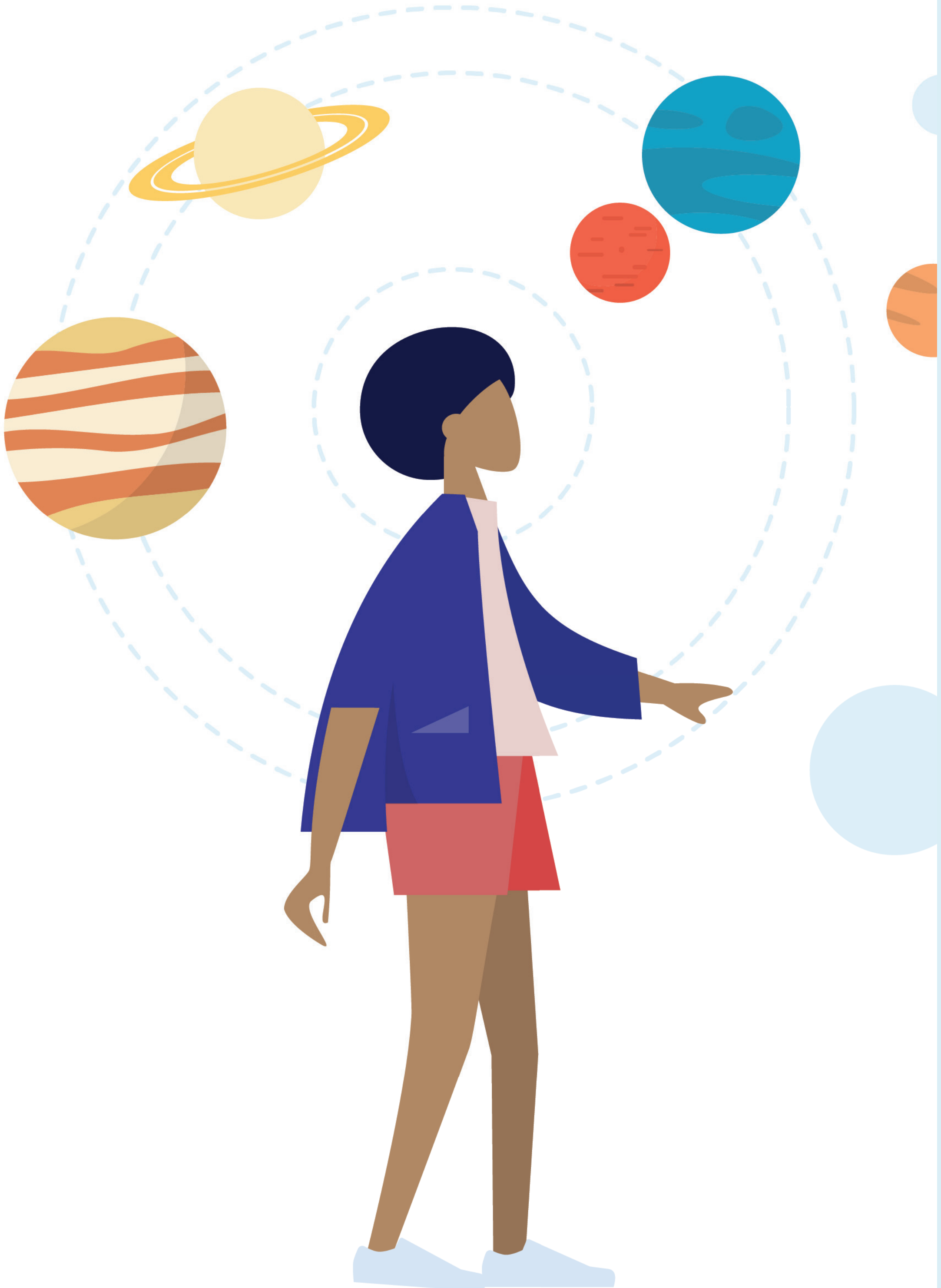

PRIMARY + STEM

Teaching Resource

ACTIVITY: Solar System

ACTIVITY OVERVIEW

While the wonder of space is first introduced to children in the form of lullabies like 'Twinkle, Twinkle Little Star', without Mathematics, that curiosity could never blossom into something more. Mathematics is the only language powerful enough to explain the phenomena we see in the skies. Applying numbers to our understanding of space has allowed us to seek out and uncover even greater unseen mysteries of the universe. By applying numbers in creative ways, scientists try to explain the origin of the universe, including the birth, life, and death of stars, black holes, and galaxies... even of dead stars that collide and send shock waves so powerful that they bend space and time!!

