Playing with machines

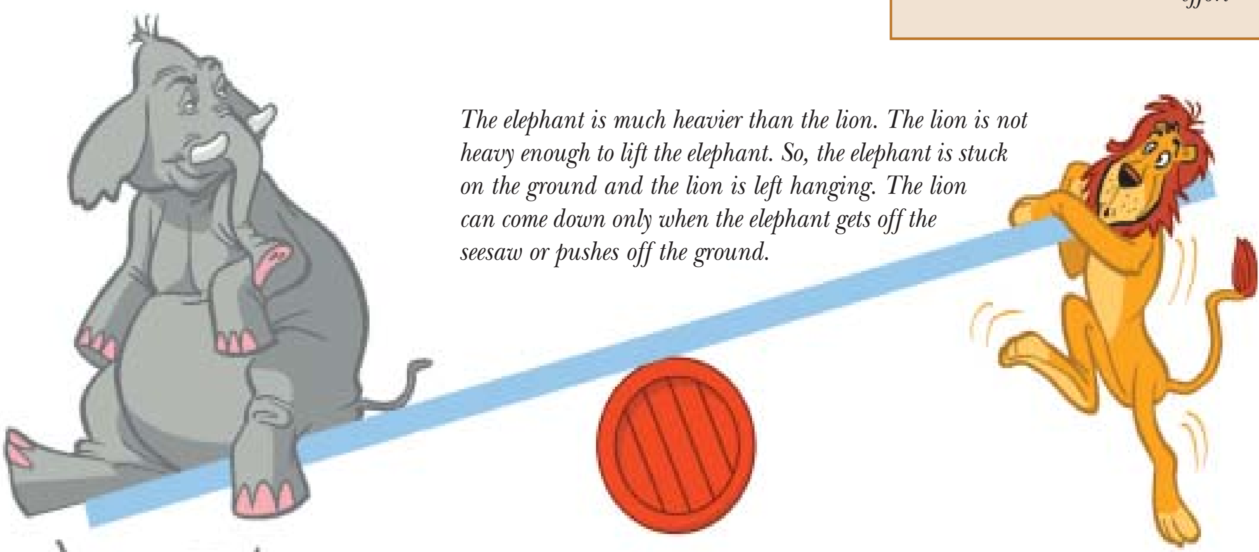
A seesaw can be a lot of fun if the two people on it are about the same size. A seesaw works best this way because both people need to apply the same **effort** to make the seesaw work. On an unbalanced seesaw, one person is left to do all the work.

Placing the fulcrum

A seesaw is a special type of **first-class lever**. The **fulcrum** of a seesaw is usually exactly in the middle of the effort and the **load**. The two people on a seesaw take turns in being the effort and the load, depending on their movement. First-class levers are **force multipliers**, so a small person *should* be able to lift a larger person on a seesaw without using much effort.

Mechanical advantage measures how much easier a lever makes a task. Mechanical advantage is calculated by dividing the load by the effort. In the example of the seesaw, the effort of the lion was able to lift the elephant. The mechanical advantage in this case is the weight of the elephant divided by the weight of the lion.

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$$



The elephant is much heavier than the lion. The lion is not heavy enough to lift the elephant. So, the elephant is stuck on the ground and the lion is left hanging. The lion can come down only when the elephant gets off the seesaw or pushes off the ground.

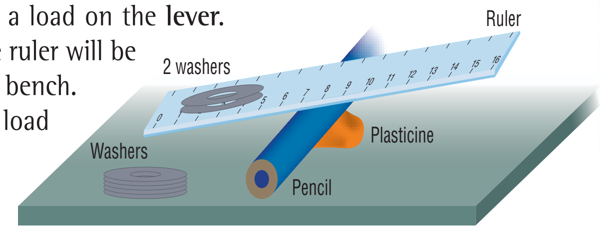
The fulcrum is closer to the elephant than the lion. The lion's effort is now multiplied, so the two animals are balanced on this seesaw. Both animals need to apply the same effort to move the seesaw up and down. Each animal takes turns pushing off the ground to make the seesaw work properly.

Go to worksheet 11

Balancing a lever

You will need:
30 cm ruler
pencil or triangular piece of wood in the shape of a prism
plasticine
6 identical washers.

- Set up the ruler with the pencil or wood as a fulcrum. The fulcrum needs to be exactly in the centre of the ruler.
- Use the plasticine to attach the pencil to the bench.
- Place two of the washers 5 cm from the fulcrum. These washers act as a load on the **lever**. The end of the ruler will be resting on the bench.



