
PRIMARY + STEM

Teaching Resource

# ACTIVITY: Planet Times

## ACTIVITY OVERVIEW

The wonder of space captures the imagination, and it is a rich landscape in which to showcase how numbers can be used to express ideas and seek understanding of the many phenomena in space. Through this activity, students learn that they can compare how quickly or slowly planets move because time is quantified in units. Students also learn to use different units of time to better describe the length of one day and the length of one year on these planets. And in the process, they discover interesting findings for themselves of what life might be like for people who travel to other planets in the solar system.

This activity can be used to enhance younger students' understanding of place value, while older students can work towards achieving skills in the units of measurement component of the Mathematics curriculum.

## SYNOPSIS

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### Foundation – Year 2

- Y1: Describe duration using months, weeks, days and hours. (VCMMG097)
- Y2: Recognise, model, represent and order numbers to at least 1000. (VCMNA104)
- F-Y2: Observable changes occur in the sky and landscape; daily and seasonal changes affect everyday life. (VCSSU046)

### Years three – four

- Y3: Tell time to the minute and investigate the relationship between units of time. (VCMMG141)
- Y4: Recognise, represent, and order numbers to at least tens of thousands. (VCMNA152)
- Y4: Convert between units of time. (VCMMG167)

### Years five – six

- Y5: Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies. (VCMSP206)
- Y6: Measure, calculate and compare elapsed time. (VCMMG227)
- Y5 – 6: Construct, interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables. (VCMSP235)
- Y5-6: Earth is part of a system of planets orbiting around a star (the Sun). (VCSSU078)

## ACTIVITY, MATERIALS AND INSTRUCTIONS

### Activity

Our understanding of how long one day is, and even when our birthdays are celebrated, is determined by how Earth moves.

Rotations bring about day and night on Earth, and one year is the length of time it takes for our planet to orbit the Sun. If Earth has an approximate 24-hour day and a year lasting 365 ¼ days, what of other planets in the solar system?

### Materials (class of 30 students)

The estimated quantities are designed for children working in pairs.

- Data sheet: Rotational times and orbital times
- Scissors
- Glue

### Instructions

1. Elicit prior knowledge of solar system.

   How do we get days and nights on Earth? What are some numbers associated with the number of hours in a day and number of days in a year? Do other planets experience the same phenomenon too? What would life be like on other planets?

2. Explain how rotations and orbits result in our understanding of one day and one year.

   When planets rotate, the result is that all parts get exposed to the Sun in regular intervals. This is how we get day and night on Earth equivalent to 23 hours and 56 minutes. The length of time it takes for a planet to orbit, or travel around, the Sun represents one planetary year. For Earth, it is 365 ¼ days.

3. Distribute the datasheet to students and explain the significance of the units used in the data.

   Students cut out the cards along the dotted lines and arrange the data in order of increasing value.

   We can measure data from all planets because the concept of time has been quantified into units like years, months, days, hours, minutes, and seconds. And the best part about using the language of numbers must be that, when we compare data, we may stumble upon other discoveries as we try to explain what we observe.

   The times in the datasheet come in different units, varying from hours to days. Do students find this more useful in helping them imagine the length of time? Or would they prefer using the same time units for all planets?

4. Discuss with students what the numbers reveal.

   What have they discovered through comparing the rotational and orbital times?

   - The orbital times are in the same order as the position of the planets in the solar system.
   - The planet with the longest day is Venus – it is equivalent to about eight months for one complete day! Jupiter has the shortest day of about 10 hours.
   - The gas giants – Jupiter and Saturn, have the shortest days. This means that they are rotating at the fastest speeds.
   - Venus has a day that is longer than its year.

- Someone who lives on Mercury would have many more birthday parties than someone living on Neptune.

- Compared to Australia, where students attend school for an average of ¼ of our day, what would schooling hours be like on other planets? On Jupiter, it would be for 2.5 hours, and on Venus they would be attending school for an equivalent of two months!

5. Show the following visualisations and online applications of the data they have been working with. These are a few ways to illustrate how mathematical calculations are powerful and fun tools.
    - Calculate student ages on different planets: [Your Age on Other Worlds | Exploratorium]
    - Relative rotational rates of planets: https://youtu.be/exkeE6allpc
    - Interactive Solar System Tour: nineplanets.org

## HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

### Foundation – Year 2

This is a great hands-on maths activity to support a science inquiry unit into space, where students order the planets by orbital times. This could be done as a teacher-led demonstration, where the figures could be displayed on a number line. Students who are interested in space would be able to recognise that the positions of the planets in the solar system are in the same order as their orbital times.

