

Forces and space

S1 Physics

Unit 1

Pupil Booklet

Wallace Hall Academy

Calculating average speed

Learning Outcome:

- ◆ I can calculate the average speed of an object.

Flash Card Words:

- ◆ **Average speed** – A measure of the distance travelled by an object over a period of time.



This Lesson

The speed of an object is a measure of the distance travelled by an object over a period of time. Speed can be measured in units such as miles per hour, kilometres per hour or metres per second. In Physics we try to use metres per second (m/s) wherever possible. In order to find the speed of an object you must measure the time it takes to travel a certain distance.

You can then calculate the speed by using the formula:

$$\text{Average Speed} = \text{Distance} \div \text{Time}$$



CLASS ACTIVITY - Copy the above equation into your jotters and complete 2 or 3 examples to calculate the average speed of some objects.

CLASS ACTIVITY - Measure a short distance (approximately 20-30m) and time how long it takes each member of the class to walk, run or skip this distance. You will need to use a trundle wheel to measure the distance travelled and a stopwatch to measure the time taken to cover the distance.

Copy this table into your jotter to record your results.

Pupil	Activity	Distance (m)	Time (s)	Speed (m/s)

What should be in your notes:



- ◆ Some examples of how to calculate the average speed of objects.
- ◆ A brief experimental write up on how to measure the average speed of pupils performing an activity.

Measuring average speed

Learning Objective:

- ◆ I can describe how to measure the average speed of an object

Flash Card Words:

- ◆ **Stopwatch** – A device used to measure the time taken by an object to travel a certain distance
- ◆ **Trundle wheel** – A device used to measure the distance travelled by an object



This Lesson

The police in Thornhill have become very concerned recently about the speed at which vehicles are being driven close to the school. They are, however, very busy dealing with other matters and have asked you to design a speed trap to measure the speed of cars passing by the school.



GROUP ACTIVITY – Design an experiment which will allow you to measure the average speed of vehicles which pass by the school. Your experiment should include details of what measurements you will need to make and how you will use these measurements to calculate the average speeds of the vehicles. **The speed limit outside the school is 9m/s.**

CLASS ACTIVITY – Go outside and measure the average speed of some vehicles which pass by the school.

CLASS ACTIVITY – Now that you have calculated the average speed of some vehicles which have driven past the school you should write a short report for the police. Your report should include as much detail as possible to help the police with their enquiries.

INDIVIDUAL ACTIVITY – Your teacher will give you some data on the top speed of 8 different types of cars. You should plot this data on a bar chart to clearly show how the top speed of the cars are different.

What should be in your notes:



- ◆ An experimental write up containing information on how you measured the average speed of vehicles passing by the school
- ◆ A report for the police providing details of what you found out about the speed of vehicles passing by the school.
- ◆ A bar graph showing the top speed of a range of cars.

Homework 1 – Speed, distance and time

1. Stuart runs 1 lap of a 400m track in a time of 80s at the school sports day. What was his average speed?



2. At the same school sports day Michelle completes half a lap of the 400m track in a time of 25s. What was her average speed?



3. Michael buys a new car and drives it round a racetrack. The racetrack is 2000m long and he completes 3 laps in a time of 4 minutes. What was his average speed in metres per second?
4. Describe how you would measure the average speed of a pupil as they walked from their Science class to their Geography class. Your description should include the following:
 - What measurements were made?
 - What was used to make the measurements?
 - What calculations were done?
5. Choice of activity

Using the information you gathered about the speed of vehicles passing by the school you should complete **one** of the following activities:

- Write a detailed description of what you observed for the Head Teacher so he can ensure steps are put in place to protect all pupils in the school. Your description should include numerical data and descriptions wherever possible.
- Design a poster to be placed in the primary school to warn the younger pupils about the dangers of the road near the school. Your poster should include information on road safety.
- Imagine you are a local news reporter. Write an article for the local paper about the speed of vehicles near the school.