Australia has many talented scientists and engineers in the field of space science, and it's amazing to think that they all began their careers in classrooms, learning to use Mathematics, just as the students are! In this activity, students create a scaled model of the solar system; working through 'Number and Algebra' as they manipulate number and place value, and fractions, to explore patterns that are hidden in plain sight in our solar system. Students then take a virtual tour of the solar system using NASA's 3D Data Visualisation to find where these planetary bodies are in real time.

SYNOPSIS

While the wonder of space is first introduced to children in the form of lullabies like 'Twinkle, Twinkle Little Star', without Mathematics, that curiosity could never blossom into something more. Mathematics is the only language powerful enough to explain the phenomena we see in the skies. Applying numbers to our understanding of space has allowed us to seek out and uncover even greater unseen mysteries of the universe. By applying numbers in creative ways, scientists try to explain the origin of the universe, including the birth, life, and death of stars, black holes, and galaxies… even of dead stars that collide and send shock waves so powerful that they bend space and time!!

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Foundation – Year 2

- Y1: Recognise and describe one-half as one of two equal parts of a whole.(VCMNA091)
- Y2: Recognise and interpret common uses of halves, quarters and eighths of shapes and collections. (VCMNA110)
- F-2: Observable changes occur in the sky and landscape; daily and seasonal changes affect everyday life. (VCSSU046)

Years three – four

- Y3: Recognise, model, represent and order numbers to at least 10 000. (VCMNA130)
- Y4: Recognise, represent and order numbers to at least tens of thousands. (VCMNA152)

Years five – six

- Y5: Recognise, represent and order numbers to at least hundreds of thousands. (VCMNA186)
- Y5: Use efficient mental and written strategies and apply appropriate digital technologies to solve problems. (VCMNA185)
- Y6: Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems, involving all four operations with whole numbers, and make estimates for these computations. (VCMNA209)
- Y5-6: Earth is part of a system of planets orbiting around a star (the Sun). (VCSSU078)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

The activity* will help students visualise how vast space is and where different planets are positioned in the solar system when they create a simplified scaled model of the solar system using simple fractions.

Note: The figures used for this activity are very approximate and includes the Asteroid belt and Kuiper belt.

**Adapted from Educator Guide: Solar system Scroll | NASA/JPL Edu*

Materials for 30 students (working in pairs)

- 15 x length of paper at least 1m long (e.g. receipt rolls)
- Coloured pencils
- Markers

Table of Planetary distance

Planetary object	Approximate distance from the Sun (km)*	Approximate AU**	Position on the receipt roll
Sun	–		0
Mercury	57,900,000	0.4	Squeezed into the remaining fraction
Venus	108,200,000	0.7	
Earth	149,600,000	1.0	
Mars	227,900,000	1.5	1/32
Asteroid belt	450,000,000	2.5	1/16
Jupiter	778,600,000	5	1/8
Saturn	1,433,500,000	10	1/4
Uranus	2,872,500,000	20	1/2
Neptune	4,495,100,000	30	3/4
Kuiper belt	5,906,380,000	40	1

** Data from scaless_reference.pdf (nasa.gov)

Instructions

1. Elicit prior knowledge from students.

   What do they know about the planets? Asteroid belt? Kuiper belt? Pluto? What is a star? What is a planet? What of moons – which planets have moons, how many moons are there on each planet?

2. The teacher lists all the items in Column 1 of the table on a whiteboard. These planetary objects are already in order of their distance away from the Sun.

3. Students mark out one end of the receipt roll as the Sun and the other end as Pluto. Using coloured pencils, students fill the receipt roll with the remaining planets and asteroid belt the way they think these planetary bodies are positioned in the solar system.

4. The teacher shows students 'columns one – three' of the table.

   Explain that actual distances are not that useful (not least because the numbers are all so large!) if we do not use them to compare distances in a way that is easy to understand. That is the usefulness of the astronomical unit AU. By using the AU, we can produce the fractions that will help us to locate the positions of the planets relative to one another.

