Science Scheme of Work Year 9 – Exemplar Unit 10 (Satellites and space)

Unit Objectives

Pupils will learn to:

- Recall some evidence for the shape of the Earth
- State what an artificial satellite is and one use for a satellite
- Describe some uses of artificial satellites
- Recall that planets and satellites are kept in their orbits by gravity
- Recall that gravity always pulls things towards the centre of the Earth
- Describe how artificial satellites can be used for scientific research
- Explain that an object on Earth has weight because of gravity
- Recall that gravity is stronger if the objects have more mass
- Recall that gravity is weaker if objects are further apart
- Recall that gravity is not the same everywhere on the Earth and explain how gravity surveys can be used to investigate the structure of the Earth
- Use data to work out the relationships between gravity, mass and distance
- Calculate weights given the strength of gravity and the mass
- Explain why it is important for spacecraft to have as small a mass as possible
- Explain why astronauts appear to be weightless in space
- Describe how gravity helped the formation of the Solar System
- Describe the benefits of gravity-assist trajectories
- Describe different types of orbit and how they are suited to different purposes
- Recognise how forces affect the way in which objects move and how the overall effects of forces can be calculated
- Consider the advantages and disadvantages of different ways of exploring the Solar System
- Recall that light is part of the electromagnetic spectrum, and how different parts of the spectrum can provide information about the Solar System and the stars

- Explain refraction and reflection using the wave model for light
- Recall one example of an early model of the Solar System
- Recognise some questions that science cannot yet answer
- Describe some ways the Solar System can be explored
- Describe some evidence showing a particular theory is incorrect
- Recall that there have been various models of the Solar System and how and why these have changed
- Explain why the acceptance or rejection of scientific theories may sometimes depend on technological developments
- Describe how astronomy and space science provide evidence of the Solar System and our galaxy
- Explain the role of prediction and testing in the acceptance of models of the Solar System

Teaching Resources
Exploring Science 9, Longman Active Science Class 8 Pupil Book (available from http://pearson.vrvbookshop.com/)
Scientific language
artificial satellite, gravity, mass, newtons (N), orbit, planets, satellite, Solar System, weight, communications satellite, Earth observation satellite, geostationary orbit, polar orbit, galaxy, natural satellite, star, Universe, elliptical, lander, orbiter, space probe electromagnetic spectrum, infrared radiation, visible light

Objectives	**Teaching**	**Resources**
Recall some evidence for the shape of the Earth State what an artificial satellite is and one use for a satellite Describe some uses of artificial satellites Recall that planets and satellites are kept in their orbits by gravity Recall that gravity always pulls things towards the centre of the Earth Describe how artificial satellites can be used for scientific research	Hold a short brainstorming session to find out what pupils know about satellites. Start by asking for the definition of a satellite, and then give pupils 1 minute to write down as many uses for satellites as they can. Ideas should be shared with the rest of the class, and if necessary a further few minutes should be given for pupils to write down further ideas. Suggest that they consider uses for satellites put into orbit around other planets. Ask pupils to research different uses for satellites (including satellites orbiting other bodies in the Solar System). Have a set of different masses available for pupils to lift, to feel the force of gravity. Include a 100g mass to show what a force of 1N feels like (note that the weight of an apple is approximately 1N).	*Exploring Science Pupil Book 9* *Longman Active Science Class 8 Pupil Book, Unit 15 'The Night Sky'* *Set of labelled masses, from 100 g to 1 or 2 kg; apple* *15 containers of similar size; range of different masses; marker pens* *ROKIT kit; bicycle pump; clinometer; anemometer; long tape measure or length of rope marked at 1 metre intervals; measuring cylinder; water. Optional: different plastic bottles to fit the ROKIT bung; launching ramp (made from a length of*