Forces introduction

Learning Objective:

- ◆ I can describe some examples of forces

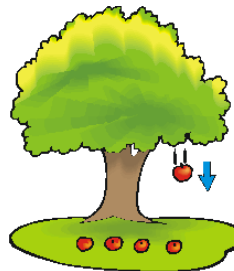
Flash Card Words:

- ◆ **Force** – Something which can change the speed, direction of movement or shape of an object.
- ◆ **Contact Force** – A force requiring two objects to be in contact, a push or a pull.
- ◆ **Non-Contact Force** – A force which doesn't require two objects to be in contact, gravitational force or magnetic force.



This Lesson

A force is something which can change the speed, direction of movement or shape of an object.



GROUP ACTIVITY – Make a list of different situations where forces act. You should try to list some situations which involve contact between objects and some which don't involve contact between objects. Once you have completed this you will share some of your examples with the rest of the class.

GROUP ACTIVITY – You will now do an experiment to see how far a spring extends when different masses are hung from the spring. The masses will cause the spring to stretch because gravity is pulling the mass down (a non-contact force) and the mass is pulling the spring (a contact force) and causing it to stretch. Before starting your experiment discuss in your group what you think the results will look like. Your final results should be plotted in a graph.



What should be in your notes:

- ◆ A list of contact and non-contact forces
- ◆ An experimental write up of how hanging masses affect the length of a spring

Newton balance

Learning Objective:

- ◆ I can describe what a Newton balance is
- ◆ I can describe how to use a Newton balance to measure force

Flash Card Words:

- ◆ **Newton balance** – Can be used to measure force
- ◆ **Newton** – The unit of Force



This Lesson

Isaac Newton was born on Christmas day in 1642. He is one of the most famous Physicists ever to have lived. He did not invent gravity as gravity has always been there but he did explain what it was for the first time. You will learn more about gravity later in this topic. Newton also gave his name to a device used to measure force – the Newton balance.



A Newton balance contains a spring which extends when a force is applied to it. By reading how much the spring has extended using the scale on the side of a Newton balance the size of the force can be measured. The unit of force is also named after him as forces are measured in Newton's.

INDIVIDUAL ACTIVITY – Your teacher will give you a Newton balance. In your jotter you should draw a picture of the Newton balance, label your diagram and describe how a Newton balance is used to measure a force.

GROUP ACTIVITY – You will now use a Newton Balance to measure some forces .Copy the following table into your jotter and measure the force needed to do each activity with the Newton balance. Add other activities you could measure if you are finished.

Activity	Force needed (Newton's)
Pull a tray of books along the bench	
Lift a pencil case	
Open a cupboard door with a handle	
Open a cupboard door in the middle	
Open the classroom door with a handle	

INDIVIDUAL ACTIVITY – You will now plot a bar chart of your data you have gathered. This will show which activities required bigger or smaller forces.

CLASS ACTIVITY – You will now watch a video on gravity with Bill Nye and learn more about how Newton was able to describe how gravity affects us all.

What should be in your notes:



- ◆ A labelled diagram of a Newton balance.
- ◆ A description of how to use a Newton balance.
- ◆ A table of the forces required to complete certain tasks.
- ◆ A bar graph showing the Force needed to complete the 5 tasks.

Mass and weight

Learning Objective:

- ◆ I can describe what mass is
- ◆ I can describe what weight is

Flash Card Words:

- ◆ **Mass** – The amount of matter an object contains, measured in kg
- ◆ **Weight** – The force due to gravity on a mass, measured in Newton's



This Lesson

To non-physicists the words 'mass' and 'weight' often mean the same thing. They are, however, different things.



The **mass** of an object describes the amount of matter (or stuff) it contains. For instance your mass is due to the particles making up your legs, arms, head, internal organs and other body parts. Mass is measured in kg.

