Durham County Council

Killhope Museum
Creative Science Programme

Key Stage 1 & Key Stage 2

"A zest for life combined with a will to experiment"

Forces & Motion

Science Detectives Discover Killhope

Resources for Teachers

SMA
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KS1 & KS2 Forces & Motion

Teachers Resource Pack
Killhope Museum Creative Science Programme

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Killhope Lead Mine
Background Information

The 18th Century Boom

Over 200 years ago the Killhope valley experienced a mining boom. New people moved into the area. Shafts, levels, 'hushes' and 'dead heaps' were scattered far and wide over the hillsides. Many of the scars of mining are hidden beneath the trees, but the landscape must have looked devastated. Nearly all the houses you can see in the valley were built during the boom times of the second half of the 18th century. The houses were not huddled together in a village, but scattered over the south-facing hillside. Each family was surrounded by land they could farm to add to the small income they got from the mines.

At Killhope the 'W B Lead' company worked the mines. This was a family business owned by the wealthy Blackett family (later through marriage the Beaumont family). The company leased the mining rights and most of the land in the valley from the Bishop of Durham. This meant that many miners had their bosses as landlords. With a tight grip on employment prospects the Blackett family was a powerful influence on the lives of the workers and their families.

Park Level Mine

Until 150 years ago the area that is now Killhope Lead Mining Museum was field, open moorland and fell. In the 1850s a new mine was started. First, a tunnel was dug to reach the lead veins upstream, then the mineshop was built, and by the 1870s the Killhope Lead Mine was one of the most productive in the whole country. W B Lead's company supplied about one-quarter of the lead mined in England. They had a prestige product that sold at premium prices on the London market. Killhope's second boom had arrived.

W B Lead built the big wheel and buildings near it, to power and house brand new ore crushing and separating machinery. This plant, known as Park Level Mill, started production in 1878.

Shortly after this the price of lead fell by half, undercut by foreign competition. The Weardale Lead Company took over Killhope and prospered, but the mine was almost worked out. The last ore was brought out in 1910.

In some places in Weardale fluorspar mining took over from lead mining and saved many jobs but this did not happen in Killhope. Machinery was sold. Stone was sold off for building. Timber and metal were scavenged. Sheep were the new inhabitants.

A new beginning

In the 1950s the Forestry Commission bought the land of the Killhope valley. The 'Weardale Forest' was planted as an experiment - the highest plantation in England. By chance, the Killhope water wheel had been left in its original location. In 1968 Durham County Council took a lease on Park Level Mill, its wheel and buildings, to develop as a picnic site. Then in the mid 1980s the County Council bought the site and adjacent woodland.

Forces & Motion

Teachers Resource Pack
Killhope Museum Creative Science Programme

National Curriculum Science KS1 and KS2

The **Forces & Motion** Package is part of the Creative Science Programme developed for Killhope Lead Mining Museum and Durham County Council.

The **Forces & Motion** teachers' resources offer a range of possible pre and post visit activities linked to the focus of on-site activities that pupils will be involved in at Killhope supported by the expert team of Information Assistants.

These pre and post visit activities are in no way comprehensive and neither are they meant to be. But they do provide a selection of activities that will support pupils in preparing for their visit, and ideas for follow up work. As you will be aware, for the value of the visit to have the maximum impact good preparation is essential. Good preparation also gives children the confidence to allow their imaginations to work, giving full reign to their thinking skills in making connections and creating their own tests and experiments.

All the activities in the **Forces & Motion** package, both on and off site are centred on the requirements of the national curriculum **Sc4 Physical Processes, KS1 and KS2**. They focus on the science principles and concepts that can be best explored at Killhope Lead Mining Museum.

The **Forces and Motion** package relates to QCA Units:

KS1 - Unit 1E Pushes & Pulls

KS1 - Unit 2E Forces and Movement

KS2 - Unit 4E Friction

KS2 - Unit 6E Forces in Action

The other three Killhope Creative Science Packages for KS1 and KS2 are

Overground, Underground Sound
Materials Maze – Materials and their Properties
Rocks and Soils

The last package – **Rocks and Soils** – can be used as an independent package or in association with the **Materials Maze** as part of **Sc3 Materials and their Properties**.

Forces and Motion in Context
Visiting Killhope Lead Mining Museum

'A safe and stimulating environment for learning'

At Killhope Lead Mine in Upper Weardale in the 19th century questions (and answers) about forces and motion were fundamental to running a successful lead mining business and for personal survival in the isolated location and harsh climate of Pennine Hills.

