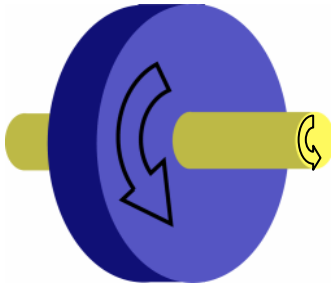


Wheels and axles

Wheels are devices that rotate around a central point known as the axis.

When a smaller wheel or a shaft is attached to the wheel through the axis, it is known as the axle. If the axle is unattached and the wheel rotates around it freely, it is known as a dead axle.



The blue wheel rotates around the yellow axle, causing it to rotate as well.

Wheels in Imagination Factory

There are two wheel exhibits in *Questacon Imagination Factory—Invent and Play*. They are:

- Wheel racer; and
- Weights and Wheels

How do wheels make life easier?

- Wheels **reduce friction** between an object and the ground so that objects can be moved around more easily. Imagine pushing a shopping cart that has no wheels!
- Wheel and axles can **magnify a force** because it takes less effort to turn the central axle by pushing along an attached wheel's edge. Larger steering wheels and dials

are easier to turn than smaller ones.

- Wheel and axles can **magnify a movement**. If you put effort into turning the central axle, you gain lots of movement as the edge of the attached wheel moves through a greater distance. Which horses on a merry-go-round would give you the longest ride, the ones on the inside of the track or the ones on the outside?

Quirky Fact

Log rolling (also known as log birling) is a sport that really gets you rolling. Two competitors stand on opposite ends of a log that is floating horizontally in the water. The log acts as a wheel that spins around. The object of the game is to roll the log so that you tip your competitor into the water without losing your own balance!

Everyday uses of wheels

Wheels have many functions besides moving cars or bikes along.

- Water wheels are used to generate electricity as the force of the large wheel is magnified at the axle, allowing the water wheel to drive machinery.
- The blades of wind turbines act as spokes of a large wheel, where the force of the blades is magnified at the rotor. This makes a generator spin and produce electric current.
- When you turn a screwdriver, you are magnifying the force of the turning handle at the screwdriver's shaft.
- A propeller pushes boats along as the spinning movement at the axle

is magnified at the propellor's blades.

- Ball bearings are spherical wheels that reduce friction. When you write with a ball-point pen, the power of wheels allows your pen (and ink) to glide across the page.

Wheels have undergone many refinements since they were first invented.

- Spoked wheels were invented so that wheels would be lighter.
- Rubber wheels were very useful inventions to smooth out a ride and absorb some of the shock as vehicles bounced along rough surfaces.
- Bicycles are often classed by their tyres – road bikes have thin tyres to reduce friction and allow the rider to go faster. Mountain bikes have thicker tyres for better grip.

Extras for experts – Working with wheels

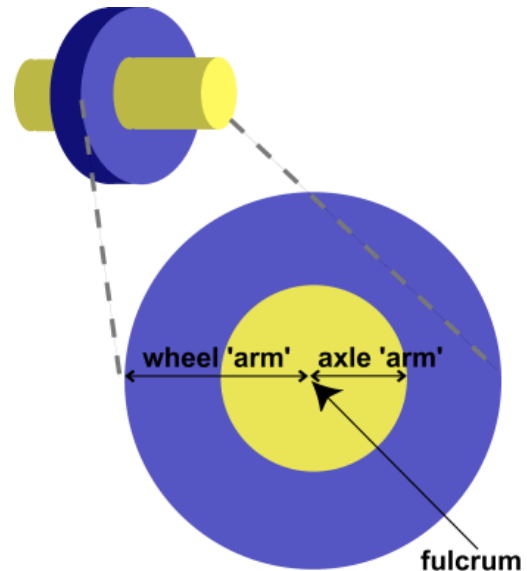
When a wheel and axle is used to magnify a movement or to magnify a force, you can think of the wheel and axle as a first-class lever with uneven arms.

The wheel's radius acts as one arm and the axle's radius acts as the other arm. The centre of the axle acts as the fulcrum.

If you put effort into rotating the wheel, the wheel acts as the effort arm. Because the wheel's radius is longer than the axle's radius, your effort arm is longer than your load arm. You have gained mechanical advantage.

However, if you rotate the axle instead, you are now using the axle as the effort arm! Because the effort arm is shorter than the load arm, you have lost

mechanical advantage, but have gained movement advantage.



Wheel and axles are rotary levers.

Examples for experts

Mechanical advantage

You can calculate the mechanical advantage of a wheel and axle by dividing the radius of the edge you are putting effort into rotating (effort radius) to the radius of the other edge that is rotating along with your push (load radius).

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

Suppose you have a wheel and axle system, where the wheel has a radius of 50 cm and the axle has a radius of 10 cm.

If you push from the wheel's edge, the mechanical advantage is:

$$= 50 / 10$$

$$= 5$$

If you push from the axle's edge, the mechanical advantage is:

$$= 10/50$$

$$= 1/5$$

The wheel now requires more force to push.

Need for speed

You can calculate movement advantage of a wheel by dividing the load radius by the effort radius. It is the inverse of the mechanical advantage!

Movement advantage =

Load Radius

Effort Radius

From the example above, when you push on the wheel's edge, the movement advantage is:

$$\text{MoA} = 10 / 50$$

$$= 1/5$$

The axle only moves one fifth of the distance that the corresponding part of the wheel's outer edge moves.

