YEAR 5: AUTUMN 2 – ROCKETMAN #1

SCIENCE: Forces

Ocean Academy Poole – an Aspirations Academy

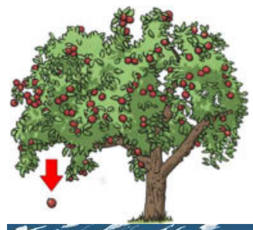
UNDERSTAND, DESCRIBE AND EXPLAIN: Gravity

To understand and explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object

Learning links:
Year 3: Science Forces and magnets
Year 5: DT Building and testing air pressure rockets and exploring the forces in action
Year 4: History Stuart Britain

Forces	*Push*	*Pull*	*Twist*	*Sir Isaac Newton*	*Theory of Gravity, 1687*
Interaction	*Movement*	*Speed*	*Direction*	*Shape*	*Affect (v)/Effect (n)*
Gravity	*Earth*	*Planets*	*Sun*	*Exerted*	*Gravitational force*

You should remember learning about forces and magnets in Year 3. If you cannot remember, or need to refresh your understanding, have a read of the Year 3 Forces and Magnets Learning Journey Map.



THINKING POINT:

What do you remember about forces and magnets from Year 3? Tell your partner.

Gravity:

Gravity is an ***invisible force*** that ***pulls. An important example is*** how the ***Earth*** and other ***planets are kept in place by the Sun***. Another important example is how it also ***keeps us*** and other objects ***on the ground***.
We can ***represent gravity*** with an ***arrow pointing down towards the Earth***.
Gravity is a ***pulling force exerted*** by the ***any massive object***.
The ***gravitational force*** from the ***Earth, for example, pulls towards the centre of the Earth***.
Gravity is ***pulling*** the apple and these skydivers ***towards the middle of the Earth***.

THINKING POINT:

In as few words as possible, summarise each sentence above.

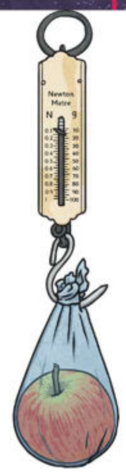
Anything, which has ***mass***, ***exerts a gravitational force***. The ***larger the mass***, the ***greater the gravitational force***.
For example, the ***Sun*** has a ***mass*** so ***huge*** that it ***creates a gravitational force strong enough*** to ***hold*** the entire ***solar system*** in place.
Planet Earth has a ***mass*** big enough to exert a ***gravitational force*** strong enough to keep everything on it ***in place*** and to ***keep a natural satellite*** (the moon) ***in orbit***.
The ***Moon's gravity*** is ***one-sixth*** (1/6) of ***Earth's gravity***, so an object with the ***same mass*** will ***weigh differently*** on Earth than it does on the ***Moon***.
For example, an astronaut ***weighs 120kg*** on Earth. Even though the astronaut ***does not change size or mass***, their ***weight*** on the ***Moon*** would be just ***20kg***.

THINKING POINT:

Why is the gravity on the moon different to the gravity on Earth?

Weight and Mass:

Mass is a ***measure*** of how much ***matter*** or 'stuff' is in an ***object***.
Small objects may contain a lot of matter, like a metal ball.
Larger objects may contain very little matter, like a polystyrene block.
Weight is the ***mass*** of an object, ***affected*** by how ***strong*** the ***gravity*** is.
Therefore, ***weight*** is ***also*** a ***force***.
Weight is the ***force*** of a ***mass pushing down*** (by ***gravity***) on the ***surface*** on which it is standing.
Weight is ***measured*** in ***Newtons***.



Sir Isaac Newton:

Sir Isaac Newton was ***born*** in ***1642*** and is ***known*** as one of the ***greatest scientists*** to have ***lived***, as he was the man who ***published*** his ***theory*** of ***gravity*** in ***1687***.
Legend has it, that ***Newton*** was ***hit on the head*** with an ***apple*** and that is how he discovered gravity.
However, this is ***not quite true***… He did ***see an apple fall*** from a tree, but rather than hitting him on the head, it ***got him thinking*** and that is how he ***worked out*** that ***gravity must exist***.
Newton discovered that ***Earth must have a force***, which ***pulls things down*** instead of ***letting things float*** upwards. We call this ***force gravity***.
Newton discovered that ***gravity attracts all objects towards each other***. The ***bigger*** an ***object***, the ***more gravity*** it would ***have***.
He ***developed*** this ***theory*** to work out that ***gravity*** kept the ***moon*** in ***orbit around Earth***.

