ROYAL OBSERVATORY GREENWICH

Teacher's Notes

Explore the moons of our Solar System

Key Stage 3

Topics covered: features (*properties and characteristics*) of some of the moons of the Solar System

Watch the video "Exploring Moons"
https://vimeo.com/323699722

Introduction

There are over 200 moons in our Solar System and they come in different shapes and sizes. Some moons have active volcanoes on their surface while others blast jets of material into space!

This resource is aimed at KS3 and will explore some of the moons of the Solar System. We will be starting off with a few teacher notes to give you an outline of the activities included and information you may find useful. You will then find a handout, printable activity sheets and answer sheets. For further exploration on the topic of moons of the Solar System, we have included a link to NASA's Solar System website – enjoy!

Teacher's Notes:

We recommend that you start off by showing your students our video 'Exploring Moons'. The video is available on our website (https://www.rmg.co.uk/discover/teacher-resources/exploring-moons) and on our Vimeo page (https://vimeo.com/323699722).

There are five activities included in this resource for your students to try. Each activity includes written instructions for the students. We recommend printing the activities on A4 sheets of paper.

In "**On the Moon**" (page 9 - 10), students are provided with an image of the Apollo 11 landing site taken by a spacecraft in orbit around the Moon. By determining the scale of the image, students will calculate the width of a crater, the width of the descent stage of the lunar module and will calculate how far the Apollo 11 astronauts landed from a crater.

The activity "**Base camp on the Moon**" (pages 11 - 12) asks students to think about what astronauts would need in order to live and work on the Moon. This ties in to the section of the video that talks about the possibility of building a base camp on the Moon. The activity is designed to get students to discuss the challenges of having a base camp on the Moon. As an extension, you could ask your students to think of how we would get supplies to the Moon, how astronauts would cope with the lower gravity on the Moon and how they would communicate with their family and friends.

In "**An astronaut's weight on different moons**" (page 13), students will calculate the weight of an astronaut on some of the moons of our Solar System.

"**Size of the moons**" (page 14 - 15) asks students to draw scaled diagrams of a selection of moons of our Solar System and compare them to the size of the Earth. Two versions of this activity have been provided – in the alternative exercise (page 16 - 17), the scale used to draw the diagram of the Earth is not provided and students must determine the scale themselves.

"**Massive moving moons!**" (page 18 - 19) explores masses and orbital periods of some of the moons of our Solar System.

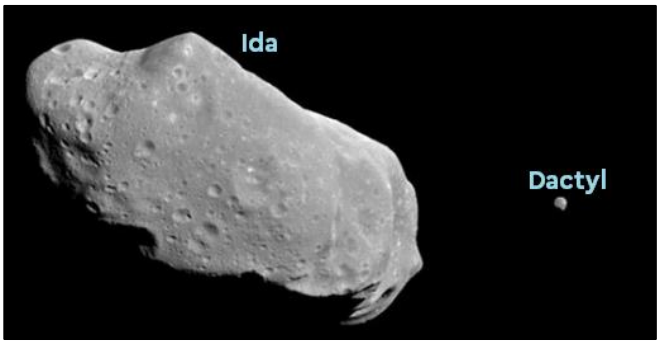
Solutions to the activities are provided at the end of the document.

Further exploration of the topic: Visit the NASA Solar System website: https://solarsystem.nasa.gov/moons/overview/

Many marvellous moons!

What is a moon?

A moon, also known as a natural satellite, is a celestial body that orbits (goes around) a planet, dwarf planet or asteroid. The image on the right shows Asteroid Ida along with its moon Dactyl.



There are over 200 moons in our Solar System and they come in different shapes and sizes. Some moons have active volcanoes on their surface while others blast jets of material into space!

Planets and their moons

Astronomers have discovered moons around most of the planets in our Solar System. Below are the number of known moons as of **November 2024.**

Planet	Number of known moons
Mercury	0
Venus	0
Earth	1
Mars	2
Jupiter	**95**
Saturn	**146**
Uranus	**28**
Neptune	**16**

Mercury and Venus don't have any moons. Mercury is the closest planet to the Sun and, because of the Sun's strong gravity, the planet wouldn't be able to hold on to a moon. Scientists still don't understand why Venus doesn't have a moon and they're working hard to solve that mystery.

Let's explore some of the moons of our Solar System.

Planet: Earth
Number of moons: 1

Our Earth only has one moon which we call the **Moon.** It's our closest neighbour in space and is, on average, 384,400 km away from the Earth. Our Moon formed from the debris (*scattered pieces or remains*) of a large object colliding with the young Earth. There is no air on the Moon but we know that there is a bit of water trapped under the surface. Our Moon is the fifth largest moon in the Solar System.

Features on the Moon

Our Moon is covered with craters which were created by space rocks that smashed into the surface. Some impacts threw up lots of material that fell back onto the surface producing bright rays that extend far from the craters. We also see lighter and darker regions on the surface. The lighter regions are called the lunar highlands while the darker regions are called the seas. Early observers thought that the Moon was covered in water which is why they called the darker regions seas. Thanks to observations that scientists have made, we know that the darker areas are where lava once flowed, then cooled down and became solid. Even though there are no real seas on the Moon, we still call the darker regions the seas.

