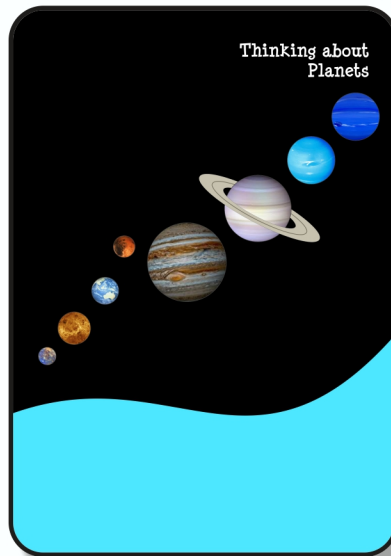
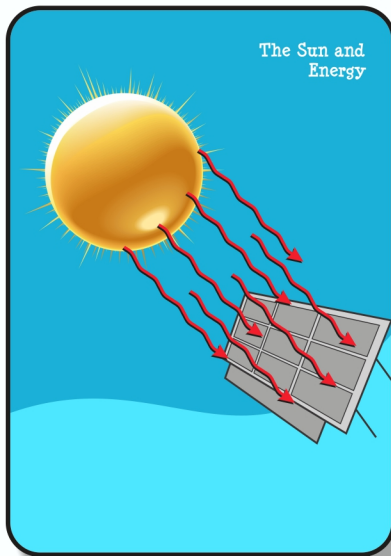
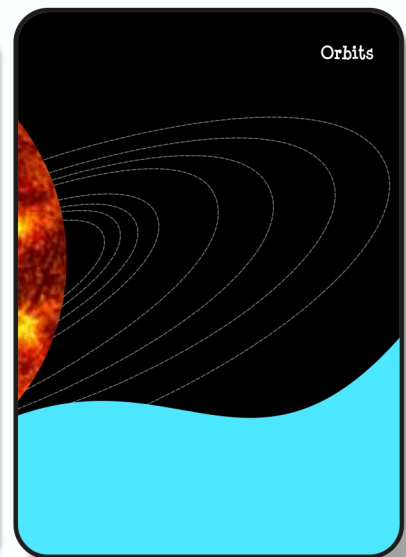
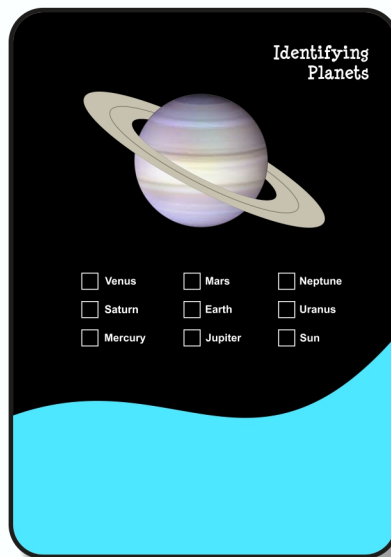
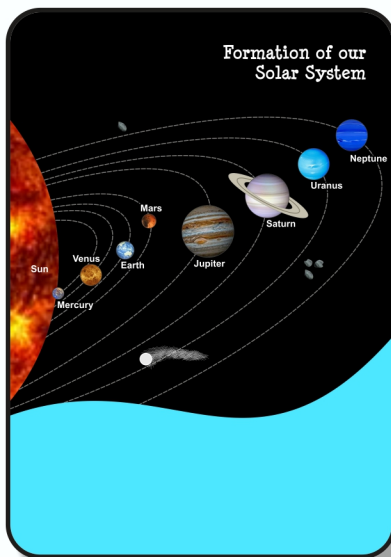
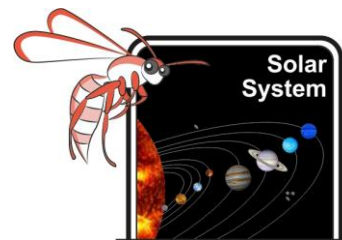


Solar System Package



WASP 5 – Teacher Introduction



The Woodside Australian Science Project (WASP) is an initiative supported by Woodside and Earth Science Western Australia (ESWA).

These activities are designed to support the Earth & Space Science topic required by the Year 5 Australian Curriculum.

Copies of this and other supporting materials can be obtained from the WASP website <http://www.wasp.edu.au> or by contacting Julia Ferguson, Julia@wasp.edu.au

Topic 1	Formation of our Solar System
Topic 2	Identifying Planets
Topic 3	Orbits
Topic 4	The Sun and Energy
Topic 5	Thinking About Planets

Earth & Space Science

Science Understanding

The Earth is part of a system of planets orbiting around a star (the sun) (ACSSU078)

- Identifying the planets of the solar system and comparing how long they take to orbit the sun
- Modeling the relative size of and distance between Earth, other planets in the solar system and the sun
- Recognising the role of the sun as a provider of energy for the Earth

Science as a Human Endeavour

Nature and development of science

- Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena (ACSHE081)
- People have made important contributions to the advancement of science from a range of cultures (ACSHE082)

Use and influence of science

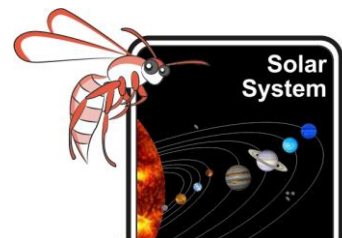
- Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives (ACSHE083)
- Scientific knowledge is used to inform personal and community decisions (ACSHE217)

Science Inquiry Skills

Questioning and predicting

- With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be (ACSI231)

WASP 5 – Teacher Introduction



Planning and conducting

- With guidance, plan appropriate investigation methods to answer questions or solve problems (AC SIS086)
- Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate (AC SIS087)
- Use equipment and materials safely, identifying potential risks (AC SIS088)

Processing and analysing data and information

- Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (AC SIS090)
- Compare data with predictions and use as evidence in developing explanations (AC SIS218)

Evaluating

- Suggest improvements to the methods used to investigate a question or solve a problem (AC SIS091)

Communicating

- Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts (AC SIS093)

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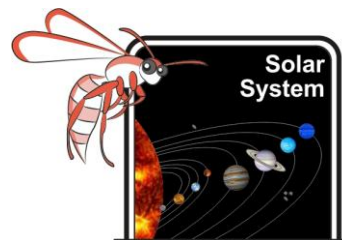
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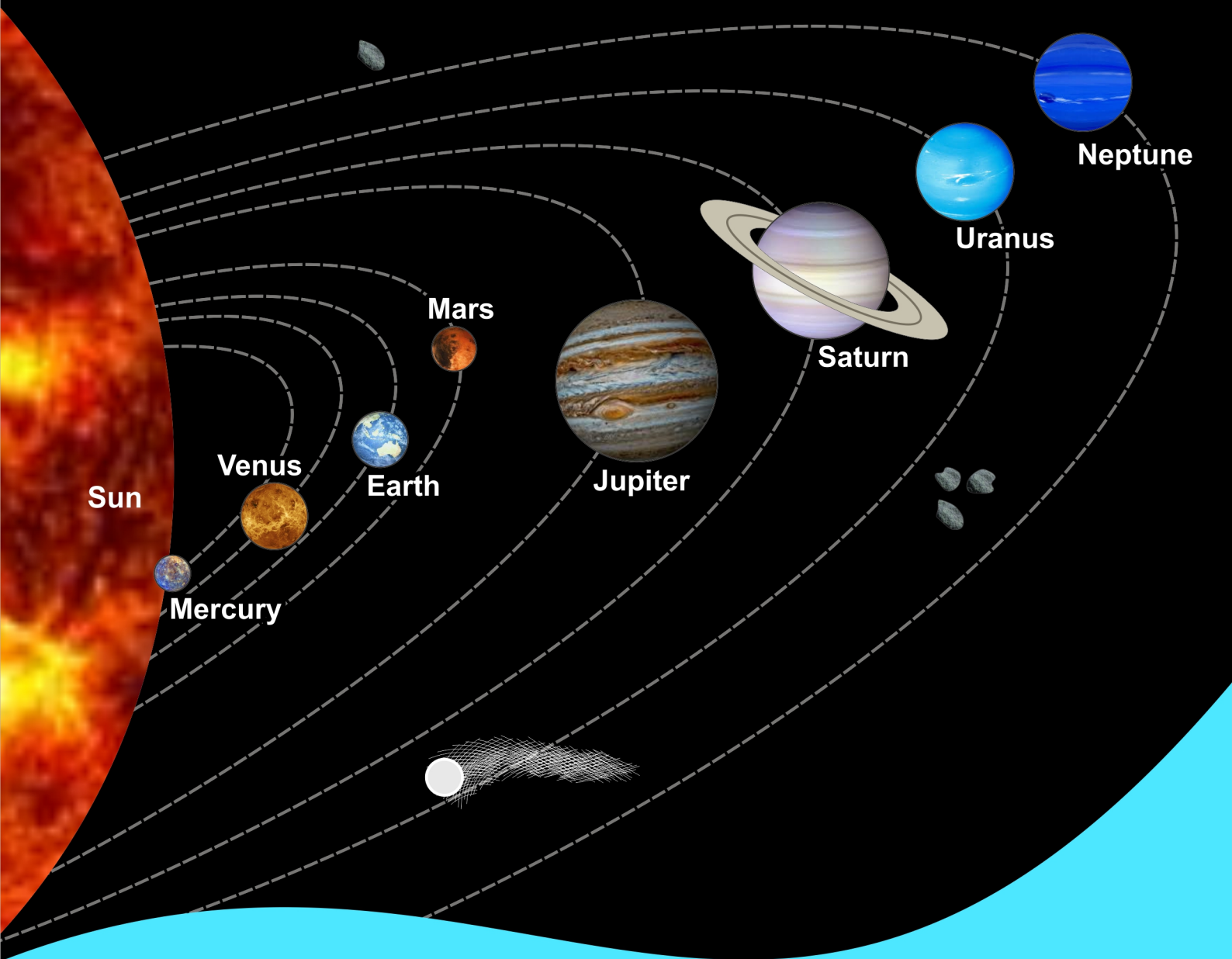
WASP 5 – Teacher Introduction



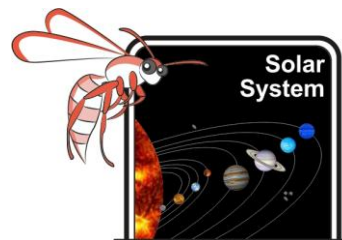
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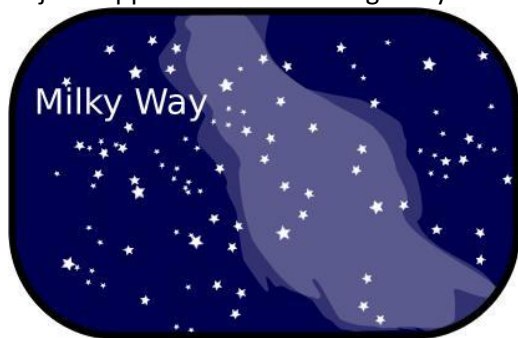
Formation of our Solar System



Formation of our Solar System – Teacher Background



So far, our best explanation about the origin of the Universe is “The Big Bang Theory”. This suggests that a mighty explosion about 13 billion years ago sent hot dense particles (mostly hydrogen) streaming outwards from a central point of singularity. Astronomers have measured that all celestial objects appear to be streaming away from an original central position.



Gravity is the major force or “glue” that holds the universe together. Gravity pulls together matter to form galaxies, stars, planets and their satellites. The cores of stars are natural nuclear reactors that smash simple atoms together to form more complex ones. When stars lose energy they collapse then explode to create great clouds of dust called nebulae that blast back out into space and eventually reform into other stars, planets etc. One such explosion blasted dust out

through the western spiral arm of our galaxy, the Milky Way and it was this raw material that formed our solar system about 4.6 billion years ago. We know that our planet is made from star stuff because there are complex elements such as iron and potassium found in the rocks, soils and in ourselves. These elements are only made in the cores of very large, very hot, stars

We are all made of “star stuff” recycled by our planet.

Static Electricity and Gravity – The Universe’s Glue

Both static electricity and gravity are forces. Forces cause other objects to move or change the direction of their movement. Both static electricity and gravity can also act at a distance unlike a push or a pull, which need contact. Static electricity acts over small distances while gravity can act over great distances.

Static electricity however is the first weak force that pulls together small particles that rub against each other. It is the build up of small particles to more massive ones that permit gravity to exert its pulling force.

1. **Static electricity** – a minor weak force



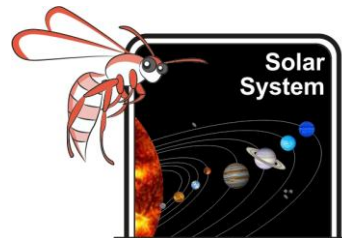
During the explosion forming the nebula, small particles in the dust cloud rush out into space. When affected by gravity from another large body such as another star, they would be drawn together to form a proto-planetary disc and some would start rubbing together. Outer electrons would be lost from one atom and transferred to another. This would leave the atom that had lost an electron with a positive electrical charge and the atom that had gained an electron with a negative electrical charge. They would then stick to each other like little magnets because of their opposing electrostatic charges. Opposites attract. (Static electricity does not flow like the electricity we use as power but completely discharges at once.)

The dust “bugs” and “mice” that are often found under student’s beds are bound together by such a rubbing and charging process.

The moving draft from wind or a fan causes particles to rub, become charged and then to stick together. Students may also have felt static discharge from the release and rubbing of a car seatbelt or by rubbing a balloon against a jumper and “sticking” it to a wall or ceiling.



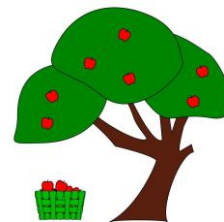
Formation of our Solar System – Teacher Background



With the clumping of dust due to static electricity, the first step towards building the solar system had been taken.

2. Gravity – the major force.

Gravity is a force related to the mass of an object. Mass is the “stuff” (atoms and molecules) that the body is made from. Any object which has mass will attract another object which has mass. Apocryphal tales have it that Isaac Newton first proposed this force after he saw an apple fall down from the tree he was sitting under. He realised that on Earth all things fall downwards towards the centre of the planet, that they must be attracted to it. He proposed that the force of attraction is dependant on the size of the masses and how far apart they are. The larger its mass, the larger its gravitational force of attraction. The closer the bodies are the greater their attraction.



The more massive lumps of the proto-planetary dust cloud were gravitationally attracted to each other slowly accreting until they fell towards the centre of the solar disc to form the Sun. (This sun used to be named **Sol**, hence the **solar** system). The remaining lighter matter formed the outer, mostly gassy solar disc. Rocky denser planets were pulled closer to the sun and the larger gassy less dense planets pushed further out. The position of the inner planets is thought to have been relatively constant. The outer gas giants however are thought to have migrated under the effect of each other's gravitational pull. The rocky and icy lumps forming the asteroid belt that lies between the inner rocky planets and the outer gas giants is thought to be remnants of the proto planetary disc which did not have sufficient mass to be pulled together and form a planet. The number and position of planets has changed over time. It is thought that one of the smaller earlier planets smashed into the Earth early after its formation, remelting its surface and leaving fragments in our orbit that came together to form the Moon. Interestingly, astronomers studying other distant suns and their exo-planets have found that most have gas giants much closer to their sun than we have in our solar system. Perhaps the “Goldilocks” set of conditions that required to support life as we know it are rarer than we initially had thought.

Australian Aboriginal creation stories can be found at:
www.abc.net.au/dustechoes/dustEchoesFlash.htm

The Sun's gravity holds the planets in their orbits though, of course, they are affected by the gravitational pull of each other. About 5 billion years from now the Sun will be less massive, it will cool and start to expand enveloping the inner planets including Earth before eventually it collapses in on itself.

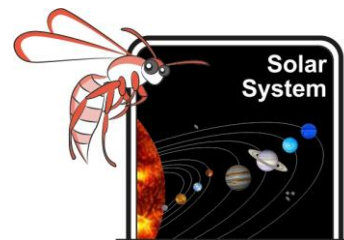
The weight of an object (or person) on Earth is a measure of their mass and the force that gravity has on that mass.

$$\text{Weight} = \text{Mass} + \text{Gravity}$$

If you were weighed on a smaller planet or on a moon our mass (the amount of stuff that makes our body) would remain the same because all the body would still be there but your weight would be much less as the moon has a much smaller mass and consequently smaller gravitational pull than the Earth. A student who weighs 32 kg on Earth will weigh 5.3kg on the moon. If they survived the horrific heat on the Sun their weight would be an equally horrific 866.3kg.

“Your weight on other worlds” at www.exploratorium.edu/ronh/weight/ will allow students to calculate their weight on planets and moons of our solar system.

Formation of our Solar System – Teacher Background



Students may also be horrified to know that although their body is attracted to the centre of the Earth it is also attracted towards other students body mass and even to the more massive school building! Even our Moon, which is a relatively small piece of rock in the solar system, can attract the mobile water in Earth's oceans when it is close and pull them upwards creating high and low tides.

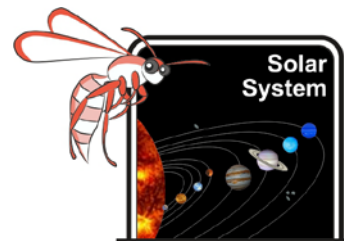
In the words of Monty Python's "Universe Song"

Just remember that you're standing on a planet that's evolving
And revolving at nine hundred miles an hour
That's orbiting at nineteen miles a second, so it's reckoned
A sun that is the source of all our power

The Sun and you and me and all the stars that we can see
Are moving at a million miles a day
In an outer spiral arm, at forty thousand miles an hour
Of the galaxy we call the 'Milky Way'

Although most of the measurements in the song are fairly accurate and the concepts well covered, some of the language used in other verses is perhaps not suitable for students.

Solar System Static – Teacher Notes



So far, our best explanation of the origin of the Universe is “The Big Bang Theory”. This suggests that a mighty explosion about 13 billion years ago sent hot dense particles streaming outwards from a central point of singularity. Some of this material came together to form giant stars that later exploded and again sent material flying out into space. One such explosion created a nebula (cloud) of stardust that travelled out to the western spiral arm of the Milky Way and came together to form our solar system. Out bodies, the food we eat, the air we breathe and the rocks we stand on are all made from that dust.

Forces cause other objects to move or change the direction of their movement. Two forces pulled the stardust together. Unlike a push or a pull, these forces do not have to touch the object but can act at a distance.

The first is a weak force called **static electricity**



When one piece of dust rubbed up against another, outer negatively charged electrons would be lost from one particle and passed onto the other. This would mean one piece of dust would have a different electrical charge than the other and they would be attracted together like little magnets. Static charge discharges immediately when the two objects touch. The plastic must be rubbed again for the attraction force to be recreated.

Activity - Static Electricity – a weak force pulling objects together over a short distance

Part 1 Comb & Paper

Materials per student or group

- A plastic comb (a plastic ruler works less well)
- Chads (paper circles) from a hole punch. These need to be separated into individual pieces (or very small pieces of torn paper). Static charge is weak so the paper pieces need to be small and light.
- An A4 sheet of paper
- A willing student with a good head of hair



NOTE *Static electricity does not flow like the current electricity we use in houses. It discharges instantly. The comb needs to be rubbed again if it is to be used again.*

Method

1. Separate paper chads and spread in a thin layer on the desk.
2. Comb hair vigorously for about 20 seconds.
3. Hold the comb just above the paper pieces. They should not touch.
4. Observe any changes.
5. Repeat but use the whole sheet of paper.
6. Observe any changes.

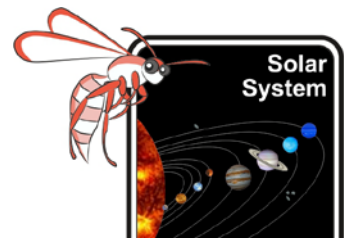
Prediction

What do you think will happen?

Any reasonable answer.



Solar System Static – Teacher Notes



Observations

The paper pieces “danced” and some rose to stick to the comb.
The force of attraction was not sufficient to raise the sheet of paper.

Conclusion

Did a force cause a change in the chads of paper?
Yes. The paper danced and was attracted towards the comb
Did the force act close up or at a distance?
Close up
Is static electricity a strong force or a weak force?
A weak force

Part 2 Balloon & Metal Can

Materials

- An inflated balloon (a plastic ruler works less well)
- An empty aluminium can (other metals are too massive for this weak force)
- A willing student with a good head of hair



Method

1. Lay the aluminium can on its side on the desk surface.
2. Rub the balloon on the student's hair vigorously.
3. Place the balloon close to the can (about 2cm) and then move it slowly away.
4. Observe what happens to the balloon.
5. Move the can to 4cm from the balloon and repeat.
6. Observe what happens to the can.

Prediction

What do you think will happen?
Any reasonable answer.

Observation

What happened when the balloon was slowly moved away from the can?
The can started to roll following the retreating balloon when it was close but if the can was moved further away it did not move.

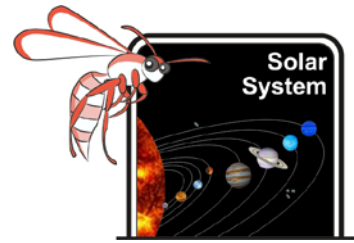
Conclusion

Did a force cause a change in the can? Explain your answer
Yes. The can was attracted to the balloon. It caused it to move.