- Try lifting the load by using two washers placed close to the fulcrum. Slide the washers away from the fulcrum in the opposite direction of the load, until they *just* lift the load. These washers act as the effort in the lever system. What is the closest distance between the effort and the fulcrum that allows you to lift the load washers?

Record your results in a table like this one:

Number of washers used as the load	2	2	3	4
Distance between the load and the fulcrum (cm)	5	5	5	5
Number of washers used as the effort	2	1	1	2
Distance between the effort and the fulcrum (cm)				
Mechanical advantage (load/effort)				

- Remove the two effort washers. Now use just one of the washers to lift the original two load washers. Record the smallest distance between the effort and the fulcrum that allows you to *just* lift the load washers.
- Predict where a washer needs to be placed if the load is increased to three washers. Record your prediction.

1. Test your prediction and record your results.

- Increase the load to four washers. Use two washers as the effort to just lift the load. Record your results.

2. Look for patterns in your table of results. Write a simple rule that explains how to place the effort washers so that they *just* lift the load washers.
3. Predict the largest load that you could lift with an effort of just one washer. Borrow some identical washers from another group and test your prediction.
4. Was your prediction correct? If not, explain why.
5. What happens to mechanical advantage when the distance between the effort and the fulcrum is increased?

Activities

REMEMBER

1. True or false?
   (a) First-class levers have the load between the fulcrum and the effort.
   (b) Levers are better force multipliers when the fulcrum is closest to the load.
   (c) Only people of the same size can balance out a seesaw.

THINK

2. (a) Calculate the mechanical advantage of a seesaw that allows a 40 kg person to lift a 60 kg person.
   (b) Draw a scaled diagram to show how these two people can balance a 6 m long seesaw.
3. Explain how the distance between the fulcrum and the effort affects the mechanical advantage of a lever.

CREATE

4. Draw or design a piece of playground equipment that makes use of at least one lever. Be sure to label the fulcrum, load and effort.

CONNECT

5. Go to www.jaconline.com.au/science/weblinks and click on the Balancing Frogs link for this textbook to balance some frogs on a seesaw.

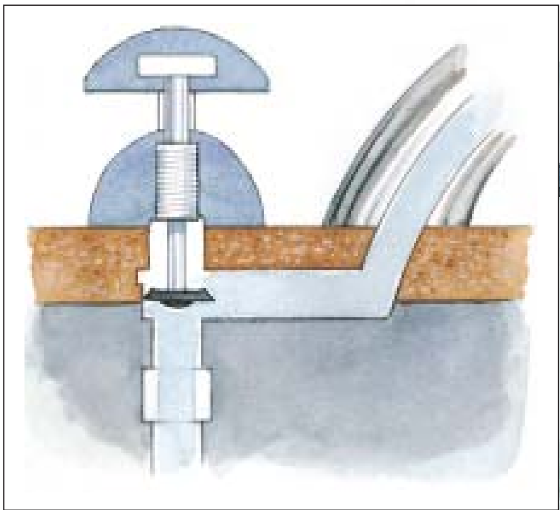
checklist

I can:
- ☐ understand what occurs if the fulcrum is moved
- ☐ relate the mechanical advantage of a lever to the distances between the effort, fulcrum and load.