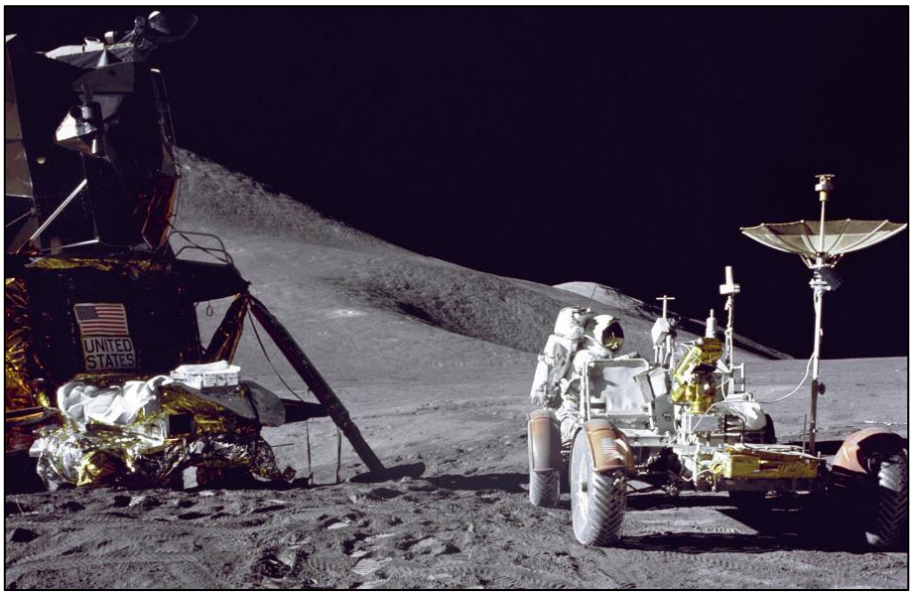
The side of the Moon that we can see here from the Earth is called the **near side** and the side we can't see is called the **far side**.

Have any astronauts been to the Moon?

Yes! NASA's Apollo space programme sent astronauts to the Moon and 12 of those astronauts have walked on its surface. During their missions, the astronauts collected samples of the surface of the Moon and they performed scientific experiments.

The astronauts who walked on the Moon are:

Apollo Mission	Astronauts
11	Neil Armstrong (1st man on the Moon) Edwin "Buzz" Aldrin
12	Pete Conrad Alan Bean
14	Alan Shepard Edgar Mitchell
15	David Scott James Irwin
16	John Young Charles Duke
17	Eugene Cernan Harrison Schmitt



Astronauts of Apollo missions 15 – 17 had a Lunar Rover and could drive around on the surface of the Moon!
Image Credit: NASA

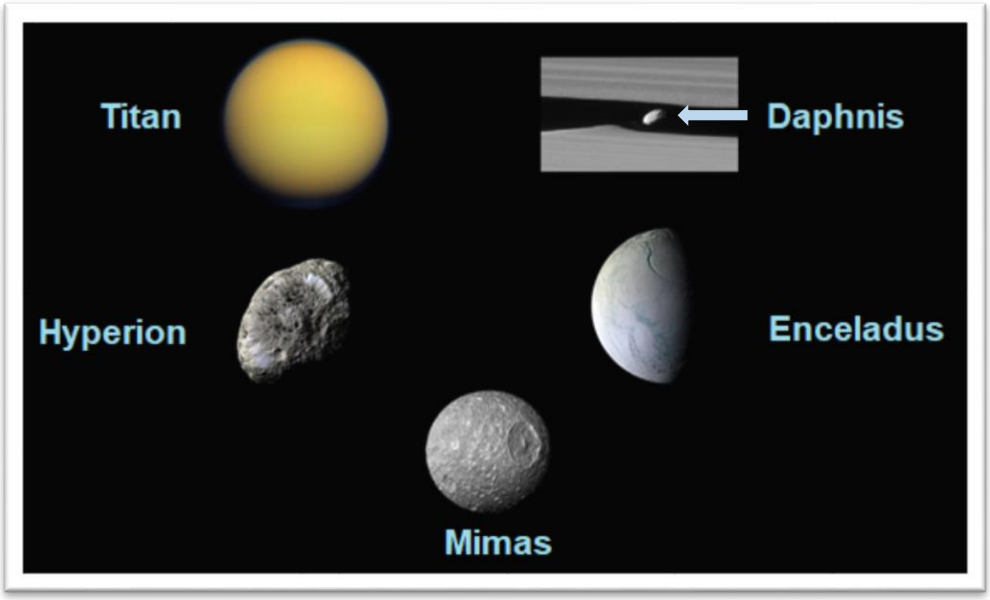
Planet: Mars
Number of moons: 2

Mars has two moons called **Phobos** and **Deimos**. Both moons look very different to our own Moon. Though they probably formed in a similar way to our own moon, many scientists think that the moons of Mars were asteroids pulled into orbit by the planet's gravity. The moons of Mars are much smaller than the Moon – Phobos is only 23 km across and Deimos is only 12 km across. Phobos and Deimos are much closer to Mars than the Moon is to the Earth. Phobos is just over 9,000 km and Deimos just over 23,000 km away from Mars.