What force caused the can to be attracted to the balloon and the paper to be attracted to the comb?
Static electricity

Repeat these experiments and find out how close the two objects have to be for the force to work.
What did you find out?
The objects had to be very close together/less than 2cm.

Solar System Static – Teacher Notes



Discussion

Could static electricity bind together small objects of different kinds of material?

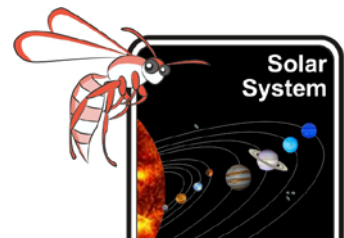
Yes.

Could static electricity bind together the planets and the Sun in our solar system? Explain your answer

No. The objects are too massive and too far apart. A stronger force is necessary

The first step towards building the solar system had been taken when static electricity bound together the fine dust of the proto-planetary disc and created more massive clumps.

Solar System Static – Student Activities



So far, our best explanation of the origin of the Universe is “The Big Bang Theory”. This suggests that a mighty explosion about 13 billion years ago sent hot dense particles streaming outwards from a central point. This material came together to form giant stars that later exploded and again sent material flying out into space. One such explosion created a nebula (cloud) of stardust that travelled out to the western spiral arm of the Milky Way and came together to form our solar system. Force from the explosion caused the dust to spin creating an enormous spinning proto-planetary disc from which our solar system began to form. Our bodies, the food we eat, the air we breathe and the rocks we stand on are all made from that dust.

Forces cause other objects to move or change the direction of their movement. Two forces (static electricity and gravity) pulled the stardust together to clump into larger pieces. Unlike a push or a pull, these forces do not have to touch the object but can act at a distance.

The first is a weak force called **static electricity**



When one piece of dust rubbed up against another, outer negatively charged electrons would be lost from one particle and passed onto the other. This would mean one piece of dust would have a differing electrical charge than the other and they would be attracted together like little magnets

Activity - Static electricity – a weak force pulling objects together over a short distance

Part 1 Comb & Paper

Materials per student or group

- A plastic comb
- Chads (paper circles) from a hole punch. These need to be separated into individual pieces of paper.
- A willing student with a good head of hair

NOTE Static electricity does not flow like the current electricity we use in houses. It discharges instantly. The comb needs to be rubbed again if it is to be used again.



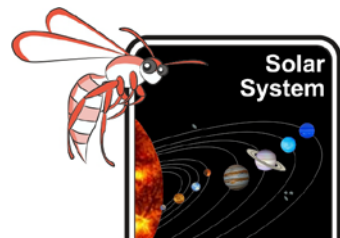
Method

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2. Comb hair vigorously for about 20 seconds.
3. Hold the comb just above the paper pieces. They should not touch.
4. Observe any changes.
5. Repeat but use the whole sheet of paper.
6. Observe any changes.



Prediction (what do you think will happen?)

Solar System Static – Student Activities



Observations

Conclusion

Did a force cause a change in the chads of paper? _____

Did the force act close up or at a distance? _____

Is static electricity a strong force or a weak force? _____

Part 2 Balloon & Metal Can

Materials per student or group

- An inflated balloon
- An empty aluminium can
- A willing student with a good head of hair



Method

1. Lay the aluminium can on its side on the desk surface.
2. Rub the balloon on the student's hair vigorously.
3. Place the balloon close to the can (about 2cm) and then move it slowly away.
4. Observe what happens to the balloon.
5. Move the can to 4cm from the balloon and repeat.
6. Observe what happens to the can.

Prediction (what do you think will happen?)

Observation

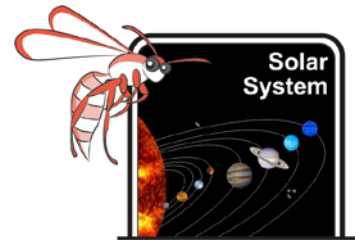
What happened when the balloon was slowly moved away from the can? _____

Conclusion

Did a force cause a change in the can? Explain your answer. _____

What force caused the can to be attracted to the balloon and the paper to be attracted to the comb?

Solar System Static – Student Activities



Repeat these experiments and find out how close the two objects have to be for the force to work. What did you find out?

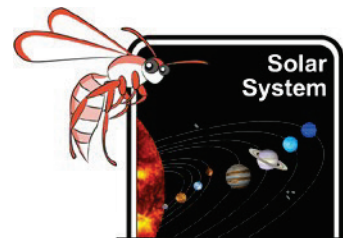
Discussion

Could static electricity bind together very small particles of different kinds of material? _____

Could static electricity bind together the planets and the Sun in our solar system? Explain your answer.

The first step towards building the solar system had been taken when static electricity bound together the fine dust of the proto-planetary disc and created more massive clumps.

Solar System Gravity – Teacher Notes



Gravity is a force that attracts objects to each other. The more massive an object is, the stronger is its gravitational force of attraction. Gravity acts over great distances. Gravity is the “glue that binds the Solar System together”

The Formation of the Solar System *(continued from static electricity activities).*

As the clumps of nebula dust held together by static electricity increased in mass they would also have been attracted together by the much stronger force of gravity. The spinning proto-planetary disc pulled larger pieces towards its centre creating the proto-Sun. This became very hot and exploded, blowing away most of the surrounding disc. The remaining pieces dispersed, crashed and reassembled to eventually form the planets of the Solar System and were held in place by the Sun’s gravitational pull. The more massive rocky planets lie closest to the Sun and the less massive gas giants lie farther away. All objects will eventually be pulled into the Sun but if they are massive and moving fast this will take a very long time.

The story goes that Isaac Newton first proposed the existence of gravity when an apple fell from the tree he was sitting under and he realised that Earth pulled things towards itself.

Teacher Demonstration - The effect of gravity on objects in the Solar System

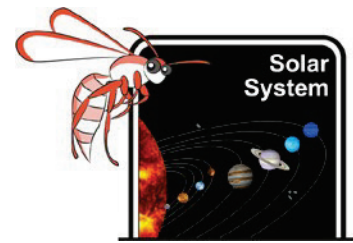


Materials

- Half a heavy duty rubbish bag
- A circular bucket or rubbish bin
- A heavy elastic band or gaffer tape
- A heavy object (lead weight or rock) and lighter spherical object (marble or Ping-Pong ball).

Method

1. Stretch a thick flexible plastic membrane, such as a single sheet cut from a large bin bag, over a circular container (rubbish bin or bucket) and anchor it to keep the membrane taut (elastic bands and gaffer tape).
2. Depress the centre point by placing a sufficiently heavy object (lead weight) on it.
3. Set the marble or Ping-Pong ball spinning round the outer edge of the stretched plastic. If the marble is travelling fast it will not be sufficiently deviated from its forward path. With a little less speed the marble will spiral down towards the denser weight at the centre with increasing speed.
4. Repeat step 3 to confirm observation.



Solar System Gravity – Teacher Notes

Observation

What happened to the plastic surface when a heavy weight was placed on it?

The plastic became depressed – it sank down/sagged

What is this depression supposed to represent?

The effect of the Sun's gravity that will change the path of any passing object/body/planet and eventually pull the object down in a curved path towards its centre.

What happened when the marble was moving fast?

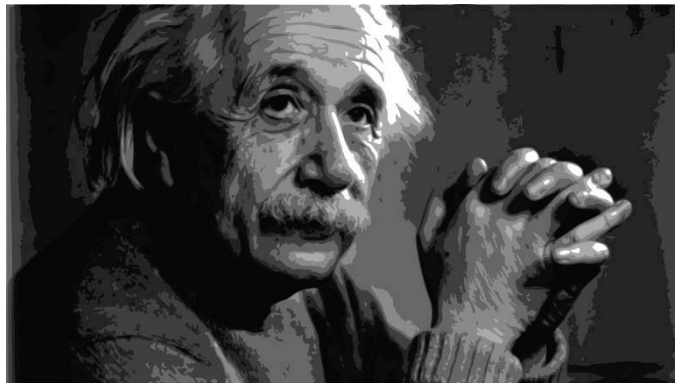
It was only slightly deviated.

What happened when the marble was travelling slower?

It spiralled down towards the heavy weight with increasing speed.

According to Newton, this curved path is due to the gravitational force exerted by the massive object at the centre of the plastic.

According to the great physicist Albert Einstein (1879-1955,) the great mass of the central body distorts space-time and results in a gravitational pull. Einstein proposed a fourth dimension "Time" needed to be included His 'General Theory of Relativity' can be translated as:



Matter tells space how to curve.

Space tells matter how to move.

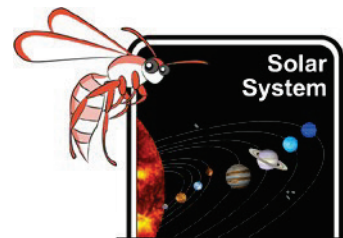
This explains why planets move around the Sun, why planets closer to the Sun orbit faster than planets further away and why smaller objects are drawn to the gravitational centre of the larger object they orbit.

(Einstein also said "Gravity cannot be held responsible for people falling in love".)

Of course all the planets have their own gravitational "pull" which affect each other, the paths of any moons they may hold and of comets passing by. The eccentric nature of the orbits of Neptune and Uranus suggest that our planets have not always been in their present orbits. Examination of other star systems with exo-planets demonstrates that their gas giants are held closer to the star than in our solar system. Perhaps the combination of circumstances that was necessary to produce life on Earth is less common than we had previously considered.

As an object approaches the Sun, or any massive astronomical body, it experiences the pull of gravity that makes it move faster. The increase of speed makes it shoot past the Sun until it is slowed as gravity opposes then overcomes motion. This is known as the "slingshot" effect. This effect has been used to provide an extra boost to spacecraft after they have left Earth.

Solar System Gravity – Teacher Notes

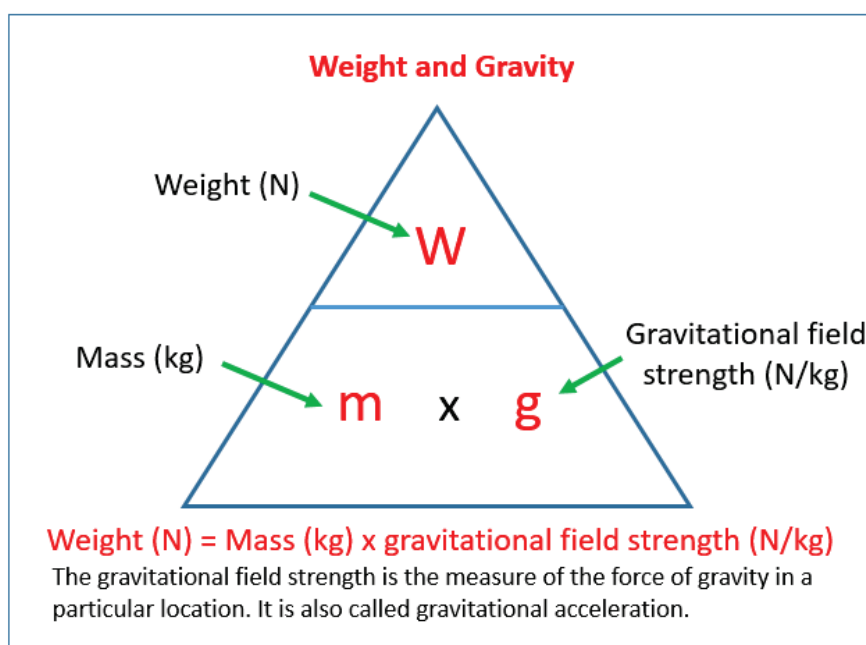


Extension - Weight, mass and gravity

Students will need to know their own weight or guess it. Some students are very sensitive about this information. They may accept a nominal weight of 32kg (the average weight of a Year 5 Australian student).

Materials

- A set of scales
- Access to the Internet



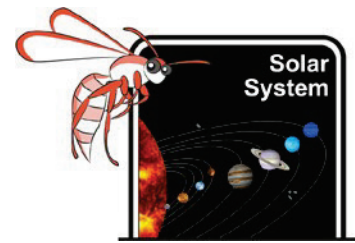
- Mass is the amount of matter in an object and is measured in kilograms
- Weight is a force due to the pull of gravity on an object and is measured in Newtons.
- Weight = mass x gravity

As gravity changes on different planets (the larger the planet the greater the gravitational pull), your weight will also change. Your mass however will stay the same (unless you burn off some kilos in transit).

The gravitational pull on Earth is ~ 10 N/kg

A student with a mass of 32 kg on Earth therefore weighs 320 N. However, their weight on the moon would only be 53 N, as the gravitational pull is much less.

If they survived the horrific heat on the Sun their weight would be an equally horrific 8,663 N



Solar System Gravity – Teacher Notes

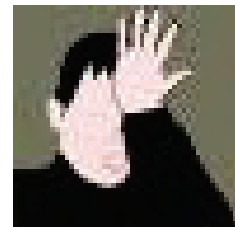
Your weight on other worlds www.exploratorium.edu/ronh/weight/ will allow you to calculate your weight on planets and moons of our solar system (answers based on 32kg).

	My weight (N)
Mercury	120
Venus	290
Earth	320
Mars	120
Jupiter	756
Saturn	340
Uranus	284
Neptune	360

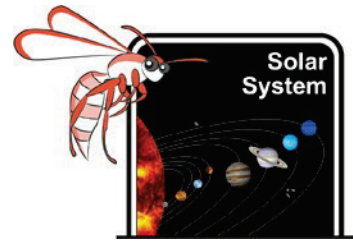
Students may also be horrified to know that although their body is attracted to the centre of the Earth it is also attracted towards other student's body mass and even to the more massive school building!

Your body finds the school attractive! Luckily the mass of your school is very small compared to a planet.

Planet Earth has a mass of 5972000000000000000000kg



Even our Moon, which is quite a relatively small piece of rock in the Solar System, can attract the mobile water in Earth's oceans when it is close and pull them upwards creating high and low tides.



Solar System Gravity – Student Activity

Gravity is a force that attracts objects to each other. The more massive an object is, the stronger is its gravitational force of attraction. Gravity acts over great distances. Gravity is the “glue that binds the Solar System together”

The Formation of the Solar System (continued from static electricity activities).

As the clumps of nebula dust held together by static electricity increased in mass they would also have been attracted together by the much stronger force of gravity. The spinning proto-planetary disc pulled larger pieces towards its centre creating the proto-Sun. This became very hot and exploded, blowing away most of the surrounding disc. The remaining pieces dispersed, crashed and reassembled to eventually form the planets of the Solar System and were held in place by the Sun’s gravitational pull.

Teacher demonstration -The effect of gravity on objects in the Solar System



Method

1. Watch the demonstration by your teacher to answer the following questions.

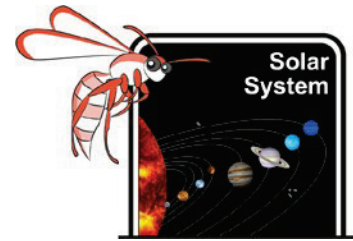
Observation

What happened to the plastic surface when a heavy weight was placed on it? _____

What is this depression supposed to represent? _____

What happened when the marble (or Ping Pong ball) was moving fast? _____

What happened when the marble (or Ping Pong ball) was travelling slower? _____

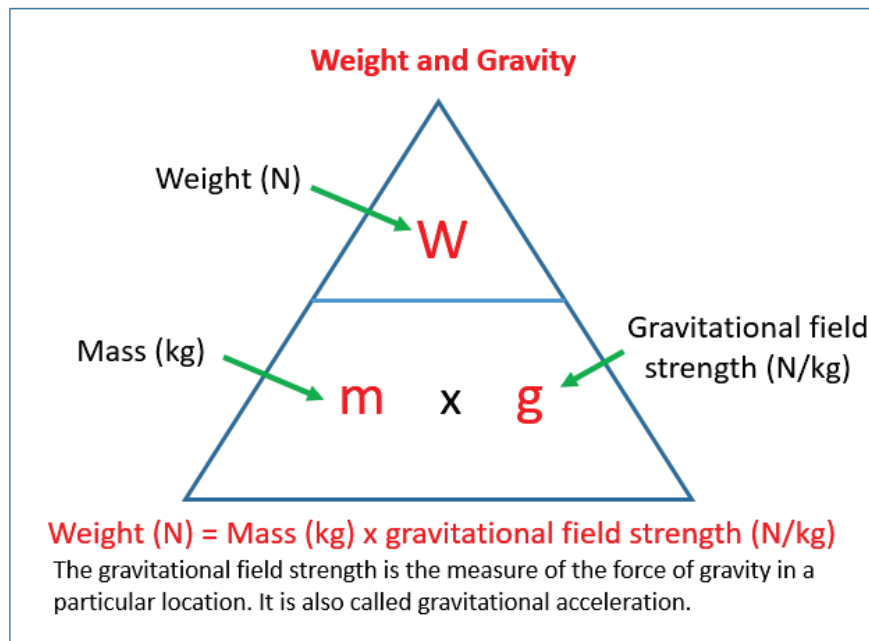


Solar System Gravity – Student Activity

Extension - Weight, mass and gravity

Materials

- Access to the Internet



- Mass is the amount of matter in an object and is measured in kilograms
- Weight is a force due to the pull of gravity on an object and is measured in Newtons.
- Weight = mass x gravity

As gravity changes on different planets (the larger the planet the greater the gravitational pull), your weight will also change. Your mass however will stay the same (unless you burn off some kilos in transit).

The gravitational pull on Earth is ~ 10 N/kg

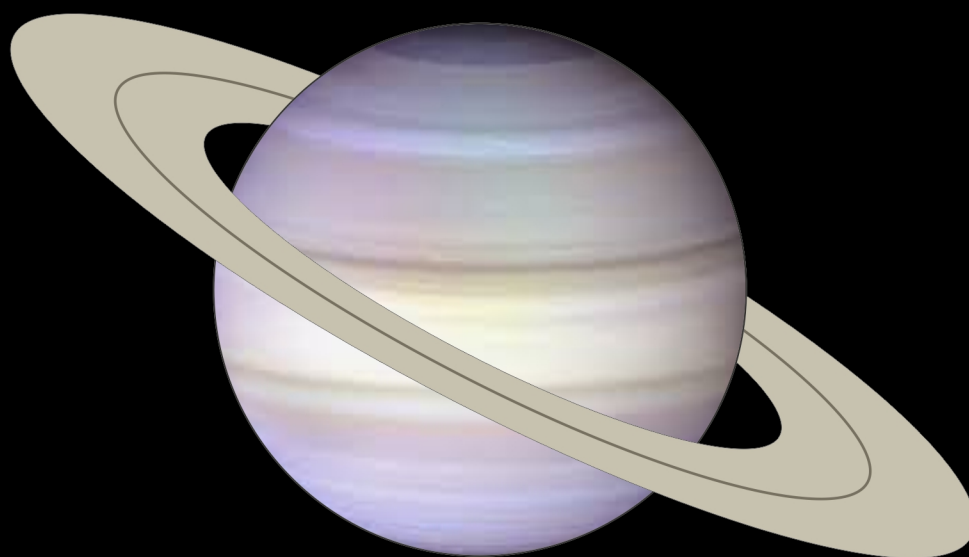
A student with a mass of 32 kg on Earth therefore weighs 320 N. However, their weight on the moon would only be 53 N, as the gravitational pull is much less.

If they survived the horrific heat on the Sun their weight would be an equally horrific 8,663 N

“Your weight on other worlds” www.exploratorium.edu/ronh/weight/ will allow you to calculate your weight on planets and moons of our Solar System.

	My weight (N)		My weight (N)
Mercury		Jupiter	
Venus		Saturn	
Earth		Uranus	
Mars		Neptune	

Identifying Planets



☐ Venus

☐ Mars

☐ Neptune

☐ Saturn

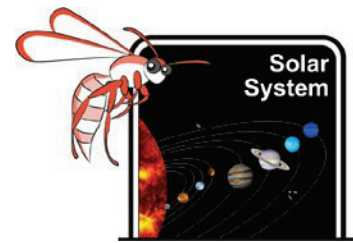
☐ Earth

☐ Uranus

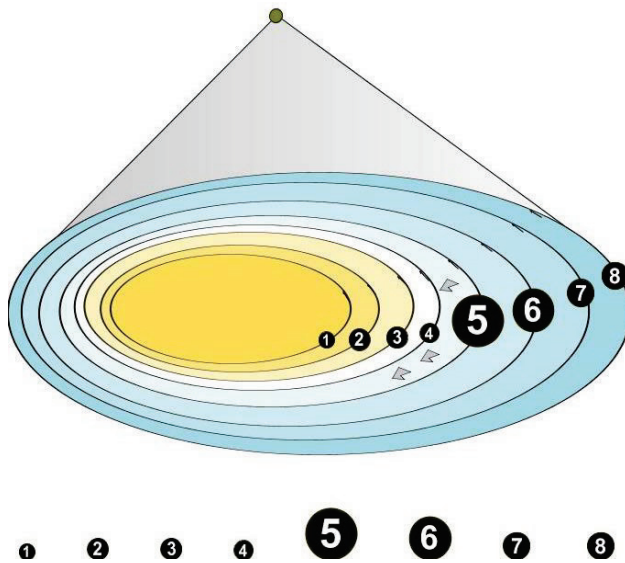
☐ Mercury

☐ Jupiter

☐ Sun



Orbit and Size – Teacher Notes



This diagram is an artist's impression of the planets in our solar system, their orbits and their relative sizes. After finishing these activities, decide how accurate this diagram is.