Explain that an object on Earth has weight because of gravity Recall that gravity is stronger if the objects have more mass Recall that gravity is weaker if objects are further apart Recall that gravity is not the same everywhere on the Earth and explain how gravity surveys can be used to investigate the structure of the Earth Recall that gravity is not the same everywhere on the Earth and explain how gravity surveys can be used to investigate the structure of the Earth .	Allow pupils to feel the weights of the different masses, and tell them what the weight of each one is in g/kg. Provide pupils with a set of labelled masses and ask them to work out the weight of each one in newtons (10N/kg is sufficiently accurate for this task). Demonstrate the safe use of a model rocket kit. A suitable kit is the ROKIT, available from equipment suppliers or direct from Hinterland Limited (www.rokit.com/uk) The ROKIT consists of a plastic bottle, a pressure valve and stabilising fins. The bottle is partly filled with water, and the air remaining inside is pressurised using a normal bicycle pump. The pressure valve releases at a fixed pressure, forcing water out and producing an upwards force that launches the ROKIT. A large playground or sports field should be used to launch the ROKIT. Groups of pupils could use the kit to investigate how the volume of the bottle or the volume of water used affects the maximum height reached by the ROKIT, how the angle of launch or the wind speed affect the range, or how the ROKIT can be streamlined. The ROKIT is accompanied by a booklet showing how to make a clinometer to measure the maximum height, how to make various weather-measuring instruments, and how teams of pupils can be organised into a 'Rocket Range Crew'. This is an excellent opportunity for pupils to work together in teams, as this investigation cannot easily be carried out by individuals or even by pairs of pupils. It also links well with the study of trigonometry in maths. The height the ROKIT reaches can also be measured by tying cotton thread to it and measuring the amount of thread pulled by the ROKIT. Use strong cotton thread and lay it out in zigzags on the ground, rather than just allowing it to be pulled off the reel, as it is likely to break in the latter case. If pupils use this method, they should be encouraged to consider what is actually being measured (the range, the height, or a combination of both) and what effect pulling the thread will have on the	*guttering and a wire hoop); card or plastic and plasticine or Blu-Tack (to make nose cones); reel of cotton thread; eye protection* *Library/internet access*

	height and/or range of the ROKIT. Ask pupils to work in small teams to complete an alphabet quiz. Each team writes out all the letters of the alphabet, and then attempts to write at least one word for each letter, the words all being connected with the Earth, the Solar System or with space. Give the groups 5 or 10 minutes to work on their lists, then go round the class gathering ideas and asking pupils to define the words.	
Use data to work out the relationships between gravity, mass and distance Calculate weights given the strength of gravity and the mass Explain why it is important for spacecraft to have as small a mass as possible Explain why astronauts appear to be weightless in space Describe how gravity helped the formation of the Solar System Describe the benefits of gravity-assist trajectories Describe different types of orbit and how they are suited to different purposes Recognise how forces affect the way in which objects move and how the overall effects of forces can be calculated	Ask pupils to draw a concept map to show what they recall of earlier work on the Solar System, and encourage them to include anything they know about gravity. Give pupils a few minutes to work on this individually, then ask them to join up in groups of three or four to pool their knowledge. Follow up by asking for ideas from all groups to compile a class concept map on the Solar System, ensuring that all pupils recall that the Sun is in the centre with the planets orbiting it Give pupils some facts about the tides, and ask them to suggest or find descriptions of models to explain the tides. Ask pupils to summarise the models, to describe their strengths and weaknesses, and to justify their choice of the most appropriate model. Pupils should start by finding out more about the tides, and compile a list of things that any model would have to explain, including: ● why the tides are approximately an hour later every day ● the variation in the time of high tide from place to place in the UK and across the world ● the variation in tidal range from place to place in the UK and across the world ● why Southampton, in England, has four high tides per day, not two as in other places ● why shores in the Mediterranean Sea have little or no tidal movement ● why there are two high tides per day. The simplest model normally used to explain tides and their variations	*Exploring Science Pupil Book 9* *Longman Active Science Class 8 Pupil Book, Unit 15 'The Night Sky'* *Library/internet access* *Length of string; small object that can be securely fastened to the string (eg a small, bored bung)*

	involves the Moon attracting water, and explains spring tides as being due to the gravitational pulls of the Sun and the Moon being aligned. This model does not explain the tidal bulge on the side of the Earth opposite to the Moon, which is explained by a more complex model involving the Earth and the Moon both rotating around the centre of mass of the combined Earth–Moon system. Demonstrate the role of gravity by swinging a small object around on a length of string. Demonstrate what would happen if gravity did not exist by letting go of the string. This model could also be used to demonstrate the different speeds needed to keep the object 'orbiting' with different lengths of string. Discuss the fact that the model represents the forces involved, and ask them to identify the similarities and differences between the model and orbiting bodies. There are videos available via YouTube or similar sites that show astronauts in 'weightless' conditions inside their spacecraft. Show one or more of these videos and ask pupils to suggest why the astronauts are floating around as they are. If pupils answer suggesting that there is no gravity in space, ask how, if this is so, the spacecraft stays in orbit around the Earth instead of just flying off into space. The terms 'zero-g' or 'weightless' are often used, and these refer to how it feels or appears to be in such conditions, not to the fact that things really have no weight or are not subject to gravitational forces. Ask pupils to work in groups to produce a list of five or six key points about gravity and space. Each group could present their results, and an agreed class summary could be produced	
Consider the advantages and disadvantages of different ways of exploring the Solar System Recall that light is part of the electromagnetic spectrum, and how different parts of the spectrum can provide information about the Solar System and the stars. Explain refraction and reflection using the wave	Write the following words/phrases on the board: space probe, flyby, orbiter, lander, rover. Ask pupils to suggest what they mean. A space probe is a general term for a spacecraft that visits other planets, moons or other bodies; a flyby happens when a probe passes a planet (as the Voyager and Pioneer craft did, and as Galileo and Cassini did to various planets on their way to Jupiter and Saturn respectively); an orbiter is a space probe that is put into orbit around another planet or	*Exploring Science Pupil Book 9* *Library/internet access* *Cardboard or small cardboard boxes; paper and/or thin card; straws; sticky tape; glue; Blu-Tack or plasticine; metal foil; scissors*

