Forces 8

Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117).

- ★ Investigate the effects of applying different forces to familiar objects.
- ★ Investigate common situations where forces are balanced, such as stationary objects, and unbalanced, such as falling objects.
- ★ Investigate a simple machine such as lever or pulley system.

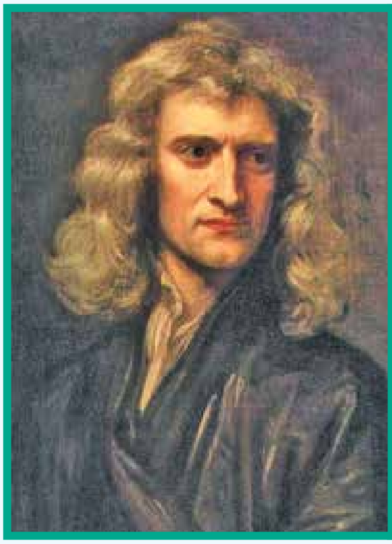
A Task

The fence behind the Angus cattle needs removing. The ground is too boggy to get a tractor near the posts.

Design a simple machine to get the steel posts out of the ground.

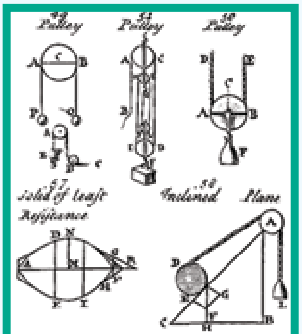
Sketch your simple machine (including forces).

Little Jay is showing you a close up of a steel post. The barbed wire will be taken off first.



Newton (1642-1727) was one of the greatest mathematicians/physicists of all time. Only a few relevant achievements are listed here.

- Theory of gravitation: Every particle of matter attracts every other particle of matter.
- White light is made up of colours mixed together. This explains the colours of the rainbow.
- Newton invented the reflecting telescope.

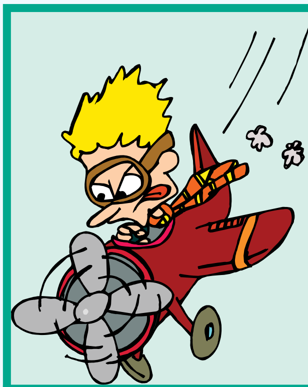


Simple machines, 1728

8.1 Applying forces

A 'throw-in' involves a **push** on the ball.

A force can be a push, a pull, or a twist.



A 'dive' involves a **pull** from the propellor, and a **pull** from gravity, on the plane.

Forces

Forces are everywhere in the universe.

Almost every aspect of our everyday life involves thousands of examples of applying forces.
Only by applying forces can we move around.

Forces can be massive, and involve non-contact, such as the pull of the Sun on our planet, Earth.

Examples of non-contact forces are gravity, electricity, magnetism, microwaves, light waves, radio waves, X-rays, nuclear forces.

Forces can be relatively small, and involve contact, such as using your finger to push your ruler along the top of your desk.

Contact forces occur whenever there is force at the point of contact between two objects. Friction is a very common contact force.

Opening the can involves a **twist** on the can opener.

I'm reading a book about anti-gravity. It's impossible to put down.

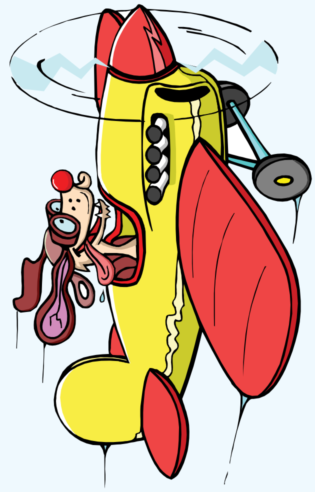
Exercise

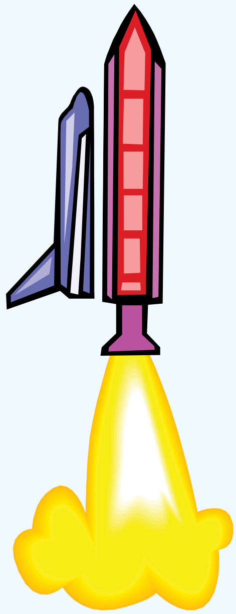
1 Use verbs such as push, pull, or twist to describe the forces applied in each of the diagrams.

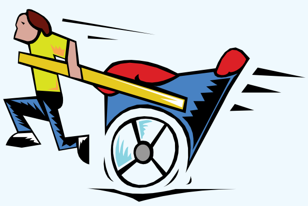
2 There are 10 examples of the effects of applied forces on this page. Your turn to provide 10 examples of applied forces in everyday life.

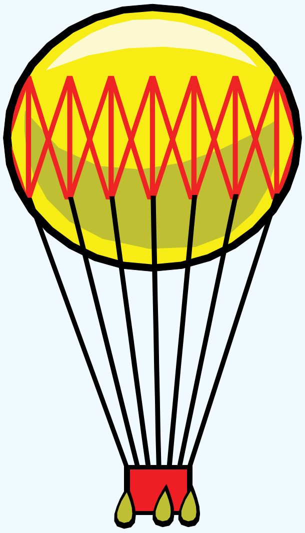
3 How many examples of non-contact forces can you find on this page?

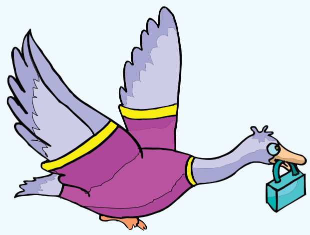
4 How many examples on this page involve friction?

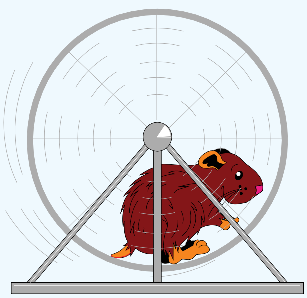












Challenge

Does a force always cause something to move, or change shape?

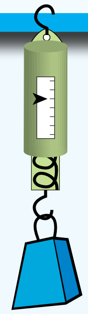
Measuring force

Forces can be measured using a force meter.

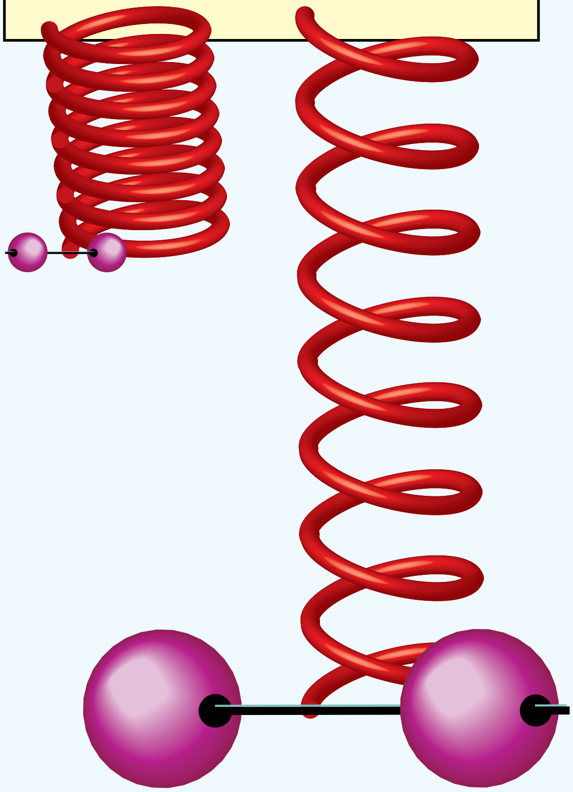
Extension meters measure the size of the pull.

Compression meters measure the size of the push.

Torsion meters measure the size of the twist.



It takes more and more force to stretch a spring further and further.



The SI System

The Systeme International D'unites (SI) is the world's most widely used measurement system. The SI system is a metric system (base 10).

The SI unit for length is the metre.

The SI unit for time is the second.

The SI unit for **force** is the **Newton**.

A meter is a device for measuring.
A metre is the SI unit of length.

The Newton

The size of a force is measured in Newtons (N).

A mass of 1 kg pushes down, due to gravity, with a force of 9.8 N.

This means that a mass of 1 kg is attracted to the Earth with a force of 9.8 N.

Without gravity, the attraction between the mass and the Earth, the mass would float off into space.

Exercise

1 What is the SI unit of force?

2 What is the SI unit of length?

3 What is the SI unit of mass?

4 Name an instrument for measuring push.

5 What is the difference between meter and metre?

6 What is the difference between an extension meter and a torsion meter?

Gravity

Gravity is the force of attraction between two objects.

A mass of 1 kg on Earth: The force of attraction between the mass of 1 kg and our Earth is 9.8 N.

