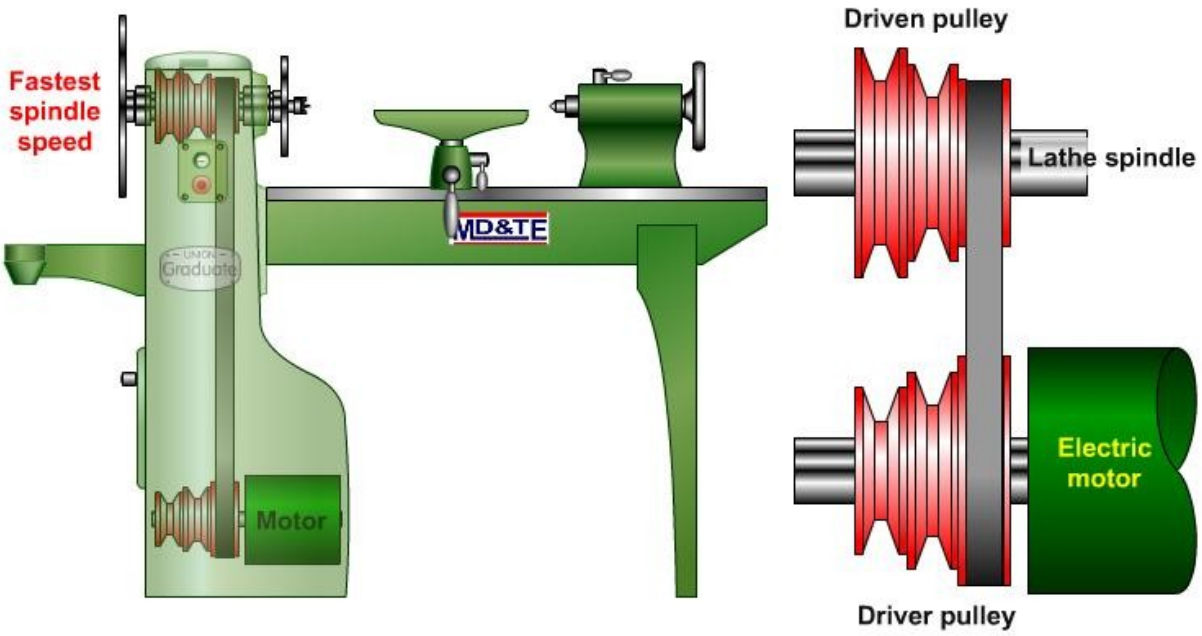
Stepped cone pulleys are fitted to machines such as pillar drilling machines and wood lathes so that the rotational velocity of the chuck or spindle centre can be altered quickly and easily.



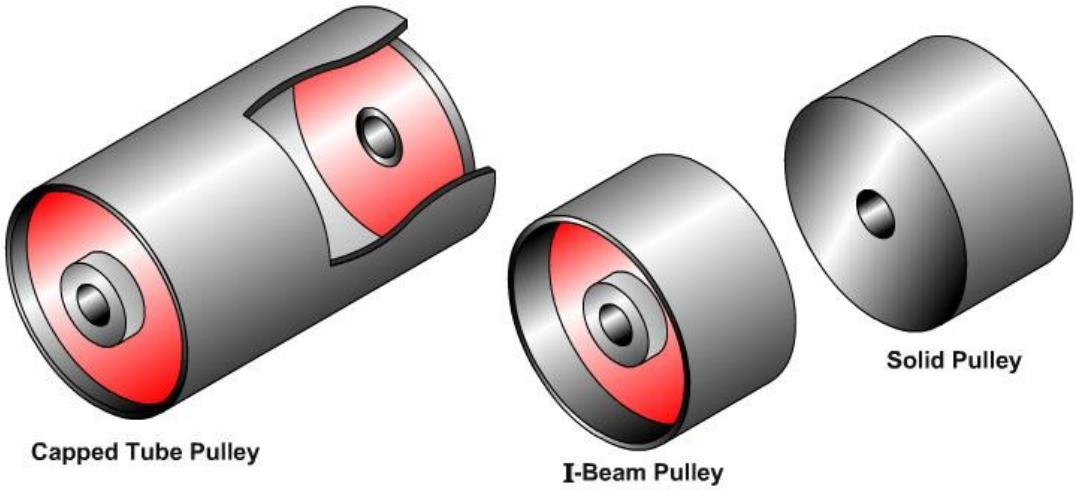
A stepped cone pulley is a single pulley made up of 2,3,4 or more steps. Each step has a groove for a belt.