5. Show students how to use the astronomical unit to scale the solar system. As the teacher gives instructions a) to h), students copy over their original work on the receipt roll. This time they use a marker.
   a. Mark the Sun as '0' and Pluto as '1'. Everything else in the between will be a fraction less than 1.
   b. Bring Kuiper belt to the Sun and fold. Unfold and mark out Uranus at the crease. This planet sits at the halfway point of the receipt roll.

c. Bring the Sun to Uranus and fold. Unfold and label the crease as Saturn. It sits at the 1/4th fraction of the receipt roll.
d. Bring the Sun to Saturn and fold. Unfold and label the crease as Jupiter. It sits at the 1/8th fraction of the receipt roll.
e. Bring the Sun to Jupiter and fold. Unfold and label the crease as the asteroid belt. The belt of asteroids sits at the 1/16th fraction of the receipt roll.
f. Bring the Sun to the asteroid belt and fold. Unfold and label the crease as Mars. It sits at the 1/32th fraction of the receipt roll.
g. The remaining space between the Sun and Mars is where one finds Earth, Venus, and Mercury.
h. The last step is to bring Pluto to Uranus and fold. Unfold and label the crease Neptune. Neptune sits at the 3/4th fraction of the receipt roll.

6. Discuss.
   How did the student guesses compare to the actual positions of the planets? Are students surprised at the actual positions of the planets in the solar system? Emphasise to students those planets do not align in a straight line as they appear on the receipt roll.

7. Find where all these planetary bodies are in the solar system in real time, as well as space probes, spacecrafts, and notable asteroids and comets. This NASA web application produces the simulated view of our solar system with real data. It works a treat with touch screens but will also work well with a computer and keyboard. Link: NASA/JPL Eyes

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

The value of the activity to this group is in the actual making of the receipt roll scale model of the solar system. Every time students fold a section of the receipt roll by half, they create even smaller parts from the whole.

Through this activity should be able to appreciate how fractions get smaller in size when they get divided into more parts.

As an extension, students could draw pictures of planets and write interesting numbers on them sourced from Planetary Fact Sheet (nasa.gov) especially the number of moons, gravitational pull, and diameter of planets.

How do all these numbers compare to that of Earth? Bigger or smaller than Earth? More, or less than Earth?

Years 3/4

Take the opportunity to get students to work with the numbers in this activity before making the receipt roll scale model of the solar system.

Give students the numbers in 'column two' in a random fashion and get them to read it out to one another.

They then order these numbers in increasing order before the names of the planetary bodies are revealed to them.

As an extension, problem sums could be given to students to get them to add and subtract these large numbers. For example:

a. Find the distance between Jupiter and Mars = (Distance of Jupiter from the Sun) – (Distance of Mars from the Sun)
b. What is the total distance travelled if a space probe from Earth first travels to Venus, back to Earth, and then to Mercury?

Years 5/6

There are several ways students can use the data in this activity.

Using a calculator, students could calculate the astronomical units themselves. For example,

= Distance of any planet from Sun/Distance of Earth from the Sun

For planets closer to the Sun than Earth, the AU would be less than one.

For planets farther from the Sun than Earth, the AU would be greater than one.

By using the astronomical units, can students derive the fractions used in this activity?

For example, the AU for the Kuiper Belt is 40 and Uranus is 20.

Would they be able to tell that the distance of Uranus is halfway between the Sun and the Kuiper Belt? For students looking for a challenge, they can construct the scale model on the receipt roll themselves.

Students could extend their learning by creating scale models of other data (e.g. planet diameters, gravity on other planets, etc.). The data can be found here: Planetary Fact Sheet (nasa.gov)

DISCUSSION SECTION AND KEY THEMES

The solar system comprises our beloved star and the planets that orbit it. Other celestial bodies include asteroids, meteors, comets, and satellites.

KEY THEMES

Distances

Distances within the solar system are so large with numbers so unwieldly that astronomers sometimes describe the distances in astronomical units (AU) instead of kilometres. One AU represents the approximate distance between Earth and the Sun (i.e. 1,500,000km), and other distances are compared to this. Any planets farther from the Sun than Earth would have an AU greater than one, and any planets closer to the Sun would have an AU less than one. For example, the distance between the Sun to Saturn can be described as 10AU, instead of 1,500,000,000km; and Mercury is 0.4AU instead of 57,900,000km. These figures represent the average distances away from the Sun, since planetary orbits are elliptical rather than circular.