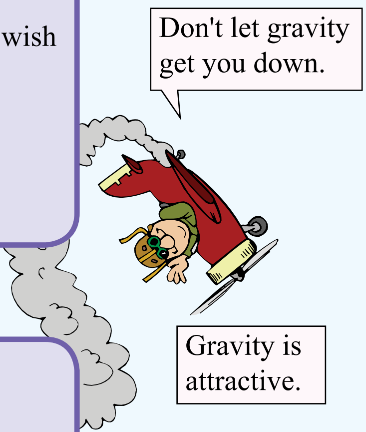
A mass of 1 kg on the Moon: The force of attraction between the mass of 1 kg and the moon is 1.63 N.

Activity

Force meter

Design and make a force meter based on a rubber band.

Other materials that you may wish to use are:
- paper clips.
- sticky tape.
- toilet rolls.
- cotton thread.



Exercise

1. What is gravity?
2. Why is gravity on the Moon less than gravity on Earth?
3. Is gravity a pull or push force?
4. Is gravity the same throughout the universe? Explain.
5. Is mass the same throughout the universe? Explain.
5. The gravity on the Moon is 1/6 that of the Earth. Can you deduce something about the mass of the Moon?
6. Explain how an anti-gravity device might work?

Activity

Force meter

Calibrate your force meter so that it measures Newtons.

Probably the easiest way is to use a spring balance from school. How?

A bit of trivia

- Objects with mass attract each other. This attraction is called gravity.
- Tides are caused by the attraction between our seas and the Moon.
- A 1 kg mass 100 km above Earth has a gravitational force of 9.5 N (Not much less than the surface of the Earth).

Challenge

Force due to gravity on Earth
$F = ma$ $\{a = 9.8\ m/s^2\}$

Example:
The gravitational force of 1 kg
$F = ma$
$F = 1 \times 9.8$ Newtons
$= 9.8$ N

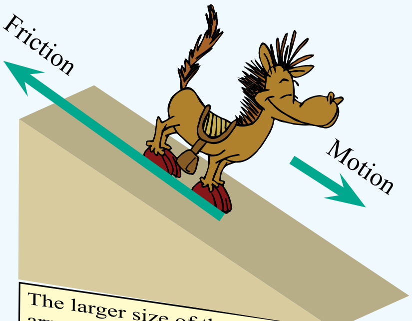
What is the gravitational force of a person of mass 45 kg?

Find out more about torsion meters.

Friction

Friction is a force of resistance.
The SI unit of friction is Newtons.

Forces can be shown as arrows. The length of the arrow can indicate the size of the force.



Friction

Friction is a force of resistance.

Friction is a force resisting motion along the contact surface of two objects.

Frictional force is opposite to the direction of motion.

Experiment with friction online. Search for 'interactive friction'.

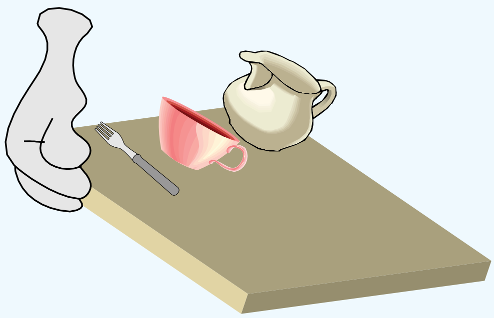
Activity

Friction

Do different surfaces mean different forces of resistance?

1. Collect a variety of objects.
2. Gather some flat surfaces such as wood, cutting board, pizza dish.
3. Put the first objects on one end of one of the flat surfaces.
4. Gradually raise the flat surface.
5. Repeat with the other flat surfaces.

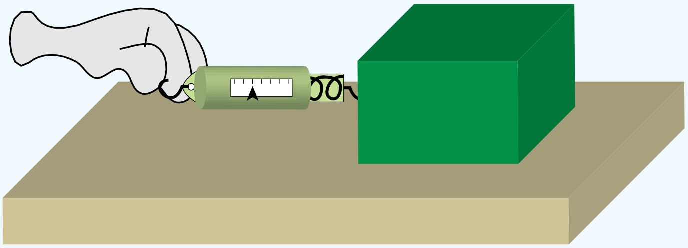
Can you explain your results?



Activity

Measure friction

1. Collect a variety of objects.
2. Use a spring balance (showing Newtons) to evenly pull an object along a flat surface.
3. Record your results.
4. If you wanted as large a friction as possible, what could you do?



Friction opposes motion, wears away the contact surfaces, and generates heat.

Friction is a drag.

Useful Friction

Friction is a force of resistance.

Friction allows you to walk. Try walking with little or no friction - such as on ice.

Brakes on bikes and cars use friction to stop. Try stopping your bike without using any kind of friction.

Friction can cause wanted heat - microwaves, fridges, heat pumps, air conditioners.

Problem Friction

Friction is a force of resistance.

Friction will slow motion - cars/trucks use a lot of fuel overcoming friction including air resistance.

Friction will wear away surfaces - car tyres wear out and are expensive to replace.

Friction will cause unwanted heat - computer processors generate heat, due to friction, that can harm the processor.

A computer processor. It will generate a lot of heat in a computer.

A bit of trivia

- Rub your hands together and friction causes heat. Rub them harder and faster to get more heat.
- Microwaves heat food by frictional movement.
- Fridges and air conditioners work by compressing fluid - this frictional compression causes heat which is removed. The fluid is thus cooler.

Take a 'computer tour' to see where the processor is in a computer and to see how the heat is removed.

As heat increases in brakes, the stopping power reduces. This is called **brake fade**. Research 'brake fade'.

Watch some 'Friction videos.'

Watch some 'air resistance videos'.

Exercise

1 Give five examples of surfaces that have very little friction.

2 Give five examples of surfaces that have large friction.

3 Give three examples where friction is useful.

4 Give three examples where friction is a problem.

5 Friction will slow motion. Suggest two ways in which cars can be modified to reduce air resistance.

6 Friction will wear away surfaces. Suggest two ways in which friction between surfaces can be reduced.

7 Friction will generate heat. Suggest two ways of stopping computer processors from overheating.

8 Cars with underinflated tyres use more fuel. Why?

Magnetic forces

Magnetic force is a non-contact force.
Magnets can push or pull without touching.

A magnet pulls on objects made of iron, nickel, and cobalt.

A magnet can pull or push other magnets.

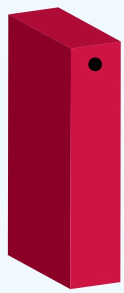
Magnets

Magnetic fields are invisible.

When magnetic material is in the field it will experience a pull or push.

The closer the magnetic material to the magnet the stronger the force.

A magnet has a north pole and a south pole.

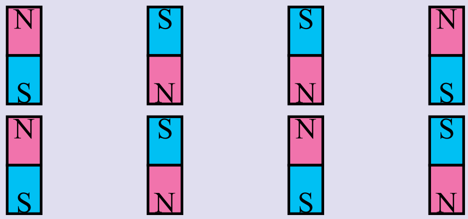


The north pole is marked with a N or a dot.

Activity

Magnets pull and push?

1. Get two magnets and note which end is north and which end is south.
2. Arrange the magnets as below and note whether they pull or push each other.



3. When do magnets pull each other? When do magnets push each other?

Activity

Magnetic field - what does it look like?

1. Cover a magnet with paper or clear plastic. Make the cover level.
2. Carefully sprinkle iron filings over the cover. Gently tap the cover.
3. Photograph or draw your result. Compare it with other groups.
4. Experiment with two magnets.
   Experiment with a horseshoe magnet.
   Experiment with different shaped fridge magnets.
   Can you think of other experiments?

Experiment with magnets.
Search for 'interactive magnet'.

Challenge

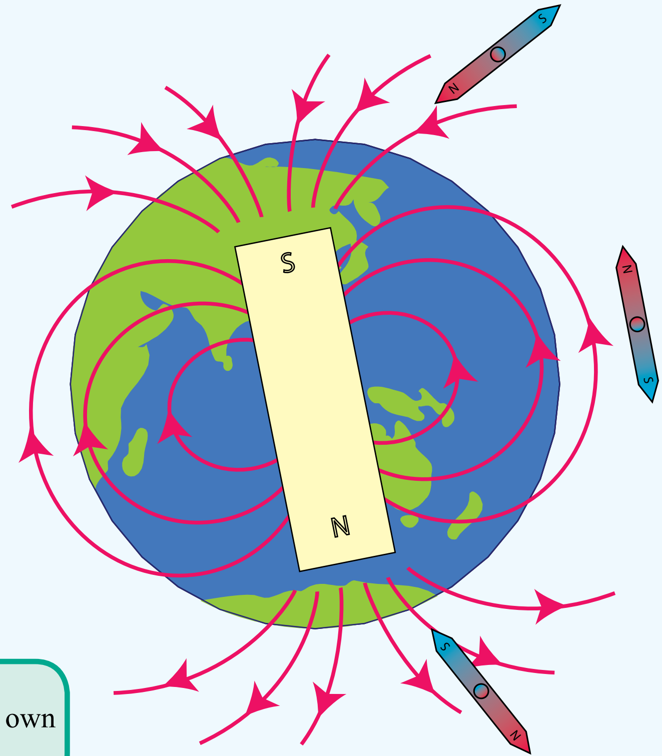
Design and make an instrument to measure the magnetic strength of a magnet.