THINKING POINT:

Why does large not always mean heavy?

EXPLORE AND INVESTIGATE:

HYPOTHESISE
ENQUIRE
TEST
RECORD
REPORT
CONCLUDE

Measuring weight on different planets, moons and stars:

Scales have been designed to incorporate the Earth's gravity (9.8 m/s) when measuring mass so that the items weight is reflective of that on Earth.
However, depending on the size of the planet/star, the force of gravity is different.
Use a set of measuring scales to measure the weight of various everyday objects on Earth.
You can work out how much the same item would weigh if placed on different stars, moons or planets by multiplying or dividing their Earth weight.

- Gravity of the Sun = 27 x stronger than the Earth.
- Gravity of the Moon = 6 x weaker (divide) than the Earth.
- Gravity of Jupiter = 2.5 x stronger than the Earth.
- Gravity of Mars = 3 x weaker (divide) than the Earth.

KEY ASSESSMENT AND APPLICATION OPPORTUNITIES:

EXS:

1. What is gravity? Can you explain it in 5 sentences?
2. What is the difference between weight and mass?
3. How does gravity differ on different planets? What would happen if I dropped the same tennis ball on Earth, the Moon and Jupiter?

GDS:

1. Using labelled diagrams, create an encyclopaedia page to explain gravity to a target audience of your choice – consider your language choices.

UNDERSTAND, DESCRIBE AND EXPLAIN: Air resistance, water resistance and friction

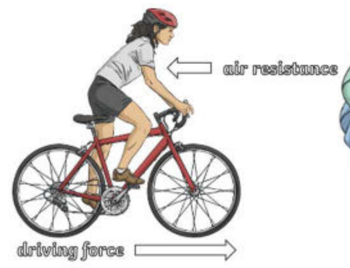
To identify and understand the effects of air resistance, water resistance and friction, that act between moving surfaces

Learning links:
Year 3: Science Forces and magnets
Year 5: DT Building and testing air pressure rockets and exploring the forces in action
Year 4: History Stuart Britain

Air resistance	*Gas*	*Counteracts*	*Galileo Galilei (1564 – 1642)*	*Opposing forces*	*Surface area*	*Comparison*
Water resistance	*LIquid*	*Dense*	*Streamline(d)*	*Efficient*	*Reducing resistance*	

<u>What is air resistance?</u>

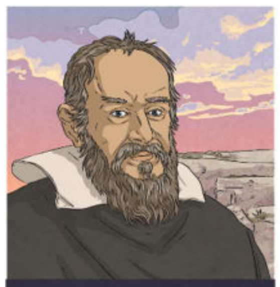
Air resistance is the name of the ***force*** that is ***pushing up against the parachute***.
Gravity is ***pulling*** the skydivers ***towards*** the ***ground***. However, they are ***slowed down*** because a ***force*** (***air resistance***) ***pushes against*** the inside of the ***parachute*** and they ***descend more slowly***. ***Gravity*** and ***air resistance*** are ***opposing*** forces in this situation but ***gravity*** is still the ***stronger of the two***. ***The forces are unbalanced.***
Air resistance can be a ***useful force***, but it can ***also*** be ***unhelpful*** in certain situations.
In a ***cyclist's situation***, the ***air resistance*** is ***unhelpful*** as it is ***slowing down*** the ***speed*** being ***generated*** by ***pedalling***; making it ***harder work to move forward***.
When ***parachuting***, ***air resistance*** is a ***useful force*** as it ***counteracts*** the force of ***gravity*** to ***slow*** the ***speed down*** so that the passenger can ***land safely***.



<u>THINKING POINT:</u>

Can you think of any other ways where air resistance can be useful?