Stepped cone pulleys on the wood lathe spindle and the motor are connected by a belt. The speed of the spindle can be varied by adjusting the position of the belt. The belt is on a large driver pulley and a small driven pulley. The driven pulley rotates faster than the driver pulley because of its smaller diameter.



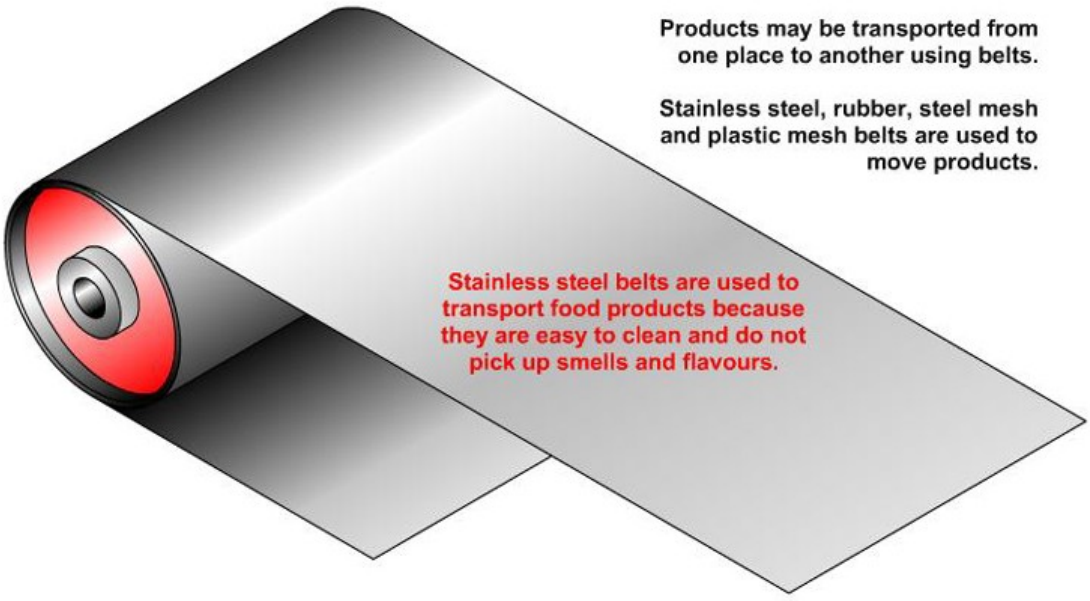
Cylinder Pulleys



Belt and pulley / conveyor belt at a supermarket checkout

A rubber belt is used to move products at a supermarket checkout.

A similar system, on a much larger scale, is used to move people at airport terminals.

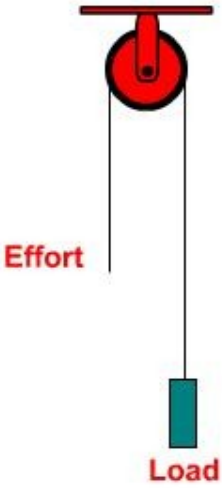


Products may be transported from one place to another using belts.

Stainless steel, rubber, steel mesh and plastic mesh belts are used to move products.

Stainless steel belts are used to transport food products because they are easy to clean and do not pick up smells and flavours.