This is not very accurate. The orbits are too elliptical and they are not spread out enough. The distance between the planets should be much greater.

We look towards the Moon or the planets in the night sky and they appear to be quite small because they are far away. Artists use this apparent shrinkage to create a sense of distance or perspective. Let's test this idea.

Activity A - Perspective and Scale

Materials per student

- 2 rulers

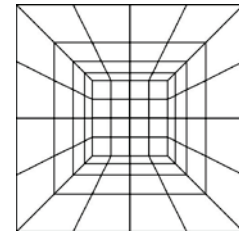
Method

1. Place one ruler on top of the other with the closer ruler displaced downwards so that the measurement units on both rulers can be seen.
2. Hold up both rulers about 8cm in front of your nose.

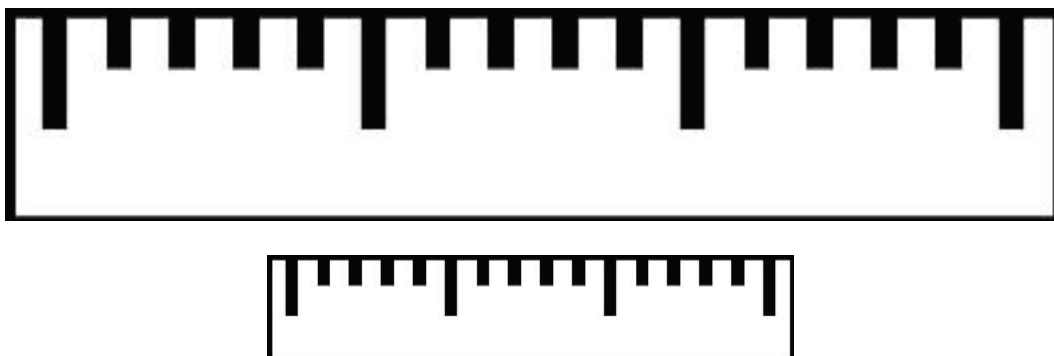
Q. Do both rulers appear to be the same length? **YES**

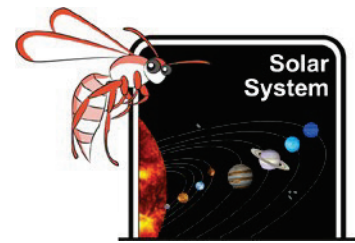
3. With your right hand move the back ruler away until your right arm is fully extended.

Q. Do both rulers look the same length now? **No, the back ruler appears to get smaller the further away it moves. The average student will find that the apparent length of the ruler is halved on full extension of one arm.**



Long ago many people thought that the Sun was smaller than the Earth because it appeared to be so in the sky. They did not appreciate how big it really was because of how far away it was. When we deliberately draw things smaller than they are we say they are "**scaled down**".





Orbit and Size – Teacher Notes

By how much has the lower ruler been scaled down? [By half or 1:2](#)

Has the real length of the ruler changed? [No](#)

Making scale models of the solar system

Scientists often have to work out the best way to describe things so people can more easily understand them. Scale models and scale drawings are often used as the old adage goes, “a picture is worth a thousand words”. When it comes to astronomy, however, the distances between planets and their size are so large that any models have to be severely scaled down because of the enormous distances involved.

It is often a good idea for students to make a rough attempt at a scale drawing on scrap paper before they attempt the final copy. That way any mistakes can be avoided and difficulties can be overcome with a little more thought or direction.

Activity B - Distances of Planets from the Sun

Measurements across our solar system are HUGE! The average distance of the Earth from the Sun is 149,597,870.7 kilometres. My pocket calculator refuses to attempt to compute the distance from Earth to Neptune in kilometres ($39.53 \times 149,597,870.7\text{km}$). To fit the distances from the Sun onto a small area we need to change scale to another unit of measurement. Instead of kilometres we use the distance of the Earth to the Sun and call this one Astronomical Unit or AU.

1 Astronomical Unit (AU) is 149,597,870.7km

Why do we use the mean (average) distance of planets from the Sun?

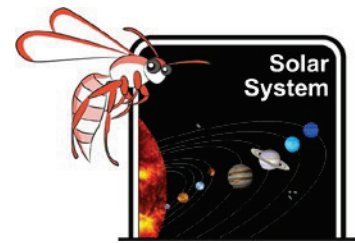
[Planets travel in an elliptical orbit around the Sun so their distance from the Sun will vary during their orbit.](#)

Use the information in the table below in this activity.

Planet	Distance to the Sun (mean) AU	Scaled distance on paper (cm:AU)		
		1:1	1:0.75	1:0.5
Mercury	0.39	0.39	0.29	0.19
Venus	0.72	0.72	0.54	0.36
Earth	1.00	1.00	0.75	0.5
Mars	1.52	1.52	1.14	0.75
Jupiter	5.2	5.2	2.60	3.90
Saturn	9.51	9.51	7.13	4.76
Uranus	19.3	19.30	14.48	9.65
Neptune	30.07	30.07	22.55	15.04

Materials

- One sheet of A4 paper for good work
- Scrap paper for rough work
- Sellotape or glue
- A pencil eraser and ruler
- A calculator



Orbit and Size – Teacher Notes

Method

1. Lay your worksheet “landscape” and measure the length of the longest edge.
29.6cm or 296mm
2. Do you think these measurements need to be scaled up or scaled down to fit onto your worksheet?
Scaled down.
3. Select an appropriate scale so that the largest distance will fit across this paper
You may prefer to give students some scrap paper to work this scale out for themselves. If 1 cm: 1 AU is used, the worksheet will be too small as its greatest length (including border) is only 29.6 cm. Half scale may be used simply dividing the distance from the Sun in AU by 2. However this will cause the first three planets to be squashed into the first cm. 1:0.75 or three quarter scale has been given as this allows for all planets to fit on the page. By sticking another sheet landscape onto the worksheet a scale of 1cm = 1Au can be achieved.
4. Calculate the model distances from the Sun according to your scale and put these in the table provided.
5. Draw up the scaled model on the worksheet

Discussion

What problems did you have working at the scale you chose?

Depends on their choice. It was difficult to fit the first three planets into 1cm. The paper wasn't big enough.

Extension

Method

- Select a student to represent the Sun
- Select groups of 3 or 4 students to represent each of the eight planets
- Grab a long measuring tape (perhaps borrowed from Phys. Ed.) and locate the groups in the correct position along the tape using scales of 1m:1AU.

Activity C - Relative Sizes of Planets

Materials

- Ruler
- A pair of compasses and pencil

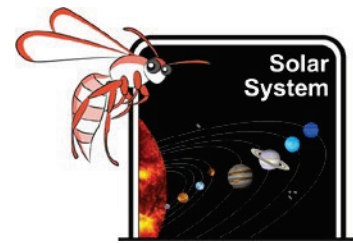
Method

1. Estimate the scale required to fit Uranus and Saturn on one page.

What scale can you use to be able to draw all the planets on the paper provided?

To fit Saturn and Uranus on the same page a scale of 1cm: 1 AU is required. The other planets can be fitted into the remaining spaces

Planet	Diameter of planet (km)	Diameter of planet 1cm: 10,000 km
Mercury	4,879	<i>0.48</i>
Venus	12,104	<i>1.21</i>
Earth	12,756	<i>1.27</i>



Orbit and Size – Teacher Notes

Mars	6,792	0.68
Jupiter	142,984	14.30
Saturn	120,536	12.05
Uranus	51,118	5.11
Neptune	49,528	4.95

Extension

The diameter of the Sun is 1,392,700 km.

How many sheets of A4 paper would you need to be able to represent the Sun at the scale 1cm: 10, 000 km?

1 sheet of A4 paper measures 21cm X 29.5 cm

The diameter of the Sun is 139.27 cm.

You would need paper to cover an area of 140 cm X 140 cm

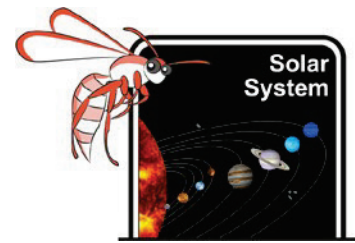
You would need a block of papers 7 (140/21) by 5 (140/29.5)

You would need 35 pieces of A4 paper.

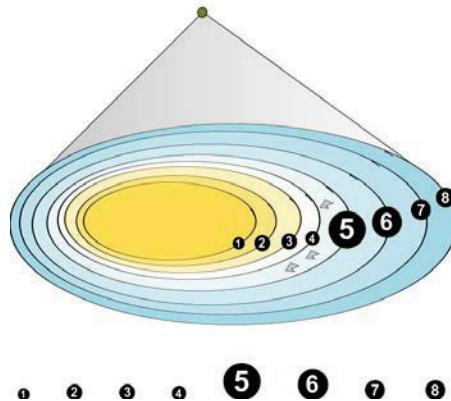
Take a piece of string 70 cm long, attach this to a piece of chalk. Ask one student to anchor one end and use the end with the chalk to draw a circle to represent the relative size of the Sun. Compare this to a bead or marble representing the relative size of the Earth.

RESOURCE POSTER

Paul Floyd has generously created an A3 poster comparing the sizes of Earth and Saturn correctly scaled. The poster is free to download at: http://nightskyonline.info/?page_id=17508



Orbit and Size- Student Activity



This diagram is an artist's impression of the planets, their orbits and their relative sizes. After finishing these activities, decide how accurate it is.

We look towards the Moon or the planets in the night sky and they appear to be quite small because they are far away. Artists use this apparent shrinkage to create a sense of distance or perspective. Let's test this idea.

Activity A - Perspective and Scale

Materials per student

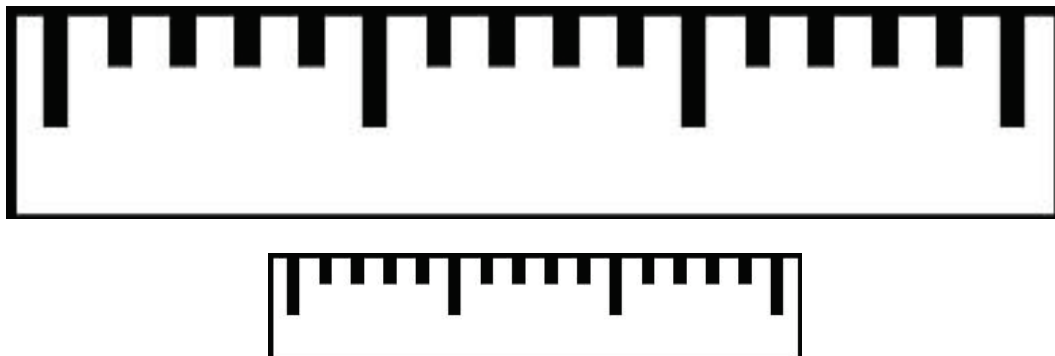
- 2 rulers

Method

1. Place one ruler on top of the other with the closer ruler displaced downwards so that the measurement units on both rulers can be seen.
 2. Hold up both rulers about 8cm in front of your nose.
- Q.** Do both rulers appear to be the same length? _____
3. With your right hand move the back ruler away until your right arm is fully extended.

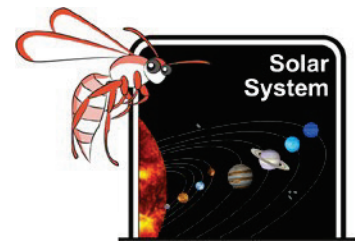
Q. Do both rulers look the same length now? _____

Long ago many people thought that the Sun was smaller than the Earth because it appeared to be so in the sky. They did not appreciate how big it really was because of how far away it was. When we deliberately draw things smaller than they are we say they are "**scaled down**".



By how much has the lower ruler been scaled down? _____

Has the real length of the ruler changed? _____



Orbit and Size- Student Activity

Making scale models of the solar system

Scientists often have to work out the best way to describe things so that people can more easily understand them. Scale models and scale drawings are often used as the old adage goes, “a picture is worth a thousand words”. When it comes to astronomy, however, the distances between planets and their size are so large that any models have to be severely scaled down because of the enormous distances involved.

Activity B - Distances of Planets from the Sun

Measurements across our solar system are HUGE! The average distance of the Earth from the Sun is 149,597,870.7 kilometres. My pocket calculator refuses to attempt to compute the distance from Earth to Neptune in kilometres ($39.53 \times 149,597,870.7\text{km}$). To fit the distances from the Sun onto a small area we need to change scale to another unit of measurement. Instead of kilometres we use the distance of the Earth to the Sun and call this one Astronomical Unit or AU.

1 Astronomical Unit (AU) is 149,597,870.7km

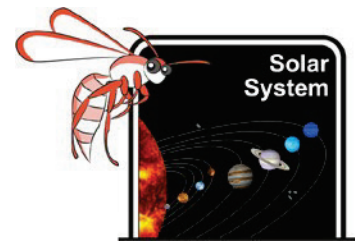
Q. Why do we use the mean (average) distance of planets from the Sun?

Use the information in the table below to complete the activity:

Planet	Distance to the Sun (mean) AU	Scaled distance on paper (cm:AU)
Mercury	0.39	
Venus	0.72	
Earth	1.00	
Mars	1.52	
Jupiter	5.2	
Saturn	9.51	
Uranus	19.3	
Neptune	30.07	

Materials

- One sheet of A4 paper for good work
- Scrap paper for rough work
- Sellotape or glue
- A pencil eraser and ruler
- A calculator



Orbit and Size- Student Activity

Method

1. Lay your worksheet "landscape" and measure the length of the longest edge. _____ cm
2. Decide if these measurements need to be scaled up or scaled down to fit onto your worksheet? _____
3. Select an appropriate scale so that the largest distance will fit across this paper _____
4. Calculate the model distances from the Sun according to your scale and put these in the table provided.
5. Draw up the scaled model on the worksheet

Discussion

What problems did you have working at the scale you chose?

Activity C - Relative Sizes of planets

Materials

- Ruler
- A pair of compasses and pencil

Method

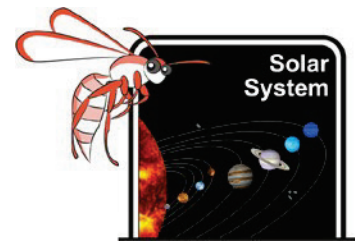
1. Estimate the scale required to fit Jupiter and Saturn on one page.
2. Decide which scale can you use to be able to draw all the planets on the paper provided.

Planet	Diameter of planet (km)	Diameter of planet 1cm: 10,000 km
Mercury	4,879	
Venus	12,104	
Earth	12,756	
Mars	6,792	
Jupiter	142,984	
Saturn	120,536	
Uranus	51,118	
Neptune	49,528	

Extension

The diameter of the Sun is 1,392,700 km.

How many sheets of A4 paper would you need to be able to represent the Sun at the scale 1cm: 10,000 km?



Planet Mnemonic – Teacher Notes

Our solar system consists of the Sun, Sol, four inner stony or terrestrial planets, a zone of rocky planetessimals called the Asteroid Belt, the four outer giant gas planets, and beyond that the zone of icy comets and dwarf planets known as the Kuiper Belt. Beyond all of this lies the Oort Cloud, containing more comets and dwarf planets.

Distances

The Kuiper Belt stretches out to 12 billion kilometres from the Sun. To simplify the problem of using multiple digits a unit based on the average distance of the Earth from the Sun is used when estimating distances within the Solar System. It is called the Astronomical Unit or AU

$$1\text{AU} = 149,597,870.70 \text{ kilometres}$$

When it comes to describing greater distances, such as how far away another star is from our Sun, the time it would take for light to travel from that source to our planet is used. This is known as the Universal physical constant or c.

$$C = 299,792,458\text{m/s or } 1,080\text{km/h}$$

Stars

Stars are giant thermonuclear reactors that produce their own energy. Everything else in space is only visible because their surfaces reflect starlight. Our Sun is a star and we see the planets, asteroids, meteors and comets in our night sky because light from our Sun is reflected from their surfaces. Activities for teacher demonstrations or student activities are given in “Twinkle, Twinkle?”

Our ancestors viewed the night skies and recognised patterns and progressions of movement that allowed them to:

- Navigate on land and on sea.
- Recognise the seasons (when to plant and when to reap).
- Recognise when an eclipse might occur.

They also noticed some star groups formed patterns or constellations (con=together stella = star). These seemed to move as a group and could be used to indicate the passing of seasons or points of the compass. Some groups, like South American Indians and Australian Aboriginals, also noted shapes of voids where no stars appeared visible to human eyes such as the Emu, which lies near the Coal Sack, a dark shape in the Milky Way. Although the Coal Sack appears as empty sky it is actually caused by dust stopping light penetration.

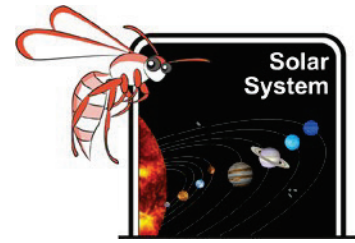
Planets

In amongst these well-ordered celestial bodies were large bright bodies, which didn't twinkle or follow the same pattern of seasonal movement as the others and “wandered around”. In Greek, planet means wanderer. Stars elsewhere in the Milky Way Galaxy have surrounding planets. Early astronomers called any large body a planet, but as telescopes improved many more bodies were discovered. Your grandparents would have included Pluto in the planets, but in 2006 the International Astronomical Union declared that Pluto no longer qualified.

To be a planet, a body must:

1. Orbit a sun
2. Be large enough to take on a shape that is nearly round (most planets are slightly flattened towards their poles).
3. Clear the orbit of other planets.

Planet Mnemonic – Teacher Notes



Alas, Pluto's orbit overlaps that of Neptune. It was declared a planetesimal and joins other dwarf planets found in the trans-Neptunian zone of the Kuiper Belt.

The four inner rocky planets of the solar system are Mercury, Venus, Earth and Mars. The four outer gas giants are Jupiter, Saturn, Uranus and Neptune.

Between these two groups lies a belt of smaller objects known as the Asteroid Belt. When the solar system was forming it may have started to assemble as another planet but the fragments would not bind together because of the influence of Jupiter's gravitational force. Most of the mass in the belt is made of the four largest asteroids and the rest is mostly space with a little dust.

Curtin University's "Fireballs in the sky" teacher's resource materials are available through the landing page at: <http://fireballsinthesky.com.au/about/activities/>. There are many fun, hands on and slightly messy activities and loads of background information about meteorites, meteors, asteroids and comets. They also have information about how students can participate in the Desert Fireball Network using its free App and their mobiles.

Activity - Planetary mnemonics

Mnemonics (Greek mnemon = mindful)

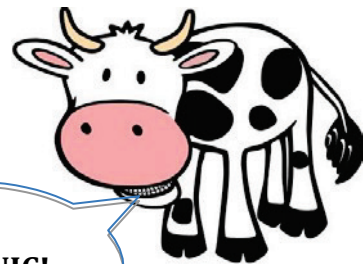
Mnemonics are phrases used to remember important things.

Many primary schools use the science mnemonic "cows moo softly" because the first letter of each word reminds them of how to make sure their experiments are fair tests.

C = Change one thing

M = Measure one thing

S = Same. Keep everything else the same.



MNEMONIC!

The International Astronomical Union suggested the following to remember the sequence of the planets from the Sun.



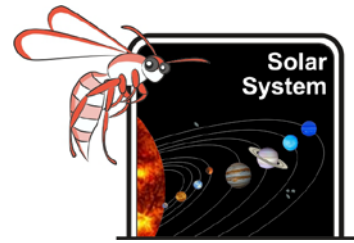
**My very educated
mother just served us
nachos**

Students can be challenged to create memorable (but polite) mnemonics and they can be boarded and voted upon to find the most acceptable.

Write down the names of the planets moving outwards from the Sun.

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune

Planet Mnemonic – Student Activity

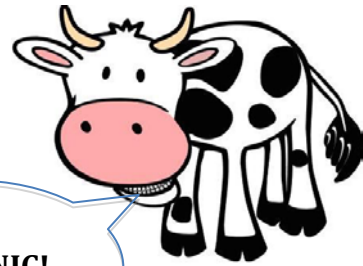


Mnemonics (Greek mnemon = mindful)

Mnemonics are phrases used to remember important things.

Many schools use the science mnemonic “cows moo softly”

because the first letter of each word reminds them of how to make sure their experiments are “fair tests”.



MNEMONIC!

C = Change one thing

M = Measure one thing

S = Same. Keep everything else the same.

Write down the names of the planets moving outwards from the Sun.

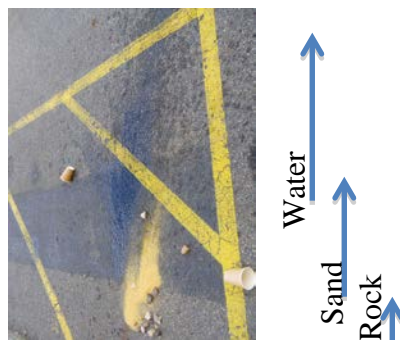
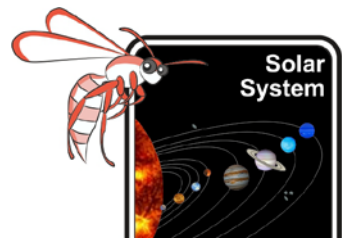
HINT : Check there are eight

Take their first initial and create your own mnemonic. Remember they must be polite!

