Forces and Their Effects

Forces are measured in newtons, using a newton meter.

The table below lists some forces and their descriptions.

Force	Description
friction	The force between two surfaces that are sliding, or trying to slide, past each other.
air resistance	The force that acts in the opposite direction to an object's movement as it moves through the air.
reaction	The force that supports an object on a solid surface.
tension	The force transmitted through a rope, string or wire when pulled by forces acting from opposite ends.
upthrust	The upward force exerted by a fluid on an object floating in it.
gravitational force	The force acting on an object due to gravity.
magnetic force	The force exerted by a magnetic field on a magnetic material.
electrostatic force	The force that acts between two charged objects.

1. Name the force that is acting in each of the situations described below.

The force of the water acting on a boat that keeps it afloat.	
The force of the table acting on a cup that is resting on the table.	
The force that keeps a car on the ground.	
The force that holds up a decoration that is hanging from a string.	
The force that causes a paperclip to be attracted to a magnet.	
The force of the air acting on a moving bus.	
The force that holds together sodium and chloride ions to make salt.	
The force of the doormat on your shoes when you wipe your feet.	

We can't see forces but we can see their effects on objects.
Forces can make objects change speed, direction or even shape.

2. On a sheet of paper, draw diagrams to help you remember the three things that forces can do.

Contact and Non-Contact Forces

Contact forces act between objects that are physically touching each other. Non-contact forces act between objects that are not physically touching each other.

Non-contact forces act in fields. The field is a special area where an object can experience a non-contact force.

- A gravitational field is found around an object with mass.
- A magnetic field is found around a magnetic object.
- An electrostatic field is found around a charged object.

As an object gets farther away from the object exerting a force, the field gets weaker. This means that the size of the force an object experiences will decrease as it gets further away.

1. Tick the correct box in the table below to identify the contact and non-contact forces. There are three non-contact forces.

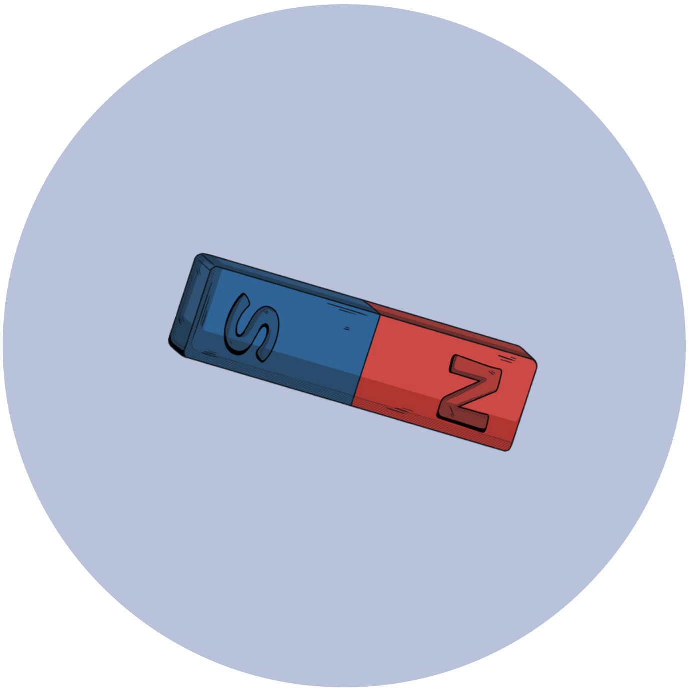
Force	Contact	Non-Contact
upthrust	☐	☐
air resistance	☐	☐
electrostatic	☐	☐
tension	☐	☐
magnetic	☐	☐
reaction	☐	☐
water resistance	☐	☐
gravitational	☐	☐
friction	☐	☐

The diagram below shows a bar magnet surrounded by its magnetic field.