model for light	moon, and a lander lands on the planet or moon. A rover is effectively a lander with wheels that can move around on the surface. Follow this up by asking pupils to think about the advantages and disadvantages of the different ways of investigating planets (flybys, orbiters, landers and rovers), and what kinds of evidence each could gather. Suggest theories that scientists have about different planets, and ask how pupils would choose the best type of probe to answer the questions. Ask them to think about the criteria they should use to choose a type of probe. Possible theories could include: Titan has rocks and lakes on its surface beneath the clouds. Mars is made from sedimentary rocks. Venus has mountains beneath those clouds. There may once have been microbes living in the soil on Mars. Ask pupils to build a model space probe (an orbiter, a lander or a rover), and describe what the parts of their probe are for. They may need to do some research before starting to build their model. They could include the following things, as appropriate to the kind of probe: a source of power, a back-up battery for when the probe is in shadow (if the power source is solar cells), fuel and a set of nozzles for small rocket motors to correct the probe's position, sensing instruments, an aerial or dish for transmitting information to Earth. This task is aimed at getting pupils to think about the things necessary for operating a probe, not at pupils producing an accurate model of a real one. Pupils may wish to find images or diagrams of different space probes to help them with their design Ask pupils to imagine that they are serving on a scientific committee that has to decide how to spend some research money. The committee has to decide which of the following things the money should be spent on: ● a new large telescope on the ground ● a new space telescope	

	● space probes to visit the moons of Jupiter or Saturn ● a crewed mission to Mars. Divide pupils into groups and give each group one type of investment each. Each group could then research the approximate cost of their project, and the kinds of things their project might find out. They should also evaluate its benefits and drawbacks compared to other ways of finding out about space. A spokesperson from each group could then report back, and the different options could be compared. Pupils should also be encouraged to consider how the amount of money available for spending might depend on the society's priorities for research in other scientific areas (for example, if medical research is considered more valuable), and on other factors unconnected with science, such as the economic climate at the time which could constrain the amount of money available for research of any kind. Ask pupils to individually write down one thing about gathering data about other planets that they are sure about, one thing that they are unsure about, and one thing that they want to know more about. Then ask them to work in groups of five or six to come up with group lists. Finally ask a spokesperson from each group to say what that group has decided and come to a consensus as a class about what things pupils are generally confident about, what things they are less confident about and what things they want to know more about.	
Recall one example of an early model of the Solar System Recognise some questions that science cannot yet answer Describe some ways the Solar System can be explored Describe some evidence showing a particular theory is incorrect Recall that there have been various models of the Solar System and how and why these have	Point out to pupils that, for someone who has not studied astronomy or space science at all, it is logical to assume that the Earth is flat. Ask them to work in small groups for 5 minutes to jot down as many reasons as they can why we now reject this theory and know that the Earth is roughly spherical. This starter leads into the main theme of this topic, which is the use of evidence to reject or accept scientific theories. Ask pupils to draw a concept map to show what they know about changing ideas about gravity and the Solar System. Ask pupils to research older ideas about the Solar System, and how and why they have changed.	*Exploring Science Pupil Book 9* *Library/internet access*

changed Explain why the acceptance or rejection of scientific theories may sometimes depend on technological developments Describe how astronomy and space science provide evidence of the Solar System and our galaxy Explain the role of prediction and testing in the acceptance of models of the Solar System	Pupils could present their descriptions in written form, or as short 1-minute monologue playlets. Each pupil writes their monologue from the perspective of Ptolemy, Newton, Copernicus or Kepler to illustrate what that scientist discovered about the Solar System and the evidence that supports the theory. Some pupils could be challenged to write monologues from the point of view of disbelieving peers of these scientists. Monologues for and against each theory could then be presented as in a court of law, with the teacher as a judge and the rest of the class as a jury. The jury should decide whose evidence they think is stronger. Ask pupils to summarise what they know about gravity and satellites, and illustrate this with diagrams and pictures of some satellites.	