Working space below.

Share your ideas with your classmates when your teacher directs you.

Rocky & Gas Planets – Teacher Notes



The eight planets in our solar system are organised into four inner rocky or terrestrial planets and four outer gas giants. Gravity is the major force that separated the materials in the solar disc into these positions. More massive materials were drawn by gravitational attraction towards the immensely massive Sun that contains 98% of the material in the solar system. Gases, having less mass were spun to the outer edges of the system. The Sun's solar wind also blew gassy materials outward. The farther from the Sun the colder it is. The gases froze and planets became solid. Comets from these outer zones are mostly "dirty snowballs" of frozen water.

Other Objects in the Solar System

The *Desert Fireball Network* is a meteorite research group based at Curtin University who aim to study meteorites by tracking them as they enter our atmosphere as meteors (fireballs). The students and schools can also get involved in the Fireballs community by using the free app, hosting a camera and participating in the online conversation via social media.

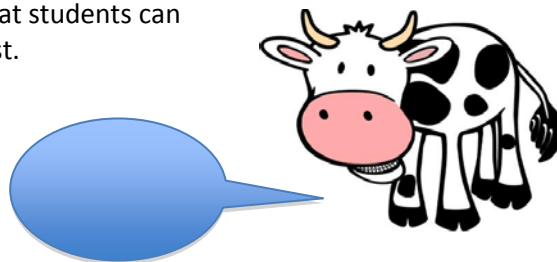
The pull of gravity on materials with different masses can be easily demonstrated by the following experiment that could be a teacher demonstration or student activity. The experiment process is deliberately flawed so that students can suggest improvements and replay to make a fair test.

Cows Moo Softly

Change one thing

Measure one thing

Keep everything else the Same



Activity - To demonstrate how gravity separated the planets into inner terrestrial or rocky planets and outer gas planets

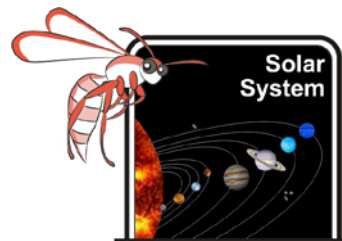
Materials

- Three paper or plastic cups
- Some stones, sand and water. Sufficient material to half fill a cup
- A cricket bat
- An open sealed area of veranda or playground

Method

1. Approximately half fill one cup with stones, the second with sand and the third with water
2. Line up the cups as in the picture above
3. Hit each cup firmly with the cricket bat. Alternatively a student with robust shoes could kick the cup
4. Observe what happens to the contents of the cups and report below

Rocky & Gas Planets – Teacher Notes



Prediction

What do you think will happen to the different materials when they are hit?

Any reasonable answer

Observations

What happened to the contents of the cups?

The heavy rocks did not travel far, the sand started dropping about half way along the rocks and the water started dropping before the end of the sand but extended well beyond it.

Discussion

Was this a “fair test”? (Did the Cow Moo Softly?)

No

C = Change. We were only supposed to change one thing, the material in the cup. However

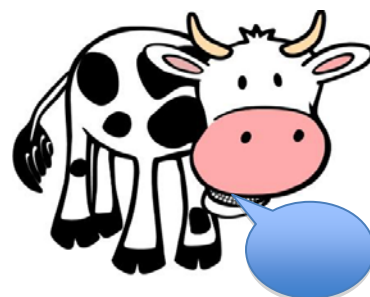
1. We did not have exactly the same amount of material in the cups
2. We did not control the amount of energy used for the three hits or kicks

M = Measure

1. We did not measure the distance the different materials travelled

S = Same

Everything else needs to be kept the same (see above)



What could be adjusted to make this a fair test?

Make a mark at the same level on all paper cups (5cm?) and fill to that point.

With a ruler and chalk mark 35cm behind the cups and only swing the bat from that point

Measure the spread of each material with a ruler.

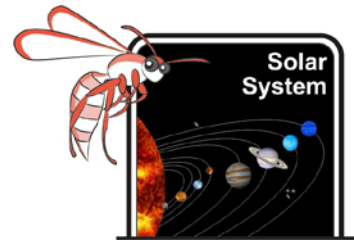
Extension - Solar Wind

Our Sun is a massive energy source. Early in planetary formation it was even more energetic and particles streamed away from it as a solar wind. This also moved lighter particles away from the inner planets towards the outer solar system. The magnetic field round the Earth defends us against particles in the solar wind.

If the wind is blowing strongly outside the classroom, grab a handful of dry soil, sand and stones. Release this into the wind and plot the movement of the different materials.



Mercury, the innermost and smallest rocky planet, has hardly any atmosphere at all. Only a little helium gas can be detected. Scientists suspect that any gas present is blown away by the present, weaker solar wind.



Rocky & Gas Planets – Student Activity

The eight planets in our solar system are organised into four inner rocky or terrestrial planets and four outer gas giants.

Activity - To demonstrate how gravity may have separated the planets into inner rocky (terrestrial) planets and outer gas planets



Materials

- Three paper or plastic cups
- Some stones, sand and water, sufficient of each material to half fill one cup
- A cricket bat
- An open area of veranda or sealed playground

Method

1. Approximately half fill one cup with stones, the second with sand and the third with water
2. Line up the cups as in the picture above
3. Hit each cup firmly with the cricket bat.
4. Observe what happens to the contents of the cups and report below

Prediction

What do you think will happen to the different materials when they are hit?

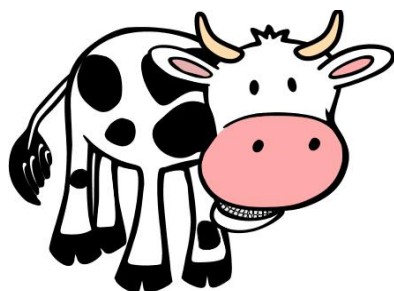
Observations

What happened to the contents of the cups? _____

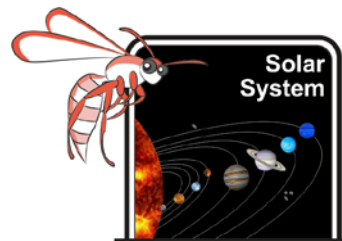
Discussion

Was this a “fair test”? Did the Cow Moo Softly? Explain your answer. **C** _____

M _____ **S** _____



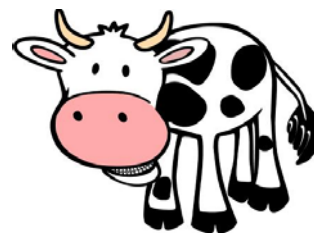
Rocky & Gas Planets – Student Activity



What could be adjusted to make this a fair test?

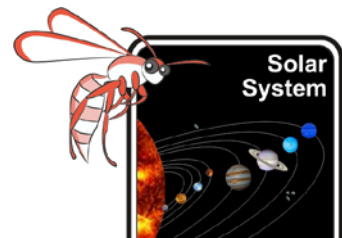
1. _____
2. _____
3. _____

If these changes are carried out, will this be a fair test? Will the cow moo softly?



Does this activity prove that gravity was the main source of separation of the planets into inner terrestrial planets and outer gas planets?

Planetary Passport - Teacher Notes



This activity asks students to consider the quality of some source materials and to write a proper bibliography describing these sources. Most school libraries have prepared guides for students. If books and computers are already available, the average student should only take about 30 minutes to find and confirm the data required for their planet. Less information is known about the outer planets so these may be allocated to the less able students. If students use the marking key for their rough notes, staple it to their final copy and hand them in before the end of the session plagiarism is discouraged. Only one mark is allocated for the drawing of the planet so a simple sketch is fine. Student's work can be used for the "Planetary Quiz" worksheet.

When starting any research project a scientist has to first place a value on the secondary (other person's) material they are using. Not all newspaper reports or all Internet sources are reliable.



G I G O



Garbage In = Garbage Out

Academic work and many government researchers are required to use peer review before publication. Not all newspaper articles and many Internet sites are less than careful with authenticating facts. If you do not check information by using more than one source you could end up writing rubbish! This is why we always add a bibliography of our sources. Please provide students with your school's bibliography requirements.

When you apply for a passport your application has to be checked and approved by a person of good standing in the community such as a teacher. You will be collecting scientific and historical information about one of the other planets in our solar system to provide it with its' planetary passport. Luckily we do need a "true copy and likeness" of the picture to be verified by the signature of an astronomer!



Use the marking key for your rough notes

Marking Key - Any measurement should have units (AU or km)

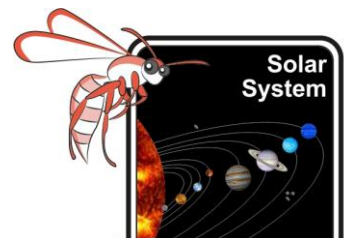
Picture	1
Name of planet	1
Reason for name	2
Position in solar system	1
Distance from the Sun	1
Diameter relative to Earth	1
Orbital path direction	1
Moons present or absent	1
Atmosphere	2
5 fascinating facts	5
Bibliography	4 marks

TOTAL 20 marks

SCORE _____

Information gained here can be used to answer the "Planetary Quiz".

Planetary Passport- Student Research



When starting any research project a scientist has to first place a value on the secondary (other person's) material they are using. Not all newspaper reports or all Internet sources are reliable.



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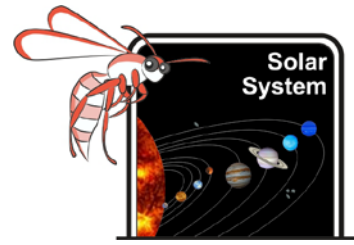


Use the marking key for your rough notes

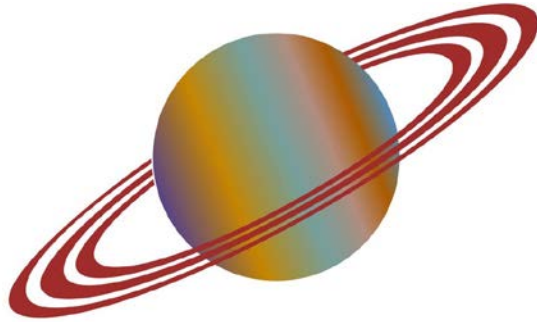
Marking Key Any measurement should have units (AU or km)

Picture	1
Name of planet	1
Reason for name	2
Position in solar system	1
Distance from the Sun	1
Diameter relative to Earth	1
Orbital path direction	1
Moons present or absent	1
Atmosphere	2
5 fascinating facts	5
Bibliography	4 marks
TOTAL 20 marks	SCORE _____

Planetary Quiz – Teacher Notes



Name the planets below (not to scale).



Saturn



Mercury



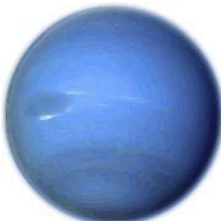
Venus



Earth



Mars



Neptune



Uranus



Jupiter

How many stars are there in our solar system? **One, the Sun.**

Name the fifth largest planet in our solar system **Earth**

Which planet has the most circular orbit? **Mercury – closest to the Sun**

Which planet is farthest from the Sun? **Neptune**

Which two planets rotate in the opposite direction on their axes to the direction they orbit the Sun? **Venus & Uranus**

Name four rocky planets **Mercury, Venus, Earth and Mars**

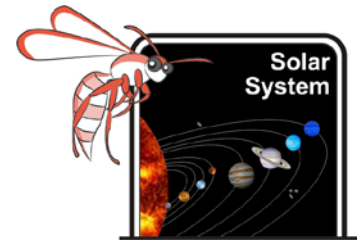
Name four gas giants **Jupiter, Saturn, Uranus and Neptune**

Why is Mars known as “The red planet”? **The ancient Egyptians thought it looked red. The red colour is due to iron oxide or rust.**

Which planet is so massive (not large) that it’s mass is greater than all the other planets put together? **Jupiter. It has a mass of 1,899 million, billion, billion kilograms**

What is the name of the highest mountain on Mars? **Olympus Mons**

Planetary Quiz – Teacher Notes



Which planet has The Great Red Spot and what causes it? **Jupiter**. The spot is caused by a massive atmospheric storm

Name Earth's only satellite **The Moon**

Which moon of Jupiter may possibly have life? **Europa may have life because its surface is covered in water and ice.**

What is the surface temperature of Uranus estimated to be? **-200°C**

How long does Uranus take to orbit the Sun? **30,589 Earth days – a long time between birthdays!**

Which planet takes about 365 days to orbit the Sun? **Earth**

Which planet has a very cold atmosphere of hydrogen, methane and helium giving it a blue colour? **Neptune**

Extra for experts

If you stood on the surface of Mercury, would the Sun appear larger or smaller than it does on Earth? Explain your answer.

Larger because it is closer to the Sun

Venus is about the same size as Earth, has a similar gravity and is a similarly rocky planet. Why do we not colonise Venus? Give three good reasons. **The atmosphere has no oxygen and has high amounts of carbon dioxide. This makes it very, very hot (4650°C at the surface). The pressure of its atmosphere is a crushing 90 times stronger than on Earth.**

What weight would a 50kg human have on the surface of the Sun?

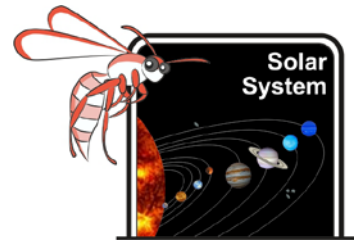
Trick question. The Sun does not have a solid surface and the human would have been vaporised by its extreme heat.

Which planet is the largest (takes up most room) in our Solar System? **Saturn.**

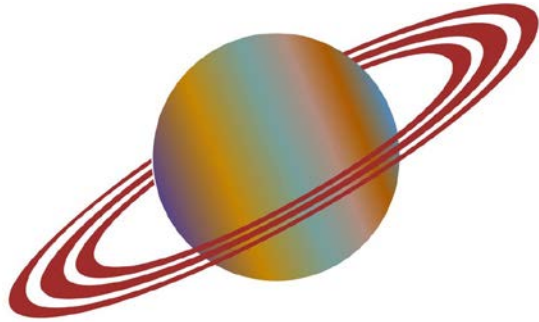
What are Saturn's rings made of? **Frozen water, gas and dust.**

Planet Earth's atmosphere is four-fifths nitrogen. Which other orbiting body has an atmosphere with four fifth's nitrogen? **Titan, one of the moons of Saturn. There is also deadly hydrogen cyanide however!**

Planetary Quiz – Student Activity



Name the planets below (not to scale).



How many stars are there in our Solar System? _____

Name the fifth largest planet in our solar system _____

Which planet has the most circular orbit? _____

Which planet is farthest from the Sun? _____

Which two planets rotate in the opposite direction on their axes to the direction they orbit the Sun?

Name four rocky planets _____

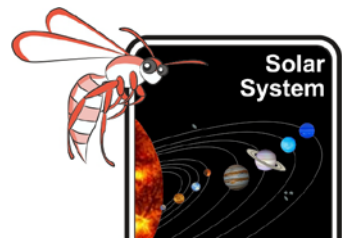
Name four gas giants _____

Why is Mars known as “The red planet”? _____

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Planetary Quiz – Student Activity



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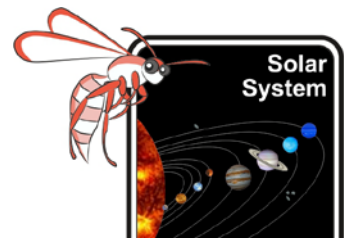
[Which planet has the least density? You could float a ball of it in your bath at home.](#)

Which planet is the largest (takes up most room) in our Solar System? [Saturn.](#)

What are Saturn's rings made of? [Frozen water, gas and dust.](#)

Planet Earth's atmosphere is four-fifths nitrogen. Which other orbiting body has an atmosphere with four fifth's nitrogen? [Titan, one of the moons of Saturn. There is also deadly hydrogen cyanide however!](#)

Twinkle Twinkle?- Teacher Demonstrations



Stars are giant thermonuclear reactors that produce their own energy. Everything else in space is only visible because their surfaces reflect starlight. Our Sun is a star and we see the planets, asteroids, meteors and comets in our night sky because light from our Sun is reflected from their surfaces.



Stars appear to twinkle or scintillate when viewed from Earth because their light is bent or refracted as it moves down through layers of Earth's atmosphere. Each ray of light follows a zigzag path.

Fractured Pencil – Teacher Demonstration

A pencil placed in a glass half full of water and topped up with oil demonstrates refraction (bending) of light rays passing through two different liquids and a mixture of gases (air). The solid pencil appears fractured but is straight and entire when removed. Our atmosphere has various layers with different compositions.

Twinkle Torch – Teacher Demonstration

This explains why starlight appears to twinkle or scintillate whereas planets do not.



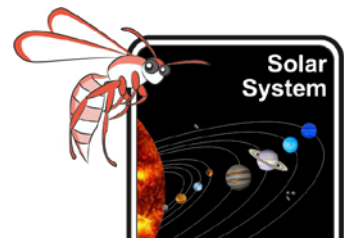
Materials

- A darkened room
- A torch
- A cardboard box (tissue boxes are excellent)
- A container of hot water
- A nail or pin to puncture a hole at the end of the box
- You may also need a board eraser or equivalent to raise the level of the torch inside the box

Method

1. Place the torch inside the box and make a small hole to allow the light beam to emerge.
2. Prepare hot water (or a nice cup of coffee for yourself)
3. View the round light source from the other side of the hole
4. Outside the box, place a container of very hot water under the hole to allow the steam to rise in front of the hole.
5. View the light again

Twinkle Twinkle?- Teacher Demonstrations



Observation

Initially the light is a round point source but when viewed through rising steam it radiates from the hole and scintillates.



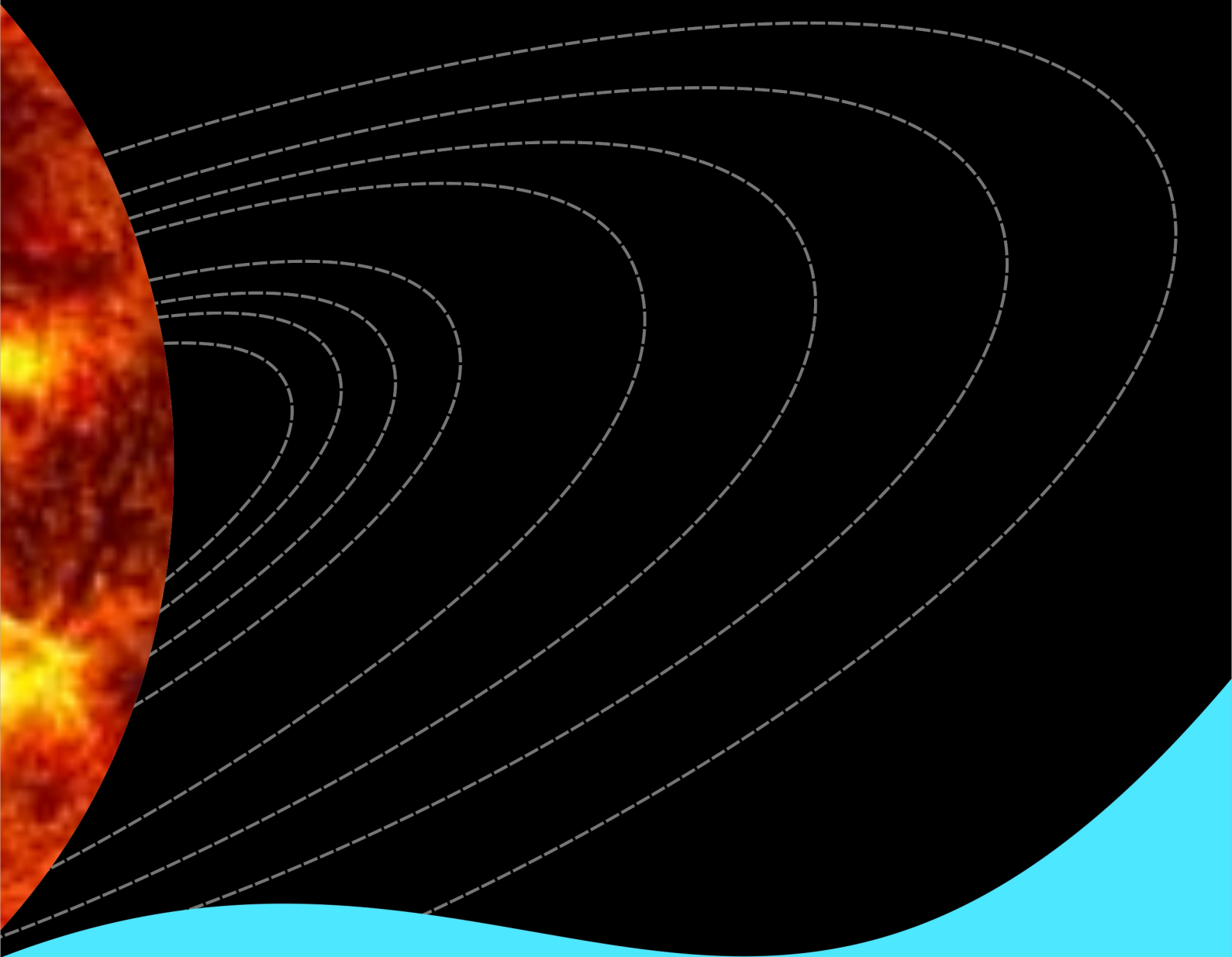
Conclusion

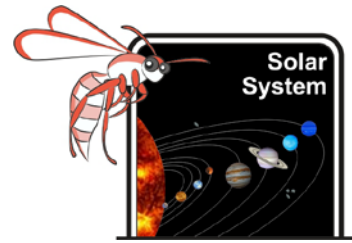
Steam bent or refracted the light causing it to appear star like and twinkle. Stars twinkle because we view their light through the layers of our planet's atmosphere.