2. Draw the diagram onto a sheet of paper. On your diagram:

   - write a letter S where the magnetic force is the strongest

   - write a letter W where the magnetic force is the weakest

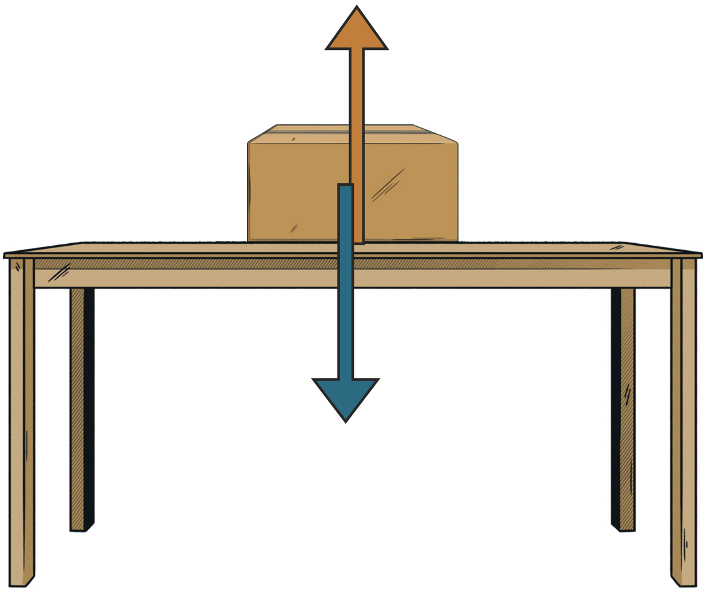


Force Diagrams

The forces acting on an object can be represented using arrows. Force arrows point in the direction the force acts in. The length of the arrow represents the size of the force.

The arrows must touch the object in the diagram.

If an object is stationary, or moving at a constant speed, the forces on it are balanced. Balanced forces act in opposite directions and are the same size. The forces in the diagram below are balanced.



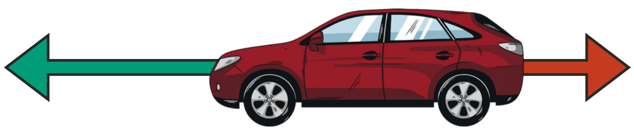
The upwards arrow represents the **reaction** force.
This is the force of the table supporting the box.

The downwards arrow represents the gravitational force acting on the box, also known as **weight.**
This is the force of the Earth acting on the box.

If forces acting on an object are unbalanced, the object will be accelerating or slowing down.

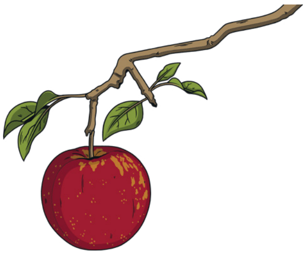
If an object is speeding up, the forward arrow will be larger.

If an object is slowing down, the backward arrow will be larger.

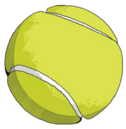


On a sheet of paper, draw the diagrams below and add force arrows to each diagram. Label the arrows with the force and add descriptions in the fields below that say whether the forces are balanced or unbalanced.

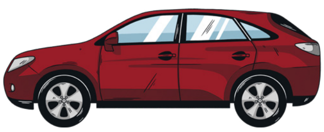
A person sitting on a chair.



An apple hanging on a tree.



A ball accelerating downwards.



A car travelling at a constant speed.