Planet: Jupiter
Number of moons: 95

The four largest moons of Jupiter are the Galilean moons **Io** ("eye-oh"), **Europa**, **Ganymede** and **Callisto**. The moons were discovered by Galileo Galilei in 1610. Io is the most volcanically active body in the Solar System and is covered with hundreds of volcanoes. Europa is an icy moon and is the smallest of the Galilean moons. Scientists think that Europa has a salt-water ocean hidden beneath its icy surface. Ganymede is the largest moon of Jupiter and the largest moon in the Solar System – it's even bigger than the planet Mercury! The surface of Callisto is covered in craters which makes this moon the most heavily cratered object in our Solar System.

Planet: Saturn
Number of moons: 146



With **over 100 moons**, Saturn is home to some of the strangest moons of our Solar System. Let's have a look at some of the moons of Saturn. **Titan**, the largest moon of Saturn, is the only moon in the Solar System that has a thick atmosphere and the only other body that has liquid on its surface. We don't find liquid water on Titan, the temperatures are far too cold for water to be a liquid, but we've found liquid methane and ethane. **Enceladus** is an icy moon and, just like Jupiter's moon Europa, scientists think there is an ocean of water underneath an icy shell. NASA's Cassini spacecraft spotted jets of water vapour and ice particles blasting out near the south pole of Enceladus which supports the idea of a subsurface ocean. **Hyperion** is shaped like a potato but looks like a sponge. Scientists think that this moon might be the remains of a bigger moon that was destroyed by a big impact. **Mimas** looks just like the Death Star from Star Wars! The big impact crater on Mimas is called Herschel crater. Some of the smaller moons of Saturn, including the moon **Daphnis**, orbit inside the planet's rings. We call these moons the 'shepherd moons' because they act like shepherds and keep the ring particles in place.

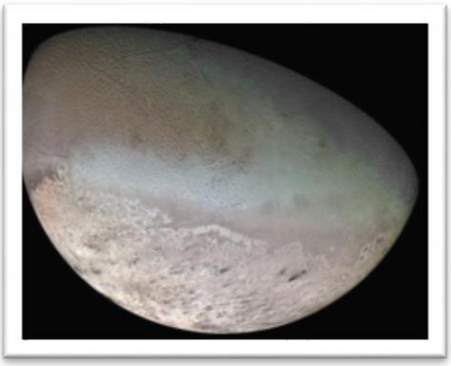
Planet: Uranus

Number of moons: 28

The best images that we have of the biggest moons of Uranus were taken by the Voyager 2 spacecraft. Just like Frankenstein's monster, **Miranda** looks like it was put together with pieces that don't quite fit together properly. Miranda is home to the tallest cliff in the Solar System – it's around 10 kilometres high! **Titania** is the largest moon of Uranus and is covered with craters and canyons.

Planet: Neptune

Number of moons: 16



Triton is the largest of moon of Neptune. This icy moon has active ice volcanoes and geysers spewing material out onto the surface of the moon. Part of the surface of Triton looks like a cantaloupe (a type of melon). This moon is one of the coolest objects in our Solar System with a surface temperature of -235 degrees Celsius!

Dwarf planet: Pluto

Number of moons: 5

The largest moon of Pluto is called **Charon** and it is almost half the size of Pluto. NASA's New Horizons spacecraft returned the only close-up images we have of the moon. The images revealed that Charon is covered in craters and has a canyon that is far longer and deeper than the Grand Canyon on Earth.

Activity: On the Moon

The image below was taken by NASA's Lunar Reconnaissance Orbiter (LRO). In the image we can see the descent stage of the Apollo 11 lunar module (LM) and we can see where Apollo 11 astronauts Neil Armstrong and Edwin "Buzz" Aldrin placed equipment on the surface of the Moon (LRRR & PSEP). The camera that filmed Armstrong and Aldrin on the Moon can also be seen in the image.