The **weight** of an object describes the effect of gravity on a mass. For instance your weight is due to gravity pulling down on the particles making up your legs, arms, head, internal organs and other body parts. Weight is measured in Newton's.

GROUP ACTIVITY – You will now use a Newton Balance to find a link between mass and weight. If we hold a Newton balance vertically we can hang masses from the end of it. Gravity will exert a non-contact force on the masses which is called weight. The weight will cause the spring to extend and the size of this weight will be displayed on the Newton balance. Plot your results in a table like the one shown below.



Mass (kg)	Weight (Newton's)	Weight ÷ Mass
0.1		
0.2		
0.3		
0.4		
0.5		

Weight and mass are linked by how strong gravity is on Earth. This number is different on different planets and you will learn more about this later in the topic.

INDIVIDUAL ACTIVITY – You will now complete a series of calculations on mass and weight.

What should be in your notes:



- ◆ A definition of both mass and weight
- ◆ A table showing how mass and weight are related
- ◆ Calculations showing how mass and weight are related

Homework 2 – Forces

1. Give one example of where a **contact force** causes an object to change its direction of movement.
2. Give one example of where a **non-contact force** causes an object to change its speed.
3. Describe how a Newton balance could be used to measure the Weight of a bag of apples.
4. There are 4 objects shown below. Calculate their weight on Earth.



Mass = 55 kg



Mass = 1200 kg



Mass = 6.4 kg



Mass = 450 g

5. Choice of activity

Using the information you have learned in class from your teacher, from the gravity video and from your notes you should complete **one** of the following activities:

- Write a poem about forces. Your poem should be between 4 and 8 lines long and contain as much Physics as possible.
- Design a poster which celebrates the life of Sir Isaac Newton. The poster should contain information about his life and the Physics he was involved in.
- Design a marketing poster which will advertise a new Newton balance that has been developed. Your poster should have a picture of a labelled Newton balance and describe clearly what it does and how much it costs.

Friction introduction**Learning Outcome:**

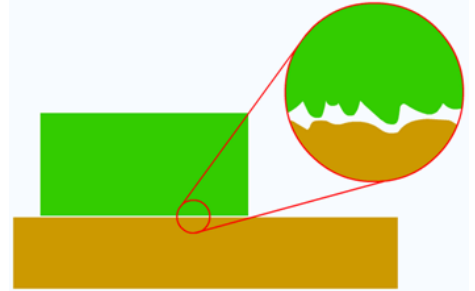
- ◆ I can give examples of where friction appears in everyday life
- ◆ I can describe which types of materials produce lots of friction
- ◆ I can describe which types of materials produce less friction

Flash Card Words:

- ◆ **Friction** – A force which acts between 2 surfaces and opposes the motion of the moving object.

**This Lesson**

When you look closely at an object using a microscope, you can see that the surface appears rough. The rubbing of these rough edges causes a force called **friction**. As friction is a force it is measured in Newton's. The force of friction will be small for smooth objects such as ice but large for objects that have a very rough surface like sandpaper.



GROUP ACTIVITY – In a group of 4 pupils make a list of all of the different situations you can think of where friction acts in everyday life. Any time 2 surfaces are in contact will involve friction. Share your ideas with the rest of the class.



CLASS ACTIVITY – Your teacher will show you how strong friction can be by holding two books together with only friction. See if you can separate the books!!!

GROUP ACTIVITY – By setting up a ramp you will compare the frictional force of different materials. Place the material to be tested under the wooden block and attach the hook to a Newton balance. Record the force required to move the block up the ramp from the Newton balance in a suitable table and repeat for various materials.

**What should be in your notes:**

- ◆ A definition of friction.
- ◆ Some examples of where friction occurs in everyday life.
- ◆ A table of results showing how different materials create different amounts of friction.