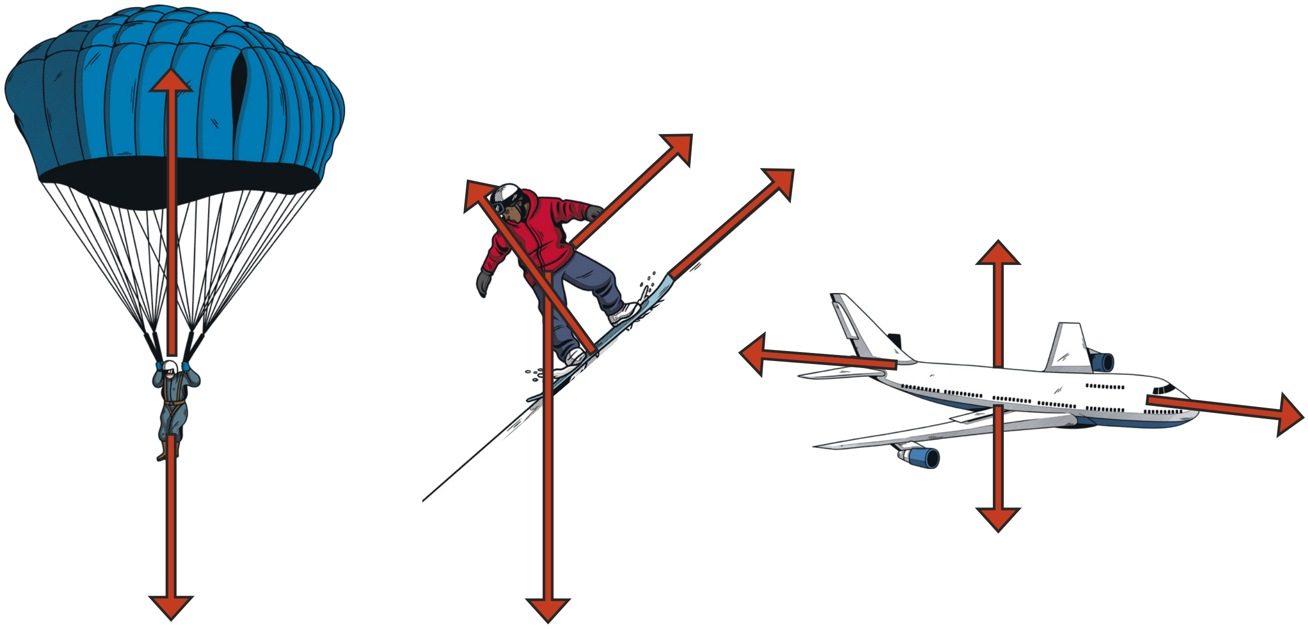
Resistive Forces

Resistive forces act in the opposite direction to the direction in which an object is moving or trying to move.

Air resistance and water resistance are drag forces. These are produced when an object has to move particles of air or water out of the way, this slows the object down.

Friction grips objects. It resists the motion of surfaces that are sliding, or trying to slide, past each other. Rougher surfaces have more grip on an object so they cause a greater frictional force when an object tries to slide over them.

1. Draw the diagrams below on a sheet of paper. On each force diagram, circle the resistive force(s).



2. Explain why carpet will slow down a toy car faster than tiles

Carpet is a ______ surface than tiles, which means it has more ______ on the toy car. This increases the force of ______ , which ______ the car faster.

Calculating the Mean

A ball was rolled down a ramp onto different surfaces and the distance travelled by the ball after leaving the ramp was measured. The investigation was repeated three times on each surface.

The results for grass are shown below.

Repeat 1: The ball travelled **120cm.**

Repeat 2: The ball travelled **113cm.**

Repeat 3: The ball travelled **118cm.**

To calculate the mean:

Step 1 - Add up the three distances travelled by the ball.

120 + 113 + 118 = 351

Step 2 - Divide the answer by three (because there were three results).

351 ÷ 3 = 117

The mean is **117cm.**

The data was collected to three significant figures, so the answer is also given to three significant figures.

Calculate the mean distance the ball travelled for the other surfaces in the table below.

Surface	**Distance Travelled (cm)**			
	Repeat 1	**Repeat 2**	**Repeat 3**	**Mean**
grass	120	113	118	117
concrete	310	307	301	
wooden decking	280	290	282	
carpet	180	184	183	