Repeat the activity using the nail to make a large hole in the box. You will find the increase in size of the disc of light reduces scintillation.

Planets do not twinkle as they are closer. Refracted light from one part of the planet cancels out refracted light from the other. They appear bigger so the twinkling is not as noticeable as it would be from an apparently tiny spot of light. In space both stars and planets would appear as round steady light sources as there is no atmosphere.

Orbits

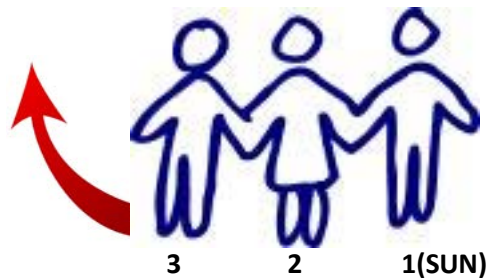




Circling the Sun – Teacher Notes

FASCINATING FACT: Just as planets orbit the Sun, our solar system orbits the centre of the Milky Way Galaxy. It takes about 225 million years to go round.

This simple (fun) outdoor activity allows students to physically experience that the farther a planet is from the Sun, the greater time and distance it takes to complete one orbit. The experiment is deliberately flawed to encourage students to think about how it could be improved to make their results more accurate and scientific.



Materials

- Space for up to 9 students to hold hands and wheel/orbit round one central student who represents the Sun, which is the centre of our solar system. Each additional student represents a planet orbiting the Sun. It is a good idea to choose the largest student in the group for the Sun position. If your students are excitable I recommend that the Sun student anchor himself or herself with one arm round a veranda or goal post.
- A large clock visible *OR* explain to students that it takes approximately 1 second to say “one Mississippi”. This ensures students don’t run and upset others’ balance.

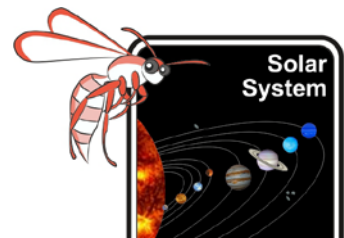
Method

1. Split class into groups of six or more students
2. The first student (The Sun) stays on the same spot and swivels all the way round.
3. The second student holds hands with the Sun and takes one step per second (or one - Mississippi) and counts how many steps they needed to complete one orbit of the Sun and return to where they started. These results are entered in the table provided
4. The third student holds the second student’s hand and repeats the process. The first two students simply adjust their step to move in time with the third.
5. This is repeated until all students in the group have orbited their Sun
6. The groups share and compare their results in the table provided

Results

	Number of seconds taken to complete an orbit			
	Group1	Group2	Group 3	Group 4
Student 1				
Student 2				
Student 3				
Student 4				
Student 5				
Student 6				
Student 7				
Student 8				
Student 9				

Circling the Sun – Teacher Notes



Conclusion

Could you see a pattern forming as more and more students/planets joined hands to circle the Sun?

Yes

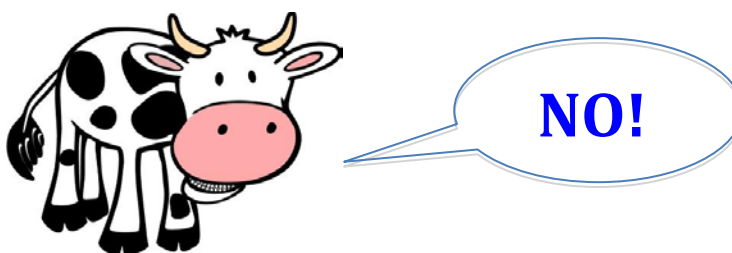
Describe this pattern.

The farther the planet's orbit was away from the Sun the longer the orbit path took.

Discussion

Why did we use nine students in this activity? To represent eight planets and the Sun

Did the cow moo softly?



In primary schools many students use the mnemonic (memory help) **"COWS MOO SOFTLY"** to ensure a fair test is carried out.

C reminds us to **C**hange only one thing. In this case the distance from the "Sun".

What was the one thing we changed? Distance from the Sun

M reminds us to **M**easure one thing.

What was the one thing we measured? The number of one-second steps.

S reminds us that everything else has to **S**tay the **S**ame

What things did we keep the same? Students from the same year, same place, steps at the same pace.

Did the cow moo softly? Explain your answer

No. We changed only one thing and we measured one thing. These were correct. However people of different sizes have different paces. A tall person would move further than a small person in one second. Tall people would have shorter orbit times and fewer paces than a small person.

What could you do to correct this mistake?

Select nine people who are about the same height and repeat the experiment.

What else was flawed about the position of the planets around the Sun?

The planets are not equally spaced away from the Sun

Using the information we gained from this activity, would the planet Mercury, which is closest to the Sun, take more or less time to complete one orbit than Neptune, which is farthest away? Less time.

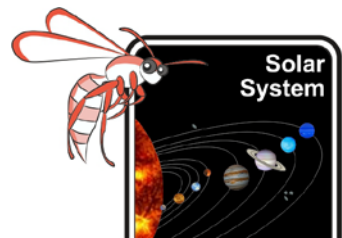
What do we call one orbit of the Sun by Earth? One year

Mercury takes 88 Earth days to orbit the Sun once, Earth takes about 365 Earth days to orbit the Sun and Neptune takes 60,189 Earth days. Which planet would give you the most birthday parties in one Earth year? Mercury

Do you think that you would age faster and die younger if you could live on Mercury?

Any reasoned answer. Probably not. If there were no other factors influencing the aging process, although you would go round the Sun four times faster and therefore be numerically four times older in mercury years you would still last the same time as you would have done on Earth. In local (Mercury) terms you would age faster and die older.

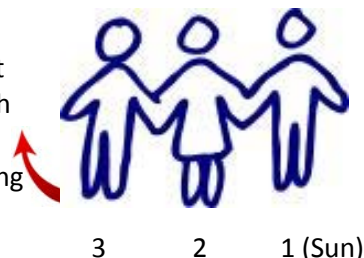
Circling the Sun – Student Activity



This experiment will give us information about the time it takes our planets to orbit the Sun.

Materials

- Space for up to 9 students to hold hands and wheel/orbit round one central student who represents the Sun, which is the centre of our solar system.
- Each additional student represents another planet orbiting the Sun.



Method

1. Split into groups of six or more students
2. The first student (The Sun) stays on the same spot and swivels all the way round.
3. The second student is the first planet to orbit the Sun. They hold hands with the Sun and take one step per second (or one - Mississippi) and count how many steps they needed to complete one orbit of the Sun and return to where they started. These results are entered in the table provided.
4. The third student holds the second student's hand and repeats the process. The first two students simply adjust their step to move in time with the third.
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Results

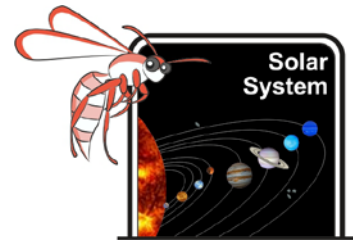
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	Group1	Group2	Group 3	Group 4
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Student 7				
Student 8				
Student 9				

Conclusion

Could you see a pattern forming as more and more students/planets joined hands to circle the Sun?

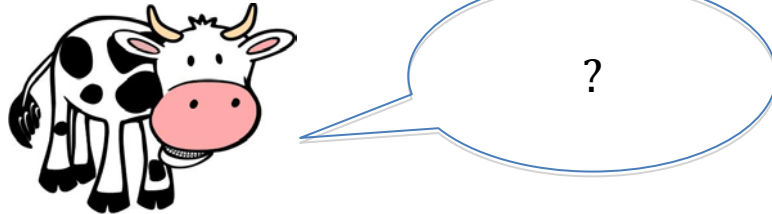
Describe this pattern. _____

Circling the Sun – Student Activity



Discussion

Did the cow moo softly?



Many students use the mnemonic (memory help) “**COWS MOO SOFTLY**” to ensure a fair test is carried out in science experiments.

C reminds us to **C**hange only one thing.

What was the one thing we changed? _____

M reminds us to **m**easure one thing.

What was the one thing we measured? _____

S reminds us that everything else has to stay the same.

Was everything else we used the same for each group? _____

Did the cow moo softly? Explain your answer _____

What could you do to correct this mistake? _____

What else was flawed about the position of the planets around the Sun? _____

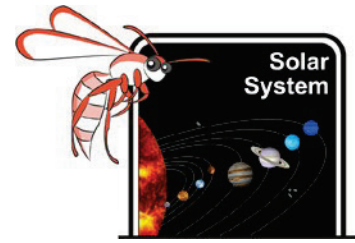
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What do we call one orbit of the Sun by Earth? _____

Mercury takes 88 Earth days to orbit the Sun once, Earth takes about 365 Earth days and Neptune takes 60,189 Earth days. Which planet would give you the most birthday parties in one period?

Do you think that you would age faster and die younger if you could live on Mercury? _____

Ellipse - Teacher Notes



Students often confuse **planetary rotation** (spinning on its axis) with **planetary revolution**, orbiting a position in space. Although some textbooks refer to revolution, it is less confusing if we use the terms orbit and orbiting instead of revolution.

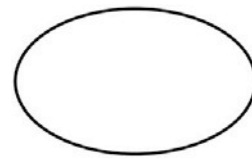
Definition - A planetary orbit is: **The gravitationally curved path of an object around a point in space.**



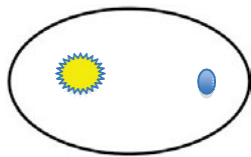
Johannes Kepler (1571-1780) was a German astronomer and mathematician. He used scientific observations and mathematics to disprove earlier ideas of planets being in simple circular orbits round the Sun. He proposed three laws that described planetary motion as observed.

Kepler's first law stated that:

PLANETARY ORBITS ARE ELLIPSES

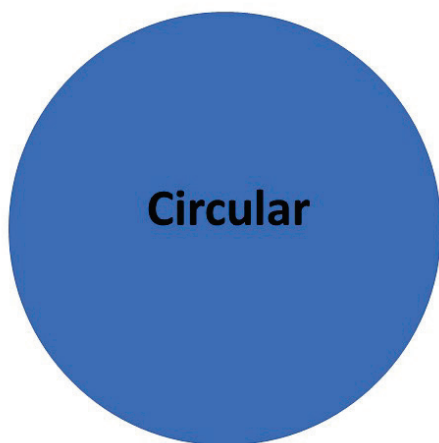


The English scientist and mathematician **Isaac Newton** (1643-1727) corrected some mathematical mistakes Kepler made and using his own and other's observations suggested that it was the **FORCE OF GRAVITY** originating from the huge mass of the Sun that deflected the straight paths of celestial objects into ellipses around the Sun.



The ellipse does not have one centre like a circle but two foci because it is the product of two competing factors (the motion of the planet and the pull of gravity). Because the Sun has over 98% of all the matter in the solar system its gravitational pull is MASSIVE!

Student Activity - To investigate the eccentricity of ellipses and discuss why it took astronomers so long to realise the planets were travelling in elliptical orbits



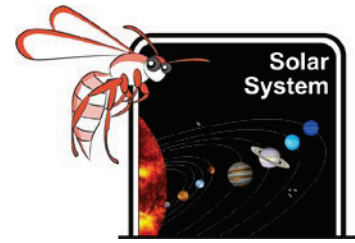
Circular



Highly elliptical

Figure 1. The more elliptical an object the higher its eccentricity

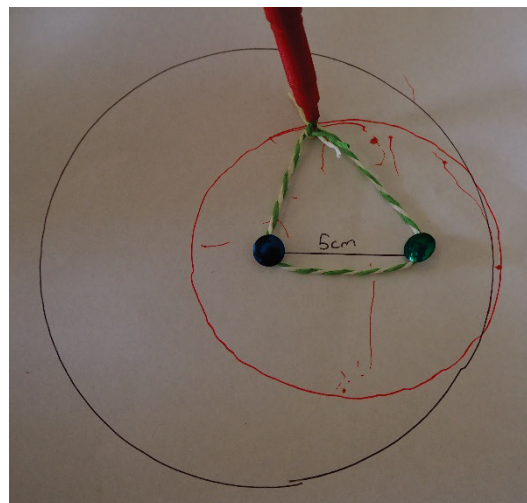
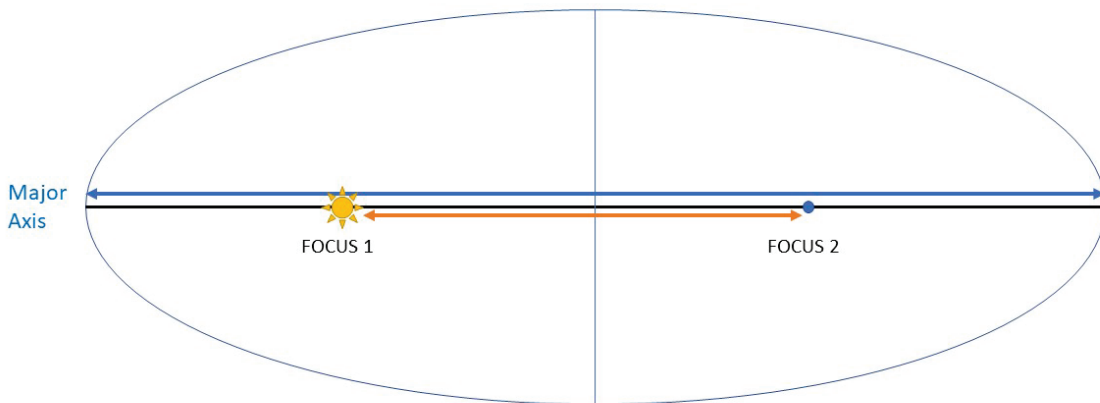
Ellipse - Teacher Notes



Materials per student or group

- Two thumb tacks or nails. If neither is possible, one student can hold a pencil point down at each of the foci whilst the other draws the path of the ellipse.
- A large sheet of scrap paper newspaper or cardboard. Placing polystyrene or thick card beneath the paper permits the nails or tacks to be easily pressed in and prevents damaging the table beneath.
- A piece of string about 20 cm long
- Three different coloured pencils
- A ruler

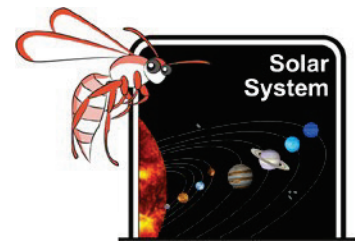
$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$



Method

1. Loosely tie the piece of string into a loop (note everyone's loop will end up being a slightly different length, meaning they will all have slightly different answers).
2. Fold your piece of paper in four to find the central point
3. Push the first tack into the centre
4. Place the loop over the tack and then stretch it using a pencil and draw the first ellipse. This should be perfectly circular.
5. Place the second tack 1 cm away from the other tack
6. Put the loop over the two tacks as shown in the picture above and use a different colour pencil

An initiative supported by Woodside and ESWA



Ellipse - Teacher Notes

to mark out the ellipse.

7. Measure the length of the major axis and enter this in the table.
8. Repeat step 6 and 7 with the tacks 4 cm and 7 cm apart.
9. Calculate the eccentricity of the ellipses using the formula given above.

Orbit of object	Distance between foci (cm)	Length of major axis (cm)	Eccentricity
Orbit 1 (circle)	0	Will vary	0
Orbit 2	1	Will vary	Will vary
Orbit 3	4	Will vary	Will vary
Orbit 4	7	Will vary	Will vary

Observations

What happens to the shape as the distance between the foci increases? *It becomes more elliptical (more squashed looking)*

What happens to the eccentricity as the distance between the foci increases? *It increases.*

Applying your knowledge

Below is a table of the eccentricity of different planets in the Solar System.

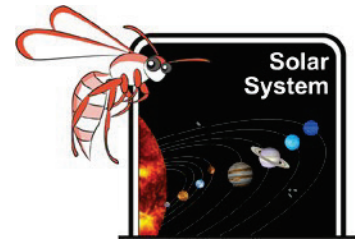
Planet	Major axis (AU)	Eccentricity
Mercury	0.774	0.2056
Venus	1.446	0.0068
Earth	2	0.0167
Mars	3.048	0.0934
Jupiter	10.406	0.0484
Saturn	19.074	0.0542
Neptune	60.14	0.0086

1. Is there any relationship between eccentricity and distance from the Sun? *No, in fact Mercury has the most elliptical orbit of all planets. However, comets and dwarf planets beyond Neptune can have highly elliptical orbits.*
2. Which planet has the highest eccentricity? *Mercury*
3. Why do you think it took astronomers so long to realise that the planets were orbiting in ellipses? *The eccentricity of most of the planets is so small their orbit is nearly circular. They would have had to take very detailed measurements and do lots of calculations to determine their orbit.*

To learn more about the planets orbit and view them in 3D go to this website:

<https://theskylive.com/3dsolarsystem>

Ellipse - Teacher Notes



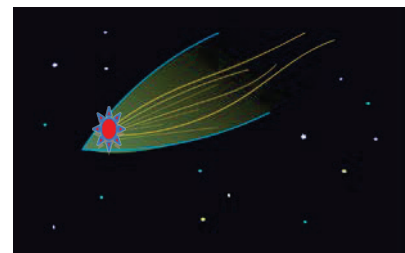
These results and this equipment can be saved for the following “Rockets and Range” experiment.

EXTENSION - Further out - Apply your knowledge

Out beyond the planets, right at the edge of our solar system lie two zones or belts of small icy objects that circle the Sun. The innermost is called the Kuiper Belt, which stretches out to about a billion kilometres from the Sun, and the outermost is called the Oort Cloud. Interestingly, astronomers Gerard Kuiper and Jan Oort each theorised that they must exist long before astronomers finally were able to see them. Oort suggested that as the solar system was forming, the large planets would move closer to the Sun under the influence of its gravity. This would push the smaller bodies further out into the Kuiper belt and the Oort Cloud. Objects within these belts can take thousands of years to orbit the Sun. Comets from the Kuiper Belt tend to have more rocky material than the “dirty ice” comets from the Oort cloud.

These zones are the sources of the comets that move across the night sky trailing tails of gas that point away from the Sun.

Because they exist far from the gravitational influence of the Sun, movement and changes elsewhere in the Milky Way Galaxy can affect objects in this zone. Every so often one becomes unstable and plunges down towards the Sun to orbit it and then swing back out beyond the planets again. We call them comets. (“Comet” comes from the Greek word for hair as when the icy object nears the Sun a stream of gas lies behind it). The comet will keep periodically orbiting until its forward motion slows down and gravitational pull will cause it to plummet into the Sun or a large nearby planet.

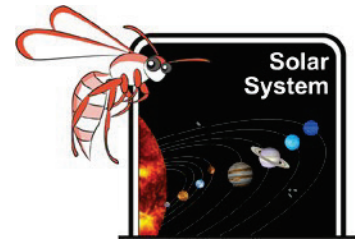


Comets are classified as long period comets and short period comets. Long period comets take more than 200 years before they return to pass the Earth and circuit the Sun.

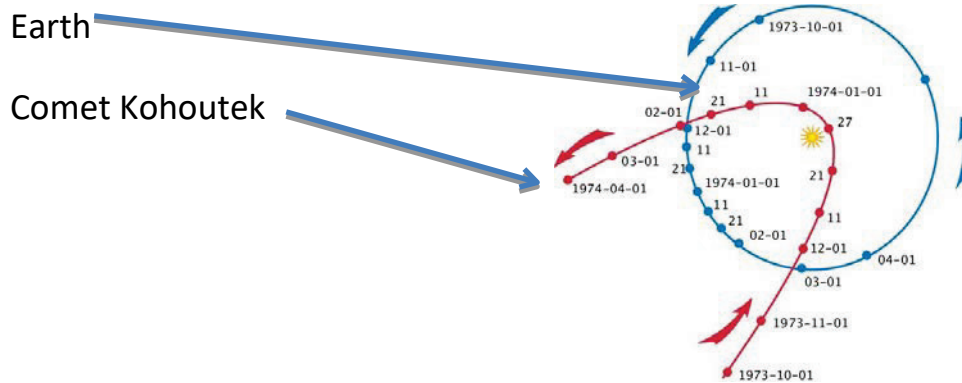
From which of these outer zones do you think that long period comets would come? Please explain your answer.

Long period comets would come from the outer Oort Cloud as it would take longer to travel from there to the Sun.

Ellipse - Teacher Notes



This diagram describes the orbits of comet Kohoutek and Earth round the Sun in 1973 and 1974. Label the orbits of Earth and the comet.