Reducing friction – Streamlining**Learning Outcome:**

- ◆ I can describe ways of reducing friction in everyday situations through streamlining

Flash Card Words:

- ◆ **Streamlining** – Reducing friction by changing the shape of an object

**This Lesson**

When an object moves, it comes into contact with molecules in the air. Each of these molecules exerts a force on the object that will slow it down. The more molecules that hit the object the bigger the force will be acting against it. This is sometimes called drag, air resistance or air friction.

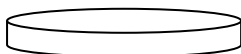
Designers try to ensure that their product is streamlined so that they can reduce the force acting against it. A more streamlined design allows the object to move faster through the air or use less fuel. Streamlined vehicles are often close to the ground and have a more curved shape.



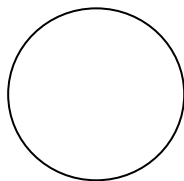
CLASS ACTIVITY- Your teacher will now show you a video on streamlining.

GROUP ACTIVITY – In small groups you will now investigate how the shape of plasticine objects affects how long it takes them to fall through water. Make the following shapes out of plasticine and design an experiment to compare how streamlined they are.

Flat cylinder



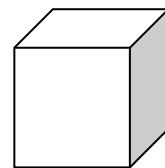
Sphere/Ball



Narrow cylinder



Cube

**What should be in your notes:**

- ◆ A definition of what streamlining is.
- ◆ Some examples of where streamlining is used in everyday situations.
- ◆ An experimental write up of how different shapes affect the amount of resistance encountered by objects.

Reducing friction – Lubrication**Learning Outcome:**

- ◆ I can describe ways of reducing friction in everyday situations through lubrication.

Flash Card Words:

- ◆ **Lubrication** – Reducing friction by placing a fluid between two surfaces

**This Lesson**

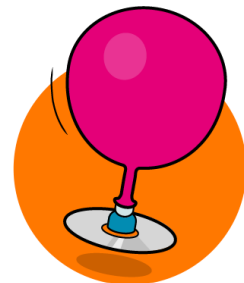
When an object is in contact with another surface and it tries to move it encounters friction. Sometimes this friction is useful but in some situations we want to reduce friction. One way of doing this is through lubrication. Lubrication is when fluids are placed between two surfaces to reduce friction. Examples of fluids often used to do this are oil, water and air.

GROUP ACTIVITY – In a group discuss situations in the real world where surfaces are lubricated to reduce friction. As a whole class discuss these further and write down a few examples in your jotter.



CLASS ACTIVITY- Your teacher will now show you a video on lubrication.

GROUP ACTIVITY – You will now build a hovercraft in pairs. A hovercraft reduces friction between itself and the water or land it travel on by blowing air underneath itself. This creates a bed of air for it to float on. The air acts as a lubricant. Once you have built your hovercraft you can test it against other pupils.

**What should be in your notes:**

- ◆ A definition of what lubrication is.
- ◆ Some examples of where lubrication is used in everyday situations.

Friction research and presentation

Learning Outcome:

- ◆ I can describe ways where friction plays a significant role in everyday situations.
- ◆ I can create a presentation which is factually correct, interesting and well presented.

This Lesson (2 lessons)

During this topic you have learned about forces and about how friction can affect us in everyday situations.

GROUP ACTIVITY – In a small group of 2 or 3 pupils you will investigate how friction plays a significant role in a moving or mechanical system. Your research should be through using your notes from this topic, from books and from the internet. Once you have completed your research you will present your findings to the rest of the class. Your presentation should be 2 or 3 minutes long and should contain about 5 or 6 power point slides. Your teacher will assess your presentation in 3 ways:

1. Content – how accurate is the content of your presentation and have you used scientific vocabulary
2. Expression – did you speak at an appropriate pace and with clarity
3. Awareness of audience – how well did you engage with your audience through eye contact and body language



You should choose only one topic to investigate for your presentation. Some ideas are listed below but please feel free to pick your own topic.