The orbital times are expressed to the nearest whole number, but the figures do vary between the order of tens to the tens of thousands. For this reason, this activity may be best suited for the older students in this age bracket.

### Years 3/4

There are many opportunities for students to learn about the different units of time in this activity, since the rotational and orbital times range from months to minutes. Converting between the different scales of time highlights the use of numbers to help us make meaning of things (e.g. Venus' rotational period of 5,832 hours may not have as much relevance to students, compared to describing it as eight months.

As an extension, use the accompanying worksheet, so students can convert the rotational period expressed as hours into months/days/minutes. There are 24 hours in a day, 60 minutes in an hour, and 60 seconds in a minute. Would students be keen to convert the times further into seconds? In which form is the information more meaningful to them?

### Years 5/6

This activity supports student exploration into the solar system as outlined in the Science curriculum. It reinforces the concept of planetary orbits from a mathematical perspective and extends this learning into what it means in terms of time. By using tables, these data (i.e. rotational and orbital times) are easy to visualise. However, the differences between the planets are made starker when the data is displayed as graphs.

Students should be able to convert the rotational hours into other units of time in the accompanying worksheet and go onto representing any part of this data, with or without digital technologies. Using column graphs is a good way to represent the rotational times of the planets. It is easy to create one graph to represent all the data if doing it digitally, using an Excel spreadsheet. However, doing it by hand may prove to be difficult because of the large range. One solution is to do it in two separate graphs. One graph to represent Mercury and Venus (with increments of 1,000; ranging between 0 to 6,000), and another to represent all other planets in the solar system (with increments of 1; ranging between 0 to 25).

# DISCUSSION SECTION AND KEY THEMES

## KEY THEMES

### Measuring time

By observing the regular motion of the Sun, the Moon, constellations and planets, many early civilisations found similar ways of using these regular patterns in the skies to keep track of time. This was an important part of successful civilisations, as it helped people make predictions of weather changes, and changes to plant and animal behaviour.

- **Calendars**

  The earliest calendars were based on either, or both, the patterns of the Moon and the Sun, and similar 12-month, 360/365/366-day calendars were used by the ancient Babylonian, Egyptian, Chinese, and Indian civilisations. There were variations to this (e.g. the Mayan divided the 365-day calendar into 18 months and the Romans had a 355-day calendar divided into 10 months). There was no perfect calendar, and irregularities in the different calendar years were corrected in different ways - for example, the leap year that we are familiar with where an extra day is added to every fourth year. The change is credited to Julius Caesar in 45BCE and takes into consideration that there is 365 ¼ days to one year and not 365 days.

- **Hours, minutes, and seconds**

  The 24-hour day was developed by the Egyptians, who based it on the time it took for certain constellations to pass through the sky. In this system, the length of each hour varied between seasons to reflect the changing amounts of day light and was useful then for people to plan their day-to-day activities. The subdivision of the 24-hour day into hours, minutes, and seconds, came later and is credited to the Babylonian base-60 system of mathematics. This is the reason why there are 60 minutes to the hour and 60 seconds to the minute.

- **Converting units of time.**

  To convert:

  - Years into months: Multiply by 12
  - Years into days: Multiply by 365
  - Days into hours: Multiply by 24
  - Hours into minutes: Multiply by 60
  - Minutes into seconds: Multiply by 60

  (e.g. To convert five years into seconds,

  = 5 years x 365 days x 24 hours x 60 minutes x 60 seconds)

  To go in the other direction (e.g. converting seconds to years), divide the numbers in the reverse order.

### Planetary motion and time

Planets rotate about their own axis, and they orbit the Sun. These motions result in regular patterns in the skies that early people observed and used as a means for measuring time. The length of one day and one year varies from planet to planet, depending on how fast they are spinning and moving around the Sun.

- **Rotations: Measuring the length of a day**

  Most people associate the length of one day by the number of hours of daytime and nighttime. This is known as a solar day. It is determined by measuring the time it takes for the Sun to reach its highest position in the sky, from midday to the next midday.

By doing it this way, the length of one day increases by four minutes every day. This is because, as Earth rotates, it is also simultaneously moving around (orbiting) the Sun. This makes the Sun appear at different positions in the sky at the same time every day.