Over 100 years later, Killhope is no longer a working lead mine but is a museum run by Durham County Council. The purpose of Killhope Museum is to care for and display buildings, refurbished industrial equipment and show life above and below ground in a nineteenth century lead mine in the North Pennines. Current features of the museum include: tours of the mine, refurbished working water wheel, displays in the miners' living accommodation, blacksmith's shop, and mineral displays, washing floor, jigger house, woodland areas, museum display areas and café, shop and toilet facilities.

Killhope Lead Mining Museum provides a safe and stimulating environment for educational visits.

Educational visits to Killhope have a very good reputation. Visiting teachers and pupils particularly value the involvement of trained staff from the museum during every visit, and the focus on hands on and participatory activities. This approach to site-based learning was commended recently in *The Guardian*'s Education supplement. The newspaper reported that Killhope is "an inventive and vibrant museum with an excellent tour and educational package…..the Museum prides itself on being a worksheet -free zone: pupils are encouraged to 'do' rather than observe….."

The Killhope Creative Science Programme builds on the established reputation of Killhope Lead Mining Museum for 'hands on' and participatory activities, making full use of the expertise of the trained staff team. The Killhope Museum site and collection of buildings, machinery and artifacts in their original setting within the landscape of the North Pennine hills offer a unique opportunity to explore innovatory approaches to science education at KS1 and KS2 and forces and motion in context.

At Killhope Lead Mining Museum different types of forces can be seen at work both during the extraction process in the underground mine and outside where the separation process of the lead ore – **GALENA** – from the waste rock and mud took place before it was taken away on horse back to the lead smelting mills. These forces are used in different ways and will provide excellent examples for science learning.

Whereas the main focus of the creative science activities on Forces and Motion on-site at Killhope Lead Mining Museum is on the lead mining extraction process underground and the two lead separation processes - one manual involving hard physical exertion, the other mechanical involving high volumes of fast running water - a secondary theme relates to the vegetable garden and traditional fairy stories.

We have included the traditional Russian tale of 'The Gigantic Turnip' for younger children. You may like to check whether one of the Information Assistants will be telling the Killhope Interpretation of the Tale to your class. You may want to request 'The Killhope Gigantic Turnip'.

Creative Science at Killhope

Inspiring learning through Creative Science

The concept of creative science is an exciting new approach to engaging pupils in learning about science supported by QCA. Creativity allows for greater flexibility in terms of learning opportunities. Thinking creatively means that science can be inspiring. Once the traditional boundaries between arts and science are broken the creative arts can also be a rich source of inspiration for science learning.

Other boundaries are crossed too. Links can be made to real life situations beyond the home/ school environment. Undertaking interesting new scientific experiments relevant to a particular place and industrial practices enables pupils to gain a better understanding of scientific principles, their application and usefulness.

Science Detectives

Detectives need to be equipped with a range of special qualities and some special equipment. Discuss with the class what these special qualities are and what equipment would be helpful in looking at different materials in detail.

Explain that when the class arrives at Killhope, they will be divided into several groups and that each group will complete at least two Detective Trails of Discovery during the day. When the class gets back to school one of the tasks will be for each group to report back to others in the class on their observations, the evidence they have found, the tests and experiments they have carried out and their experiences.

It is up to individual teachers how far they pursue the ‘science detective’ idea. Digital cameras, video cameras and voice recorders would be useful for recording purposes.

Pupils will need to understand the importance of

- Close observation and examination of clues
- Gathering and sifting through evidence, then sorting it into different categories
- Carrying out investigations and tests
- Using different methods to solve a problem

Subject links and cross-curricular learning

Across all four Killhope Creative Science Packages art, drama and dance are used when appropriate as innovative approaches to experiential learning in primary science alongside ‘hands-on’, inter-active practical sessions at the Museum.

Cross-curricular learning is encouraged, in particular the use of ICT and literacy. In turn pupils of primary school age are inspired to explore, experiment and gain an understanding of the application of scientific principles in the context of a ‘real life’ situation – Killhope – a nineteenth century lead mine in the North Pennines, County Durham.

Forces and Motion: Creative Science Learning Activities

The **Forces and Motion** Teachers' Resource Pack is divided into three sections that have their own logical progression. However, these activities are also designed for a flexible approach.

You may choose to do more preparation or more follow up. You may choose to take a strong science focus supported by the creative work or you may choose to integrate 'arts/ science' learning.