The actual distances vary, depending on the time of the year.

Planet	Distance from the Sun (km)	Approximate AU
Sun	-	
Mercury	57,900,000	0.4
Venus	108,200,000	0.7
Earth	149,600,000	1.0
Mars	227,900,000	1.5
Asteroid belt	450,000,000	2.5
Jupiter	778,600,000	5
Saturn	1,433,500,000	10
Uranus	2,872,500,000	20
Neptune	4,495,100,000	30

Data from the Solar system Sizes | NASA Solar system Exploration

Diameters

Planet	Diameter (km)	Comparison to Earth
Sun	1,391,400	
Mercury	4,879	1/3 the size of Earth
Venus	12,104	Slightly smaller than Earth
Earth	12,756	1
Mars	6,792	About half the size of Earth
Jupiter	142,984	11 times the size of Earth
Saturn	120,536	9 times the size of Earth
Uranus	51,118	4 times the size of Earth
Neptune	4,495,100,000	Slightly smaller than Uranus
Neptune	4,495,100,000	30

Data from the Solar system Sizes | NASA Solar system Exploration

Parts of the solar system

Sun

The 4.5billion year old star is a yellow dwarf star-type meaning that it is rather an average star in comparison to other stars. It comprises almost 99.8 per cent of all the mass of the entire solar system and is the source of energy for life.

Planets

The word planet is derived from the Greek word 'planaomai', meaning 'to wander' or 'to roam'. This is because when humans first studied the skies, they noticed that while shining stars appeared to stay in place, planets kept changing their positions and 'wandered' the skies.

- *Mercury* is the smallest of the planets. It is rocky and is about the size of Earth's Moon.
- *Venus* is a rocky planet with the hottest temperatures in the solar system. It has so much carbon dioxide gas in its atmosphere (96.5%) that temperatures reach upwards of 460˚C!
- *Earth* is the third rocky planet from the Sun, only slightly bigger than Venus. In the 'Goldilocks Zone', Earth's temperature is just right for water to exist in all three forms – solid, liquid, and gas. Earth has one moon.
- *Mars* is the fourth and last of the rocky planets. It's about half the size of Earth. Mars has two moons.
- *Jupiter* is the first of the gas giants. It's more than 11 times the size of Earth and has as much mass as 2.5 times of all the other planets put together! And it has 79 moons.
- *Saturn* is another gas giant and it is the second largest planet in the solar system. It has beautiful rings made of ice particles and dust and has 82 moons orbiting it!
- *Uranus* is an ice giant planet and, unlike all the other planets, it lies on its side. It was also the first planet to be discovered using a telescope. Uranus has 27 moons.
- *Neptune* is the last planet in the solar system and it is another ice giant planet. It is about the same size as Uranus. Neptune has 14 moons.

Other planetary bodies

- The asteroid belt lies between Mars and Jupiter. It is a vast belt about 150,000,000 km wide, made up of moving pebbles, rocks, ice, and even dwarf planets.
- The Kuiper belt can be found beyond Neptune. Pluto, other dwarf planets, rock and ice can be found here.
- Oort cloud is an idea that is yet to be proven, but it is thought to be like a big bubble that surrounds our entire solar system and is the remains of the early stages of the solar system's formation.

QUESTIONS AND ANSWERS

Is Saturn the only planet with rings?

Even though that is what is illustrated when we see pictures of the solar system in books, the fact is that several planets have rings, including Jupiter, Uranus, and Neptune.

Saturn's rings were most visible from Earth because they are brightest and widest, but with more exploration by spacecraft to the planets in recent years, we now know that all gas giants (i.e. Jupiter, Saturn, Uranus, and Neptune) have their own ring systems.

Which Planets Have Rings? - Universe Today

Does the solar system end at Neptune?

Neptune may be the last planet, but the solar system doesn't end there. The solar system neighbourhood includes the Kuiper belt and the Oort cloud. The Kuiper belt lies beyond Neptune, and it is a layer of moving rock, ice, and dwarf planets (including Pluto!)

The Oort cloud was first proposed by Dutch astronomer JH Oort (1950) as a reservoir of comets that travel through the solar system. It is believed that this cloud of ice is like a big bubble that surrounds our entire solar system and is the remains of the early stages of the solar system's formation.