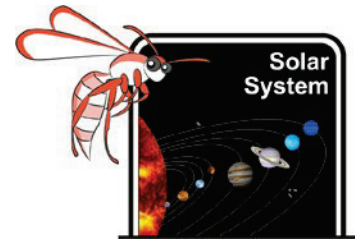
On first sighting the comet was thought to be mostly ice and gas, however later spectral analyses demonstrated that it has quite a lot of rocky material in its core. Where would this comet have come from? [The Kuiper Belt](#).

More information

The effect of gravitational pull on a satellite does not always result in a simple elliptical orbit. Interested students might like to get information about a small object that is presently circling Earth in a very complex spiralling horseshoe pattern.

3753 Cruithne is probably an asteroid. It will share Earth's orbit round the Sun for the next 5,000 years and then leave to return to its point of origin in the Asteroid Belt. At present we are orbiting it while it is also orbiting us and both it and Earth are in co-orbit round the Sun. It takes nearly 800 years to complete its orbit round the Earth.

Astronomers are finding more and more of these small quasi-orbital satellites around Earth and other planets. There is much discussion on whether they can be called "moons" as their moon like status is temporary.



Ellipse – Student Activity

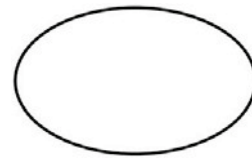
Definition - A planetary orbit is: _____

Some ancient scientists thought that all the heavens orbited (circled) the Earth. Slowly observations showed that in our solar system most planets orbit the Sun.



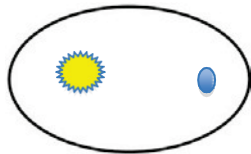
Johannes Kepler (1571-1780) was a German astronomer and mathematician. He used scientific observations and mathematics to disprove earlier ideas of planets being in simple circular orbits round the Sun. He proposed three laws that described planetary motion as observed.

Kepler's first law stated that:



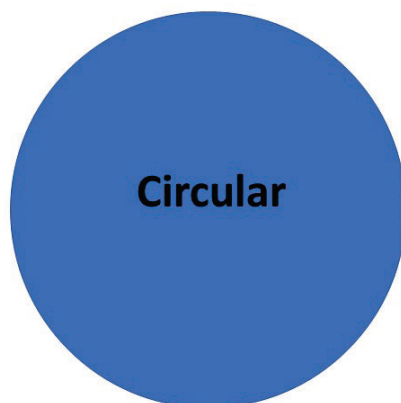
PLANETARY ORBITS ARE ELLIPSES

The English scientist and mathematician **Isaac Newton** (1643-1727) corrected some mathematical mistakes Kepler made and using his own and other's observations suggested that it was the **FORCE OF GRAVITY** originating from the huge mass of the Sun that deflected the straight paths of celestial objects into ellipses around the Sun.



The ellipse does not have one centre like a circle but two foci because it is the product of two competing factors (the motion of the planet and the pull of gravity).

Investigate the eccentricity of ellipses and discuss why it took astronomers so long to realise the planets were travelling in elliptical orbits

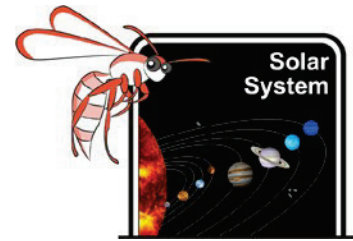


Circular



Highly elliptical

Figure 1. The more elliptical an object the higher its eccentricity

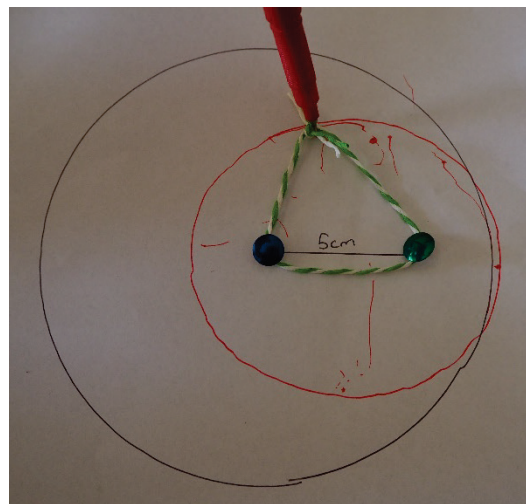
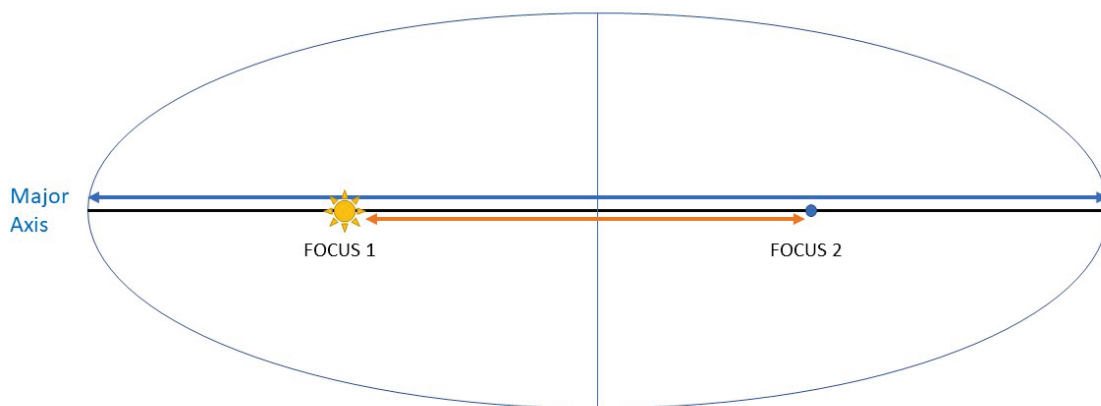


Ellipse - Student Activity

Materials per student or group

- Two thumb tacks or nails. If neither is possible, one student can hold a pencil point down at each of the foci whilst the other draws the path of the ellipse.
- A large sheet of scrap paper newspaper or cardboard. Placing polystyrene or thick card beneath the paper permits the nails or tacks to be easily pressed in and prevents damaging the table beneath.
- A piece of string about 20 cm long
- Three different coloured pencils
- A ruler

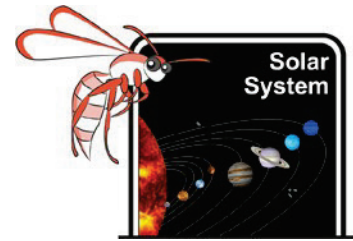
$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$



Method

1. Loosely tie the piece of string into a loop.
2. Fold your piece of paper in four to find the central point.
3. Push the first tack into the centre.
4. Place the loop over the tack and then stretch it using a pencil and draw the first ellipse. This should be perfectly circular.
5. Place the second tack 1 cm away from the other tack.
6. Put the loop over the two tacks as shown in the picture above and use a different colour pencil to mark out the ellipse.
7. Measure the length of the major axis and enter this in the table.
8. Repeat step 6 and 7 with the tacks 4 cm and 7 cm apart.
9. Calculate the eccentricity of the ellipses using the formula given above.

An initiative supported by Woodside and ESWA



Ellipse - Student Activity

Orbit of object	Distance between foci (cm)	Length of major axis (cm)	Eccentricity
Orbit 1 (circle)	0		
Orbit 2	1		
Orbit 3	4		
Orbit 4	7		

Observations

What happens to the shape as the distance between the foci increases? _____

What happens to the eccentricity as the distance between the foci increases? _____

Applying your knowledge

Below is a table of the eccentricity of different planets in the Solar System.

Planet	Major axis (AU)	Eccentricity
Mercury	0.774	0.2056
Venus	1.446	0.0068
Earth	2	0.0167
Mars	3.048	0.0934
Jupiter	10.406	0.0484
Saturn	19.074	0.0542
Neptune	60.14	0.0086

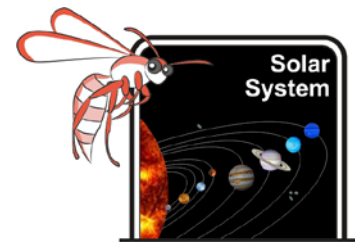
1. Is there any relationship between eccentricity and distance from the Sun? _____

2. Which planet has the highest eccentricity? _____
3. Why do you think it took astronomers so long to realise that the planets were orbiting in ellipses?

To learn more about the planets orbit and view them in 3D go to this website:

<https://theskylive.com/3dsolarsystem>

Planets fall round the Sun rather than into the Sun



Rockets and Range – Teacher Notes

Earth is only one of the eight planets orbiting our Sun. Many of these have their own moons orbiting them. The distances between them are pretty large so we use the Astronomical Unit (AU) as the base measurement. This unit is the distance from Earth to the Sun (149,596,870.7 kilometres). Some astronomers consider that our solar system stretches out to the edge of the heliosphere where light from the Sun will no longer penetrate into space.

	Distances from the Sun	Diameter at equator (km)
Sun	0	1.4million
Mercury	0.387 AU	4,878
Venus	0.723 AU	12,105
Earth	1 AU	12,756
Mars	1.524 AU	6,786
Between Mars and Jupiter lies the Asteroid Belt		
Jupiter	5.203AU	142,984
Saturn	9.502 AU	120,536
Uranus	19.19 AU	51,118
Neptune	30.06 AU	49,528

Measurements of planetary diameter are taken from each planet's equator as spinning in space causes flattening at the poles and bulge at their equators.

Beyond these lie the dwarf planets such as Sedna and Pluto, the many small bodies in the Kuiper Belt and the Oort Cloud.

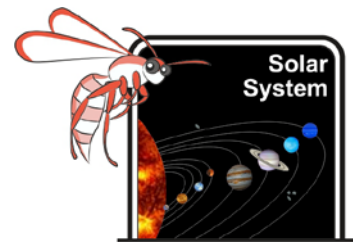
A major misconception of students and space moviemakers is that the Asteroid Belt is closely packed with huge asteroids. This is not so. In this belt lumps of rock less than half a kilometre wide travel thousands of kilometres apart. Most asteroids are the size of a tennis ball. Indeed if all the mass of the objects in the whole asteroid belt was added up it would only be equivalent to one third of the mass of our Moon. NASA estimates that the probes it sends through the Asteroid Belt to reach outer planets and beyond have a one in a billion chance of being hit.

Travelling through space poses many problems. These activities can be done as individual tasks or student groups may cover them and present a report of their findings at the end.

Factors to consider could be:

- Distance
- Technology
- Fuel load
- Opposition (Position of planets relative to each other)
- Gravity sling
- Is it necessary to send manned spacecraft at all?





Rockets and Range – Teacher Notes

1. **Distance.** The further away from Earth the planet lies the longer it will take. Mars can be reached in between 150 to 300 days. Saturn takes very much longer, between 4 and 6 years.
2. **Technology** improvement and the use of more efficient fuels reducing “load”.

Firing balloon rockets along string-controlled trajectories can test these two concepts.

Student Activity

To investigate differences encountered in sending rockets to Mars and to Jupiter.

Mars is approximately 0.5AU from Earth

Jupiter is approximately 4.2AU from Earth

What is an AU? **An AU is an Astronomical Unit and is the distance of Earth to the Sun**

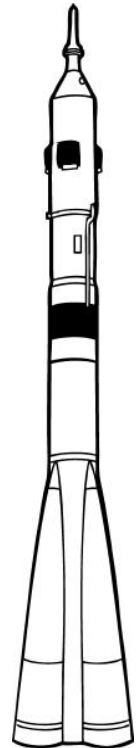
Why do we use AU? **We use AU because the distances are immense if measured in other units.**

Materials per group

- 4m strings *Washing line is ideal as its smooth surface minimises friction.*
- Marking pen
- A large balloon
- Masking tape
- Stopwatch/mobile/clock with second hand

Method

1. Stretch out about 4m of taut string between two students
2. Tie loops at the end of the string as handles
3. Make a mark at 25cm from the start for the distance to Mars and another at 2.1m representing the relative distance to Jupiter
4. Inflate a balloon and hold it in the air with your fingers round the neck. *It may be advisable to ask students with breathing difficulties not to blow up the balloons*
5. Loop a tab of paper over the string and stick each end onto the balloon with masking tape
6. Test run the balloon by releasing your hold on the neck of the balloon. The air released from the back of the balloon should drive it forwards along the string.
7. Adjust equipment for maximum movement
8. Measure the time taken for the rocket to reach Mars and Jupiter.
9. Repeat to gain an average and more accurate measurement.



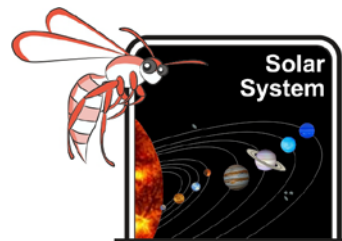
Why were 25 cm and 2.1m chosen to represent the distances from Earth to Mars and Jupiter?

They are proportional to the distances to Mars (0.5AU) and Jupiter (4.2AU)

Observations

TEST	Time to Mars (seconds)	Time to Saturn (seconds)
1		
2		
3		
Average time		

Rockets and Range – Teacher Notes



What did the results of your tests tell you? **It takes longer to reach Saturn. Although Saturn lies approximately 8.2 times further away it took more than that to reach it. The spacecraft slowed down as friction from the string opposed its movement and it lost air pressure power.**

Was this a fair test? **No we couldn't control the amount of air blown into the balloon and consequently the air pressure powering it.**

More ideas to consider and perhaps test

Would increased air pressure in the balloon make it travel faster and further? **YES**

Does the rocket travel at the same speed along the string? **No it slows towards the end as air pressure decreases and friction increases.**

Does adding a weight to the rocket affect speed? **Yes**

Would the increased fuel load required for travel to Jupiter affect travel time? **Yes**

What adjustments could be made to your balloon rocket to make it work better? **Larger balloon, stronger balloon, fins, tube attached to neck to control direction of air drive, use a straw over the string to reduce friction.**

Opposition

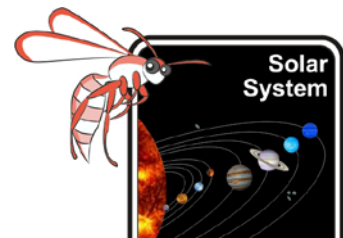
Planets circle the Sun at different rates. This means that it is only at certain times that they are close to each other. At the time they are closest, they are said to be "in opposition". Use you results from the ellipse activity to work out the following.

How often does Saturn come into opposition to the Earth? **14-15 years**

If you are concerned about time taken to travel and fuel economy, how often would it be between launches of spacecraft bound for Saturn? **14-15 years.**



Rockets and Range – Teacher Notes



Every two years Mars and Earth are “in opposition” and these times are selected for Mars launches. Why do you think we choose to investigate the surface of Mars before the surface of Saturn? List your answers.

Mars is closer than Saturn

Travel to Mars is cheaper and takes less time than to Saturn

Opposition to Mars occurs more often

Gravity on Mars is weaker than on Earth and a Mars day is about the same length as an Earth day

Saturn is further away from the Sun so its surface temperature is -140°C . Temperatures on Mars range from 20°C in summer at the equator to -8°C near the poles at night in winter. Temperatures are more tolerable in most parts of Mars.

Gravity Slingshot Effect

Most of a rocket’s energy supplies are required to get it out of Earth’s orbit and into space. The escape velocity necessary to escape Earth’s gravity is 40,320km/h. Once in space all excess weight such as the booster rockets it needed to launch and the fuel tanks for those rockets are jettisoned. Once a rocket is moving in space there is little to slow it down but it still needs some energy to move forward and to slow down if it is to survive the impact of landing.

Many probes sent out into our solar system are not sent in a straight line towards their target. They loop round other planets or the Sun to pick up energy from their gravity. This is called “gravity assist” or “the slingshot effect”. The Cassini-Huygens probe was launched for Saturn in 1997 and arrived in 2004.

It travelled from:

Earth to loop round Venus twice

Venus orbit to fly by Earth and pick up energy from its gravitational pull

Earth orbit to fly by Jupiter and pick up energy from its gravitational pull

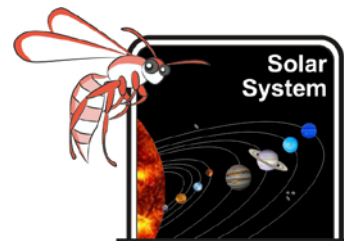
Jupiter orbit to eventually reach Saturn

This capacity of a fast moving object to pick up energy from another body is familiar to those who play contact sports or enjoy folk dancing. In both cases a person travelling fast in one direction may be passed by another, swung round them and released to travel faster on their way. Excitable students may have to imagine (and perhaps remember) this. Or a line of students may sequentially link arms and spin a student who travels along their length in loops round each student in line. This activity is best performed outside and on grass and sedately (see below).



ASIDE - In Scotland folk dancing is sometimes treated as a polite form of warfare. The pull and added speed from the more stationary dancers could be greatly increased by them dipping as they linked arms and spun the traveller round before releasing them. By lowering the centre of gravity of the individuals in the line the moving dancer ended up travelling extremely fast though not always in the direction they wished.

Rockets and Range – Teacher Notes



Activity - Manned spacecraft or not

Students are asked to suggest:

Positive (PLUS) aspects of manned spacecraft:

The ability to respond to occasions not programmed

A human perspective of what happens

The chance to experience what no human has done before

The capacity to change programs to meet new challenges

Recognise opportunities to learn new things

Collect unknowns for testing

Negative (MINUS) aspects are:

Extra load of fuel for human support

Effect of human loss on public perceptions and funding

Extra expense required for high needs load

INTERESTING aspects are:

The challenge of meeting and overcoming totally new experiences

The development of new materials required

Rocket Science - Teacher Demonstration

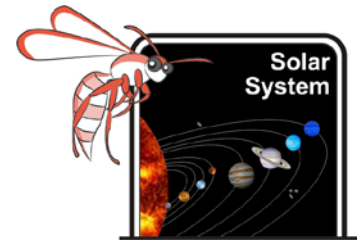


If the school owns a bicycle pump driven bottle rocket, teachers and selected students can test to find the optimum pressure (number of pumps) and volume of water in the bottle to produce the farthest flight. Perhaps the Laboratory Technician in the nearest secondary school might even lend you theirs.

Care must be taken not to put cool drink bottles under too much pressure or they will explode. Modern bottles are very much thinner than their predecessors. The experiment should be done outside, preferably in an open grassed area.

Bottle kits can also be bought from game shops or through the Internet. Adventurous teachers will also find do-it-yourself directions for constructing these rockets and suggestions for class activities on the Internet

Rockets and Range – Student Activity



Earth is only one of the eight planets orbiting our Sun. Many of these have their own moons orbiting them. The distances between them are pretty large so we use the Astronomical Unit (AU) as the base measurement. This unit is the distance from Earth to the Sun (149,596,870.7 kilometres).

Travelling through space poses many problems.

Factors to consider could be:

- **Distance**
 - **Technology**
 - **Fuel load**
 - **Opposition** (Position of planets relative to each other)
 - **Gravity sling**
 - **Is it necessary to send manned spacecraft at all?**
1. **Distance.** The further away from Earth the planet lies the longer it will take. Mars can be reached in between 150 to 300 days. Saturn takes very much longer, between 4 and 6 years.
 2. **Technology** improvement and the use more efficient fuels reducing “load”.



Student Activity

We shall investigate differences encountered in sending rockets to Mars and to Jupiter.

Mars is approximately 0.5AU from Earth.

Jupiter is approximately 4.2AU from Earth.

What is an AU? _____

Materials per group

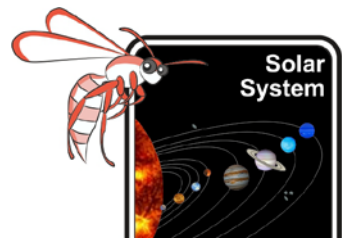
- 4m string
- Marking pen
- A large balloon
- Masking tape
- Stopwatch/mobile/clock with second hand

Method

1. Stretch out about 4m of taut string between two students.
2. Tie loops at the end of the string as handles or attach to solid objects at height.
3. Make a mark at 25cm from the start for the distance to Mars and another at 2.1m representing the relative distance to Jupiter.
4. Inflate a balloon and hold in the air with your fingers round the neck.
5. Loop a tab of paper over the string and stick each end onto the balloon with masking tape.
6. Test run the balloon by releasing your hold on the neck of the balloon. The air released from the back of the balloon should drive it forwards along the string.
7. Adjust equipment for maximum movement



Rockets and Range – Student Activity



8. Measure the time taken for the rocket to reach Mars and Jupiter.
9. Repeat to gain an average and more accurate measurement.

Why were 25 cm and 2.1m chosen to represent the distances from Earth to Mars and Jupiter?

The average time of any readings can be estimated by adding all the readings up and dividing by the number of readings.