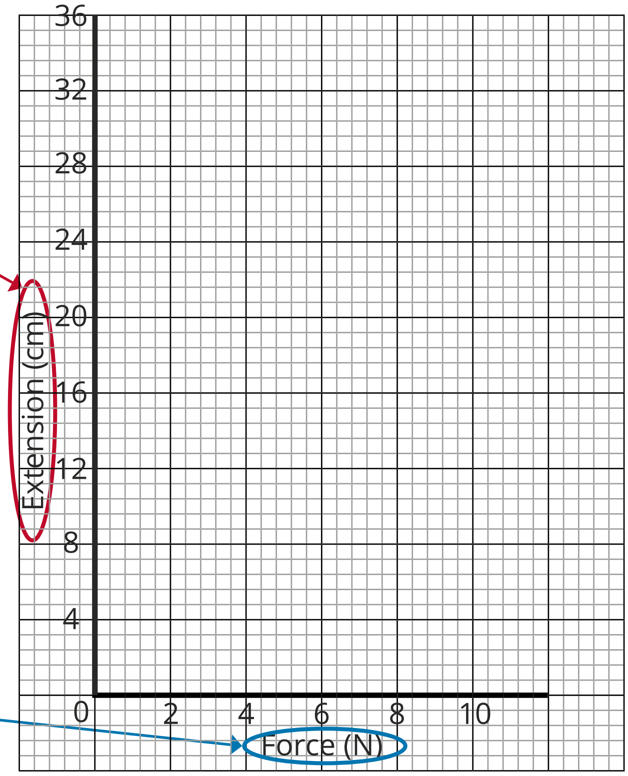
Using Data to Draw a Graph

The table below shows some data collected in a Hooke's law investigation.

The dependent variable (the value of which is measured for each change in the independent variable) goes on the y-axis.

Force (N)	Extension (cm)
0	0
2	4
4	8
6	12
8	20
10	36

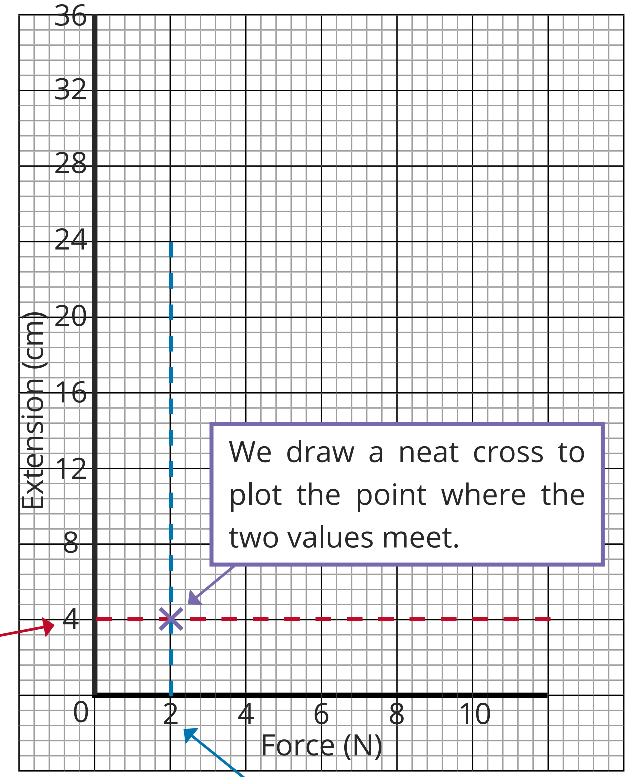
The independent variable (the values of which are changed or chosen) goes on the x-axis.



Force (N)	Extension (cm)
0	0
2	4
4	8
6	12
8	20
10	36

This row tells us that when a force of 2N is added to the spring, the extension is 4cm.

The value on the y-axis is 4cm.