1. Pre-visit Activities: Discovering Forces

The pre-visit activities enable the teacher to lead their class in taking an integrated approach to creative science learning form the outset using story telling, art, movement and dance combined with scientific experiments relating to the Forces and Motion they will encounter at Killhope Mining Museum.

Healthy eating and physical exercise mix naturally with the 'pushes' and 'pulls' in the vegetable garden.

2. On-site Activities: Forces in Action

The on-visit allows the class to explore the use of forces in the mining and extraction of lead ore and rock underground and the various stages in the manual and mechanical processes used for separating the lead ore – Galena – from the waste rock – graphically described as *deads* –outside the mine.

Your class will find out about the importance of 'pushes' and 'pulls', friction, the force of gravity, floating and sinking and water power as well as how they are used in each task.

Health and safety was always a difficult issue underground. Here again the available forces were used to their maximum advantage.

3. Post-visit Follow Up Activities: Creative Forces

The post-visit follow up sessions are designed to build on the creative learning begun in the pre-visit sessions. Specific links are made to literature; art and design; drama, movement and dance.

How you decide to approach **Forces and Motion** at Killhope will depend on how you want to include the on-site learning within your curriculum planning, schemes of work and the timing of the visit to Killhope.

1. Pre-visit Activities

1a KS1 Fairy Tale Forces: The Vegetable Garden

This activity includes both pre-visit and post-visit activities. It is designed to be adapted to meet the learning objectives of the visit to Killhope matched with the learning abilities of your group. For example some groups will prefer to emphasise the story approach using **Fairy Tale Forces** and others will focus on the tools used and plants grown in **The Vegetable Garden**. You might like to tell/ perform the story of The Gigantic Turnip on-site at Killhope. (See also **3a Post Visit Follow Up Activity 1: Forces and Fairy Stories**)

Activity 1: Story Telling – The Gigantic Turnip

The Gigantic Turnip

In this well-known Russian folktale by Aleksei Tolstoy, a gigantic turnip is too large for a farmer to pull out of the ground. His wife joins him, and then each of their children has a try. A variety of neighbours, strangers and farm animals join in the attempt. They hold on to one another's waists. In the end their joint weight and strength provides the physical force - the pulling power - they need to pull the stubborn turnip from the ground. Typically the story ends with turnip soup for everyone.

In one version, a little girl is left out because she is 'too small to do anything useful' but finds a way to help. She whispers encouragement to the turnip. When the entire line-up cannot tug the turnip out of the ground, she steps over to the turnip and whispers, "Little turnip, you have grown big. You have grown gigantic. Now it is time to come up. Come up, little turnip, come up." Then she takes her place at the end of the line. All the people pull their hardest once more and finally pull the turnip from the ground. In another version the role of the little girl is played by a mouse and in yet another it is played by a bird – a robin.

You may have your own favourite version of this story or know another Fairy Tale that will illustrate 'pushes and pulls' in a similarly graphic way.

The one below features a mouse!

The Gigantic Turnip

Long ago, an old man and an old woman lived together in a crooked old cottage with a large overgrown garden. The old man and the old woman kept six yellow canaries, five white geese, four speckled hens, three black cats, two pot-bellied pigs and one big brown cow.

One fine spring morning, the old man and the old woman sow seeds in their garden. Their vegetable patch flourishes and at the end of the summer their garden is full of peas and carrots and potatoes and beans. But at the end of the row of turnips there is a gigantic turnip. However hard the old man pulls he cannot move it, so he has to ask for help. First from his wife, then from the cow, the two pot-bellied pigs, the three black cats, the four speckled hens, the five white geese and six yellow canaries. But still the turnip will not move.

But finally the old woman enlists the aid of a hungry mouse with spectacular results……..

Performance

This story works well as a short play because you can add characters to the line-up and include all the students who want to participate. You might add animals, such as a dog, cat, goat, or a sheep, to heighten interest. Suggest that when the turnip finally comes out of the ground, children fall backward like a row of dominoes.

You can embellish the tale by adding a planting exercise, digging, sowing the seeds, planting out seedlings by pushing the roots in, pulling up the weeds etc

Discussion

Ask your pupils, "What would have happened if everyone did not want to help?"

Remember if you are planning to make strong links to literature you can extend this activity either before or after a visit to Killhope using 3a – Post Visit Follow Up Activity 1: Forces and Fairy Stories

Activity 2: Word & Picture Collection & Collage

Pre-visit preparation

Prepare for your visit to Killhope by starting to assemble materials for a Word & Picture Collection & Collage on 'Growing Vegetables' and 'Working in the Garden'.