There is another, more regular, way to determine the length of a day. Instead of using the Sun, other 'background' stars in the sky that do not appear to change in their positions are used as reference instead. This is known as a sidereal day. These are the figures used for this activity.

- **Orbits: Measuring the length of a year**

  One year on a planet is the time it takes for it to travel around the Sun. Planets remain in orbit because of the Sun's strong gravitational pull and cursory inspection of orbital times shows that the further a planet is from the Sun, the longer it takes to travel around the star.

  From early Greek geocentric models that placed Earth in the centre of the system, to heliocentric models where all planets orbit the Sun, it was through painstaking observations and calculations by early astronomers and mathematicians that we have gained the understanding of space that we have today. Notable thinkers include Tycho Brahe (1546 - 1601), a Danish astronomer, who dedicated his life to accurate observations and documentation of the skies. He had made many corrections to highly inaccurate data of the time and his work underpinned Johannes Keppler's (1571 – 1630) mathematical analysis which changed our understanding of the solar system forever. It's amazing to think that he did this without the aid of a telescope - because they had not been invented yet!

  During the time of Johannes Kepler, orbits were still considered to be circular in shape and had produced many inconsistencies in what astronomers were observing. It was his mathematical brilliance and powerful imagination that led to the game-changing discoveries that still apply today. His discoveries include the elliptical orbit of the planets, how the orbit of a planet sweeps out in equal areas in equal intervals of time, and the relationship between the orbital time and distance away from the Sun. 'Kepler's Laws of Planetary Motion' are still used today to predict the orbits of planets, comets, stars, galaxies, and even spacecraft. Orbits and Kepler's Laws | NASA Solar System Exploration

## QUESTIONS AND ANSWERS

### Are there other solar systems?

The term 'solar system' is used only to describe our planetary system, but as to whether there are other planetary systems, the answer is a resounding 'yes'.

Just in the Milky Way galaxy alone, NASA astronomers have discovered more than 3,200 other stars with planets orbiting them. Given that there are at least 100 billion stars in our galaxy alone, with an average of one planet orbiting each one, there must be more planetary systems out there waiting to be discovered.

That said, it is no easy task to find them because stars are so large and so bright compared to the planets orbiting them.

### Why do planets rotate?

Scientists think that the rotations are due to the 'spin' that was created when huge moving clouds of interstellar gas and dust collapsed into each other. Since these materials were in constant motion to begin with, this motion was retained as the planet was forming.

## Are there other planets like Earth?

Astronomers from the world over are busy looking for a second Earth. To qualify as being Earth-like, planets must be rocky and be orbiting in a 'Goldilocks' zone around a star with temperatures that allow water to be in liquid form.

4,461 exoplanets (planets outside of the solar system) have been identified to date. More than half of these discoveries were made by NASA's Kepler space telescope, which was launched in 2009 to find other Earth-like planets in the Milky Way galaxy. The European Space Agency has plans to launch three missions within 10 years to study exoplanets and learn how they form and evolve.

Here are several possibilities so far: The 10 most Earth-like exoplanets | Space

## Does the Sun rotate and orbit too?

Yes, it does. According to NASA, the Sun rotates, on average, once every 27 days. The Sun is gaseous and so doesn't rotate like Earth. Different parts of the Sun spin at different speeds – its equator spins much faster than its poles, and the inner layers spin faster than the outer layers. The Sun and everything in the solar system also orbits the centre of the Milky Way galaxy at about 720,000 kilometres per hour! At this speed, it takes about 230 million years for the Sun to make one complete trip.

## Am I the same age on other planets?

Your body may age the same way on all planets, but the number of candles on your birthday cake will vary wildly depending on which planet you are on. Since the inner planets orbit the Sun faster than the outer gas giants, we would be a lot older in the former than in the latter. Use this mathematical tool to find your age on different planets: Your Age on Other Worlds | Exploratorium

## Do I have to study mathematics to be an astronomer?

Yes. Mathematics is the language that is best suited for discovering and expressing the mysteries in space. Like learning any language, being good at numbers is a skill that can be gained with practice and perseverance.

## Did our first peoples study the stars too?

The early Aboriginal and Torres Strait Islander peoples studied patterns in the sky and they used the regularity of those patterns to predict changes in weather patterns, animal, and plant behaviour, and navigate the land using seasonal calendars.

This knowledge of the Sun, moon, planets and stars were passed down the generations through oral traditions, such as stories, songs and dances. Aboriginal groups give spiritual or mythological meaning to these planetary bodies, and even though different groups interpret and decipher the skies in different ways, the Sun is often depicted as a woman and the Moon as a man.

