

# Grade 8 Science

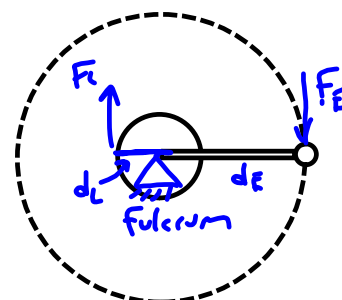
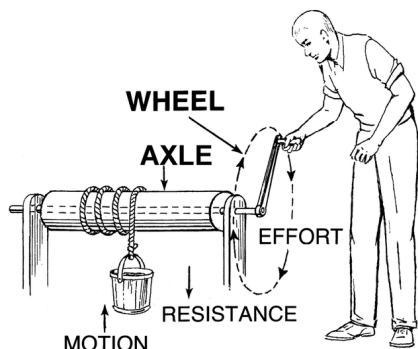
## Unit 4: Systems in Action

### Machines That Turn

Last class we looked at the idea of a boat winch, a wheel and axle used to get a boat out of the water, onto a trailer. You rotate the handle (wheel), which is connected to the cylinder holding the cable or strap (axle). This allows you to pull the boat in with a larger force than you would be able to produce manually.



To understand why this works, let's take a closer look at a wheel and axle:



# Machines That Turn

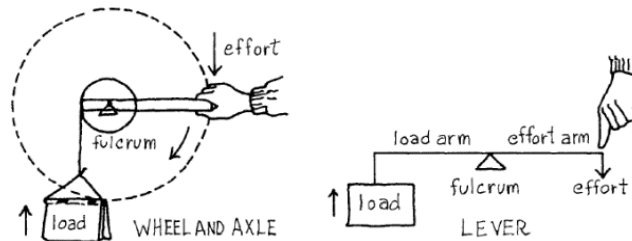
The comparison on the previous page shows us that a wheel and axle functions in the exact same manner as a lever. The advantage is, however, that the distance over which a wheel and axle may be used is much larger than that of a lever.

Recall that the mechanical advantage of a wheel (the part you turn) and axle (the part that gets turned) is:

$$IMA = \frac{\text{Diameter of Wheel}}{\text{Diameter of Axle}}$$

← Note: You can also use radius or circumference

The diagram below shows why this equation makes sense, being that we understand the mechanical advantage of levers.



# Machines That Turn

Can you think of more things that use a wheel and axle to produce a mechanical advantage?

- Door Knob
- Key and Lock
- Steering Wheel
- Faucet
- Propellor
- Clock
- Water Wheel
- Fan
- Spinning Chair
- Windmill
- Crane
- Wind up Toy
- Radio Dial
- Fishing reel
- Washing machine
- etc.

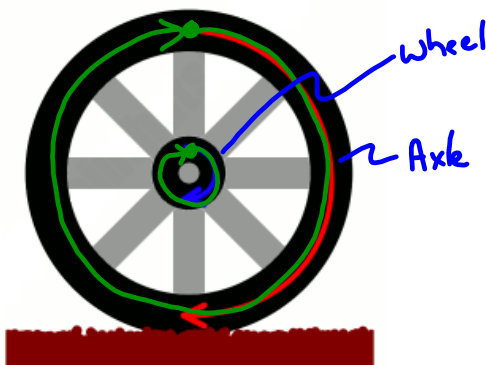
If you have an idea, come write it on the board.



# Machines That Turn

Mechanical Advantage is not always the desired outcome from a wheel and axle. Like a class three lever, if a smaller wheel is used to turn a large axle, you can increase the speed with which something is moving.

Look at the diagram below. Knowing that this is used to increase speed, can someone please come up and label the "wheel" and the "axle?" Think carefully about how we have defined those two words.