Ski equipment (clothing, ski shape, waxing of ski's, how to slow down, body position)



Hovercraft design (air lubrication, hovercraft shape, brakes, oiling of parts)

Speedboat design (boat shape, oiling of parts, waxing of hull, brakes)



Bicycle equipment and racing (clothing, bike shape, oiling of parts, helmet design, drafting, brakes, body position)



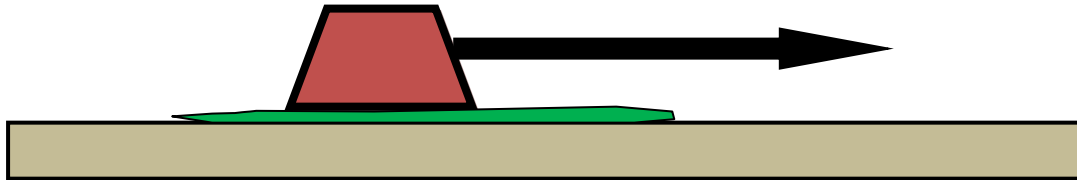
Aeroplane design (aeroplane shape, oiling of parts, use of flaps on wings, brakes)



Car design and racing (car shape, oiling of parts, drafting, down-force, tyre types, brakes)

Homework 3 - Friction

1. Describe a situation where friction is useful in everyday life.
2. Describe a situation where friction is a problem in everyday life.
3. A pupil carries out an experiment where they drag a mass along a bench. The pupil changes the material in between the mass and the bench.



The table below shows how much force is required to pull the mass when different materials are placed between the mass and the bench. Plot a bar graph of these results.

Material	Force required to pull mass (N)
Nothing	20
Water	14
Oil	3
Washing up liquid	6
Sandpaper	35
Gravel	30

4. Choice of activity

Using the information you have learned in class from your teacher, activities you have completed and from your notes you should complete **one** of the following activities:

- Write a poem about friction. Your poem should be between 4 and 8 lines long and contain as much Physics as possible.
- Design a poster which explains how to use lubrication to reduce the friction in a moving system. The poster should be aimed at people who have no knowledge of Physics so should be clear and well explained.
- Imagine you are a marketing executive for Ferrari. Design a marketing poster for a new Ferrari and explain in the poster how your new car utilises streamlining and lubrication to make the car as fast and as safe as possible.



Rockets

Learning Outcome:

- ◆ I can design a rocket using what I know about streamlining
- ◆ I can calculate the speed of a rocket

This Lesson

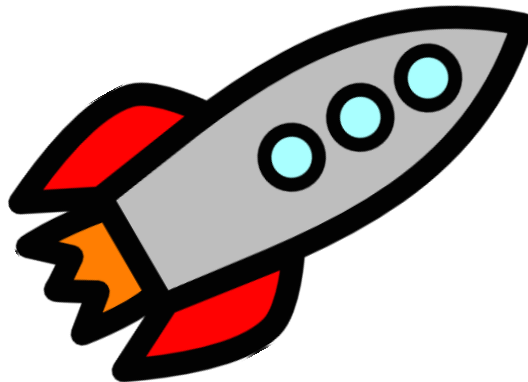
CLASS ACTIVITY- Your teacher will now show you the first in a series of 5 videos on Space.

There are 3 main ways that we have increased our knowledge of space.

1. Manned space flight
2. Un-manned space flight
3. Observations using telescopes

In order to conduct manned or un-manned space flights it is necessary to use rockets as we need to get to very high speeds to escape the Earth's gravity.

GROUP ACTIVITY – In a pair you will design a paper rocket which will be fired across the playground. You must use your knowledge of streamlining to design the rocket to travel as far as possible.



Space introduction

Learning Outcome:

- ◆ I can state what is meant by the Universe, a Galaxy, a Solar system and a Planet.

Flash Card Words:

- ◆ **Galaxy, Planet, Solar system and Universe.** – You are not given the definitions of these words at this stage, you will have to work them out during the lesson.



This Lesson

CLASS ACTIVITY- Your teacher will now show you the second in a series of 5 videos on Space.