It could be that Australian Aboriginal people were the earliest astronomers in the world.

## How many seconds have passed since I was born?

What a fun mathematical challenge! To get an estimate of the number of seconds since your birth, take your age in years to the nearest whole number, and multiply that by the number of days in a year; then change that to the number of hours in a day; then minutes in an hour; then seconds in a minute.

For example,

To the year,

= 9 years x 365 days x 24 hours x 60 minutes x 60 seconds

To be more accurate, use your age closest to the nearest month (e.g. If you are nine years and 6/12 months, use 9.5 years. If you are nine years 3/12 months, use 9.25 years).

Check your answer against this mathematical tool:

How Old Am I - Get your age in seconds, milliseconds, weeks and more

## Who invented time?

When early humans observed the regularity of the patterns in the skies, those patterns were used as a means of observing time (e.g. the movement of the Sun across the skies, the monthly changes in the shape of the Moon, and constellations like Orion). The earliest calendars were based on either, or both, the patterns of the Moon and Sun, and similar 12-month, 360/365/366-day calendars were used by the ancient Babylonian, Egyptian, Indian, and Chinese civilisations. Similar development of the calendar was also used by civilisations in the Americas. Credit is given to the ancient Egyptians for the 24-hour day, but the subdivision of hours and minutes into 60 comes from the ancient Babylonians.

## What is an ellipse?

In mathematics, an ellipse is a shape with two focal points within it. Adding two distances from any point on the curve to the focal points always produces a constant answer. A circle is a special type of ellipse where the two focal points are the same.

It was Johannes Kepler, who made the breakthrough discovery that planets orbit the Sun in an elliptical shape, and not a circular shape as proposed by famed astronomer and mathematician Nicolaus Copernicus.

The ellipse was mathematically accurate and produced a model of the solar system that was elegant and simple.

# OUTSIDE OR SUPPLEMENTARY READING

## Fact sheets

- Planetary Fact Sheet (nasa.gov)
- Orbital Speed of Planets in Order - Rotational Speed Comparison (planetfacts.org)

## NASA resources

- How Many Solar Systems Are in Our Galaxy? | NASA Space Place – NASA Science for Kids
- Overview | Beyond Our Solar System – NASA Solar System Exploration
- How many exoplanets are there? – Exoplanet Exploration: Planets Beyond our Solar System (nasa.gov)

## Measuring time

- A Brief History of Time Measurement (maths.org)
- Why are there 24 hours in a day? › Ask an Expert (ABC Science)

## Your age on different worlds

- Your Age on Other Worlds | Exploratorium

# TOPIC WORDS

- Orbit
- Rotation
- Year
- Day
- Hour
- Minute
- Second
- Planet
- Solar system
- Ellipse
- Time

## DATASHEET: ORBITAL TIMES AND ROTATIONAL TIMES

Cut along dotted lines and arrange the planets in increasing order of time.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Rotational times**<br>How long a day is | **Mercury**<br>**58 days 15h** | **Venus**<br>**243 days** | **Earth**<br>**23h 54min** | **Mars**<br>**24h 36min** | **Jupiter**<br>**9h 54min** | **Saturn**<br>**10h 42min** | **Uranus**<br>**17h 12min** | **Neptune**<br>**16h 6min** |
| **Orbital times (Earth days)**<br>The number of days in one year | **Mars**<br>**687 days** | **Jupiter**<br>**4,331 days** | **Uranus**<br>**30,589 days** | **Mercury**<br>**88 days** | **Neptune**<br>**59,800 days** | **Saturn**<br>**10,747 days** | **Earth**<br>**365 days** | **Venus**<br>**228 days** |

Figures based on data from Planetary Fact Sheet (nasa.gov)

## WORKSHEET: ONE DAY ON THE PLANETS OF THE SOLAR SYSTEM

Time for figurine to drop without parachute: __________ (s)

| Planet | Rotational times (hours) | Rotational times |
|---|---|---|
| Mercury | 1407.6 | _____ days ______ h |
| Venus | 5832.5 | ______ days / ______ months |
| Earth | 23.90 | _____ h _____ min |
| Mars | 24.6 | _____ h _____ min |
| Jupiter | 9.9 | _____ h _____ min |
| Saturn | 10.7 | _____ h _____ min |
| Uranus | 17.2 | _____ h _____ min |
| Neptune | 16.1 | _____ h _____ min |

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