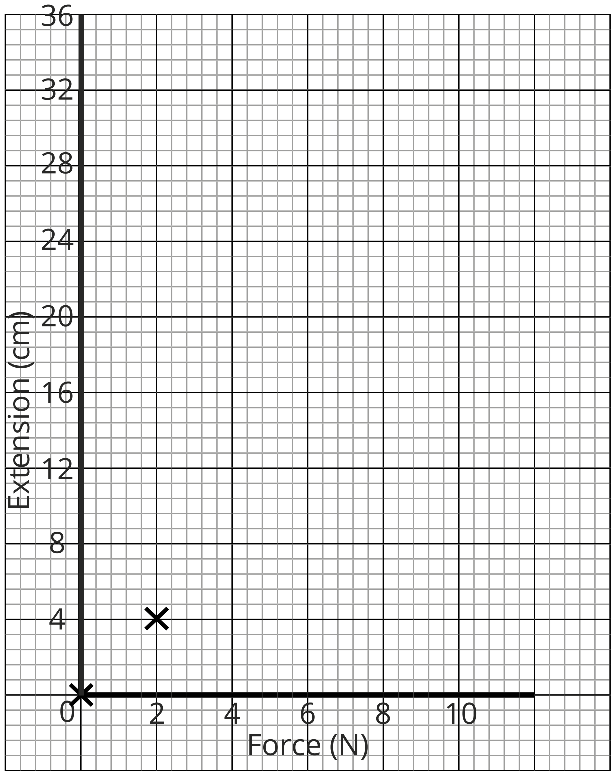


We draw a neat cross to plot the point where the two values meet.

The value on the x-axis is 2N.

1. Draw the graph below on a sheet of paper and plot the points shown on this graph. The first two points have been plotted for you.

Force (N)	Extension (cm)
0	0
2	4
4	8
6	12
8	20
10	36



The line of best fit is the most reasonable continuous line determined by the points; it helps to visualise the relationship between variables by averaging out any errors. The line may not pass through every point and may not be a be straight line.

2. Add a line of best fit to the graph you plotted on your sheet.

3. Use your graph to predict the extension when a force of 3N is added to the spring.

Planning an Investigation

A student wanted to investigate how **the type of surface** affected **the distance travelled by a ball.**

The **independent variable** is the variable that you change or select the values for.

You need to decide the values you will use for the independent variable.

The independent variable in this investigation is the type of surface.

When planning the investigation, the student will need to list the types of surface they will use.

‘The ball will be rolled onto four different surfaces: grass, concrete, stones and sand.’

The **dependent variable** is the variable that is measured for each change of the independent variable.

You need to decide how you will measure the dependent variable.

The dependent variable in this investigation is the distance travelled by the ball.

When planning the investigation, the student will need to state the equipment they will use to measure the distance travelled by the ball.

‘The distance travelled by the ball will be measured from the bottom of the ramp using a ruler.’

The student should also say how many times they will repeat each measurement.

A **control variable** is one which may, in addition to the **independent variable**, affect the outcome of the investigation and therefore must be kept constant.

You need to identify the variables that you need to keep the same.

When planning the investigation, the student will need to identify the other variables that might affect the distance travelled by the ball and say how they will control them.

‘The same ball will be used each time so that the size and surface of the ball stay the same. The ball will be let go (not pushed) from the top of a 1m long ramp that is 20cm off the ground at the start point. The same ramp will be used each time.’

The student’s plan:

The ball will be rolled from the top of a ramp onto four different surfaces: grass, concrete, stones and sand. The distance travelled by the ball will be measured from the bottom of the ramp using a ruler. The same ball will be used for each surface so that the size and surface of the ball stay the same. The ball will be let go (not pushed) from the top of a 1m long ramp that is 20cm off the ground at the start point. The same ramp will be used each time.

For each surface, the investigation will be repeated three times and the mean distance travelled by the ball will be calculated.

Now that you've looked at an example, have a go at writing your own plan.

Two students wanted to investigate how the **material of a parachute** affects the **time it takes for an object to fall.**
The students have four types of material available: bin bags, felt, paper and cotton.
They have a wooden block with a hook, string, sticky tape and a timer.

Plan the investigation. Make sure you state the independent variable, the dependent variable and the control variables. Use the information on the front of the sheet to help you structure your plan.