The Tumbling Tommy – An unusual Australian Invention

Everybody knows that you shouldn't sit beneath a bird unless you want a nasty surprise to land on your head! But if a bird does poo on you, at least you can wash your hair.

Life is much tougher for people who park their cars underneath bird resting spots (or should that be restroom spots?), as the acid in bird poo can peel away paint if it's not washed off quickly enough.

So Braidwood inventor Tom Edwards has invented the "Tumbling Tommy", a humane way to discourage birds from relieving themselves on inappropriate places.

In for a spin

The Tumbling Tommy works by taking birds for a ride. Have you ever seen parrots or cockatoos playing by somersaulting around a perch while clasp it with their feet? These birds enjoy spinning when they're in control but no bird enjoys sitting on a perch that just will not stop spinning!

The Tumbling Tommy consists of a long pipe placed lengthwise around a thin steel wire. You can think of the pipe as a long wheel that rotates around the wire, with the wire acting as the axle.

When the Tumbling Tommy is attached to a horizontal surface, a bird that tries to land on the surface will be forced to land on the Tumbling Tommy instead. As it lands, the bird's weight causes the pipe to start spinning.

At this point, the bird finds that the ground will not stop rolling beneath its feet! The frustrated bird, unable to get its balance, flies off to find a different place to perch, meaning that pooping problems are a thing of the past!

The Tumbling Tommy has been tested with in a seaside town and has been rated as pelican-proof.



Tom Edwards with the Tumbling Tommy. Photo used with permission from Tom Edwards.

The Trackaxle® – A wheel Australian Invention

“Do not overtake turning vehicle” – it’s a phrase that’s familiar to anybody who’s driven along behind a semi-trailer.

It might be annoying having to wait for a truck as it slowly turns a corner, but those red and yellow signs are very important for protecting other road users.

As they turn around corners, semi-trailers often have to use multiple lanes to allow their attached trailers enough room to go around the corner as well. Any car attempting to overtake the vehicle risks being hit by the truck or its trailer.

While it is sensible to obey the sign, many car drivers don’t, creating a stressful and dangerous situation for all involved.

The Trackaxle® is a new system of wheels that allows trucks to turn much tighter corners without needing to take up two lanes.

It’s the truck’s turn

Semi-trailers are trucks with two parts – the prime mover which is where the driver sits, and a trailer that is coupled to the back of the prime mover.

Standard trailers come with multiple wheels that are attached to a bogie (a frame for attaching wheels). The bogie is fixed so that it faces forwards.

A fixed bogie is useful for straight roads, but the inflexibility means that standard trailers have trouble with corners.

When the truck turns, the prime mover’s wheels make a large arc, while the standard trailer’s wheels follow a much smaller arc. The truck driver compensates for this by swinging the prime mover out in a wider arc to allow the trailer to follow. This is where the warning sign comes in handy!

The Trackaxle® uses a new system for the trailer’s rear wheels. The rear wheels are attached to a bogie that has a large pivot in the centre portion.

The bogie can pivot from left to right beneath the trailer as the truck turns a corner, following a path that is much closer to that of the prime mover’s wheels.

The driver does not have to swing the prime mover into such a wide arc, reducing the danger to other drivers.

Using a pivoting bogie also reduces wear on the trailer’s tyres. With Trackaxle®, the tyres pivot so that they face into the turn, unlike standard trailers, where the sides of the fixed tyres are put under pressure as the truck turns.

The benefit is that the amount of power needed to make a turn is reduced by up to 40%, meaning savings on fuel and time.



Computer rendering of a semi-trailer fitted with Trackaxle rear tyres. The rear tyres have turned so that they are facing the same direction as the prime mover’s tyres. Image used with permission from www.trackaxle.com.au.

On the straight and narrow

When on straight roads, the Trackaxle® bogie automatically locks so that it faces forwards, to avoid any issues with runaway trailers!



Background Support Notes



Australian Government
Department of Education,
Science and Training



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Previous attempts to make pivoting bogies have run into problems as the trucks have had troubles reversing. The pivoting bogie can turn the wrong way, causing the bogie to jack-knife beneath the trailer.

The Trackaxle[®] system overcomes this by allowing the driver to steer the rear bogie as it reverses. This prevents jack-knifing and also allows semi-trailers to reverse into tight spaces without strenuous manoeuvring.

- New Inventors - <http://www.abc.net.au/tv/newinventors/txt/s1431219.htm>

Find out more

About Wheels:

- *The New Way Things Work*. David Macaulay. 1998. 30-35.
- *Hands-On Physics Activities with real-life applications*. James Cunningham and Norman Herr. 1994. 347-8.
- University of Arkansas Simple Machines information sheet- <http://www.uark.edu/depts/aeedhp/agscience/simpmach.htm>
- Washington State University, Torque makes the wheel go 'round! <http://www.wsu.edu/~jtd/Physics205/Chap9/Torque.htm>

About the Tumbling Tommy:

- New Inventors – <http://www.abc.net.au/tv/newinventors/txt/s1571378.htm>

About the Trackaxle[®]:

- Trackaxle[®] homepage - <http://www.trackaxle.com.au>
- Radio Australia Innovations interview - <http://www.abc.net.au/ra/innovations/stories/s1672216.htm>