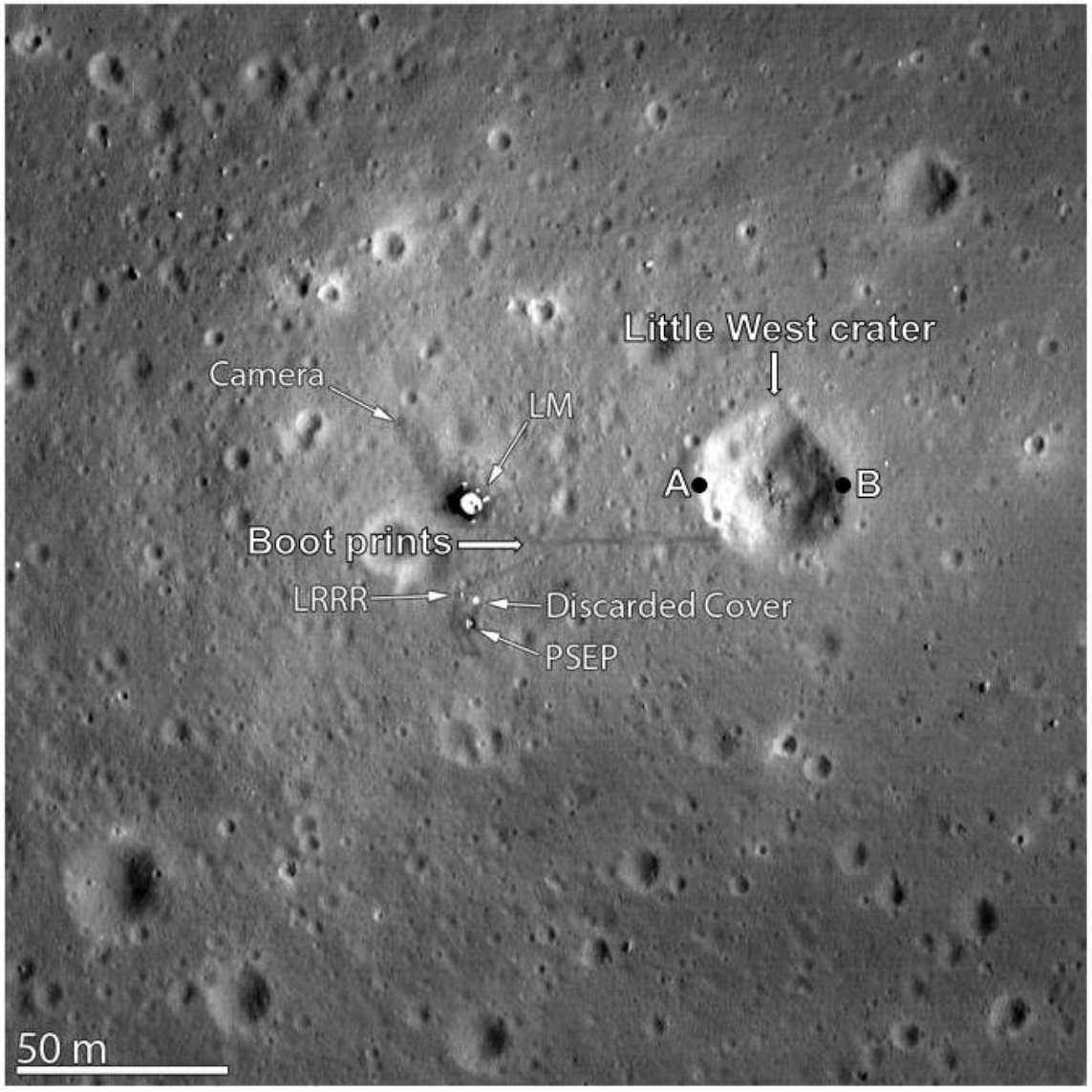


Image Credit: NASA Goddard/Arizona State University

Also captured in the image are the paths formed by boot prints left behind by Armstrong and Aldrin – we can see where the astronauts walked on the Moon! In this activity, you are going to determine the scale of the image and solve some problems.

Determine the scale of the image

At the bottom left of the image is a white bar. Use a millimetre ruler to measure the length of the white bar in centimetres. To determine the scale of the image, divide the number above the white bar by the number you measured to give you the scale in units of metres per centimetre. Round your scale to one decimal place.

Example:
Measurement of length of white bar = 1.7 cm

Scale of image (m/cm) = 50 m/1.7 cm
= 29.4 m / cm (29.4 m per cm)

This would mean that every centimetre you measure on the image would in reality be a distance of 29.4 m.

Problems

1. Measure the width of the descent stage of the lunar module **in centimetres** – don't worry about the shadow or the landing feet, just measure the width of the white circle. Using the scale that you determined, calculate the width of the descent stage **in metres**.

2. How far away from the edge of Little West crater did the lunar module land **in metres**? (HINT: Measure from the centre of the descent stage of the lunar module to point A).

3. Points A and B are located on the edge of Little West crater. Calculate the distance between these two points in **metres**.

Activity: Base camp on the Moon

Scientists are planning to return to the Moon to set up a base camp where future astronauts will live and work. There are a number of things that developers need to think about when designing a base camp:

- There is no air on the Moon.
- There is a bit of water on the Moon but it is trapped under the surface as ice.
- Extreme surface temperatures on the Moon: 127 degrees Celsius on the daytime side and –173 degrees Celsius on the night time side.
- The strength of gravity is lower on the Moon than on the Earth – astronauts will need to do a lot of exercise to maintain their muscles and bones.
- Some items such as food, clothes and medicine could be sent to the Moon from the Earth when needed. Ideally, astronauts would need to grow their own food on the Moon.
- How would astronauts deal with medical emergencies?

Considering all of this, what should the design for a base camp include in order to provide a safe environment for astronauts to live and work? Write down your ideas below and then draw your design for a base camp on the next page. Label all the features it has that might help some of the challenges astronauts would face when living and working on the Moon.

Activity: An astronaut's weight on different moons

The weight of an object depends on its mass and on the gravitational field strength *g*. We can calculate the weight using the following formula

Weight (N) = mass (kg) × gravitational field strength (N/kg) (1)

On the Earth, the gravitational field strength is 9.8 N/kg. This means that every kilogram of material on Earth weighs 9.8 N.

Assume a fully suited astronaut has a mass of 190 kg. On the Earth, the astronaut would have a weight of 1,862 N (190 kg × 9.8 N/kg). Using the information given in the table below and equation (1) above, calculate the weight of the astronaut, rounded to the nearest whole number, on the following moons of our Solar System:

Moon	Strength of gravity (compared to the Earth)	Weight of astronaut (N)
The Moon	$^1/_6$	
Io	$^1/_5$	
Ganymede	$^1/_7$	
Titan	$^1/_7$	
Enceladus	$^1/_{87}$	
Miranda	$^1/_{124}$	
Triton	$^1/_{13}$	
Charon	$^1/_{35}$	

Activity: Sizes of the moons

Moons come in different shapes and sizes. In this activity, you'll compare the sizes of some of the moons of our Solar System to the size of our Earth. To do that, you'll use a scaled drawing of the Earth and draw scaled moons. We've given you 6 scaled Earth diagrams – you need to calculate the scaled radius, to one decimal place, for each of the moons listed in the table and draw them on the given Earth diagrams. Read through the sections below before beginning the activity.

