

Pulleys

Pulleys allow you to either:

1. lift something up by pulling a rope, or
2. spin things at different speeds.

Pulleys in Imagination Factory

There are two pulley exhibits in *Questacon Imagination Factory—Invent and Play*.

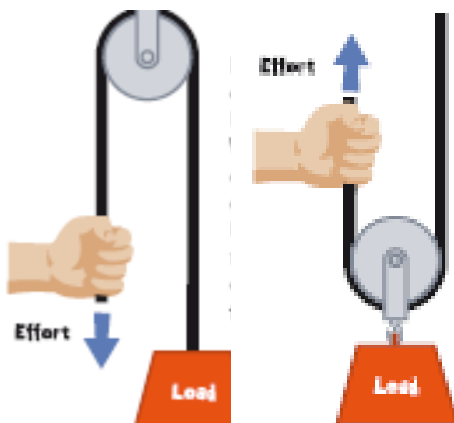
They are:

- Play with Pulleys and
- Pulley Power

How do pulleys make life easier?

Pulleys are wheels that have a groove around their outer edge and rope or cord fits in the groove.

A **load** is attached to the other end of the rope or to the pulley itself (for fixed pulleys) and you pull up or pull down the other end of the rope.



It's easier to pull something down than to lift it straight up. While single pulleys do allow you to pull downwards to lift a load, they don't really reduce the

amount of effort you need to lift the load.

The work done by a machine (output force) can be worked out by multiplying the effort used and the distance travelled by the machine.

For a pulley, effort refers to how easy or difficult it is to pull the rope and distance refers to how much rope you needed to move through the pulley system to raise the load.

If you have many pulleys linked together, the system uses a longer length of rope (increasing the distance). It takes much less effort to pull through the rope on multiple pulley systems, but you need to pass a much longer length of rope through your hands to lift something.

When you use fewer pulleys (say two pulley wheels), you only need to pull on a short length of rope, but it's much harder to pull the rope.

Quirky Fact

Dumbwaiters are small elevators used in multistorey buildings such as libraries or restaurants.

In older buildings, dumbwaiters worked using ropes and pulley systems to lift and lower books or plates to an upper or lower floor. They saved the need for a person to physically carry things up stairs or push trolleys.

Differential pulley systems

If two different sized pulley wheels are connected by a rope or a belt loop, they can be used to lift large loads. This is called differential pulley system.

Hoists used by mechanics to lift a 200 kilogram engine out of a car use two different pulleys in a differential pulley system.

The effort you need (in newtons) to lift a load is roughly the weight of the load (kg) divided by the number of wheels or the number of rope strings between the wheels (except the rope or string that you're pulling on).

However, adding more pulley wheels means more friction between the rope and the wheels, which makes the pulley system less efficient.

Clean your clothes with pulleys

In a laundry washing machine, the motor spins at the same speed, but changes the size of the pulleys controlling the tub, so the tub spins slowly during the wash cycle, then spins fast during the spin dry cycle.

During the slower wash cycle, the motor drives a larger pulley connected to the tub. Large pulleys spin more slowly than small pulleys, which is why the tub spins slowly.

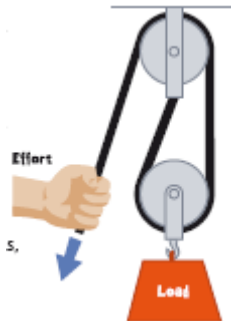
When spin drying clothes, the motor rotates at the same speed but uses a smaller pulley which spins faster and causes the tub to spin fast enough for water to fly out of the wet clothes.