E.g. For three readings of 1, 2 and 3. These would be added up to make 6 and this total would be divided by 3 to find the average of 2

Observations

TEST	Time to Mars (seconds)	Time to Saturn (seconds)
1		
2		
3		
Average time		

What did the results of your tests tell you? _____

Was this a fair test? Explain your answer. _____



More ideas to consider and perhaps test

Would increased air pressure in the balloon make it travel faster and further? _____

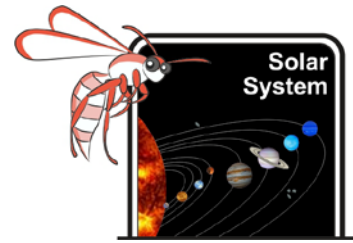
Does the rocket travel at the same speed along the string? _____

Does adding a weight to the rocket affect speed? _____

Would the increased fuel load required for travel to Jupiter affect travel time? _____

What adjustments could be made to your balloon rocket to make the experiment work better?

Rockets and Range – Student Activity



Opposition

Planets circle the Sun at different rates. This means that it is only at certain times that they are close to each other. At the time they are closest, they are said to be “in opposition”.

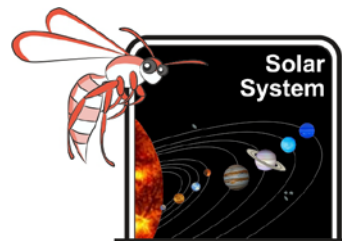
How often does Saturn come into opposition the Earth? _____

If you are concerned about time taken to travel and for fuel economy, how often would it be between minimum cost and time launches of spacecraft bound for Saturn?



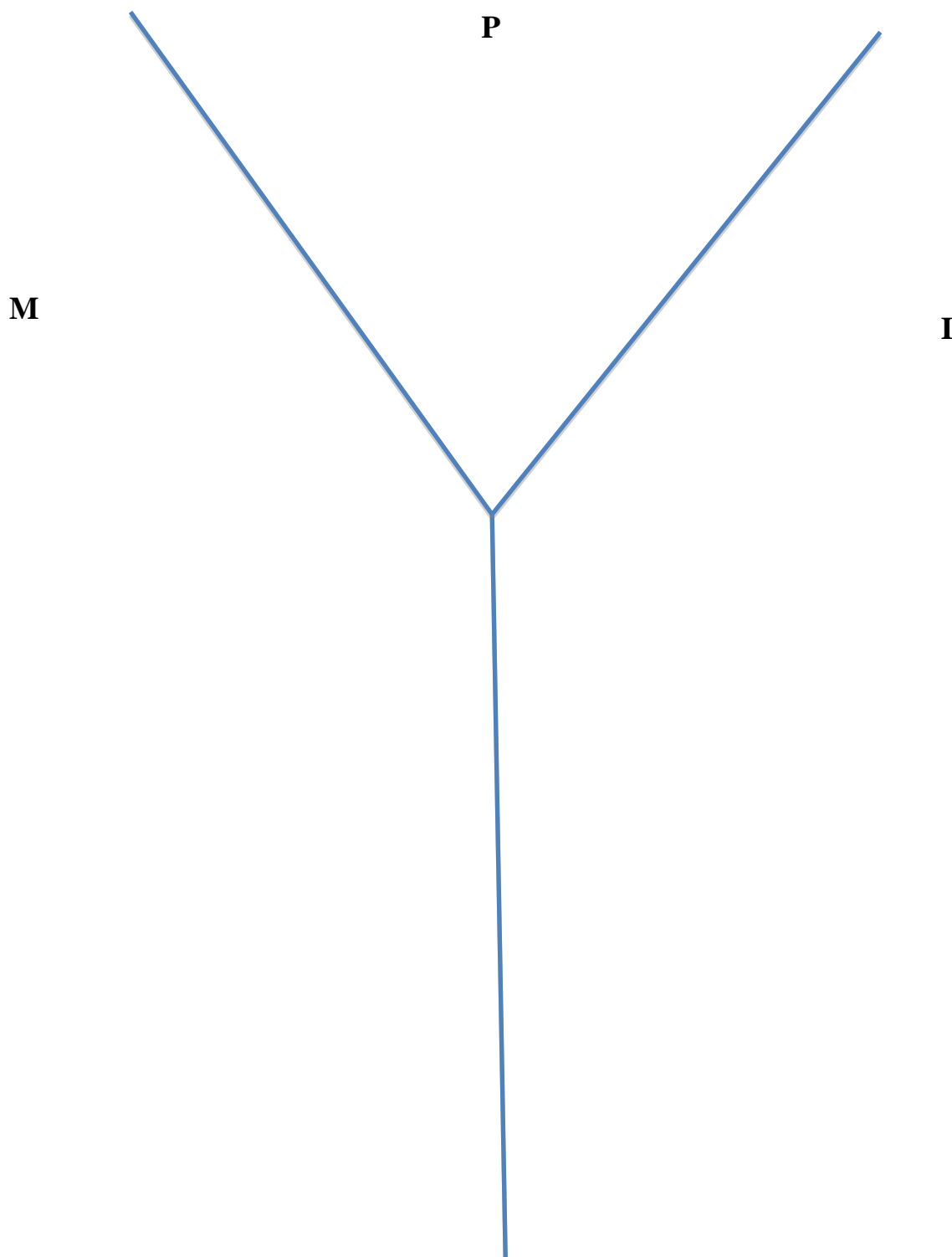
Every two years Mars and Earth are “in opposition” and these times are selected for Mars launches. Why do you think we choose to investigate the surface of Mars before the surface of Saturn? List your answers.

Rockets and Range – Student Activity

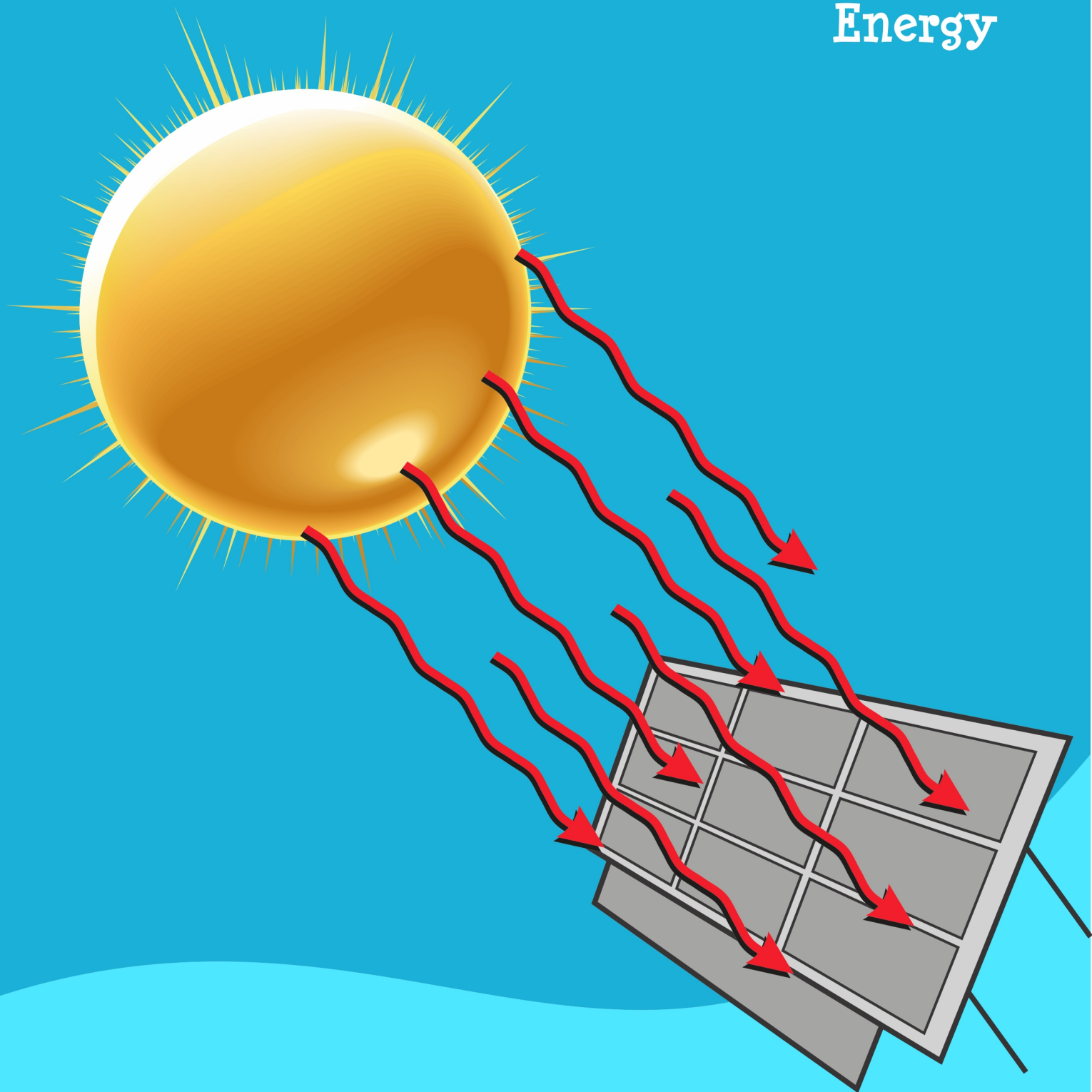


Activity - Manned spacecraft or not

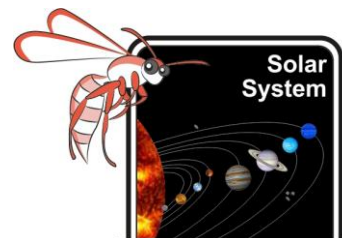
You are to create a PMI (Plus, Minus & Interesting) chart about manned spacecraft.



The Sun and Energy



Sun & Energy- Teacher Demonstration



Our sun, Sol, is the only star in our solar system. Even enormous planets such as Neptune depend on the Sun for light and heat. Stars make their own energy in a process similar to that occurring in a thermo nuclear reactor. The Sun's massive size creates an enormous gravitational pull, which smashes atoms of hydrogen together to make helium with a little energy left over. It sends the excess energy out into space as heat, light and other forms of electromagnetic radiation.



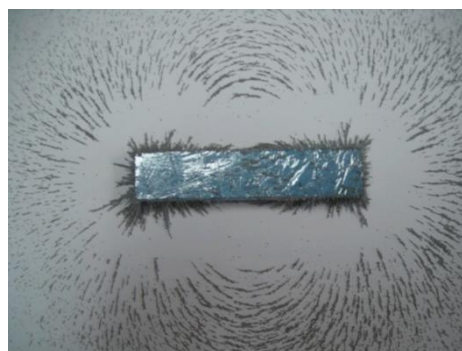
Lucky for us, the most of the dangerous forms of radiation are deflected by the magnetosphere, a magnetic shield round this planet generated by the Earth's magnetic core, and also by the ozone layer in the atmosphere. The magnetosphere extends from the ionosphere tens of thousands of kilometres out into space. It is generated by the magnetic core of our planet.

Magnetism is a force that can act at a distance.

Teacher Demonstration - Magnetosphere

Materials

- A bar magnet
- Iron filings (hardware shop)
- Kitchen wrap
- White paper



Method

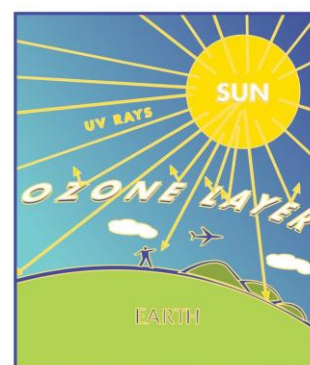
You can demonstrate how the magnetosphere extends well beyond Earth using a simple magnet, a piece of kitchen film wrapping, a sheet of white paper, and some iron filings. Wrapping the magnet in film means if any filings get attracted to it they will be more easily removed. Lay the wrapped magnet on the paper. Sprinkle the iron filings onto the paper. The magnetic effect extends well beyond the bar.

Observation

The iron filings define the lines of magnetic force acting outside the magnet.

OZONE LAYER

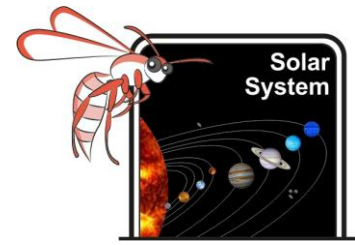
The ozone layer deflects carcinogenic ultraviolet radiation back out into space. The slow atmospheric build up of oxygen created by photosynthesis created this planetary "sun screen" and stopped life from being bathed by mutagenic rays. Increased use of CFCs (chloro-fluoro-carbons) as refrigeration gas and aerosol propellants reduced its thickness and effectiveness. The natural "holes" in the ozone layer which occur over the magnetic north and south poles have increased in size.



Light and heat penetrate down to the surface of our planet to support Life. 98% of the Sun's energy reaching Earth's surface is reflected back out into space. Luckily enough heat is retained to enable Life to exist. For this to occur we must have some carbon dioxide in our atmosphere to reflect heat leaving the surface back down again.

Although both carbon dioxide and ozone can be toxic, small amounts of both are necessary for Life.

Sun and Light Energy – Teacher Notes



Sunlight is necessary for photosynthesis in almost all plants (Photo = light, synthesis = to bring together). Plants are the basis of food chains in the oceans and on land. Energy passes from the Sun to green plants (producers) and on to animals that consume plants and further to animals that consume other animals (consumers). Decomposers consume the remains of plants and animals. Every time the energy is moved along the chains in the web there is loss due to processes within the organisms (living things) such as growth, movement, repair and reproduction.

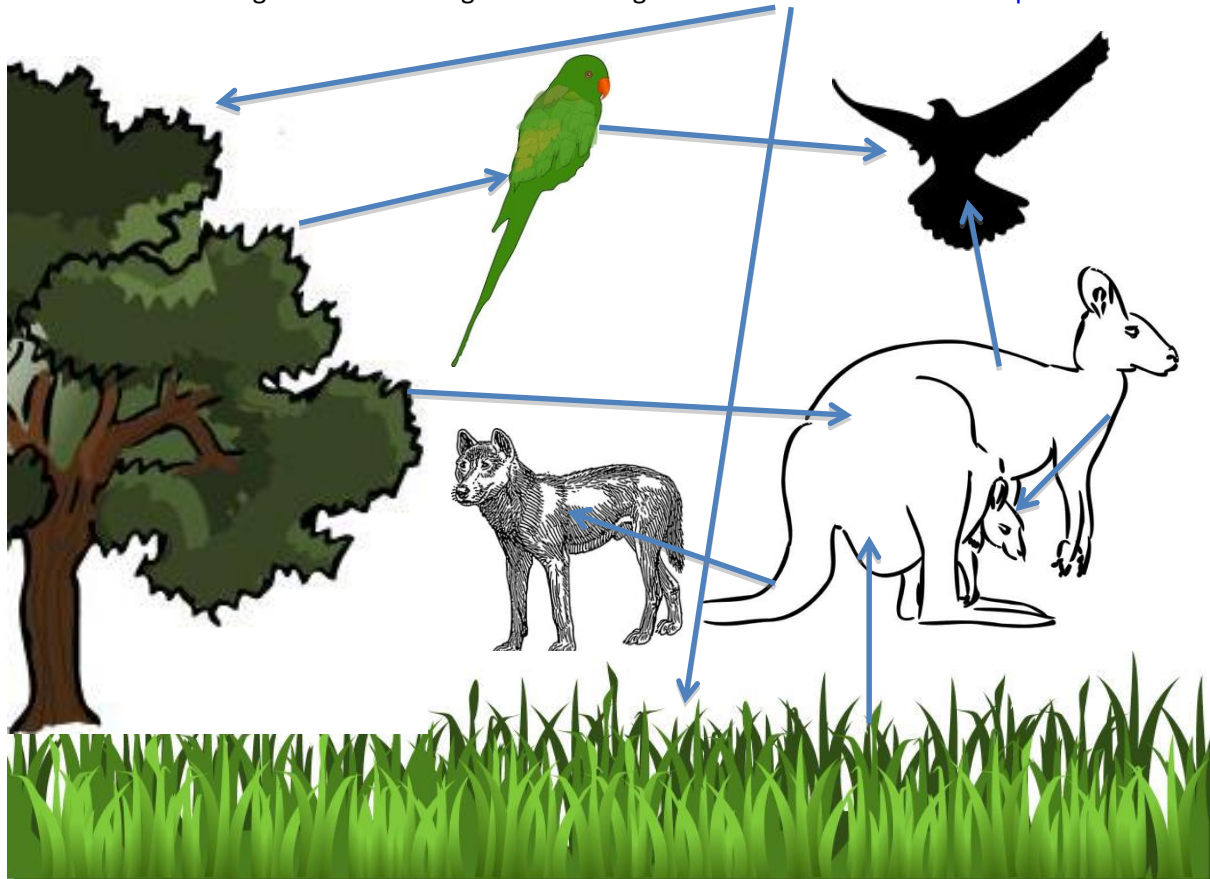
Exceptions

At great depth of the ocean where light cannot penetrate and volcanic activity creates black smokers simple microbial extremophiles such as *Pyrolobus fumarii* manage to thrive. They can make energy without sunlight by metabolising sulphur and methane. They provide energy for all the other unusual creatures that live there.

Student Activity - Energy Flowchart

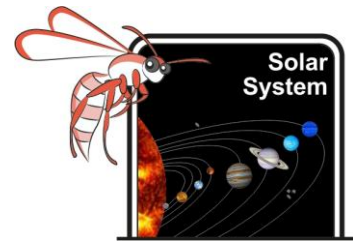
A chart demonstrating the flow of energy from the Sun through living things.

Draw in the two things that are missing from this diagram. **The Sun and some decomposers**



Draw arrows to show the movement of energy between each of these living things. The arrows should point in the direction to which the energy moves E.g. from the grass to the kangaroo because the kangaroo eats grass. **Arrows point from all organisms to the decomposers. Dingos occasionally eat grass. The diagram above should also have arrows pointing from each living thing to the soil to represent defecation, urination and decomposition on death.**

Sun and Light Energy – Teacher Notes

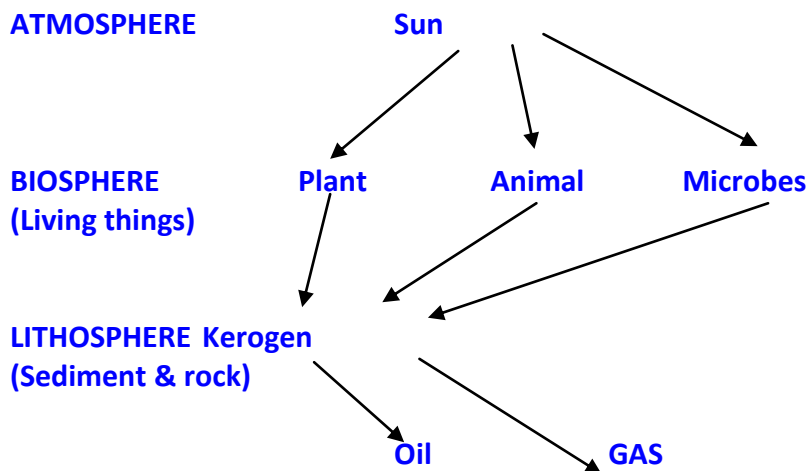


How can energy be lost by living things and not passed on?

Growth, Movement, Reproduction and Repair (and respiration – the breakdown of food to release energy requires energy itself).

Fossil fuels such as oil, gas, coal and peat derive from dead plants and animals buried in sediments.

A chart showing the flow of energy between the Atmosphere, Biosphere and Lithosphere to create oil and gas would be:

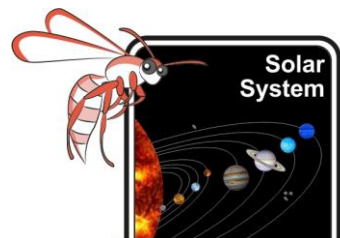


Light also powers photovoltaic cells, which produce electricity.



Interesting fact - The Sun is really white in colour. The sun emits all the colours of the rainbow (red, orange yellow, blue, green, indigo and violet) but our atmosphere filters out most of the blue and violet, which explains why the sky appears blue and the remaining colours blend into an orangey yellow colour.