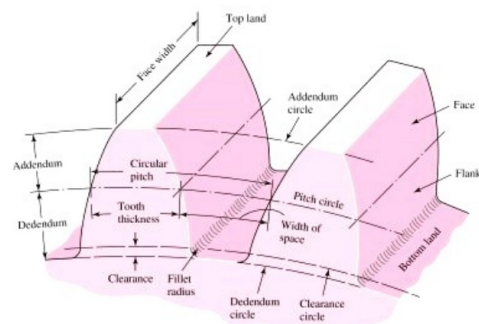
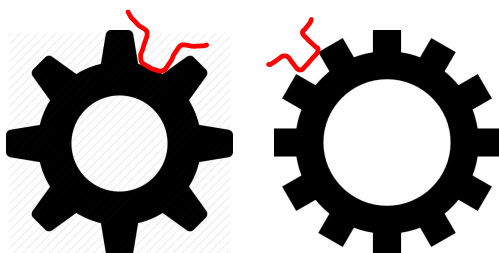
Based on the diagram, can you explain how this is used to increase speed?

Both the wheel (blue) and axle (red), have to rotate a full circle in the same amount of time. However, the axle has to go significantly further in that same amount of time, therefore it travels faster.

# Gears

A wheel and axle is a simple machine that has parts that rotate, but those parts are attached about their centre, they are on the same axis. Gears, like the wheel and axle, use rotation, but they transfer the rotation to a different axis, the gears are not attached, they use teeth that mesh together.

The teeth on gears are very specifically designed. Their shape is one that allows them to be in contact with each other for as long as possible, but yet they do not cause an obstacle for rotation. Compare the following two pictures:



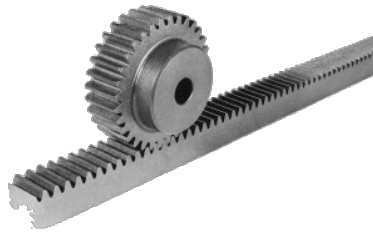
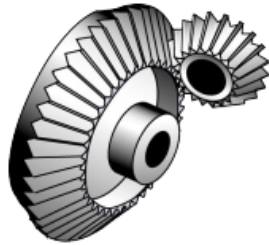
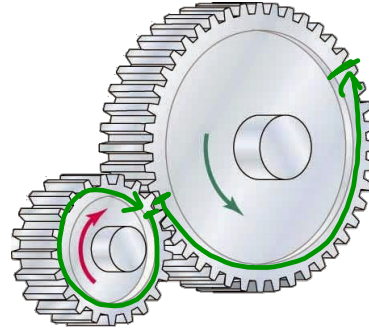
# Gears

Similar to the wheel and axle, gears can be used to increase force (increase torque, increase mechanical advantage) or increase speed. They can also be used to change the direction or type of the force.

Which gear do you turn to gain an increase in speed?

Why would this work?

What if you turned the other gear?



# Gears

The mechanical advantage of gears is more complicated to understand than other examples, as it involves looking at torque, which we will not cover in grade 8.

Instead, we will look at velocity ratio. First, we need to define the gears involved. The gear that you turn is called the "driver." The gear that turns as a result of the driver turning is called the "follower." Velocity ratio tells you how much faster the follower will turn than the driver. It is calculated as follows:

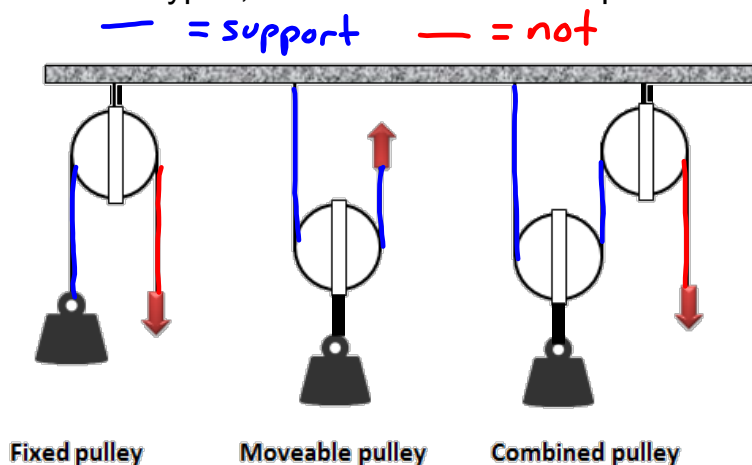
$$\text{Velocity Ratio} = \frac{\text{Diameter of Driver}}{\text{Diameter of Follower}}$$