<u>Galileo Galilei</u>, <u>**(1564-1642)**</u>
Galileo Galilei was an ***Italian scientist*** and ***mathematician*** who wondered about air resistance.
In ***1590***, he decided to ***carry out an investigation*** to ***find the answer***.
He climbed to the top of the ***Leaning Tower of Pisa*** with ***two balls of similar shape and size***, but with ***different masses***. He ***dropped both*** of the balls from the top of the tower at the ***same time***. ***Both*** balls ***hit*** the ***ground*** at the ***same time***.
Galileo's experiment ***proved*** that ***all objects fall at the same rate***, no matter what their mass is. But this can seem ***hard to believe***!
Think about a feather and a hammer. If you ***dropped both*** objects at the ***same time***, would they ***hit the ground*** at the ***same time***? No, they wouldn't. However, that isn't because of their mass, it is because of their ability to 'catch air'.



What do you think happened when astronauts stood on the Moon and dropped these two items at the same time?
The feather and the hammer ***hit*** the ***surface*** of the Moon at the ***same time***! This proved that Galileo's findings are correct.

Why did this happen?
There is ***no air on the Moon***. ***Air pushes against*** any ***object*** moving through it: ***air resistance***.
On ***Earth***, ***air resistance acts*** on ***both*** the hammer and the feather. The ***feather*** has a ***large surface area*** in ***comparison*** to its ***mass***. The ***hammer*** has a ***small surface area*** in ***comparison*** to its ***mass***. Therefore, ***air resistance*** has a ***greater upwards force*** on the ***feather*** causing the hammer to reach the ground first. Since there is ***no air*** on the ***Moon***, there is ***no air resistance*** to push against the feather, so the ***two objects fall*** at the ***same speed***.

<u>THINKING POINT:</u>

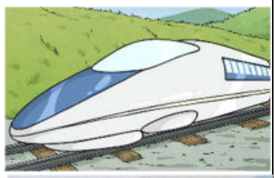
If you dropped two equal containers of different weights, would they hit the ground at the same time? Why?

<u>**What is water resistance?**</u>
In the ***same way*** that ***air*** can cause ***resistance*** to ***moving objects***, so can ***water***.
Being a ***liquid*** (***more dense*** than air), the ***effects*** of ***water resistance*** are more ***obvious***.
If you have ever ***walked through water***, you will have ***felt*** the ***effects*** of ***water resistance pushing against you***.
However, ***water resistance*** is a ***useful force*** as it ***helps*** you to ***swim***. When you ***push against*** the ***water*** with your hands, the ***water resistance pushes back*** and ***helps*** you to ***move forward***, like using oars to push against the water to row a boat.

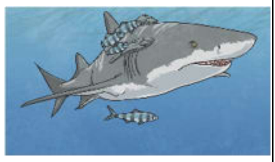
<u>THINKING POINT:</u>

Can you think of any ways where water resistance can be useful?

<u>**Streamline shapes to reduce resistance:**</u>
For ***speed*** and ***direction purposes***, ***air*** and ***water resistance*** are ***unhelpful forces*** as they ***counteract*** the ***force*** creating ***forward motion***. It is possible to ***reduce*** the ***effects*** of ***water*** and ***air resistance***. For example, cars, trains, planes and boats are ***designed*** to ***reduce*** the ***effects*** of air and water resistance to ensure the ***most efficient use of energy and fuel***. ***Objects*** that ***do not experience*** much ***water or air resistance*** are described as ***streamlined***.
This ***high-speed train*** and ***jet aircraft*** have been ***designed*** to be ***streamlined*** and ***reduce*** the ***impact*** of ***air resistance***.
Both examples have a pointed (cone-shaped) nose so that they can 'cut' through the air, a low, curved top to allow the air to flow over and around it easily and they are both also made of smooth, shiny materials.



Looking at nature too, we can see how certain animals have adapted to be more streamlined.
The great white shark, for example, has a ***pointed nose*** to ***cut through the water***, and a ***smooth, low, curved back*** to allow the ***water*** to ***flow over*** and ***around it***. It does not create much ***water resistance*** so it can ***move*** through the ***water quickly***.