You probably already know a lot about Space from primary school or from what you have seen on TV, read in newspapers or seen on the internet.

GROUP ACTIVITY – Before we move on to learn more about space it is important we all understand some details about our own planet Earth. In a group discuss the questions below. Once completed you will share your answers with the whole class.



1. Does the Sun orbit the Earth or does the Earth orbit the Sun?
2. How long, in hours, does it take for the Earth to rotate once around its axis?
3. What is meant by one year?
4. How many days is one Earth year?
5. Why do we have seasons on Earth?
6. How long does it take for the moon to make one complete orbit of the Earth?

GROUP ACTIVITY – In pairs complete the Space glossary card game to see what is meant by the terms Universe, Galaxy, Solar system and Planet. Once you are happy with your definitions try and rank the 4 in order of size from largest to smallest.



INDIVIDUAL ACTIVITY – All of the 8 planets in our solar system have different sizes. Your teacher will give you details of the sizes of the planets and you should plot this information in a bar graph.

INDIVIDUAL ACTIVITY – On a post it note write a question down that you have about Space. Your teacher will then select some of the questions to be discussed in the class.

What should be in your notes:



- ◆ Answers to the 6 questions about Earth.
- ◆ Definitions of Universe, Galaxy, Solar system and Planet.
- ◆ A bar graph showing the relative sizes of the 8 planets.

Our Solar system

Learning Outcome:

- ◆ I can state what 8 planets make up our Solar system and list their order from the Sun.
- ◆ I can describe the relative sizes of the planets.

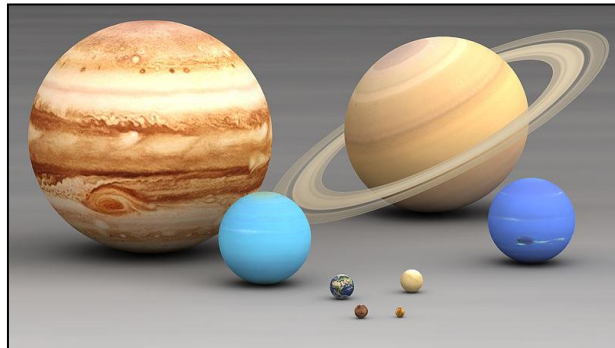
This Lesson

CLASS ACTIVITY- Your teacher will now show you the third in a series of 5 videos on Space.

Our Solar system is made up of 8 planets which orbit around the Sun. The planets are all very different sizes and orbit at very different distances.

GROUP ACTIVITY – It is important you know which planets are in our Solar system and in which order they appear from the Sun. In pairs use the card game to list the 8 planets in the order they appear from the Sun starting with the nearest and finishing with the farthest away.

GROUP ACTIVITY – The 8 planets in our Solar system are also very different sizes. In pairs complete the Planets labelling card game to identify which planet is which by how they look and their relative sizes.



CLASS ACTIVITY – Now that you have an understanding of the order in which the 8 planets appear and the relative sizes of the 8 planets in our Solar system you will now make a scale model Solar system in the classroom. Using the data below and resources provided by your teacher make a scale model Solar system in groups or with the rest of your class.

Model Planet	Distance from Sun (cm)	Diameter of model planet (cm)
Mercury	3	0.5
Venus	5	1.5
Earth	7	1.5
Mars	11	1
Jupiter	40	18
Saturn	70	15
Uranus	140	7
Neptune	220	6

What should be in your notes:



- ◆ A list of the 8 planets in our Solar system and the order in which they appear from the Sun outwards.

Weight around the solar system

Learning Outcome:

- ◆ I can calculate the weight of objects when placed on different planets in our solar system.

Flash Card Words:

- ◆ **Gravitational field strength** – How strong gravity is on different planets in the solar system, measured in Newton's per kg (N/kg).