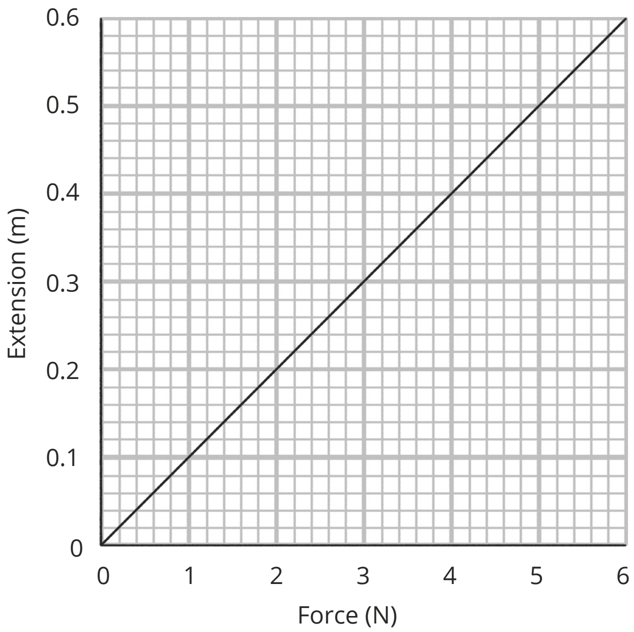
Hooke's Law

The extension of some elastic objects can be described by Hooke's law.

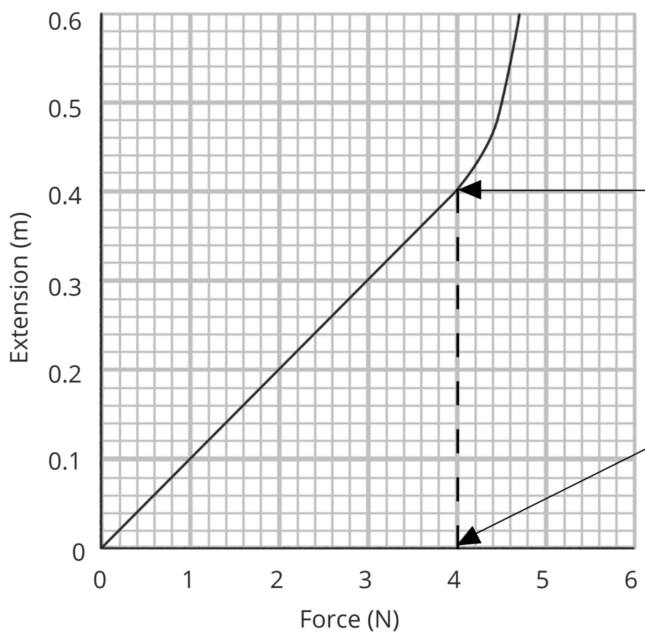
force = spring constant × extension

When a spring obeys Hooke's law, the extension of the spring is **directly proportional** to the force applied. This means that if you double the force, the extension also doubles.

On a graph, this is shown by a straight line through the origin.



At the elastic limit, the spring will no longer return to its original shape. Once a spring has reached its elastic limit, it no longer obeys Hooke's law.



This is the point at which the straight line starts to curve. You can place a ruler along the straight part of the graph to help you identify where this happens.

From this point the spring no longer obeys Hooke's law. It has reached its elastic limit.

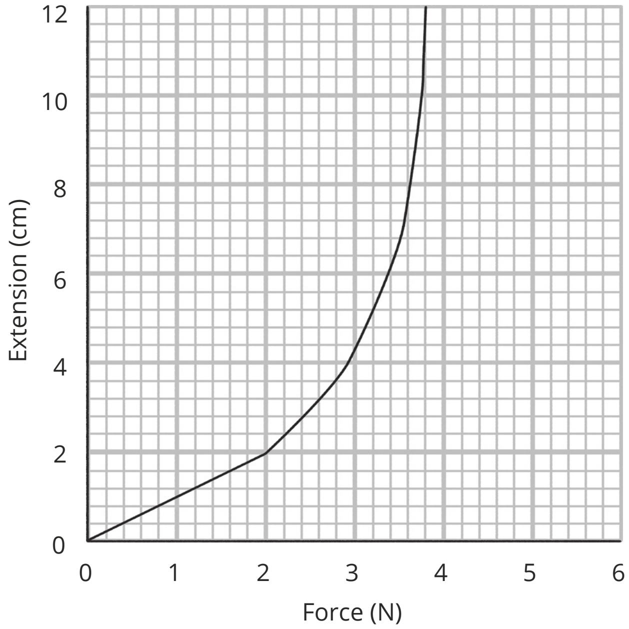
You can read the force at which the spring reaches its elastic limit from the x-axis.