Scale used:

Our Earth has a radius of 6371 km. Using the following scale

1 mm = 212.4 km

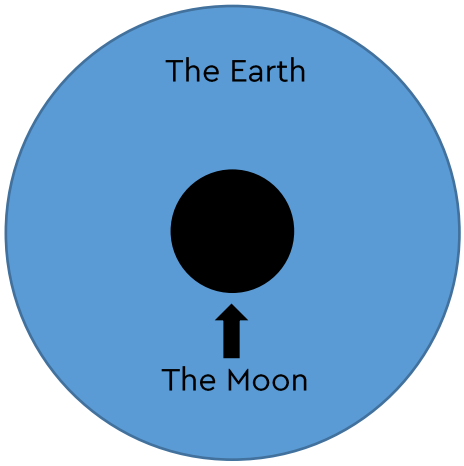
allows us to draw the Earth as a circle with a **radius** of 3 cm.

Example:

Our Moon has a radius of 1737.5 km. Using the given scale, that means that we would need to draw a circle with a radius of:

Moon radius = (1737.5 km/ 212.4 km) × 1 mm = 8.18 mm ≈ 8.2 mm

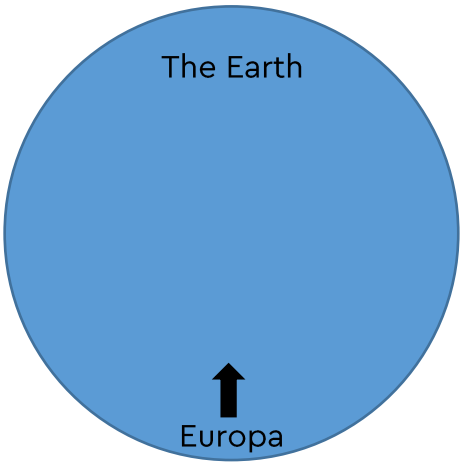
We can now draw the size of our Moon compared to the size of the Earth:

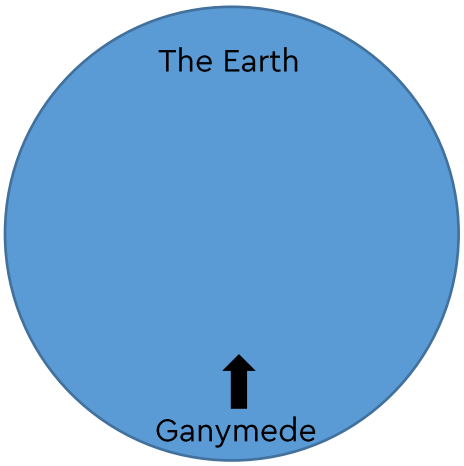


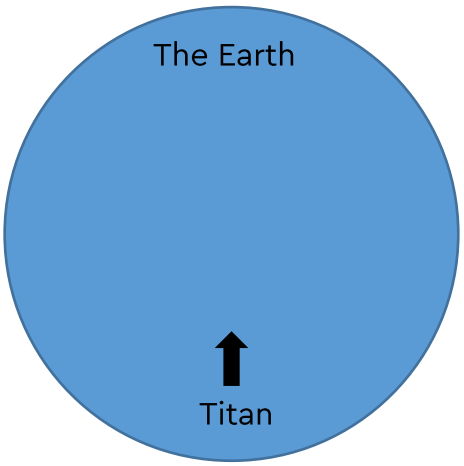
Sizes of some of the moons:

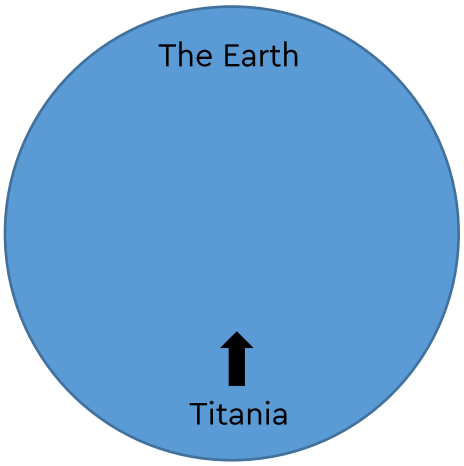
Moon	Radius (km)	Scaled radius (mm)
Europa	1,560.8	
Ganymede	2,631.2	
Titan	2,574.7	
Titania	788.9	
Triton	1,353.4	
Charon	603.6	

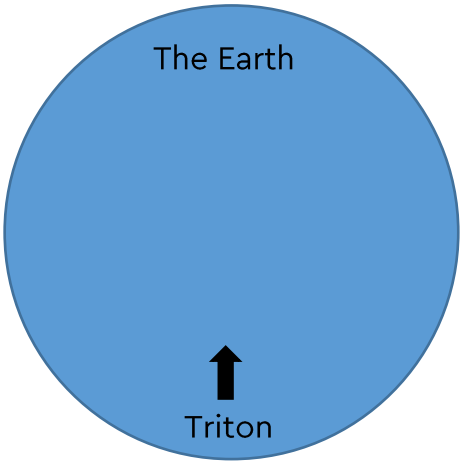
Draw the moons:

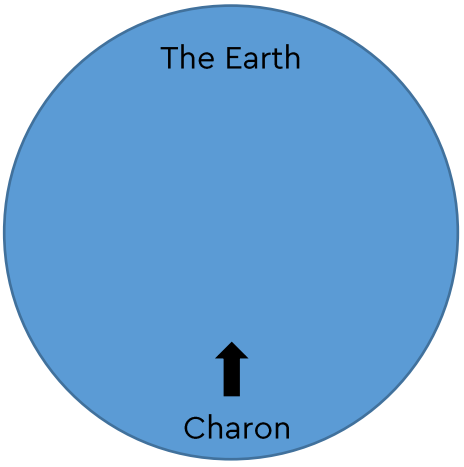










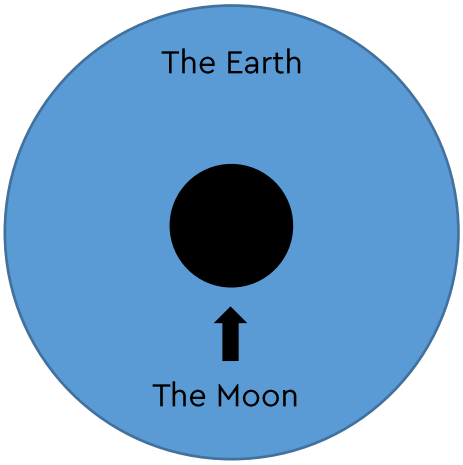


Activity: Sizes of the moons (Alternate exercise)

Moons come in different shapes and sizes. In this activity, you'll compare the sizes of some of the moons of our Solar System to the size of our Earth. To do that, you'll use a scaled drawing of the Earth and draw scaled drawings of the moons.

1. Determine the scale

Our Earth has a diameter of 12,742 km. The diagram below compares the sizes of the Earth and the Moon. Using the diagram below, determine the scale used.



2. Calculate the diameter of the Moon.

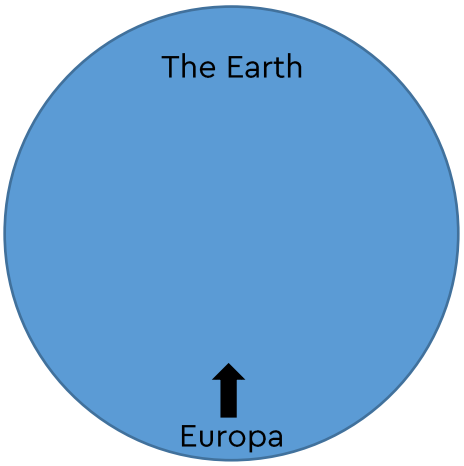
Use the scale you found in (1) to calculate the true diameter of the Moon in kilometres.

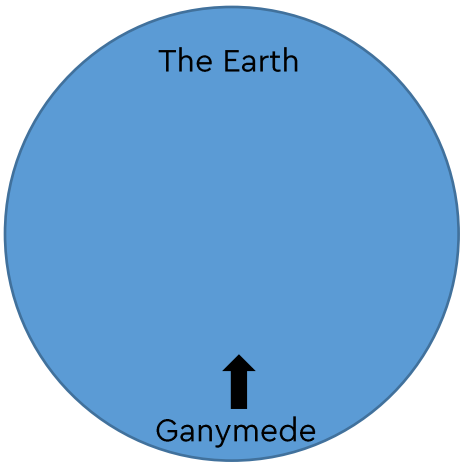
3. Draw scaled diagrams of some moons.

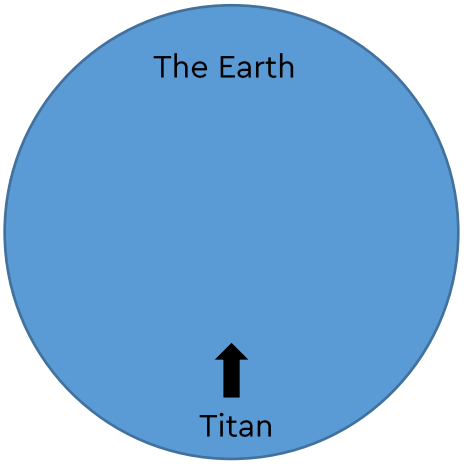
Using your scale, calculate the scaled radius to one decimal place for each moon listed in the table below. Once you have a scaled radius, draw the moons on the next page.

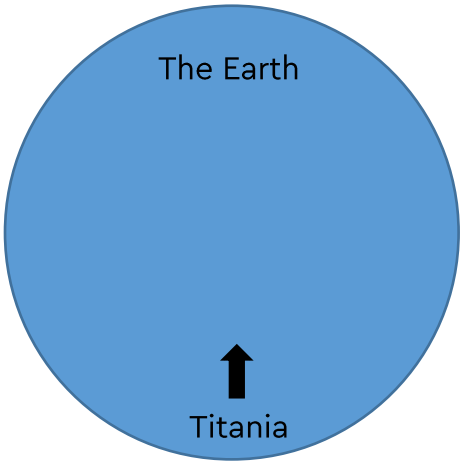
Moon	Radius (km)	Scaled radius (mm)
Europa	1,560.8	
Ganymede	2,631.2	
Titan	2,574.7	
Titania	788.9	
Triton	1,353.4	
Charon	603.6	