EXPLORE AND INVESTIGATE:

HYPOTHESISE
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<u>**Investigating air resistance:**</u>
1. Find a safe space to drop paper from a height.
2. Each group has 5 pieces of paper: 1 piece will remain in its original form, another piece will be scrunched in to a ball. The remaining 3 pieces can be designed in to any chosen shapes/forms by folding only. The paper must not be cut or ripped, only folded. Nothing can be stuck to or added to any sheet of paper.
3. One piece of paper can then be dropped from a height at once. Using a stopwatch, time how long each piece takes to reach the ground.
4. Record the results. What did you discover? What does this tell you about air resistance, shape design and surface areas?

<u>**Investigating water resistance:**</u>
1. Fill a deep container or wide measuring cylinder with water.
2. Using 3 equal portions of modelling clay, create 3 shapes (e.g. cone, sphere, cube).
3. One at a time, drop each shape in to the water-filled container.
4. Using a stopwatch, time how long each shape takes to reach the bottom of the container and record the results.
5. What did you discover? What does this tell you about water resistance, shape design and surface areas?

KEY ASSESSMENT AND APPLICATION OPPORTUNITIES:

<u>**EXS:**</u>
1. Using diagrams, can you explain air and water resistance as forces.
2. Describe how air resistance/water resistance can be a useful or unhelpful force in different situations.

<u>**GDS:**</u>
1. If you were stood on the moon and dropped 2 items, which would reach the ground first? Why is this?
2. Would a parachute be of use if landing on the moon? Why?

UNDERSTAND, DESCRIBE AND EXPLAIN: Levers, pulleys, cogs and gears

To recognise that some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect

Learning links:
Year 3: Science Forces and magnets
Year 3: DT Building and testing magnetic cranes with a pulley system

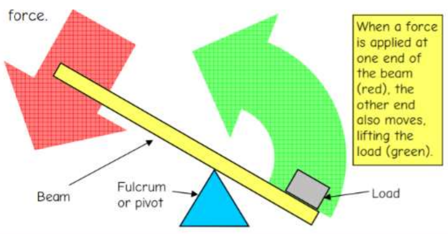
Machines	*Devices*	*Gears*	*Cogs*	*Wheels*	*Ramps*	*Wedges*	*Levers*	*Screws*	*Pulleys*

Fulcrum/Pivot	*Direction*	*Speed*	*Force*	*Increase*	*Decrease*	*Drive gear*	*Clockwise/Anticlockwise*

Machines:

Machines are ***devices*** that ***change*** the ***direction*** or ***size*** of a ***force***. There are ***six types*** of ***simple machines***: ***wheels***, ***ramps***, ***wedges***, ***levers***, ***gears*** and ***pulleys***. ***Most*** simple machines ***reduce*** the ***force*** you need to ***apply*** to ***lift*** or ***move*** a ***heavy object*** by making the ***distance*** over which you ***apply*** the ***force larger*** than the ***distance*** the ***object moves***.

Levers:

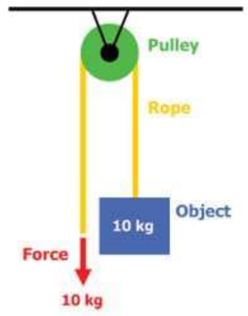


A ***lever*** is one of the oldest and ***simplest machines*** used by humans. A ***lever*** consists of just ***2 parts***: a ***beam*** (the long part) and a ***fulcrum*** or ***pivot*** (hinge). The ***beam rotates*** along the ***fulcrum*** like in this diagram here.
Levers are particularly ***useful*** because they allow ***humans*** to ***lift heavy objects*** by ***applying less force*** than if trying to lift without the lever. The boy in the picture is lifting a heavy log. It is so heavy he can hardly lift it. His friend is lifting a similar heavy log. He is lifting it more easily because he is using a small log resting on another log as a ***lever***. The ***lever*** makes lifting the heavy log easy. A ***lever*** always ***rests*** on a ***pivot***. In this case, the log on the ground is acting as a ***pivot***. A ***lever*** always has ***three things*** – the ***point*** where you ***push*** or ***pull***, the ***point*** where it ***pivots***, and the ***point*** where the ***force is applied***.