Earth's Magnetic Field

It has been known for centuries that a magnetic rock, suspended by a thread, will line up in a north-south direction.

Compasses are used for navigation.

The Earth's magnetic field protects us from a stream of charged particles from the Sun called the solar wind.



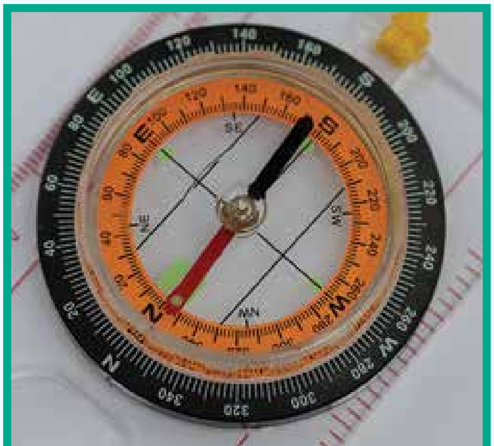
Magnet trivia

- There is not a huge bar magnet in the Earth. The magnetic field comes from molten iron alloys in the Earth's core.
- Electromagnets are found everywhere in motors, computers, video machines, alarms, etc.

Make your own compass.

Make an electromagnet.

Investigate orienteering.

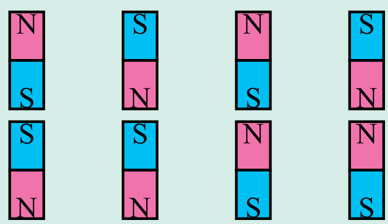


An orienteering compass. The red needle points to magnetic north.

Exercise

1. Name the two poles on a magnet.
2. Sketch the magnetic field of a magnet.
3. Which of the following statements is correct?
   a) Like poles attract and unlike poles repel.
   b) Like poles repel and unlike poles attract.
4. Indicate whether the magnets will attract or repel each other.

a) **b)** **c)** **d)**



5. The Earth's north pole is represented by a magnet with a S pole. How come?
6. Explain how a compass works.
7. Can you make a list of 10 everyday applications of an electromagnet?

8.2 Balanced forces

Forces can be shown as arrows. The length of the arrow can indicate the size of the force.

Balanced Forces

Forces on an object are balanced when:

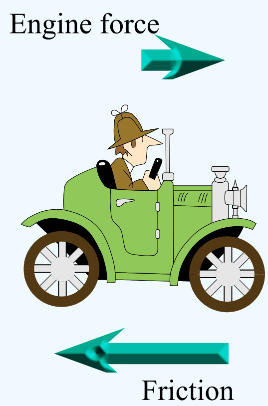
- the object is not moving.
- the object is not getting faster.
- the object is not getting slower.
- the object is not changing direction.
- the object is not changing shape.

Don't expect me to stay still for too much longer.

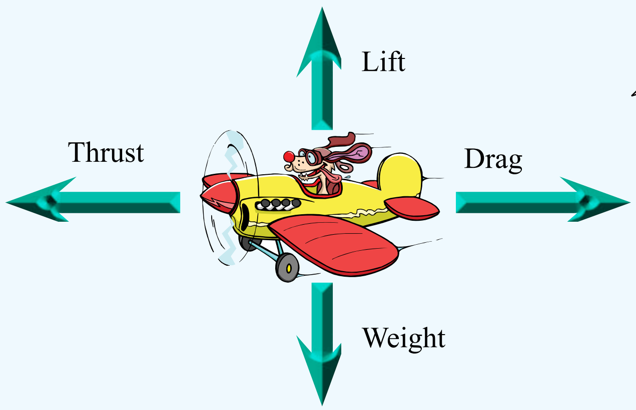
The pull of gravity down is balanced by the push of the ground up.

Engine force greater than friction. The car is getting faster.

Engine force **balanced** by friction. The car is at a constant speed.



Engine force less than friction. The car is getting slower.



Drag, air resistance, and friction are the same things. They oppose motion.

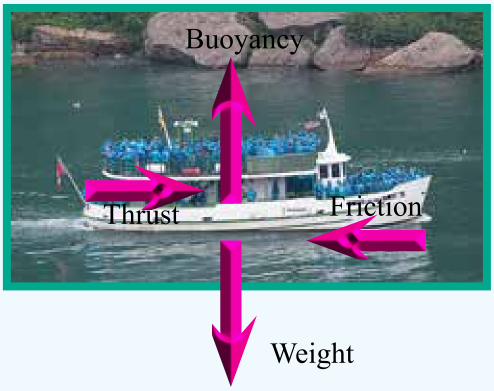
The plane is at a constant height (The gravity is **balanced** by the lift).

The plane has a constant speed (The drag is **balanced** by the thrust).

Forces in Water

A ship, surfboard, life jacket, etc will float on water because of **buoyancy**.

Water has a 'skin' on its surface called **surface tension**. This skin is strong enough to support insects such as pond skaters. A water drop forms its shape because of surface tension.



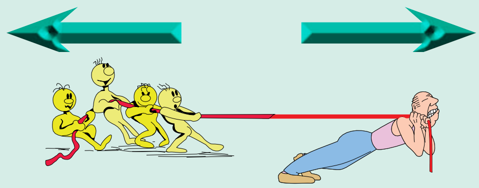
Water drops on a leaf. Surface tension is pulling tight on the 'skin' of the drop producing a spherical shape.

How do aircraft wings, moving through the air, create lift?

Exercise

1 How do you know when forces are balanced?

2 The tug of war is a tie. How do the force arrows suggest that the forces are balanced?



3 The chair is stationary.
a) Label the forces.
b) Are the force arrows correct? Explain.

4 Make a rough copy of the swing and add forces.

5 Make a rough sketch of a desk on the classroom floor. Add forces.

Challenge

Can you get a magnetised pin to float on water.

Challenge

The shape of a water drop?

Can you get a photograph of a drop just as it leaves a tap?

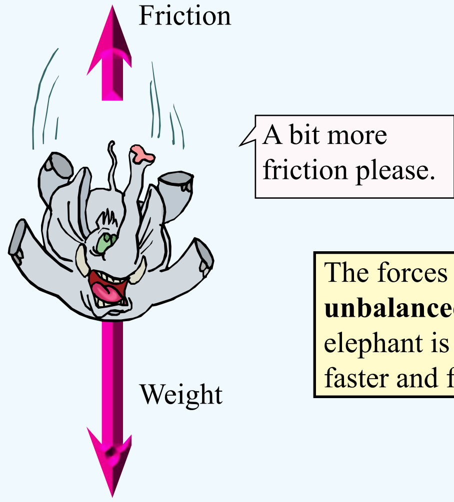
Can you get a photograph of a drop of water as it falls through the air?

8.3 Unbalanced forces

Unbalanced Forces

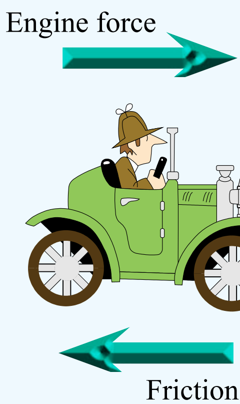
Forces on an object are unbalanced when:

- the object is getting faster.
- the object is getting slower.
- the object is changing direction.
- the object is changing shape.

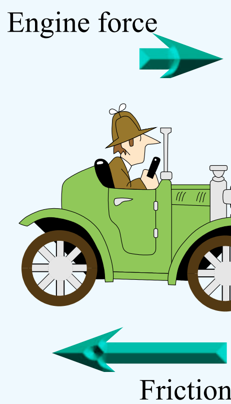


The forces are **unbalanced**. The elephant is falling faster and faster.

Unbalanced
Engine force greater than friction. The car is getting faster.



Balanced
Engine force **equals** frictional force. The car is at a constant speed.



Unbalanced
Engine force less than friction. The car is getting slower.

Challenge

A coin is dropped from a tall building.

It gets faster and faster.

Will it seriously hurt someone on the ground?

I Make a toy parachute. Experiment with it.

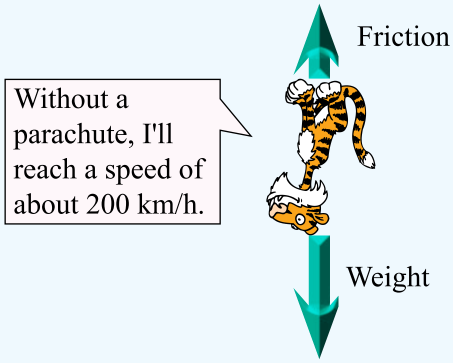
I Investigate 'terminal velocity'.