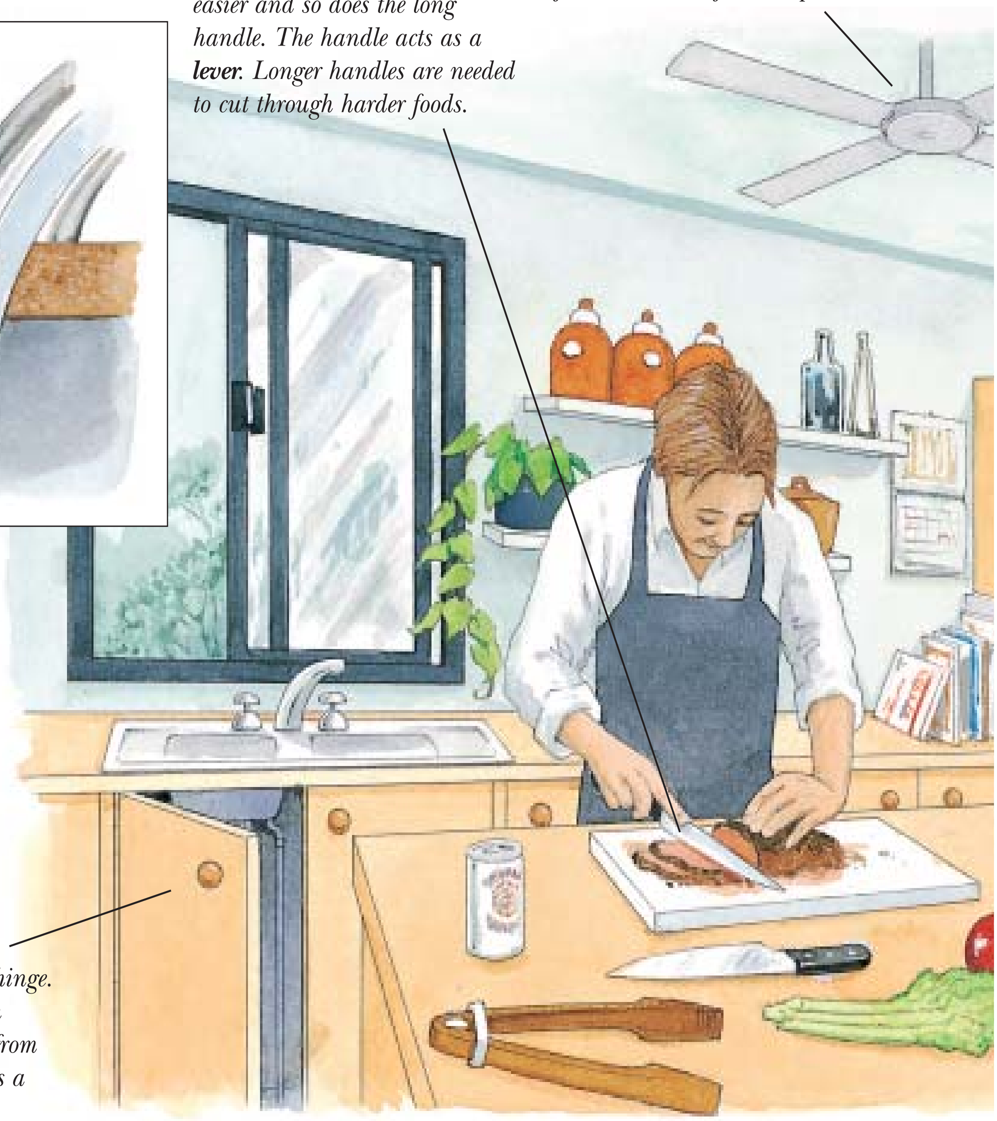
Checkpoint

Machines in the kitchen

Even some everyday items in the kitchen are simple machines. Without them, we'd find certain tasks almost impossible — like slicing a piece of meat, prising the lid off a coffee tin or stopping the flow of water into the sink. Kitchen machines can be used to multiply our effort. Tap handles and can openers are examples of **force multipliers** in our homes. Other machines, like eggbeaters, speed up our **effort**. Eggbeaters also change the direction of our effort.



Taps are wheels and axles. Larger tap handles are easier to turn than smaller ones. When the handle is turned, the axle turns, moving a small washer inside the tap to let the water flow through it.



*The blade of a knife is a sharp **wedge**. It makes chopping much easier and so does the long handle. The handle acts as a **lever**. Longer handles are needed to cut through harder foods.*

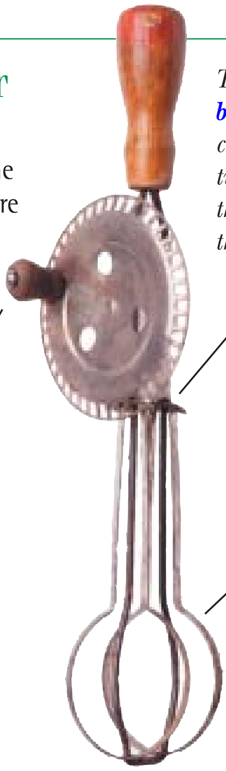
*A ceiling fan is a speed-multiplying **wheel** and **axle**. Electricity is used to apply a huge effort to the small axle in the fan's shaft. The fast-spinning blades form the wheel of the simple machine.*

*Try closing a door by pushing it close to the hinge. It is much harder than closing the same door from the handle. The door is a **second-class lever**.*