The elastic limit is reached at 4N.

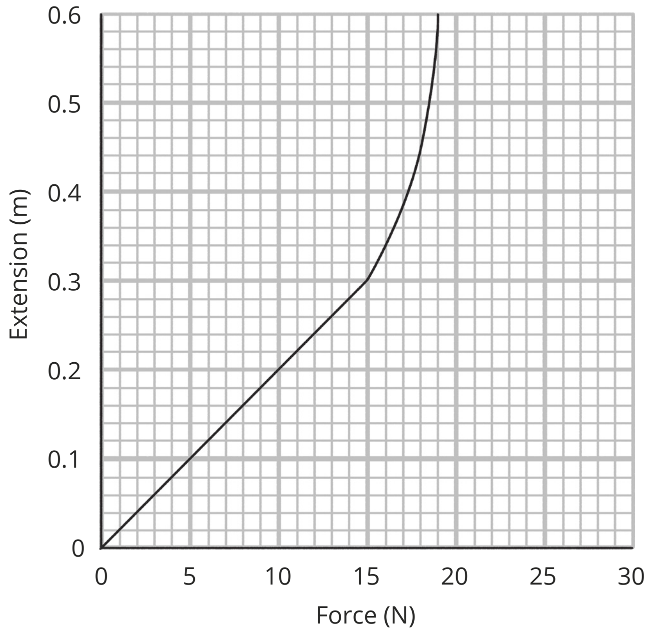
The elastic limit is reached at 4N.

Draw the example graphs below on a sheet of paper. Label the elastic limit in each of the example graphs and write down the maximum force that could be applied to the spring to ensure it can return to its original size beneath each graph.

1.



2.



Mass and Weight

Mass is the amount of matter an object is made up of, measured in kilograms (kg).

Mass is not affected by gravitational field strength so the value of mass will stay the same when the location of the object changes.

Weight is the total amount of force acting on an object due to gravity, measured in newtons (N)

Weight depends on the gravitational field strength acting on the object so if the location of an object changes, then its weight may change.

1. Of the planets in our Solar System, Mercury has the smallest mass and Jupiter has the largest mass.

Explain how the mass and weight of an object would be different on Jupiter compared to on Mercury.

To calculate weight, we use the equation:

weight = mass × gravitational field strength

An object on Earth has a mass of 5kg. The gravitational field strength on Earth is 10N/kg.

weight = mass × gravitational field strength

weight = 5kg × 10N/kg

weight = 50N

2. An object on the Moon has a mass of 0.6kg. The gravitational field strength on the Moon is 1.6N/kg.

Calculate the weight of the object.

weight =

3. An object on Jupiter has a mass of 3.4kg. The gravitational field strength on Jupiter is 25N/kg.

Calculate the weight of the object.

weight =

Rearranging Equations

To calculate the mass of an object using its weight and the gravitational field strength, we need to rearrange the following equation:

weight = mass × gravitational field strength

Mass is currently multiplied by gravitational field strength, so we need to divide it by gravitational field strength to make it the subject. Whatever we do to one side of the equation we must also do to the other.

$$\frac{\text{weight}}{\text{gravitational field strength}} = \frac{\text{mass} \times \text{gravitational field strength}}{\text{gravitational field strength}}$$

On the right-hand side of the equation, gravitational field strength cancels out, so we are left with:

$$\frac{\text{weight}}{\text{gravitational field strength}} = \text{mass}$$

1. Use the rearranged equation to calculate the mass of a 4N object on Earth. Earth has a gravitational field strength of 10N/kg.
   Include the unit.

mass =

The extension of some elastic objects can be described by Hooke's law.

force = spring constant × extension

2. Rearrange the equation to make the spring constant the subject. Use the steps above to help you.

3. Use the rearranged equation to calculate the spring constant of a spring that has an extension of 0.2m when a force of 5N is applied.

   Include the unit.