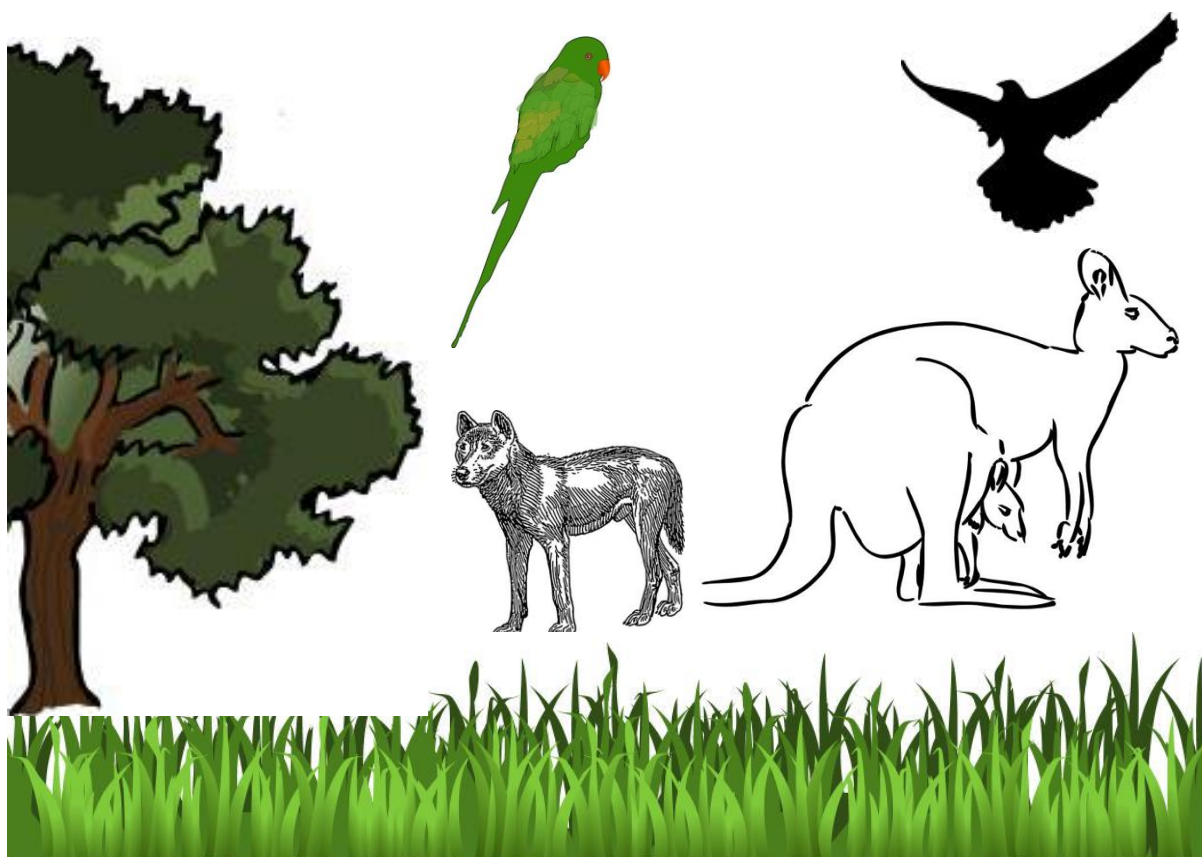
Sun and Light Energy- Student Activity



Sunlight is necessary for photosynthesis in almost all plants. Plants are the basis of food chains in the oceans and on land. Energy passes from the Sun to green plants (producers) and on to animals that consume plants and further to animals that consume other animals (consumers). Decomposers consume the remains of plants and animals.

Student Activity - Energy Flowchart

A chart demonstrating the flow of energy from the Sun through living things. Draw in the two things that are missing from this diagram.



Draw arrows to show the movement of energy between each of these living things. The arrows should point in the direction to which the energy moves E.g. from the grass to the kangaroo because the kangaroo eats grass.

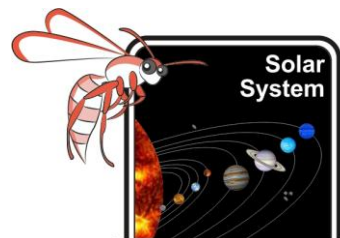
How can energy be lost by living things and not passed on?

1. _____
2. _____
3. _____
4. _____

Fossil fuels such as oil, gas, coal and peat derive from dead plants and animals buried in sediments.

Fossil fuels are stores of energy from ancient sunlight

Sun & Heat – Teacher Notes



Sun heat (infra red radiation) can be used passively (solar cooker) or be transformed into wind power or waterpower, which themselves can be further transformed to movement and electricity. Apart from heat derived from the natural breakdown of radioactivity in our rocks and from wave turbines, the Sun is the source of most of our energy

Wind energy

Land heats and cools faster than water/sea. Heat from the Sun in the day warms the atmosphere above land. The air expands and this creates upward moving air currents or wind as the cooler denser air over the sea rushes in to take its place. At night air cools down faster above land and the reverse happens. People who live near the coast enjoy this effect as the breeze coming in from the sea cools them in summer. It is often called “The Fremantle Doctor”. Darker land heats faster than lighter land.

These activities only take about 15 minutes. The class can be split with half doing one activity and the other half doing the other.

Student Activity - To demonstrate that heating air causes it to expand

Materials per group



- Empty cool drink bottle
- A Balloon
- A sunny spot, radiant heater or hairdryer
- Option – access to a fridge

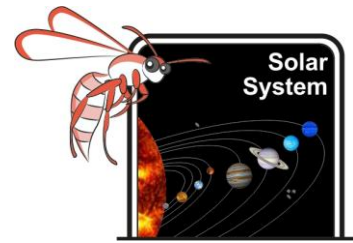
Method

1. Inflate the balloon several times to soften the latex
2. Place the balloon over the mouth of the bottle. I have placed the balloon and bottle in the fridge or in a cold-water bath to keep it cool.
3. Draw and describe the balloon (Before)
4. Place the bottle with balloon attached in a sunny area (preferably away from the wind as it will take longer to heat and may blow over)
5. Leave for 10 minutes
6. Draw and describe the balloon (After)

Warning - Some of the students may find watching the balloon inflate overly funny.

Observations

	
<p>Before (cold) The balloon was deflated</p>	<p>After (hotter) The balloon was inflated by expanding heated air in the bottle</p>



Sun & Heat – Teacher Notes

Conclusion

What do you think caused the change to the balloon?

Heat made the air in the bottle expand and the balloon was inflated

Discussion

Was this a fair test? Did the Cow Moo Softly? Explain your answer.

It was not a fair test because although we changed only one thing and kept everything else the Same, we did not Measure the expansion of the air.



Student Activity - To demonstrate that land heats faster than water



Materials per group

- Two small beakers, glasses, jam jars or containers of the same size. I have used the washed and pre-cut bottoms of cool drink bottles so there was enough equipment for the whole class. I found that a bread knife cuts them easily.
- Water and soil (preferably dark)
- A laboratory thermometer

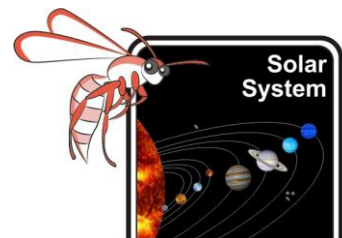
Method

1. Fill one container with water and the other with the same volume of soil
2. Take the temperature of the soil and of the water before placing in sunlight. Enter this data in the table provided
3. Place in sunlight and leave for 10 minutes
4. Take the temperature of each again and enter the data in the table provided

Observations On a 26°C day

	Temperature of water °C	Temperature of soil °C
Inside	24	24
Outside after 10 minutes	26	32

Sun & Heat – Teacher Notes



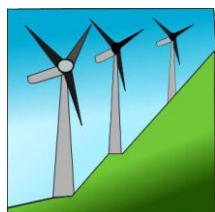
Differential heating and cooling at the surface of the Earth can be due to:

Time of day

Season/tilt of the axis

Land or sea

Colour of surface light or dark



These variations cause a difference in air pressure to occur and wind is generated. This wind can be used to turn the blades of turbines to generate electricity from wind farms.

What else can wind energy be used for?

Drying wet clothes

Wind turbines

Sailing ships. Interestingly long haul tankers and large modern cargo ships often use additional sails when out from port to cut fuel costs

Corn mills

Winnowing grain in third world countries.



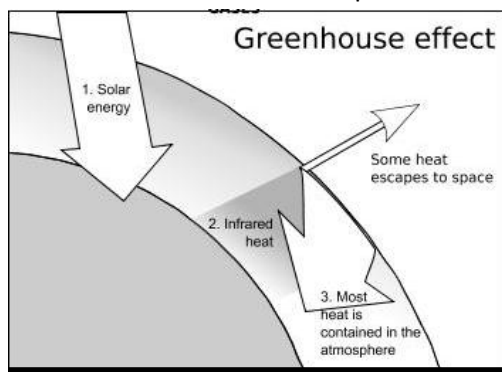
An old Australian bush trick was to leave a black plastic jerry can out in the sun during the day. When you came back from work dirty, the water would have warmed and made an excellent shower. Black plastic hose was also draped over bush roofs and beach shacks to provide hot water.

Extension at home

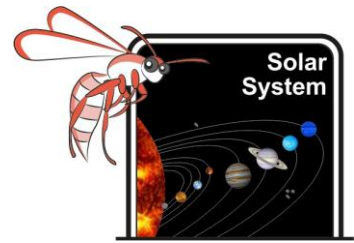
Students may try using three or four different soil types to find which heats up fastest. Suggestions would be black potting mix, grey limy soil, yellow building sand and white coastal sand. The darker the soil the faster it heats up.

Student misconception

A common student misconception is that atmospheric carbon dioxide and its greenhouse effect is dangerous. Low levels of carbon dioxide are necessary to retain heat in the atmosphere. Without some atmospheric carbon dioxide to retain heat, life could not have evolved, as the planet surface would be frozen. If the carbon dioxide levels rise too high however, an enhanced greenhouse effect occurs and temperatures increase. All life depends on enzymes that make changes in cellular behaviour. They only work within a narrow range of temperatures. Increased and decreased levels of carbon dioxide in our geological past have been linked to extinction events.



Apart from heat derived from the natural breakdown of radioactivity in our rocks and from wave turbines, the Sun is the source of most of our energy



Sun & Heat – Student Activity

Sun heat can be used passively or be transformed into wind power or waterpower, which can be then transformed to movement and electricity. Apart from heat derived from the natural breakdown of radioactivity in our rocks and from wave turbines, the Sun is the source of most of our energy

Student Activity - Heating air causes it to expand



Materials per group

- Empty cool drink bottle
- A Balloon
- A sunny spot, radiant heater or hairdryer
-

Method

1. Inflate the balloon several times to soften the latex
2. Place the balloon over the mouth of the bottle.
3. Place the bottle with balloon attached in a sunny area (preferably away from the wind as it will take longer to heat and may blow over)
4. Leave for 10 minutes
5. Draw and describe the balloon (After)

Observations

	
Before (cold) <hr/> <hr/>	After (hotter) <hr/> <hr/>

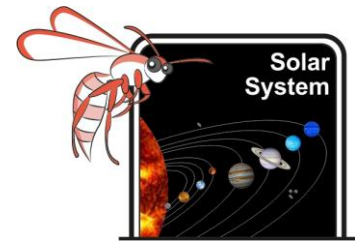
Conclusion

What do you think caused the change to the balloon? _____

Discussion

Was this a fair test? Did the Cow Moo Softly? Explain your answer.





Sun & Heat – Student Activity

Student Activity - To demonstrate that land heats faster than water

Materials per group

- Two small beakers, glasses, jam jars or containers of the same size.
- Water and soil (preferably dark)
- A laboratory thermometer

Method

1. Fill one container with water and the other with the same volume of soil
2. Take the temperature of the soil and of the water before placing in sunlight. Enter this data in the table provided
3. Place in sunlight and leave for 10 minutes
4. Take the temperature of each again and enter the data in the table provided



Observations Today's temperature is: _____

	Temperature of water °C	Temperature of soil °C
Inside		
Outside after 10 minutes		

Differential heating and cooling at the surface of the Earth can also be due to:



These variations cause a difference in air pressure to occur and wind is generated. This wind can be used to turn the blades of turbines to generate electricity from wind farms.

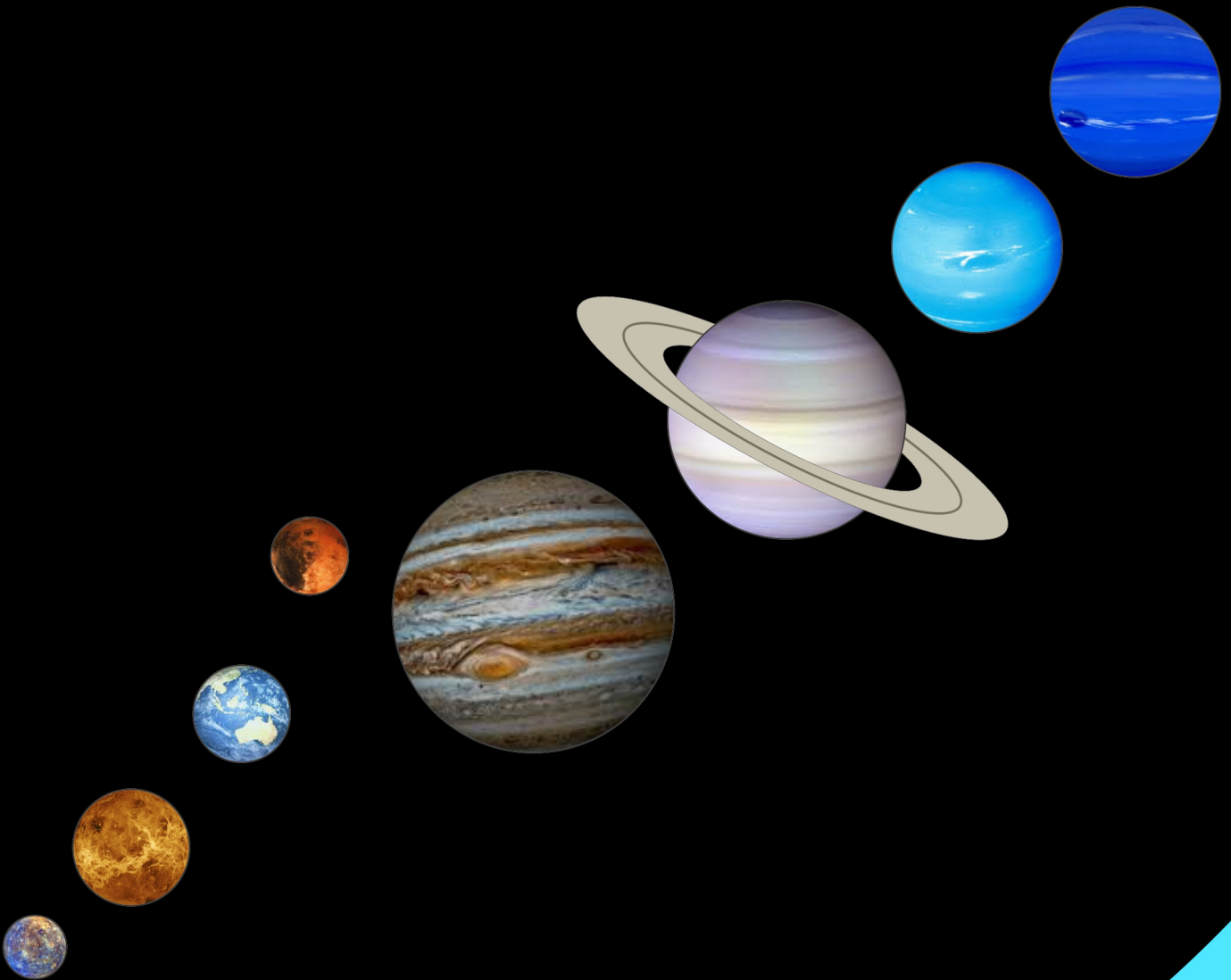


What else can wind energy be used for?

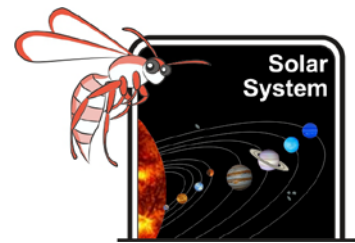


An old Australian bush trick was to leave a black plastic jerry can out in the sun during the day. When you came back from work dirty, the water would have warmed and made an excellent shower. Black plastic hose was also draped over bush roofs and beach shacks to provide hot water.

Thinking about Planets



Historical Thinking – Teacher Notes



Metacognition means thinking about thinking. The patterns and possibilities for the attributes of the planets in our solar system have changed over time. Students may be interested in studying and discussing these examples.

“It is the mark of an educated mind to be able to entertain a thought without accepting it”
Aristotle

Science tries to give the best explanation at that time for what has caused something to exist and to change. Ideas are vigorously tested and retested and theories adjusted when new information is brought in from new technologies. It can take many years for people to change their minds. In the past supporters of differing ideas have slaughtered and starved out those supporting conflicting explanations. It is very difficult to get people to change the way they think.

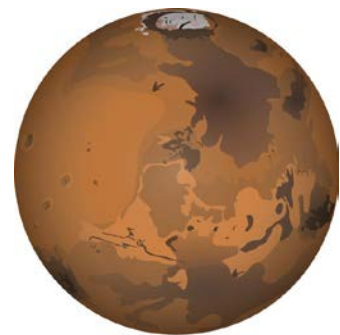
In medieval times the **Doctrine of Signatures** was a very popular way to explain things. People believed that everything was created to be useful to mankind. Each thing contained a clue or signature that would explain its use, if only you searched for it.

Example 1

The planet Mars appears red in the night sky. Red is the colour of blood therefore this planet is named after Mars the God of War. The metal copper is a red-gold colour. If you wear a copper bracelet to battle it will make you victorious like the god.

Do you think the doctrine of signatures is a good explanation for wearing a copper bracelet to war?

Any reasoned thoughts. Copper round your wrist will not protect you from a gunshot or arrow to the head. Copper will even bend if hit by a rock. A simple trial/test should disprove that this is so.



Example 2

The herb or weed dandelion has a whitish sticky juice in its stem and juice that looks a bit like urine.



If you suck juice from the stem it will make you urinate more frequently. It is a diuretic, hence its common English name “piss weed”.

Do you think the doctrine of signatures is a good explanation for the use of dandelion as a medicine for correcting water retention? Explain your answer.

Any reasoned answer. Although the juice looks like urine it doesn't smell like urine. Inconclusive. It can be useful in lowering fluid levels in a body. During WW11 coffee could not reach the UK easily. A substitute was made from dandelion.

Although both coffee and dandelion are diuretics the effect from dandelion is much stronger. Fighter pilots would refrain from drinking ersatz (pretend) coffee until after their flights. The name dandelion comes from the French “dent de lion”, lion's tooth.

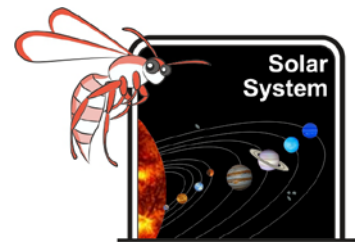
Example 3

The herb eyewort has flowers that look to some people like eyes. It was used to treat eye infections and other diseases of the eye.

Do you think the doctrine of signatures is a good explanation for the use of eyewort as an eye medicine? It was made into a tea and applied externally. Explain your answer.



Historical Thinking – Teacher Notes



Any reasoned thoughts. It doesn't look like an eye. It is mostly ineffective. Any boiled water that is at all astringent will help reduce inflammation and infection. Salt water or seawater is more effective against infection. Neither is effective against physical problems of the eye such as short sightedness or cataract development.

Example 4

The planet Venus can be clearly seen near the western horizon at dawn and at dusk. Its position was, and still is used as a navigation aid by sailors before compasses were commonly available. It became known as the sailor's planet in medieval times. A planet for sailors must also provide the hemp that was needed for sails and ropes for sailing ships at that time. It was believed that Venus must therefore have hemp growing on its surface.



Do you think hemp grows on the surface of Venus? Explain your answer.

Any reasonable answer. The carbon dioxide rich atmosphere of Venus acts like a great greenhouse that traps heat from the Sun. The surface of Venus is 465°C, hot enough to melt the metal lead. There is no water or oxygen on Venus. Plant life cannot exist.



With the advent of the Renaissance in the 16th and 17th centuries, scientists, philosophers and free thinkers were challenging traditional ideas. Those seeking explanations started depending on data (information) that is observable (subjective not objective) measurable in SI (International standard units) and repeatable. Possible explanations were tested and retested.

Science must change as more information becomes available. Scientists no longer declare "Laws" of Science. Instead they suggest hypotheses (Hypo = less than and thesis = law). Hypotheses are scientific guesses or estimates that explain why changes occur.

Example 5

The philosopher Aristotle was born in Macedonia in 384BC. He believed that "like attracts like". Stones fall towards the ground because they are both made of similar materials. Smoke rises up into the air because they are again both similar substances. Write an hypothesis to describe and explain what happens if you are holding a rock and let go of it.

If you let go of the rock then it will fall downwards. The mass of the rock is attracted to the much greater mass of the planet. The force of gravity attracts it.

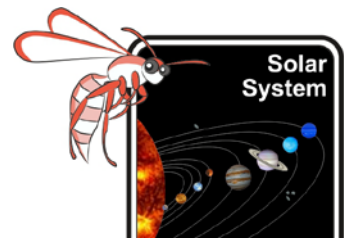


Example 6

Astronomers have noted that "rings" surround the planet Saturn. In 1610 Galileo Galilei first saw them when he turned his telescope toward this bright planet. What do you think that someone who believed in the Doctrine of signatures would interpret these rings as? Perhaps this planet is for ring makers or jewellers. It must be rich in silver and gold.

What do you think modern astronomers interpret these rings as? They are reflections from the surface of many moons and smaller objects held in orbit round the planet.

Historical Thinking – Student Activity



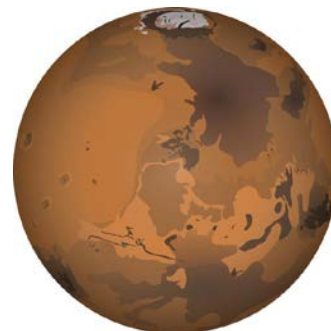
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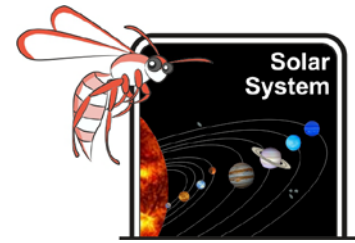


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