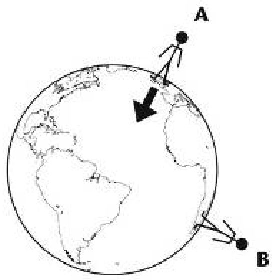
End of Unit Test

Satellites and space

(Year 9 Unit 10)

Answer the questions below.

1. The diagram shows two people standing on the surface of the Earth.

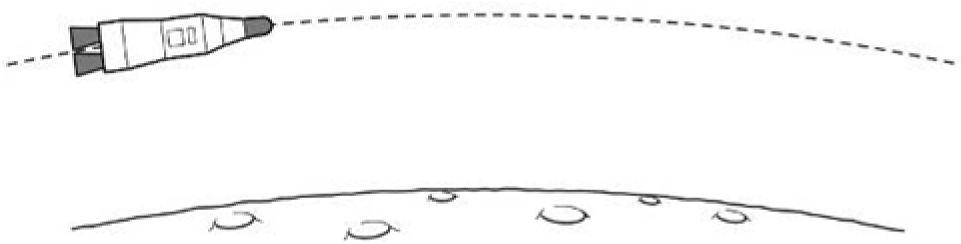


a) What is the name of the force that pulls people towards the Earth? (1 mark)

b) Draw an arrow from person B to show the direction of the force which keeps him on the Earth. (1 mark)

c) Why do the arrows drawn from the two people point in different directions? (1 mark)

2. The diagram shows a spacecraft orbiting above a moon.



a) On the diagram, draw an arrow to show the force of the moon on the spacecraft. Label the arrow M.

Draw another arrow to show the force of the spacecraft on the moon. Label the arrow S.
Draw your arrows to scale relative to each other. (2 marks)

b) How would the size of forces M and S change if the spacecraft had twice as much mass? (2 marks)

c) What is the relationship between the distance of a spacecraft from the moon and the size of the force exerted by the moon on the spacecraft? (1 mark)

3. The table shows the strength of gravity of four of Jupiter's moons.

Moon	**Gravity at the surface of the moon (N/kg)**
Lo	1.81
Europa	1.30
Ganymede	1.43
Callisto	1.25

a) Which moon would you expect to have the biggest mass? (1 mark)
b) Explain your answer to part a. (1 mark)
c) The mass of an astronaut plus spacesuit is 900 kg. (2 mark)
Calculate the weight of the astronaut plus spacesuit on Ganymede. Show your working.
(2 marks)

4. A satellite moves in a circular orbit, in space, around the Earth.
a) It does not need to use its engine to keep moving. Why not? (1 mark)
b) What causes its path to be circular? (1 mark)

5. The first satellite was launched in 1959. Describe two ways in which satellites have affected the way we live. (2 marks)

6. Which of these descriptions matches the current model of the Solar System? (1 mark)
Tick the correct box.

[ ] The Sun and Moon and the planets all move around the Earth in circular orbits.
[ ] The planets and the Moon all move around the Sun in elliptical orbits.
[ ] The planets all move around the Sun in elliptical orbits.
[ ] The planets all move around the Sun in circular orbits

7. One early idea was that the heavens were made by God, so the Earth is at the centre of everything, and everything must be perfect. The planets and stars were therefore perfect spheres that never changed, and all movement must be circular, as a circle is a 'perfect' shape. Describe two pieces of evidence that made astronomers think that these views were wrong.
(2 marks)

8. There are two types of space probe.
An orbiter is sent to another planet and is designed to orbit the planet.
A lander is designed to land on the planet.
a) Give two advantages of an orbiter compared to a lander. (2 marks)
b) Give two advantages of a lander compared to an orbiter. (2 marks)

9. Many telescopes are built on the tops of mountains. Suggest a reason for this. (2 marks)

[25 marks]

Mark Scheme for End of Unit Test

Satellites and space

(Year 9 Unit 10)

This test should be set as soon as possible after pupils have finished their work on the unit. They should work independently and should need about 30 minutes to complete the test.

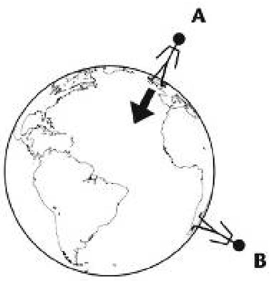
The aim of the test is to find out what pupils have learnt and understood as a result of their experience of studying the unit. The test is based on information and experiences they should have met during their work on the unit, so they should approach the test with confidence.

The teacher should be looking in their marking to award marks, not withhold them. The purpose at this stage is to give pupils the confidence that they can recall and understand scientific knowledge and concepts.