Pulleys Used for Hauling

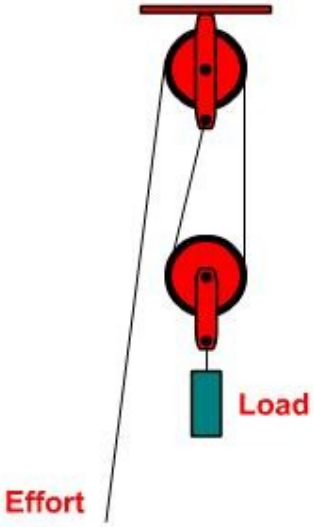


A single pulley simply changes the direction of the tension force (pulling force).

There is no mechanical advantage when using a rope around a single pulley.

This system is often used on building sites to haul loads onto high buildings.

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$



In the second example, two parts of the rope support the load. Each part supports half the load, therefore the mechanical advantage is 2.

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$

$$\text{Velocity ratio} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$

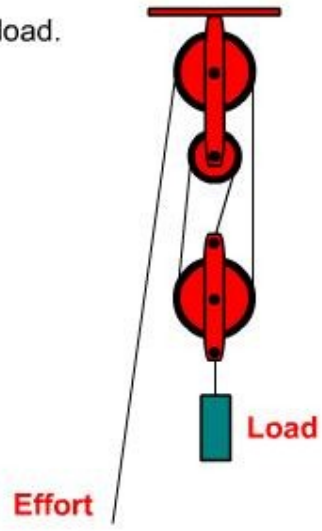
The effort force moves twice as far as the load, therefore the velocity ratio is 2

In the third example, three parts of the rope support the load. Each part supports one third of the load, therefore the mechanical advantage is 3.

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$

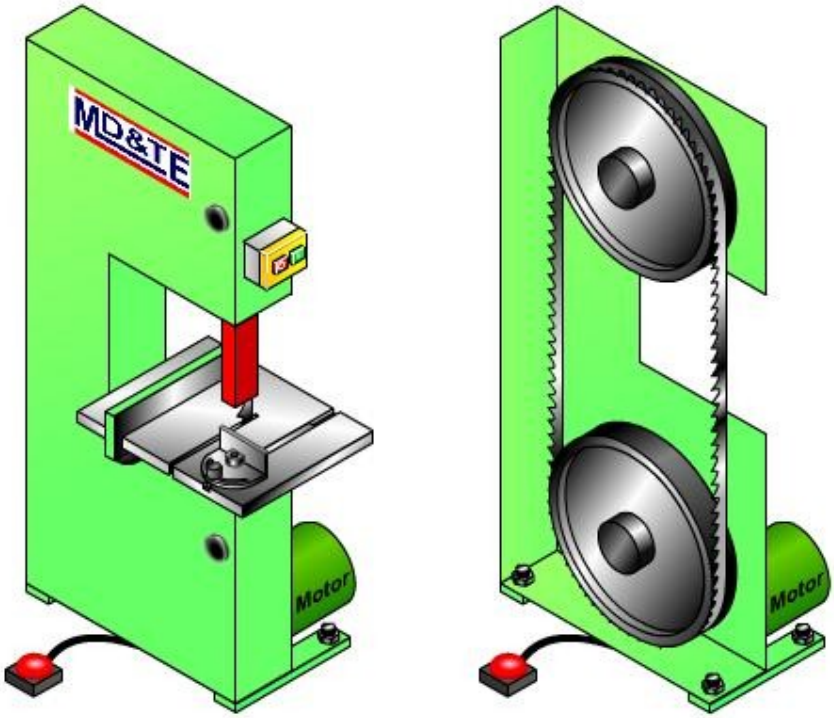
$$\text{Velocity ratio} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$

The effort force moves three times as far as the load, therefore the velocity ratio is 3.



Band Saw

Band saws are belt and pulley systems where the steel belt has been cut and formed on one side so that it has saw teeth. It can be seen that the most important parts of a band saw are the pulleys and the saw blade, i.e. the band / steel belt.



Belt Sander

The main components of a belt sander are the electric motor, a driver cylinder pulley, a driven cylinder pulley and an abrasive belt.