HOW IT WORKS

The eggbeater

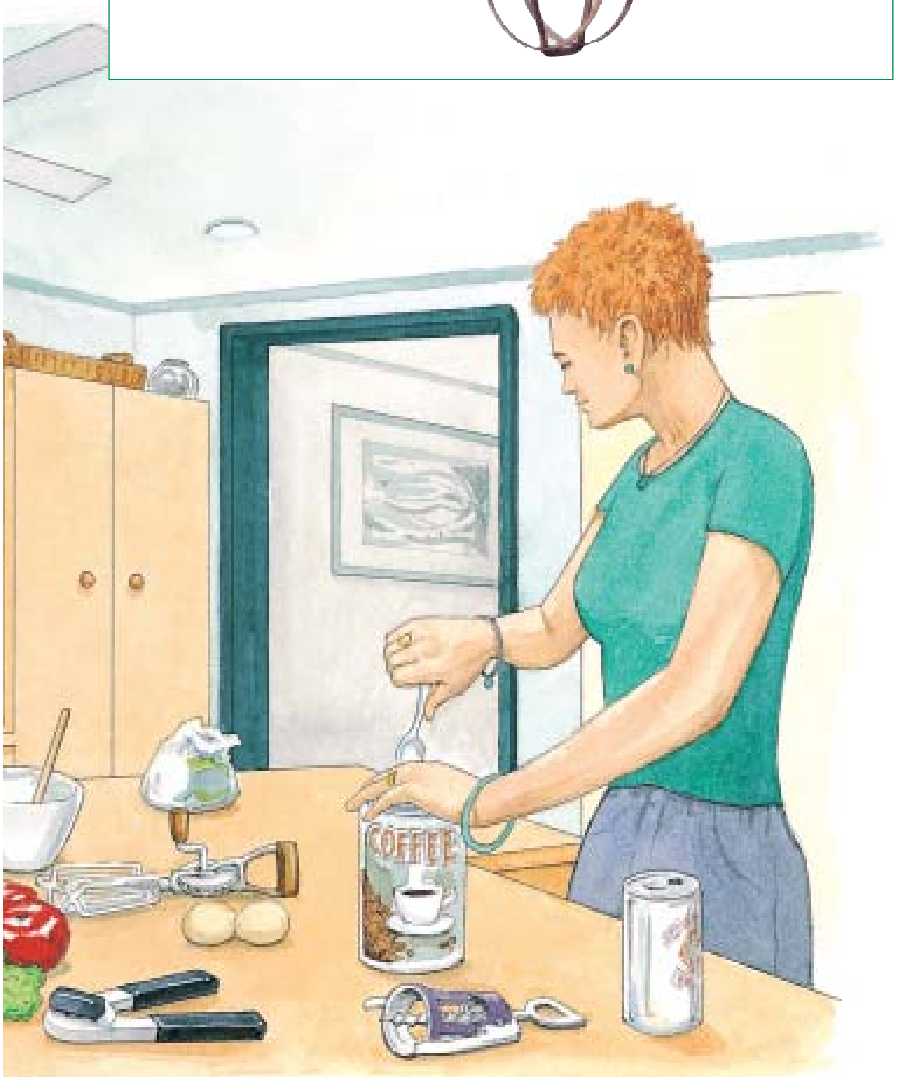
Eggbeaters are **compound machines.** The gears used in eggbeaters are designed to change the direction of the effort. They also act as **speed multipliers,** making it easy to turn the beaters quickly.



These gears are ***bevelled gears****. They change the vertical turn of the handle into the horizontal spin of the beaters.*

This handle turns in a big circle. It makes the smaller bevelled gears turn with greater speed.

The beaters spin much faster than the handle turns.



Go to worksheet 15

MI VERBAL/LINGUISTIC

Activities

SEARCH

1. Look carefully at the kitchen scene on this page. List the objects that work as simple machines. For each object, describe the simple machine and how the machine creates an advantage.

REMEMBER

2. Why are bigger tap handles easier to turn than smaller ones?
3. Label the effort, **fulcrum** and **load** on the cupboard door.
4. What class of lever is the knife when you are chopping?
5. What are bevelled gears?

THINK

6. The tap uses more than one simple machine. By looking at the diagram, find one other simple machine inside the tap. Describe how it works as a simple machine.

OBSERVE

7. Take a close look at this corkscrew. List at least three simple machines that work together in a corkscrew. Explain how they work together.

✓ checklist

I can:

- ☐ describe how bevelled gears work
- ☐ explain how some simple machines work together in compound machines.

Checkpoint