This Lesson

CLASS ACTIVITY- Your teacher will now show you the fourth in a series of 5 videos on Space.

The gravitational field strength on Earth is equal to 10. This is just an approximation though and the actual gravitational field strength varies depending on where you are on or around Earth. The strength of gravity is known as the Gravitational field strength and is measured in Newton's per kg (N/kg).

INDIVIDUAL ACTIVITY – You will now complete a diagram detailing what the strength of gravity is on and around Earth. Use the following data to complete your diagram.

Gravitational field strength on the surface of Earth = 9.81
Gravitational field strength for a satellite in orbit = 3.26

The gravitational field strength in the other 4 places identified on your diagram have values 0.04, 9.77, 9.78, and 9.83. Can you work out which value goes where?

The gravitational field strength also varies from planet to planet. Generally the larger a planet is, the larger the gravitational field strength is on the planet. The mass of objects does not vary from planet to planet. If an astronaut takes a 60g bag of crisps from Earth to the moon then they still have a 60g bag of crisps when they reach the moon. The gravitational field strength on different bodies around our solar system is listed in the table below.



Sun	270	The moon	1.6	Uranus	11
Mercury	4	Mars	4	Neptune	11
Venus	9	Jupiter	25	Earth	10

Weight = Mass x Gravitational Field Strength

CLASS ACTIVITY- Your teacher will show you a diagram of how gravity acts on the board.

INDIVIDUAL ACTIVITY – You will now complete some examples to calculate the Weight of an astronaut who travels round the Solar system.

What should be in your notes:



- ◆ A diagram about how the strength of gravity varies on and around the Earth.
- ◆ Examples of mass and weight calculations on other bodies in our solar system.

Space – Exoplanets

Learning Outcome:

- ◆ I can state what an Exoplanet is.
- ◆ I can state what 5 things an Exoplanet must have in order to sustain life.

Flash Card Words:

- ◆ **Exoplanet** – A planet which is outside our own Solar system.
- ◆ **Goldilocks region** – A region where Exoplanets can orbit and sustain life.



This Lesson (2 lessons)

CLASS ACTIVITY- Your teacher will now show you the fifth in a series of 5 videos on Space.

As we know there are 8 planets in our own Solar system but there are hundreds more outside our Solar system. These planets are called Exoplanets. Scientists believe that some Exoplanets are capable of sustaining life.



GROUP ACTIVITY – As a small group you must discuss what 5 things are absolutely essential to sustain life on another planet. Once you have completed your list you will share it with the rest of the class.

CLASS ACTIVITY- Your teacher will now show you a video on Exoplanets.

GROUP ACTIVITY – As a group you have been tasked by NASA to help them repopulate a new Exoplanet which has recently been discovered. It is very far away so it is important that we send the correct people and the correct inventions to ensure the planet can be repopulated successfully. Your task is to come up with a list of 10 people and 10 inventions that you would send to the Exoplanet. You should give each of the 10 people you take a name, an age and a gender.

Your teacher will give you a list of inventions and a list of people who you may decide to take with you. You are welcome to choose others that are not on the lists. They are only meant as a guide.

Once your group has finished you will present your ideas to the rest of the class. You must be able to justify why you are taking certain people and not others and why you are taking some inventions and not others.



What should be in your notes:

- ◆ A list of the things needed to sustain life on an Exoplanet.



HOMEWORK 4 – REVISION

When revising for a test there are a number of strategies you could employ many of which are listed below.

- Make up flashcards of all of the key words so that you may remember them and understand their meaning.
- Go through your learning outcomes sheet to ensure you understand them all. You could make a note, draw a diagram or perform a calculation on each of the learning outcomes.
- Make a mind map using the work you have completed in your jotters paying attention to key points.
- There are many good revision resources online on the topics studied in this unit. The topics you should research are,
 - a. Speed, distance and time
 - b. Forces
 - c. Friction
 - d. Gravity
 - e. The Solar System
 - f. Exoplanets