Alternatively, because of the carefully calculated way in which the teeth of gears are designed, you can also calculate velocity ratio by counting how many teeth are on the gears:

$$\text{Velocity Ratio} = \frac{\text{Number of Driver Teeth}}{\text{Number of Follower Teeth}}$$

# Pulley

The final simple machine we will look at in this unit is the pulley. A pulley can be used to both change the direction of a force, or to provide a mechanical advantage. To gain mechanical advantage, a pulley system needs to be used. This involves using a variety of pulleys, potentially of different types, to reduce the force required.



When you look at defining a pulley system you have to look at how many ropes support the load. A support rope is any rope that helps hold the load. A rope being pulled can also be a support rope (if pulled in the direction of movement.)

# Pulleys

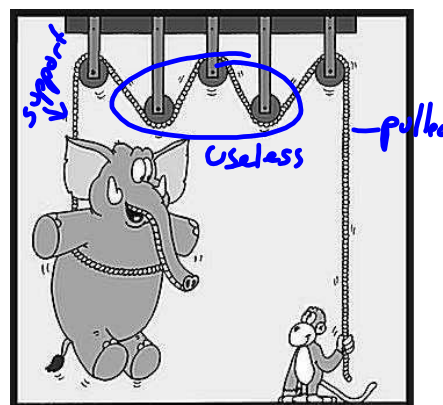
Mechanical advantage is a calculation of how much force you get from a machine divided by what you put into the machine. The way this is determined for a pulley system is by looking at the number of ropes involved:

$$IMA = \frac{\text{Number of Support Ropes}}{\text{Number of Ropes Being Pulled}}$$

In grade 4 you studied pulleys and gears. When I taught that unit, I put the following comic on the end of unit test, and the questions read: "Please explain what is wrong, relating to pulleys, about this comic."

What are your thoughts?

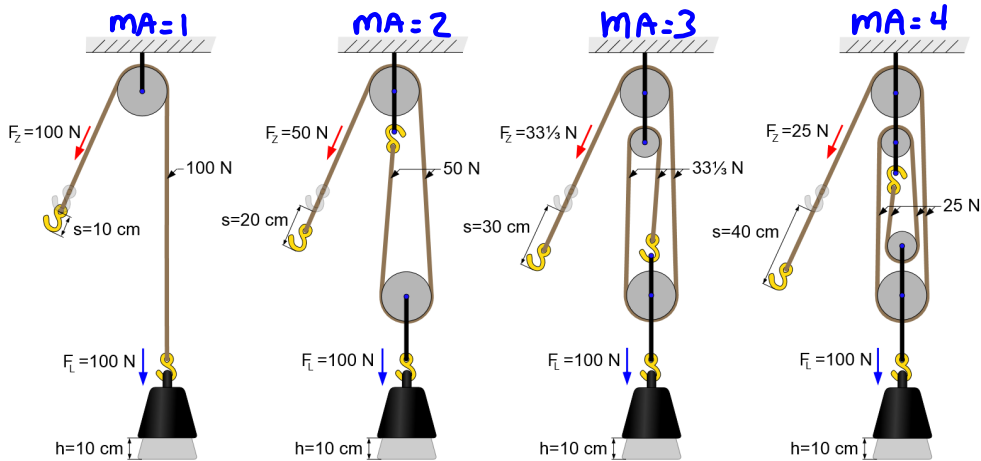
$$MA = 1$$



# Pulleys

Let's have a look at a few pulley systems.

- What is the mechanical advantage of each?
- What is the disadvantage as you gain mechanical advantage?
- Is there something that could be done to deal with this issue?



Please bring a calculator next class.