How do we know what planets look like?

Many spacecrafts armed with computers, data recorders, cameras and other equipment, were sent from Earth from as early as the 1970s to visit different planets to gather information and take photos. This information is sent back to Earth.

There are currently many spacecrafts orbiting all parts of the solar system neighbourhood including the Sun, the moons of Jupiter, comets, and asteroids. Here is a list of currently active spacecrafts: List of active Solar system probes - Wikipedia

Which spacecraft is furthest away from Earth?

The credit goes to the spacecraft Voyager 1 and Voyager 2 launched by NASA in 1977 from the USA. Their mission was to explore Jupiter, Saturn and beyond.

Together, these spacecrafts took tens of thousands of photos of Jupiter and Saturn, which has allowed us to study in detail the many moons on the planets; Jupiter's clouds, storms, and active volcanoes; and the rings of Saturn.

They have also sent photos back to Earth of the farthest planet, Neptune. The two spacecraft are on a mission-of-no-return and their current location in interstellar space (the region between stars) can be found here: Voyager - Mission Status (nasa.gov).

No other spacecraft has travelled as far as Voyagers 1 and 2.

How is it that the Voyager 1 and 2 have yet not run out of fuel?

It is the nature of travelling in the vacuum of space which has allowed the spacecrafts to go on this long - 44 years at the time of writing.

Because there are no particles in contact with the spacecraft, there is no friction, and nothing to slow it down. It is estimated that they have enough of a special radioactive fuel to last until 2025.

After that, they will not be able to communicate with Earth anymore. However, they will continue travelling until something or someone stops them. On board the Voyager spacecraft are messages from Earth, with recordings of scenes and sounds from Earth, music and greetings in different languages! [Voyager 1 and 2: The Interstellar Mission | NASA Space Place – NASA Science for Kids]

How long would it take to travel to Mars? Or even to Neptune?

It has been estimated by NASA that a trip to Mars will take about nine months, and Neptune would take about 12 years!

These are not fixed numbers because it depends on factors like where the planets are in their orbit and even the type of technology that propels the spacecraft.

Are people really going to live on Mars?

Plans are being made by space agencies of many countries, and even private organisations, to get the first colony of people on the Red Planet.

Since the first spacecraft, the Viking 1, landed on Mars in 1976, technology has advanced to the point where colonisation has become a very possible reality.

When it will happen no one quite knows for sure, but most people agree that it is only a matter of time.

What are black holes?

When a massive star at least 20 times the size of our sun dies, it implodes and collapses into a point in space.

All the matter that made up the star condenses into a small space creates such strong gravitational pull that nothing can escape it, not even light. This is one way a black hole is formed.

There are several types of black holes. 'Stellar' black holes are described in the previous paragraph. There are also big 'supermassive' black holes that can be found at the very centre of most large galaxies in the Universe, including our own Milky Way.

Finally, there are really small black holes which can be as small as just one atom!

Black holes are hard to find. Because they do not let light escape, they cannot be seen. What scientists do is to search for visible stars that are getting gobbled up by a black hole's immense gravitational pull.

Recent estimations from Italy published in 'The Astrophysical Journal' (2022) puts the number of 'stellar' black holes at 4 followed by 19 zeros (40 quintillion)!

Will our sun become a black hole?

No, because our sun is too small. When stars die, they follow one of two fates. Stars like our sun will gently burn out and turn into a 'white dwarf'.

Stars that are at least 20 times larger than our sun will explode as a supernova and either turn into a 'neutron star' or become a black hole.

Which animals have been to space?

A surprising number and variety of animals have been launched into space since 1947 – mainly to test if human beings could survive a space flight.

Fruit flies were the first animals; followed by primates, mice, dogs, rabbits, ape, guinea pigs, cats, frogs, fish, tortoises, insects, and spiders!

OUTSIDE OR SUPPLEMENTARY READING

For more numbers related to the solar system

- Planetary Fact Sheet (nasa.gov)

Interactive visualisations from NASA

- NASA's Eyes

Black holes, galaxies, stars, dark energies, the Big Bang

- Black Holes | Science Mission Directorate (nasa.gov)
- Overview | Sun – NASA Solar system Exploration

TOPIC WORDS

- Distance
- Astronomical units
- Kilometres
- Fractions
- Sun
- Star
- Planets
- Asteroids
- Gravity

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