Challenge

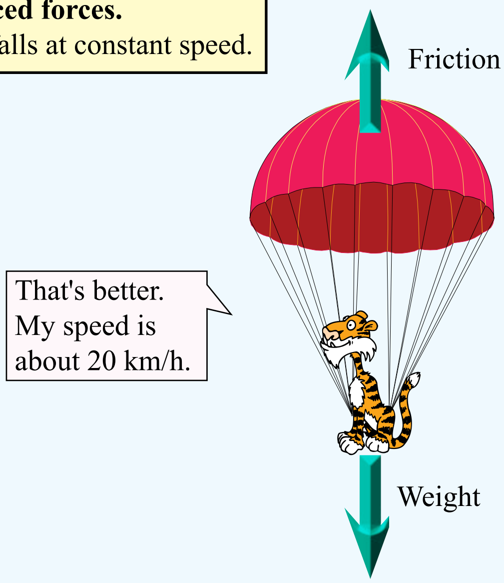
Drop a tennis ball and a shot put from the top of a tall building at the same time.

Which hits the ground first?

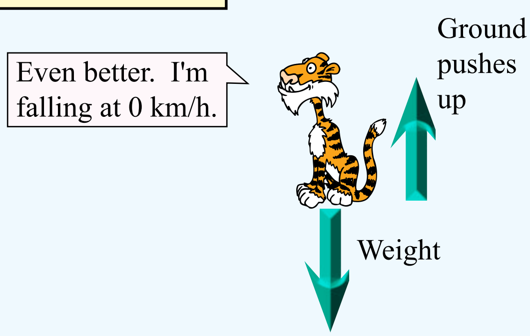
1 Tiger jumps from plane.
Unbalanced forces.
Tiger falls faster and faster.



2 Tiger uses parachute.
Balanced forces.
Tiger falls at constant speed.



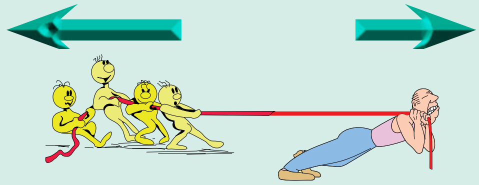
3 Tiger on ground.
Balanced forces.
Tiger is still.



Exercise

1 How do you know when forces are unbalanced?

2 How do the force arrows indicate who will win the tug of war?



3 A car slows down. Explain why the forces must be unbalanced.

4 What two forces act on a falling object?

5 A stone is falling through the air. Label the forces.

6 Make a rough sketch of the following hot air balloon. The three vertical forces acting on the balloon are weight, buoyancy, and friction (opposite direction of motion).

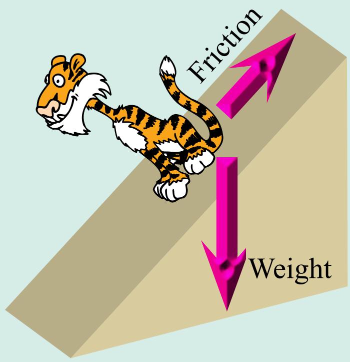
Add forces assuming:

a) The balloon is rising faster and faster

b) The balloon is falling faster and faster.

c) The balloon is vertically stationary.

7 Would you expect tiger to be sliding down the ramp? Explain.



8.4 Simple machines

Simple Machines

Simple machines make life easier.

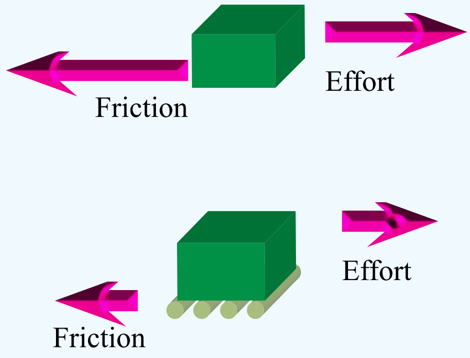
A simple machine can **magnify** the force that you apply to an object. The magnification of the force is called the **mechanical advantage**.

A simple machine can **change the direction** of the force that you apply to an object.

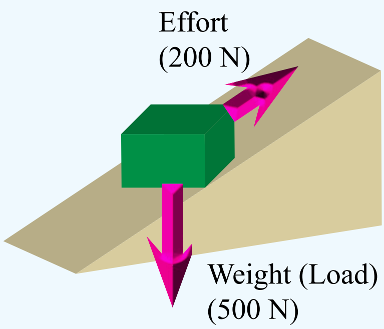
Simple machines are usually in the form of a wheel, ramp, lever, pulley, or combinations of these simple machines.

Wheel

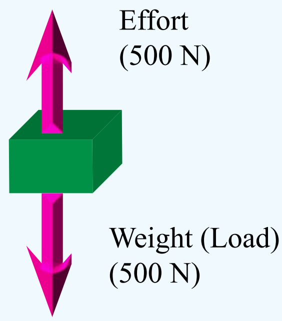
It can be easier to pull an object on wheels than without wheels.



Ramp

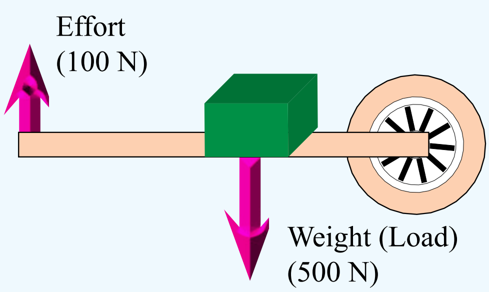


It can be easier to pull an object up a ramp than it is to vertically lift the object the same height. The force exerted by the object is called the load.

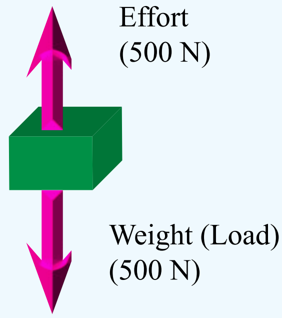


The force exerted by the object is called the **load**.

Lever

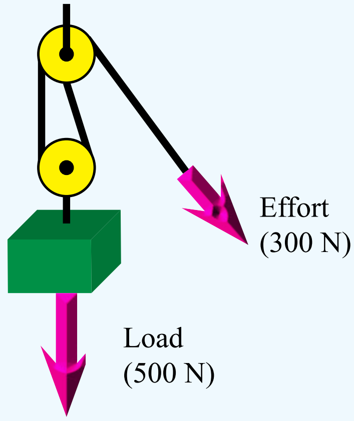


It can be easier to use a lever to carry an object than it is to directly carry the object.

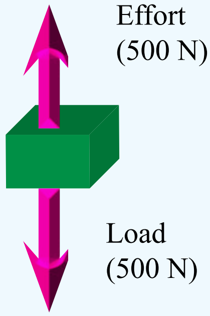


Pulley

It can be easier to use a pulley system to lift an object.



Changing the direction of effort can be useful. Pulling down can be easier than lifting upwards.



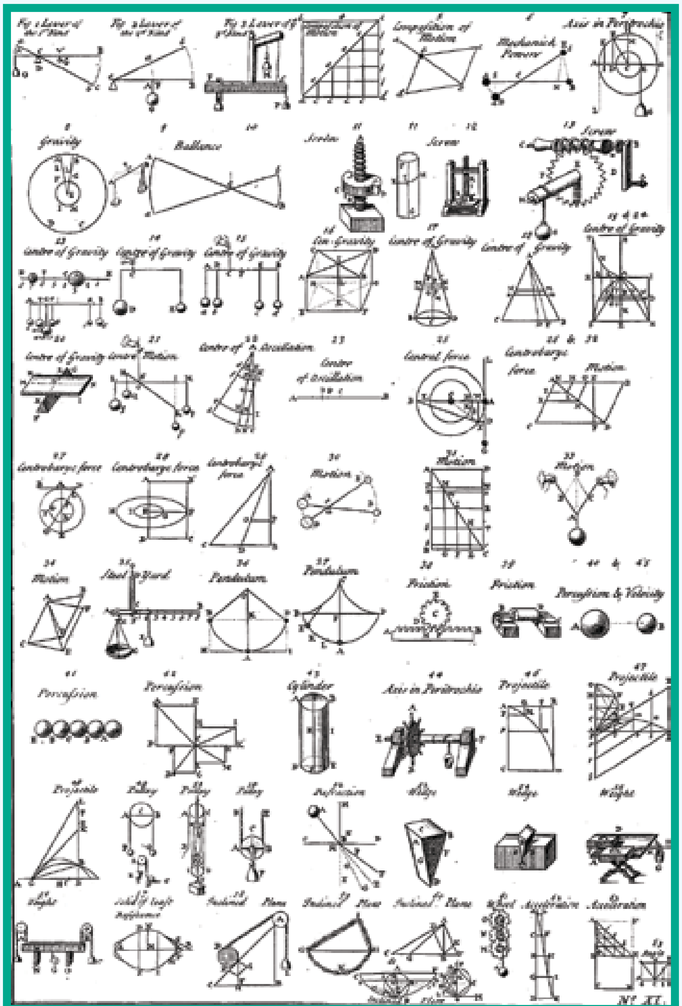


Table of Mechanicks (1728). Chambers, Ephraim.