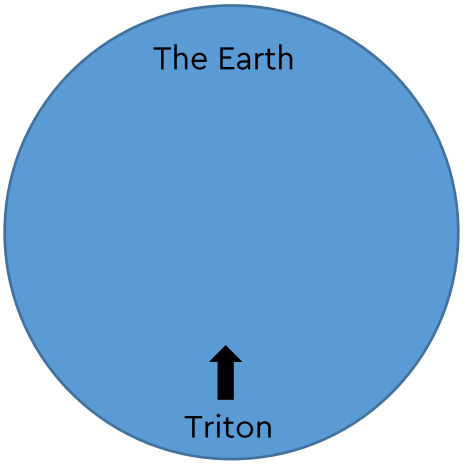
Draw the moons:

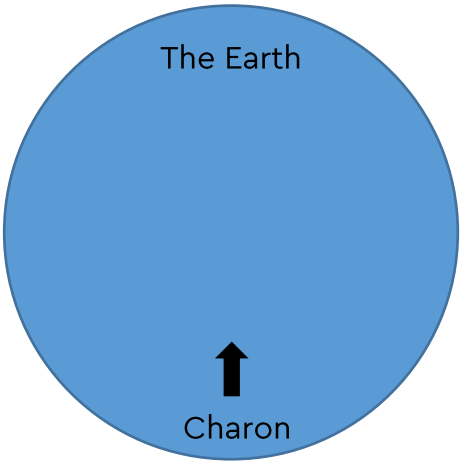












Activity: Massive moving moons!

Listed in the table below are the orbital periods and masses of some of the moons of our Solar System. The orbital period of a moon is the time it takes for the moon to complete one full orbit of its parent planet.

Distances and sizes in space are very big and often have lots of zeros – to write these large numbers in a simple way we use standard form. For example, if we are given the number 730,000 we can write it in standard form as

$$7.3 \times 10^5$$

which means 7.3 × 100,000 (a number with 5 zeros after it). You can put this in your calculator by typing

7.3 EXP 5

or

$$7.3 \times 10^x 5$$

Use the information given in the table to answer the questions on the next page.

Moon	Orbital Period	Mass
The Moon	27.3 days	7.35×10^{22} kg
Phobos	0.32 days	1.07×10^{16} kg
Deimos	30 hours	1.48×10^{15} kg
Io	1.8 days	8.93×10^{22} kg
Ganymede	7.2 days	1.48×10^{23} kg
Daphnis	14 hours	7.79×10^{13} kg
Titan	381.6 hours	1.34×10^{23} kg
Mimas	22.6 hours	3.75×10^{19} kg
Miranda	33.6 hours	6.59×10^{19} kg

Orbital periods

1. Which moon of Mars, Phobos or Deimos, has the shortest orbital period?

2. Which moon has the longest orbital period?

3. Convert the given orbital period of Mimas into days (round your answer to 2 decimal places).

4. Convert the given orbital period of Miranda into days, hours and minutes.

5. The orbital period of the Earth's moon is 27.3 days. How many hours and minutes does 0.3 days equal?

Masses

1. Which moon has the lowest mass?

2. Which moon has the highest mass?

3. The mass of the Earth is 5.97×10^{24} kg. How many times more massive is the Earth compared to the Moon? Round your answer to 1 decimal place.

4. Calculate the total mass of the moons listed in the table. Give your answer in standard form.

5. Titan is the largest moon of Saturn. How many times more massive is Titan compared to the heaviest moon of Mars? Round your answer to 2 decimal places and then write it in standard form.

Explore the moons of our Solar System: ANSWERS

Key Stage 3

Activity: On the Moon

Scale used: 17.2 m/cm

1. 5.2 m.
2. 55.0 m.
3. 34.4 m.

Activity: Base camp on the Moon

Suggested answers for this activity include:

- The base camp will need to provide air for the astronauts to breathe, otherwise astronauts would have to wear spacesuits at all times.
- Astronauts will need equipment to convert the water ice on the Moon into water that is safe for them to consume.
- The base camp will need to be built from material that can survive the extreme temperature changes on the Moon.
- In order to exercise, astronauts will need special gym equipment in the base camp.
- One section of the habitat would be dedicated to growing food for the astronauts.
- To deal with medical emergencies, the base camp would need to have medical rooms, equipment and medicine. Some astronauts living and working at the base camp would be qualified doctors.

Activity: An astronaut's weight on different moons

Moon	Strength of gravity (compared to the Earth)	Weight of astronaut (N)
The Moon	$^1/_6$	310
Io	$^1/_5$	372
Ganymede	$^1/_7$	266
Titan	$^1/_7$	266
Enceladus	$^1/_{87}$	21
Miranda	$^1/_{124}$	15
Triton	$^1/_{13}$	143
Charon	$^1/_{35}$	53

Activity: Sizes of the moons – Draw the moons

Moon	Radius (km)	Scaled radius (mm)
Europa	1,560.8	**7.3**
Ganymede	2,631.2	**12.4**
Titan	2,574.7	**12.1**
Titania	788.9	**3.7**
Triton	1,353.4	**6.4**
Charon	603.6	**2.8**

See next page for scaled moons.