Marking Guide

Answer the questions below.

1. The diagram shows two people standing on the surface of the Earth.



a) What is the name of the force that pulls people towards the Earth? (1 mark)

Gravity

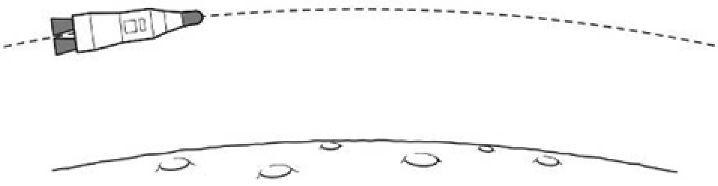
b) Draw an arrow from person B to show the direction of the force which keeps him on the Earth. (1 mark)

An arrow should be drawn pointing towards the centre of the Earth.

c) Why do the arrows drawn from the two people point in different directions? (1 mark)

Because gravity pulls everything towards the centre of the Earth.

2. The diagram shows a spacecraft orbiting above a moon.



a) On the diagram, draw an arrow to show the force of the moon on the spacecraft. Label the arrow M.
Draw another arrow to show the force of the spacecraft on the moon. Label the arrow S.
Draw your arrows to scale relative to each other. (2 marks)

Arrows should be drawn on the moon and the spacecraft, pointing towards each other; (1 mark) both arrows should be of equal size (1 mark).

b) How would the size of forces M and S change if the spacecraft had twice as much mass? (2 marks)

They would both increase; (1 mark) to double their size (1 mark).

c) What is the relationship between the distance of a spacecraft from the moon and the size of the force exerted by the moon on the spacecraft? (1 mark)

The force decreases with distance.

3. The table shows the strength of gravity of four of Jupiter's moons.

Moon	**Gravity at the surface of the moon (N/kg)**
Lo	1.81
Europa	1.30
Ganymede	1.43
Callisto	1.25

a) Which moon would you expect to have the biggest mass? (1 mark)

Lo

b) Explain your answer to part a. (1 mark)

The bigger masses produce a stronger gravitational forces/have the greatest gravity.

c) The mass of an astronaut plus spacesuit is 900 kg. (2 mark)
Calculate the weight of the astronaut plus spacesuit on Ganymede. Show your working. (2 marks)

900 × 1.43 (1 mark)
= 1287 N (1 mark)

4. A satellite moves in a circular orbit, in space, around the Earth.
a) It does not need to use its engine to keep moving. Why not? (1 mark)

There is no air in space to slow it down.

b) What causes its path to be circular? (1 mark)

Gravity or the pull of the Earth.

5. The first satellite was launched in 1959. Describe two ways in which satellites have affected the way we live. (2 marks)

Any two from: it is easier to phone people in other countries; we get TV programmes via satellites; we can use satellites to help us to navigate when driving/navigation/GPS; weather forecasting is more accurate; it has provided information about planets/outer space; spying.

6. Which of these descriptions matches the current model of the Solar System? (1 mark)
Tick the correct box.

[ ] The Sun and Moon and the planets all move around the Earth in circular orbits.
[ ] The planets and the Moon all move around the Sun in elliptical orbits.
[*X*] The planets all move around the Sun in elliptical orbits.
[ ] The planets all move around the Sun in circular orbits

7. One early idea was that the heavens were made by God, so the Earth is at the centre of everything, and everything must be perfect. The planets and stars were therefore perfect spheres that never changed, and all movement must be circular, as a circle is a 'perfect' shape. Describe two pieces of evidence that made astronomers think that these views were wrong. (2 marks)

Any two of the following: Jupiter's moons/moons of other planets do not orbit the Earth; the Moon/Earth has mountains on it so is not a perfect sphere; planets (e.g. Mars) show retrograde motion and so cannot be moving in a simple circle; predictions made using these ideas do not match observations; new stars (novae) have been seen from time to time.

8. There are two types of space probe.
An orbiter is sent to another planet and is designed to orbit the planet.
A lander is designed to land on the planet.
a) Give two advantages of an orbiter compared to a lander. (2 marks)

Any two from: can take pictures/gather data for large areas of the planet; they are less complicated to put into orbit than to land so are less likely to crash or be damaged on landing.

b) Give two advantages of a lander compared to an orbiter. (2 marks)

Any two from: can take close-up photos; can take samples for chemical analysis; can experiment on samples.

9. Many telescopes are built on the tops of mountains. Suggest a reason for this. (2 marks)

There is less pollution higher in the atmosphere/there is less atmosphere the higher up you get; the pictures will be clearer/less distorted.

[25 marks]