Exercise

1 What is the purpose of a simple machine?

2 Which statement normally applies to a simple machine.

a) the effort is larger than the load.
b) the effort is equal to the load.
c) the effort is smaller than the load.

3 Within the table of simple machines, on the left, can you find three examples of:

a) a wheel? **b)** a ramp?
c) a lever? **d)** a pulley?
e) a wedge? **f)** a screw?

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

Example: Load = 750 N, Effort = 250 N

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{750\text{N}}{250\text{N}}$$

Mechanical advantage = 3

Calculate the mechanical advantage of a machine in which:

a) Load = 600 N, Effort = 200 N.
b) Load = 600 N, Effort = 300 N.
c) Load = 600 N, Effort = 400 N.
d) Load = 600 N, Effort = 500 N.

Levers

Levers

A lever is a simple machine.

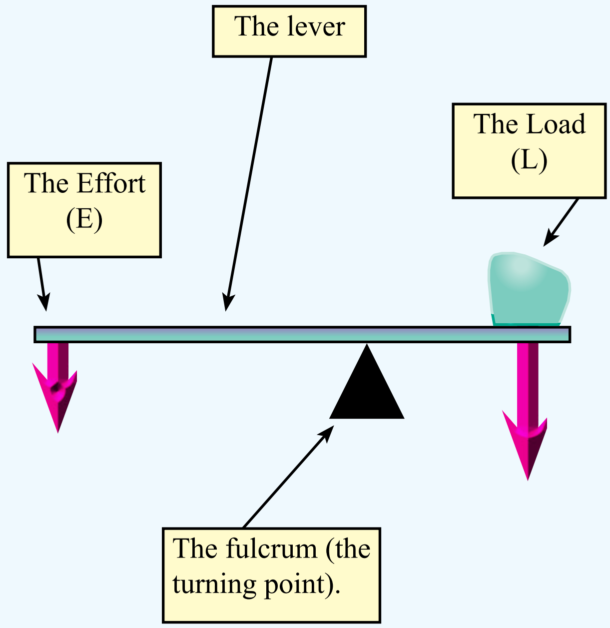
A lever consists of the lever, a load, a fulcrum, and an effort.

There are three classes of levers:

A **first class lever** has the fulcrum between the load and the effort.

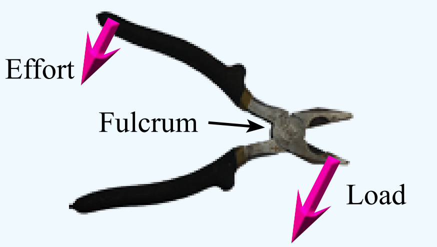
A **second class lever** has the load between the fulcrum and the effort.

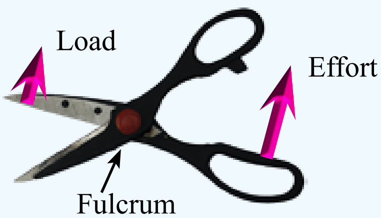
A **third class lever** has the effort between the fulcrum and the load.

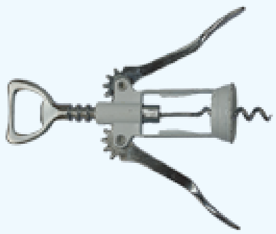


First class Lever

The fulcrum is in the middle in a first class lever.







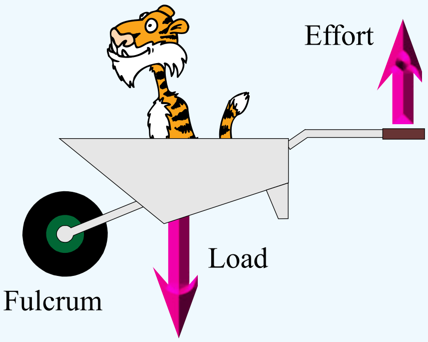
Activity

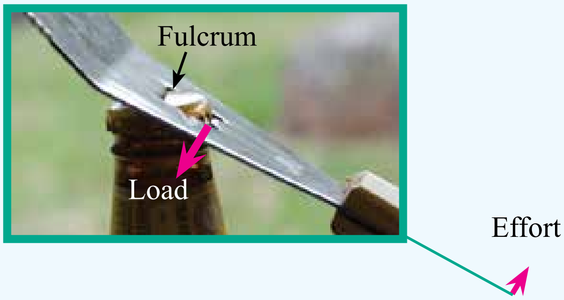
1. Set up a first class lever with a ruler (the lever), a pen (the fulcrum), and coins (the load and the effort).
2. Place the load (4 coins) at 0 and the fulcrum at 10.
3. Where should 3 coins (effort) be placed?
   Where should 2 coins (effort) be placed?
   Where should 1 coin (effort) be placed?
4. Experiment with other combinations.

6 coins are at 0 (the load). The fulcrum is at 10. Where should the 3 coins (the effort) be placed to lift the 6 coins?

Second class Lever

The load is in the middle in a second class lever.





Challenge

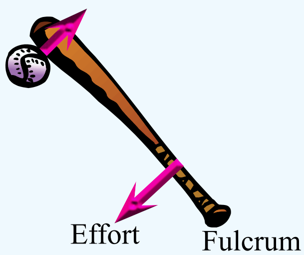
In the activity below, the direction of the effort has to be changed from down to up. How?

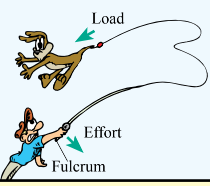
Activity

1. Set up a second class lever with a ruler (the lever), a pen (the fulcrum), and coins (the load and the effort).
2. Place the fulcrum at 0 and the load (4 coins) at 10.
3. Where should 3 coins (effort) be placed?
   Where should 2 coins (effort) be placed?
   Where should 1 coin (effort) be placed?
4. Experiment with other combinations.

Third class Lever

The effort is in the middle in a second class lever.





In class 3 levers the effort is larger than the load.

Class 3 levers can **increase speed** because moving the effort will cause the load to move further.

Exercise

1. Name the three parts of a lever.
2. Give an example of each of the three classes of levers. For each example, indicate the three parts of the lever.
3. Simple machines in the form of levers are everywhere. Find three examples of each class of lever used in a house.
4. What is the formula for mechanical advantage?
5. Explain how a class 1 lever can provide a mechanical advantage.
6. Explain how a class 2 lever can provide a mechanical advantage.
7. Explain how a class 3 lever can provide a speed advantage.

Experiment with an online 'interactive lever'.

View online examples of each class of lever.

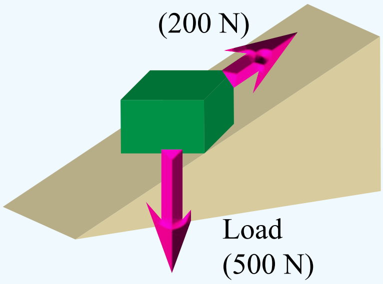
Challenge

There are numerous examples of the use of class 3 levers in sports.

Can you name 10?

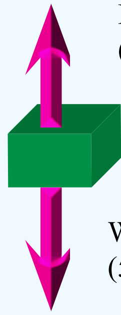
(Don't forget parts of the human body).

Ramps



$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{500\text{ N}}{200\text{ N}}$$

Mechanical advantage = 2.5



$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{500\text{ N}}{500\text{ N}}$$

Mechanical advantage = 1

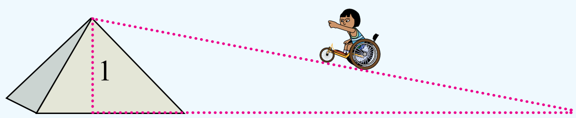
Ramps

A ramp is sometimes called an inclined plane.

The inclined means that one end is higher than the other. A plane means a flat surface.

Pulling an object up an inclined plane gives a mechanical advantage over lifting the object vertically.

There are thousands of applications of the inclined plane ranging from single ramps, such as stairs, to double ramps, such as wedges, to less obvious applications, such as can openers.



Challenge

A wheelchair ramp should have a maximum slope of 1 in 14.

How long would a wheelchair ramp need to be to get to the top of the Great Pyramid of Giza (147 m)?

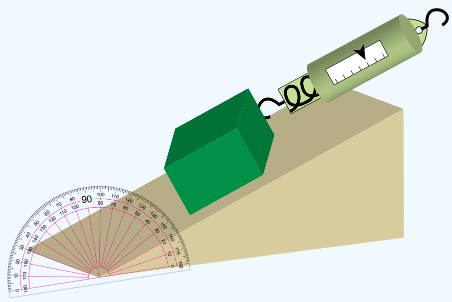
Activity

1 Using a spring balance, a ramp, and a load, record the ramp angle, load, and effort for a variety of angles.

2 Calculate the mechanical advantage.

Angle	Load	Effort	Mech advantage
10°	30 N	10 N	3
20°	30 N	14 N	2.1
30°	30 N	18 N	1.7
40°	30 N	24 N	1.3

3 Friction adds to the load. How might you reduce the friction as much as possible?



Wedges and Screws

The wedge is one or two inclined planes that makes it easier to push things apart.