Everyday uses of pulleys

- Engines (e.g. water pumps, fan belts in cars)
- Venetians blinds and awnings
- Rock climbing equipment
- Sail boats (winches for sails)
- Conveyor belts (checkouts)
- Cranes at building sites
- Flag poles
- Cassette tapes and old LP record players
- The trochlear muscle posterior to eye acts like a pulley

Multiple pulleys

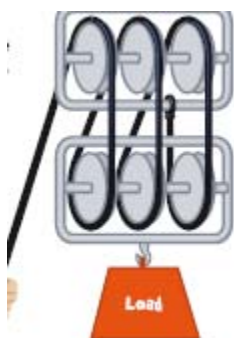


This is a double pulley. The pulley at the top is fixed, while the bottom pulley can move up and down as it carries the load.

One strand of rope is being pulled down (by the hand in the drawing), the other two strands of rope (between the two pulleys) are called support strands. The tension (T) in each of the two support strands must be half the load or $\text{load} \div 2$.

This double pulley system allows you to raise a load using half the effort of having to lift the load without the help of a machine. You would need to pull down two metres of rope for every one metre that the load is raised. Lifting twice the load means that mechanical advantage of this pulley system is 2.

Block and tackle



Many pulleys connected together in separate frames are called a block and tackle. The block is the frame around the pulleys. The tackle is the rope connecting the load to the effort.

Block and tackle pulleys are used to lift engines from cars and on huge cranes.

How much effort is needed?

When several pulleys are used together, you need less effort to pull the rope, but you need to use a longer length of rope (increase the distance).

To work out how much effort you need to lift a load using multiple pulleys, count the number of strands of rope between the pulleys.

We can calculate how much effort is needed with the equation

$\text{Effort} = \frac{\text{load (kg)}}{\text{Number of support strands}}$

You can also work out the mechanical advantage (effort needed compared to how far your load is moved) by using the equation

$\text{Mech advantage} = \frac{\text{distance load moves}}{\text{distance effort rope moves}}$
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So, a pulley system that has a mechanical advantage of '2' can apply twice as much force to lift the load than if you were trying to lift the load with your bare hands.



Background Support Notes



Australian Government
Department of Education,
Science and Training



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There's no such thing as a perfect pulley!

If a pulley system was perfect and achieving 100% efficiency, then the pulleys and their ropes would be weightless, frictionless and not stretch or warp at all.

Living in the real world, we know that this is not the case. Some of your effort is lost in overcoming this friction between the pulley wheels and the ropes.

An unusual Australian Inventions that use pulleys

T-Line Safety System

The *T-Line Safety System* is a device that protects people from falling too far when they're working at great heights.

The system only weighs 15 kilograms and looks similar to traditional abseiling equipment using pulleys and other rigging equipment, but unlike traditional systems, the *T-Line Safety System* lets workers move around freely, so they can access places that are otherwise difficult to reach.

It was invented by civil and structural engineer Leigh Dowie and was featured on the ABC Television show *New Inventors*.

If a worker is on the outside of a high rise building and they suddenly fall, the system uses a series of pulleys to stop them from falling further and it reduces how much the worker swings back and forth in mid-air like a pendulum.

Due to the unique design, the system can be fitted around overhead

obstructions such as cranes and pipes, while workers can still move freely below, which makes it more adaptable than other systems.

Dog Food Dumb Waiter

Instead of climbing down and up a flight of stairs to feed their dog Clyde, Madeleine Hawkins and Phoebe Immes created a platform lift (dumb waiter) using pulleys to make it easier for them to serve food to their dog.

The girls drew up some plans and made a prototype of a platform (to hold Clyde's bowl) that could be lowered, then lifted back up using a pulley system.

They then improved the prototype by making a box to protect the bowl from rain, but still allow Clyde to eat his food. They also inserted small triangular pieces to prevent the bowl from falling off the platform.

Clyde has learnt something from this exercise too. As soon as he hears the pulleys squeaking, he comes running for his dinner!

Further information

ABC TV *New Inventors* segment on *T-Line Safety System* (cited June, 2007)

<http://www.abc.net.au/tv/newinventors/txt/s1493116.htm>

ABC TV *New Inventors* segment on *Dog Food Dumb Waiter* (cited June, 2007)

<http://www.abc.net.au/tv/newinventors/txt/s1442900.htm>