Activity: Sizes of the moons (Alternate)

1. The diameter of the scaled earth is 6 cm (60 mm). The scale of the diagram is

   60 mm = 12,742 km
   1 mm = 212.4 km

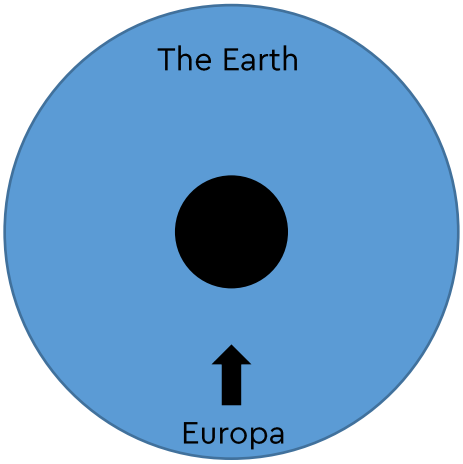
2. The diameter of the scaled drawing of the Moon is 16.4 mm. Using the scale we calculated in (1), the diameter of the Moon is:

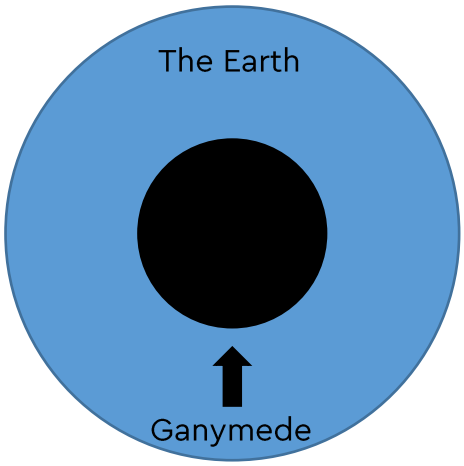
   Moon diameter = (16.4 mm) × 212.4 km/mm
   = 3,483.4 km

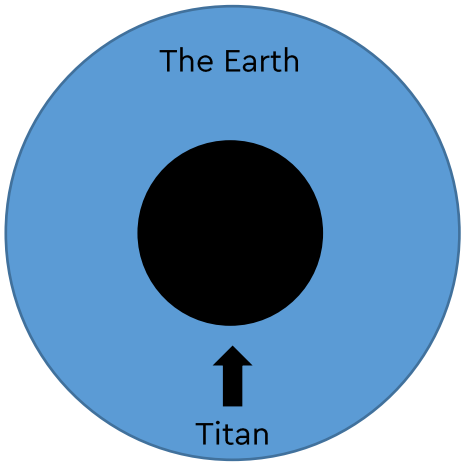
3. See table above.

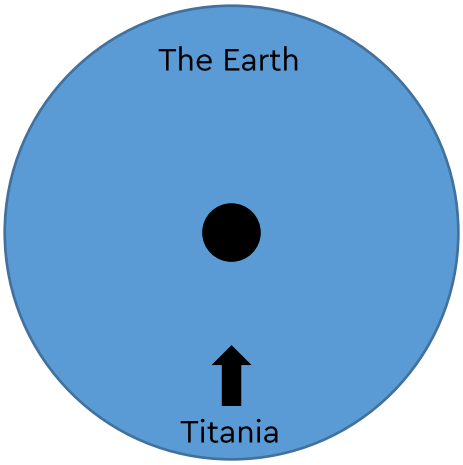
See next page for scaled moons.

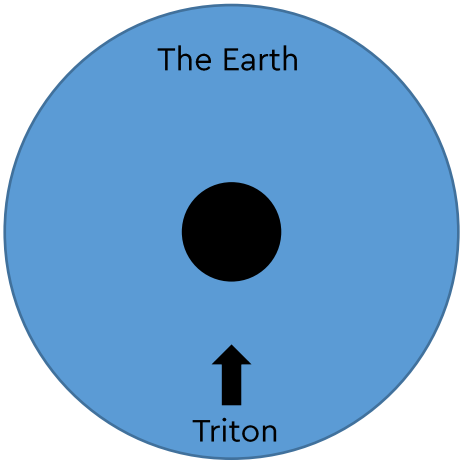
Scaled moons:

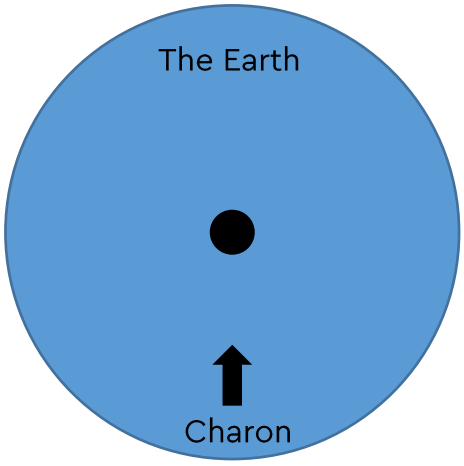












Activity: Massive moving moons!

Orbital periods:

1. Phobos – it has an orbital period of 7.68 hours which is shorter than the orbital period of Deimos.
2. The Moon.
3. 0.94 days.
4. 1 day 9 hours 36 minutes.
5. 7 hours 12 minutes.

Masses:

1. Daphnis.
2. Ganymede.
3. The Earth is 81.2 times more massive than the Moon.
4. 4.45×10^{23} kg.
5. The heaviest moon of Mars is Phobos. Titan is 1.25×10^{7} times more massive than Phobos.