The blockbuster, axe, knife, nail, scissors, chisel, and shovel are all examples of the wedge.

The screw is essentially a circular inclined plane. Screws are used to lower, raise, or keep things in place.

Wood screws, jar lids, car jacks, clamps, cork screws, taps, drills, propellors, fans, and nuts and bolts are all examples of the screw.

A blockbuster makes use of two simple machines:
- a wedge that splits the wood.
- a handle that acts as a class 3 lever.

A large wood screw. As the screw turns, the inlined plane pulls the screw into the wood. This is much easier than pushing a nail into wood.

A can opener makes use of three simple machines:
- a wheel to rotate.
- handles which act as class 2 levers.
- a wedge that cuts the can.

Interactive

Experiment with an 'interactive inclined plane'.

Webquest

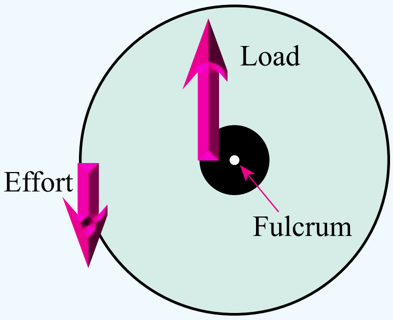
Complete an online simple machine webquest.

Exercise

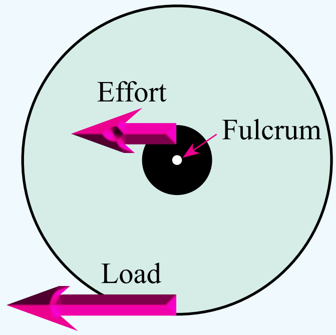
1. What is meant by the inclined plane?
2. What is the formula for mechanical advantage?
3. An effort of 600 N is needed to pull and object of weight 800 N up an inclined plane. Calculate the mechanical advantage.
4. Which is the steepest: a slope of 1 in 14 or a slope of 1 in 10?
5. Describe a wedge.
6. Name five simple machines that make use of the wedge.
7. Describe a screw.
8. Name five simple machines that make use of the screw.

Wheel

A wheel can be used to either **multiply the force** or **multiply the speed**.



A second class lever has the load in the middle.



A first class lever has the fulcrum in the middle.

Wheels

A wheel is actually a lever that rotates.

A wheel can be a **force multiplier**. A small force on the rim of the wheel will apply a larger force at the axle.

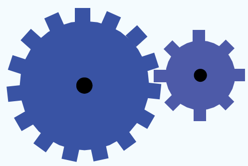
There are thousands of applications of the wheel such as the door knob, screw driver, can opener, steering wheel, windlass, wind turbines,

Gears

Gears are actually series of wheels that act as a series of levers that rotate.

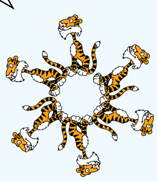
Gears can be a **speed multiplier**. A small movement on one wheel can result in a larger movement of another wheel.

Gears are combinations of wheels used as either **force multipliers** or **speed multipliers**.



What happened when the wheel was invented?

A revolution took place.



Wheel speed

Make a mouse-trap racer.

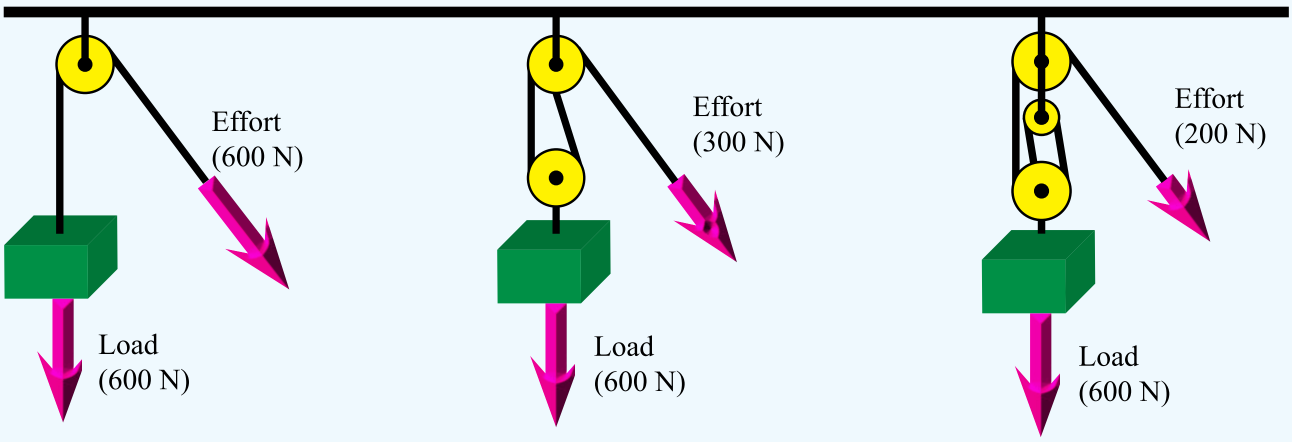
Challenge

The wheel has thousands of applications as a speed multiplier.

Can you give five examples of a wheel used to increase speed?

Pulley

Changing the direction of effort can be useful. Pulling down can be easier than lifting upwards.



The load is supported by one rope.
(Tension in rope = 600 N).

The load is supported by two ropes.
(Tension in rope = 300 N).

The load is supported by three ropes.
(Tension in rope = 200 N).

Pulleys

A pulley is a combination of wheels connected by ropes.

A pulley can magnify the force and also change the direction of the force.

A two pulley system can halve the effort although the rope needs to be pulled twice the distance. It can also be easier to pull down rather than lift up.

Activity

Design an experiment to calculate the mechanical advantage of pulley systems.

Machine whiz

Investigate Archimedes and his machines.

Wheels Gears Pulleys

Can you find a wheel, gear, or pulley simulator?

Exercise

1 Calculate the mechanical advantage of a pulley system in which:
   a) load = 600 N, effort = 600 N.
   b) load = 600 N, effort = 300 N.
   c) load = 600 N, effort = 200 N.

2 Indicate a use of a single pulley system with a mechanical advantage of 1.

3 None of the pulley systems above have included friction. What effect will friction have on mechanical advantage?

4 Are pulleys force multipliers or speed multipliers?

5 Give a sketched example of a wheel as a force multiplier - include forces.

6 Give a sketched example of a wheel as a speed multiplier - include forces.

7 Indicate how a pair of gears can be used to increase speed.

8.5 Science inquiry

Science Inquiry

Science inquiry skills are important in science, and in any situation that requires critical thinking. The process of thinking in logical steps allows us to answer questions about the world around us.

Science inquiry skills include:

- questioning and predicting
- planning and conducting
- processing and analysing
- evaluating
- communicating.

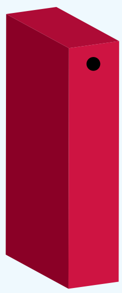
Science Investigations

Science investigations are activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem.

Investigations can involve a range of activities, including experimental testing, field work, locating and using information sources, conducting surveys, and using modelling and simulations.

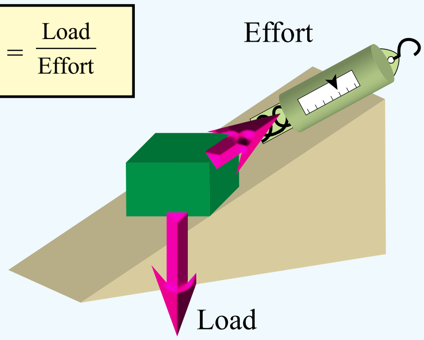
Activity

Conduct investigations to answer each of the following questions.



The north pole is marked with a N or a dot.

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



Questioning & Predicting

Can a magnet be shielded so that it doesn't attract a nearby piece of iron/steeel?

Prediction: **Well? What is your prediction?**

Questioning & Predicting

The mechanical advantage of a ramp is usually less than 3?

Prediction: **Well? What is your prediction?**

Planning & Conducting

Think about and organise an experiment to answer the question.

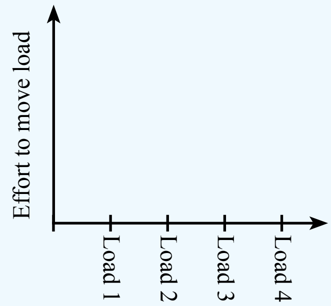
Planning an experiment is to describe in detail, the step-by-step procedures to follow

Collect your data and write it in a prepared data table.

Month	Effort	Mech Advantage
Load 1		
Load 2		
Load 3		
Load 4		

What goes on what axis?

If **MechA depends on load then**
MA on **vertical** axis
load on **horizontal** axis



Processing & Analysing

Summarise the data in the form of a graph or chart to help in understanding the data and to identify relationships.

Charts, graphs, and tables are also a great way of presenting investigation data to others.

The analysis of the data in a graph involves looking for trends, patterns and relationships in the graph.

Are you able to draw a conclusion from your experimental data?