THINKING POINT:

Can you draw a quick diagram to show how a lever works?

Pulleys:



A ***pulley*** is a ***wheel*** with a ***grooved rim*** around which a ***cord passes***. The pulley acts to ***change*** the ***direction*** of a ***force*** applied to the cord and is used to ***raise heavy weights***.
In the picture, the boy and the girl are both lifting a bucket full of wood. The girl finds it difficult, but the boy is using a pulley tied to a tree and is lifting the bucket with the rope passing under the pulley. He has to exert the same pull as his friend, but he finds it easier to pull on the rope than she does to lift the bucket up by the handle.

THINKING POINT:

Why do pulleys make it easier to lift heavy objects?

Cogs and Gears:

Gears are ***wheels*** that have ***teeth***, or ***cogs***, around the ***edges***. The cogs of one gear fit into the cogs of another. They move in ***opposite directions***. In other words, when one ***gear*** turns to the right (***clockwise***), the gear attached to it will turn to the left (***anticlockwise***). This pattern continues to ***repeat***, regardless of how many gears are attached to each other. As ***gears turn***, energy is ***transferred*** from one gear to ***another***. They can either ***increase*** or ***decrease speed*** or ***force***.
If a ***large gear*** is ***attached*** to a ***small gear*** with the large gear as the ***drive gear*** (first turn), this will cause the ***small gear to turn***. As the ***larger gear*** (***drive gear***) turns, the ***small gear*** will ***speed up*** to keep up with it. This type of ***gear sequence increases speed***.
Gears are very ***useful*** for ***transferring energy*** in to ***larger movements***, ***speed*** or ***power***.
They are used widely in bikes, motorbikes and cars.

THINKING POINT:

Looking at the diagram, can you explain how cogs and gears work?

EXPLORE AND INVESTIGATE:

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Investigating levers and fulcrums:

1. Place a weight/single object on one end of a 30cm ruler on the 0cm mark.
2. Place a pencil (fulcrum) underneath the ruler at the opposite end on the 30cm mark.
3. Place an equal weight/single object on the ruler at the 30cm mark. Did this lift the weight on the opposite side? Why not?
4. Move the pencil (fulcrum), one cm at a time, towards the original weight. Record whether the weight is lifted by the lever.
5. At what distance, on either side of the fulcrum, does the lever work?
6. Experiment with a lighter weight at the opposite end of the lever. What is the lightest weight that can be used to lever the weight?
7. What did you discover? What does this tell you about the positioning of a fulcrum and the usefulness of a lever in everyday life?

Investigating pulleys:

1. Set up a simple pulley mechanism by taping a metal can to a gap between 2 tables and laying a piece of string over the top.
2. Attach a selected weight to one end of the string and allow it to rest on the ground beneath the table.
3. Investigate and explore how the pulley system makes it easier to lift the weight. If available, use a force metre to measure the force needed to lift the weight with one pulley.
4. One at a time, add more pulleys to the system. Is it easier to lift the weight? Has the amount of force needed reduced?
5. What did you discover? What does this tell you about increasing the number of pulleys and the usefulness of a pulley in everyday life?

Investigating gears:

1. Using a compass, draw and cut various sized circles out of cardboard.
2. Cut lollipop sticks and stick to the cardboard to create cogs on their gears.
3. Once they have created each gear, they can be attached to a larger piece of cardboard using a cocktail stick/skewer.
4. From this gear, begin to create a different size gear with varying numbers of teeth to place next on the cardboard.
5. Once completed, one gear can be selected as the drive gear and the children can explore how the force from the drive gear changes as it moves through the different gears. Experiment by changing the drive gear.
6. What did you discover? What does this tell you about how gears can increase or decrease the original force or speed?

KEY ASSESSMENT AND APPLICATION OPPORTUNITIES:

EXS:

1. What effect can mechanisms like pulleys, levers and gears have?
2. Using diagrams, explain how a lever/pulley/gear works.

GDS:

1. If a small gear is used as the drive gear and is connected to a larger gear, how will this affect the original force?
2. If a large gear is used as the drive gear and is connected to a smaller gear, how will this affect the original force?