What if the ramp has a lower incline?

Evaluating

Did your experiment provide an answer to the question?

How good was your data?

Would you do anything different if you repeated your experiment?

Communicating

Write a report using scientific language.

Present your report to your target audience using digital technology.

Examples of reports are shown in Chapter 1.

Questioning & Predicting

The mechanical advantage of a wheelbarrow is usually less than 3?

Prediction: **Well? What is your prediction?**

Questioning & Predicting

The mechanical advantage of a first class lever can be massive?

Prediction: **Well? What is your prediction?**

8.6 Chapter review

A force can be a push, a pull, or a twist.

The size of a force is measured in Newtons (N).

Gravity is the force of attraction between two objects.

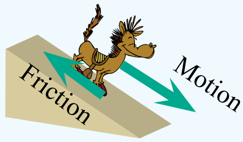
A mass of 1 kg is attracted to the Earth with a force of 9.8 N.

A mass of 1 kg is attracted to the Moon with a force of 1.6 N.

Friction is a force of resistance.

Frictional force is opposite to the direction of motion.

Friction opposes motion, wears away the contact surfaces, and generates heat.



When ready, cover the information above and answer the questions below.

Exercise

1 What is the SI unit of force?

2 What is the SI unit of mass?

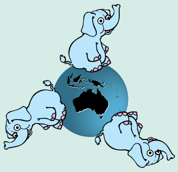
3 Name an instrument for measuring pull.

4 Name an instrument for measuring push.

5 What is gravity?

6 Is gravity a pull force or a push force?

7 Why is gravity on the Moon less than gravity on Earth?



8 Why don't the elephants fall off?

9 With what force is a mass of 2 kg attracted to the Earth?

Exercise

1 Give three examples where friction is useful.

2 Give three examples where friction is a problem.

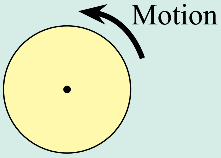
3 Friction will slow motion. Suggest two ways in which cars can be modified to reduce air resistance.

4 Friction will wear away surfaces. Suggest two ways in which friction between surfaces can be reduced.

5 Friction will generate heat. Suggest two ways of stopping computer processors from overheating.

6 Cars with underinflated tyres use more fuel. Why?

7 Indicate the direction of friction.



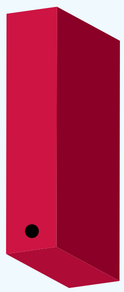
Magnetic force is a non-contact force.

Magnets can push or pull without touching.

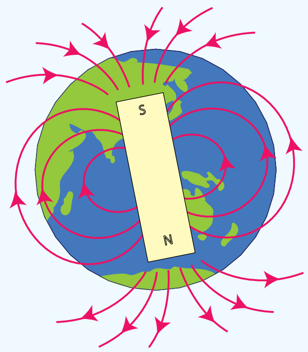
A magnet pulls on objects made of iron, nickel, and cobalt.

A magnet can pull or push other magnets.

The Earth has a magnetic field which protects us from the solar winds and is used for navigation.



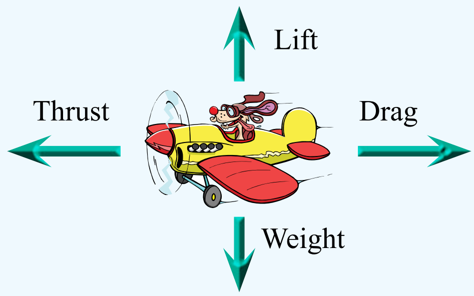
The north pole is marked with a N or a dot.



Forces on an object are **balanced** when:

- the object is not moving, or
- the object is not getting faster, or
- the object is not getting slower, or
- the object is not changing direction, or
- the object is not changing shape.

Forces can be shown as arrows. The length of the arrow can indicate the size of the force.



The plane is at a constant height (The gravity is **balanced** by the lift).

The plane has a constant speed (The drag is **balanced** by the thrust).

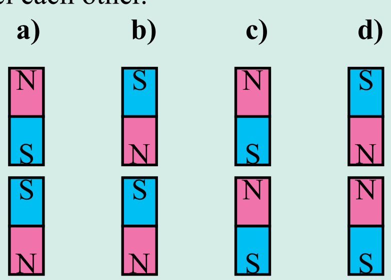
When ready, cover the information above and answer the questions below.

Exercise

1 Name the two poles on a magnet.

2 Sketch the magnetic field of a magnet.

3 Indicate whether the magnets will attract or repel each other.



4 Explain how a compass works.

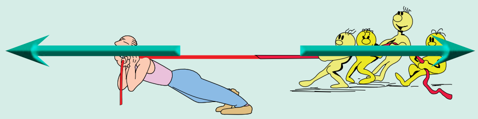
5 The Earth's north pole is represented by a magnet with a S pole. How come?

6 Can you make a list of 10 everyday applications of an electromagnet?

Exercise

1 How do you know when forces are balanced?

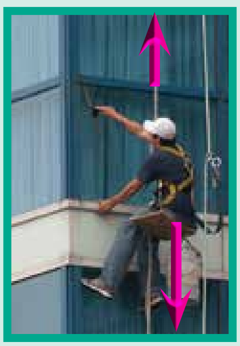
2 The tug of war is a tie. How do the force arrows suggest that the forces are balanced?



3 The widow cleaner is vertically stationary.

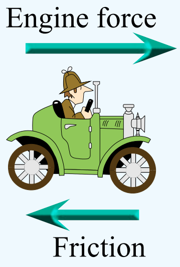
a) Label the forces.

b) Are the force arrows correct? Explain.



Forces on an object are **unbalanced** when:

- the object is getting faster.
- the object is getting slower.
- the object is changing direction.
- the object is changing shape.



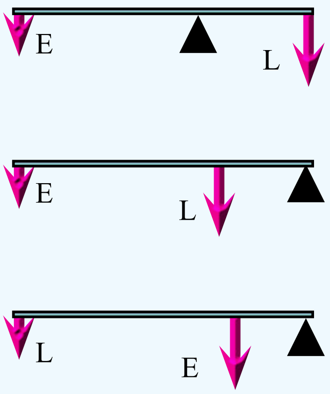
The car is getting faster thus **unbalanced** forces.

Buoyancy is the upward force that allows things to float on water.
Water has a force skin on its surface called **water tension**. Water drops are spherical because of water tension.

A lever is a simple machine.

A lever consists of the lever, a load, a fulcrum, and an effort.

Levers can either multiply the force or multiply the speed.



1st class lever

2nd class lever

3rd class lever

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

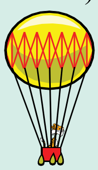
When ready, cover the information above and answer the questions below.

Exercise

1 A car slows down. Explain why the forces must be unbalanced.

2 A stone is falling through the air. Label the forces.

3 Make a rough sketch of the following hot air balloon. The three vertical forces acting on the balloon are weight, buoyancy, and friction (opposite direction of motion).
Add forces assuming:



a) The balloon is rising faster and faster
b) The balloon is falling faster and faster.
c) The balloon is vertically stationary.

4 Explain why Tiger will probably sink in water if Tiger doesn't try to swim.

Exercise

1 Name the three parts of a lever.

2 Give an example of each of the three classes of levers. For each example, indicate the three parts of the lever.

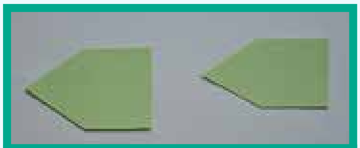
3 What is the formula for mechanical advantage?

4 Calculate the mechanical advantage of a lever in which:
a) Load = 800 N, Effort = 800 N.
b) Load = 800 N, Effort = 600 N.
c) Load = 800 N, Effort = 400 N.
d) Load = 800 N, Effort = 200 N.

5 Explain how a class 1 lever can provide a mechanical advantage.

6 Explain how a class 3 lever can provide a speed advantage.

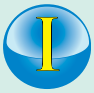
A Sweet Trick



1 Cut out some boats.

2 Carefully put a boat on water.
Nothing much happens.

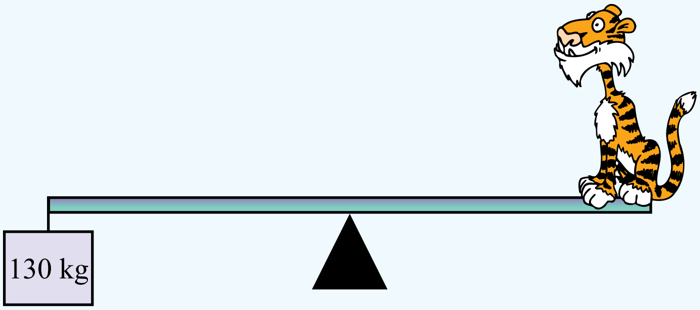
3 Put detergent on the back of a boat.
Now see what happens.



Why?
What unbalanced forces makes the detergent powered boat work?

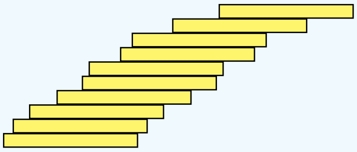
A Couple of Puzzles

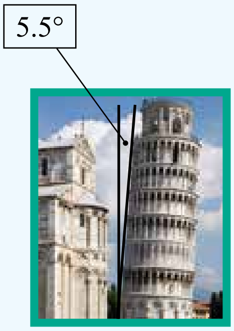
1 A tiger is sitting on a balance.
If the tiger quickly lies down, will the other end of the balance:
a) move up?
b) stay still?
c) move down?
How can you test your answer?



2 How far can you make a pile of 10 coins lean?

The largest lean of the Tower of Pisa was 5.5°.





A ramp is sometimes called an **inclined plane**.

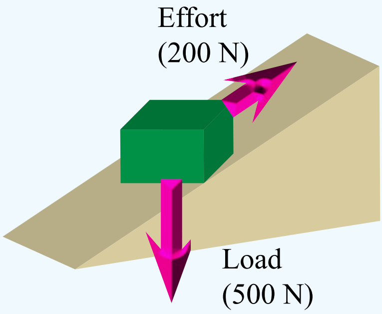
Pulling an object up an inclined plane gives a mechanical advantage over lifting the object vertically.

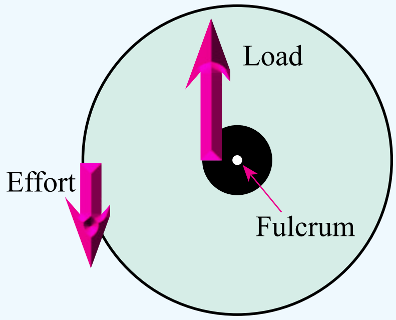
There are thousands of applications of the inclined plane ranging from single **ramps**, such as stairs, to double ramps, such as **wedges**, to less obvious applications, such as **screws**.

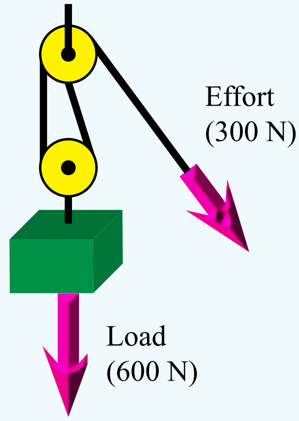
A **wheel** can be used to either **multiply the force** or **multiply the speed**.

A **pulley** is a combination of wheels connected by ropes. A pulley can magnify the force and also change the direction of the force.

A two pulley system can halve the effort although the rope needs to be pulled twice the distance. It can also be easier to pull down rather than lift up.







When ready, cover the information above and answer the questions below.

Exercise

1 What is meant by the inclined plane?

2 What is the formula for mechanical advantage?

3 An effort of 600 N is needed to pull and object of weight 900 N up an inclined plane. Calculate the mechanical advantage.

4 Which is the steepest: a slope of 1 in 14 or a slope of 1 in 10?

5 Describe a wedge.

6 Name five simple machines that make use of the wedge.

7 Describe a screw.

8 Name five simple machines that make use of the screw.

Exercise

1 Calculate the mechanical advantage of a pulley system in which:
a) load = 600 N, effort = 600 N.
b) load = 600 N, effort = 300 N.
c) load = 600 N, effort = 200 N.

2 Indicate a use of a single pulley system with a mechanical advantage of 1.

3 Are pulleys force multipliers or speed multipliers?

4 Give a sketched example of a wheel as a force multiplier - include forces.

5 Give a sketched example of a wheel as a speed multiplier - include forces.

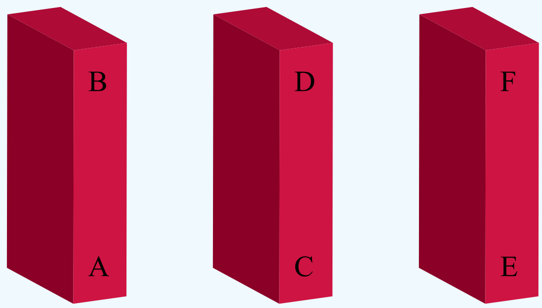
6 A pulley block attached to the load is held by four ropes. What is probably the mechanical advantage of the pulley system?

7 Indicate how a pair of gears can be used to increase speed.

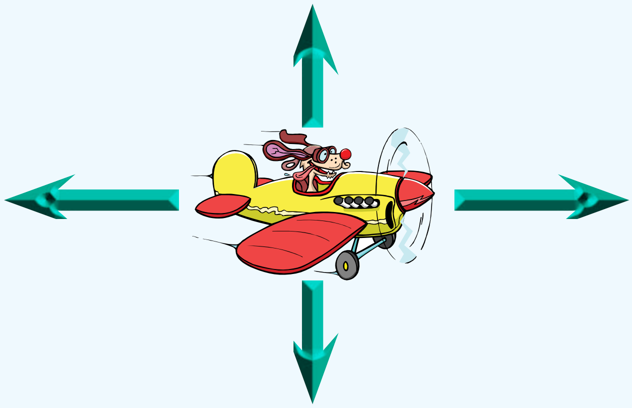
Competition Questions

1 Three magnets are shown.
- A attracts D.
- F repels C.
- The north end of a compass points to B.

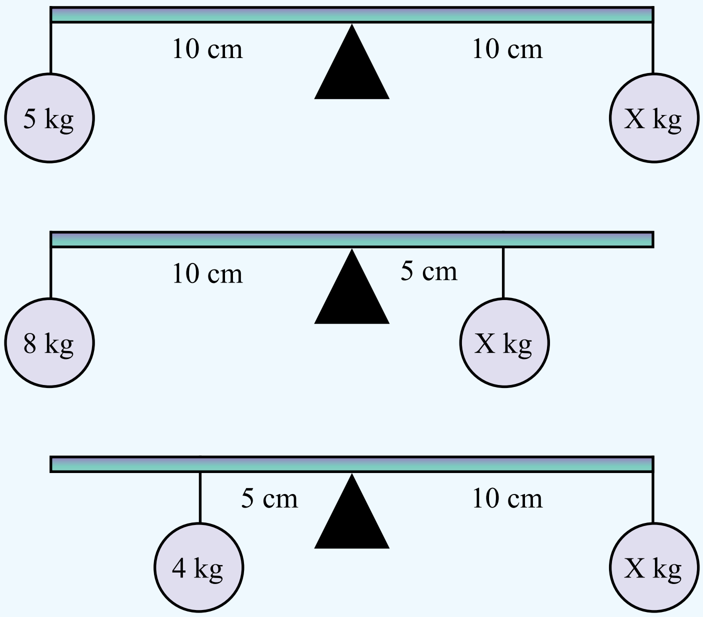
Indicate the north and south pole of each compass.



2 If friction was to be added to the plane's force diagram, where would it be placed?



3 For each of the diagrams, what is the value of X (The bar is of negligible mass)?

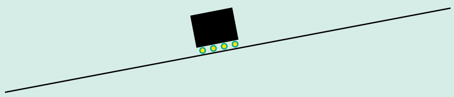


Harder Test Questions

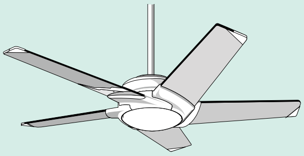
1 A bank vault door has large handles on the door opposite to the hinges. Why?

2 The ancient Egyptians are said to have made extensive use of ramps to lift large blocks of limestone more than 100 metres.

Why is it most likely that the Egyptians used zig-zagging ramps rather than a straight ramp.



3 How is a fan an example of a speed multiplying wheel?



4 Archimedes is believed to have said 'Give me a lever long enough and a fulcrum on which to place it, and I shall move the world.'

a) Draw a sketch to indicate what Archimedes possibly meant.

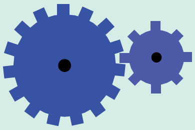
b) Is this possible? Explain.

5 A pulley system has a wonderful mechanical advantage of 8. What is a possible problem with this system?

6 With a pair of gears, an effort to make one complete turn of the first gear causes the second gear to make one quarter of a turn.

a) Is the pair of gears a force multiplier or speed multiplier?

b) What is the mechanical advantage?



7 A pair of scissors is a compound machine that makes use of a lever and a wedge (the blade).

Can you think of a compound machine that makes use of a lever, a wheel, and a ramp?

8 On the bike below, the pedal is an example of a lever. Can you find five other applications of simple machines on the bicycle?

9 A first class lever has a mechanical advantage of 2. How large a load can an effort of 60 N balance?

10 A second class lever has a mechanical advantage of 3.

What effort is needed to balance a load of 2 tonnes (1 tonne = 1000 kg)?

11 The gravitational force, F in Newtons, of attraction between a mass, m in kg, and our Earth is given by the formula:
$F = ma \quad \{a = 9.8 \text{ m/s}^2\}$.

a) What is the gravitational force of a person of mass 45 kg?

b) What mass would have a weight, gravitational force, of 980 N?