The children will see a cottage garden at Killhope. They will see many of the tools still used in the garden today as well as many vegetables they recognise (depending on the time of year of their visit!).

The same tools that are used in the garden – e.g. spades (shovels) and rakes - were used by Killhope lead miners underground for extracting the rock and lead ore – Galena - and outside where they separated the lead ore from the rock/ stone.

Many of these tools can still be seen in use on a visit to Killhope both inside the Lead Mine and outside around the Killhope Museum site.

'Pushes and Pulls' were very important in lead mining as well as gardening.

Post-visit Follow Up

Discuss what garden tools the children saw at Killhope, which ones we still use today and which ones we use today that they did not see on their visit. Why was this? Were the familiar tools exactly the same as the ones we use today? If they were different, how were they different?

Complete the Word & Picture Collection & Collage on 'Growing Vegetables' and 'Working in the Garden'

This word/ picture collection & collage should be on two different sides of the room: PUSHES on one side and PULLS on the other

- Illustrate as many things as possible that can be pushed on one side
- Show as many things as possible that can be pulled on the other
- Discuss what things are easy to pull or push and try to work out why
- What do you feel like when it is difficult to push or pull?

Activity 3: Killhope Science Detectives at Home – Exploring Gardens

Extend the second activity by asking the children to become detectives.

Tell the group they are looking for clues.

- Investigate what has to be pulled and what needs to be pushed in their garden and why
- Interview parents, guardians, grandparents or aunts and uncles who have gardens or use the school garden if you have one

Make sure you cover these tools and machines

- Spades, forks and rakes
- Lawn mowers and wheel-barrows
- Hammers and nails (to mend wooden fences)

Use this extra information to add to the word/ picture collection.

Discuss how these garden tools are used and then…

Organise a movement session on the actions.

- *Digging, raking, pushing a wheel-barrow, hammering* etc

Ask the children to think of words and phrases that describe their movements

- *Push, pull, lift, heavy, light, move, fast, slow* etc
- Make comparisons e.g. *go faster, go slower, go further*

Also remember to ask the children to think about what tools and what vegetables from their word/ picture collection they might find in the cottage garden at Killhope and both inside and around the old Lead Mine.

Extend the discussion further to talk about large vegetables.

- Find out what kind of large vegetables are grown today, who grows them and whether they have to pull them out of the ground
- Find out what vegetables the children like to eat – if any

Do we want to grow large vegetables to eat today? If not, why not?

Is the reason because

- we are not strong enough to pull them up
- machines not people do the work today
- we like small vegetables because they are tender
- we don’t need the green tops to feed the pig
- we do not grow our own food
- we can freeze our vegetables
- we can put vegetables into tin cans

1b KS1 & KS2 Dance: Pushes and Pulls

Activity: Dance Exercises

Pushes

- Place the children in pairs around the room facing each other - (one child is A, the other B) - standing at a crooked arm's length from each other. They should stand one leg in front of the other as if mid-stride.
- Place the opposing palms of their hands together at about shoulder height. At no time during this exercise must their hands separate.
- First let child 'A' push slowly and gently against child 'B' using both hands. B should allow the pushing to happen.
- Reverse the order >> B pushes A.
- Next oppose the pushing between arms i.e. both A & B push forward with the right hand and allow themselves to be pushed backwards with the left, and then reverse the order.
- You can now improvise with different leading and following movements between the pairs. This may, if you wish, include being pushed to walk backwards, forwards or around in circles. They can also try pushing together upwards and downwards.
- If you wish, you can try and fit the movements they develop to selected pieces of rhythmical music, or you may wish to let the children try a poem, or 'rap' a short passage they invent which can then be choreographed.

Pulls

- Place the children in pairs sitting on the floor facing each other. Again tag them as A's and B's.
- Place the soles of the feet against each other and hold hands.
- Child A can now gently pull B towards them and B can resist gently. B can then reverse the order and pull A towards them.
- They can try a rocking movement between each other.
- Alternate pulls from left and right hands.
- A circling movement where the pulling will have to be sensitively exchanged between the pair.
- When these movements have been practised, try putting a song into the movement. For example - Row, row, row, row the boat, gently down the stream. Merrily, merrily, merrily life is but a dream etc. etc., as they pull backwards and forwards.

1c KS1 & KS2: Forces at Work at Killhope Lead Mine

Activity 1: Scientific Issues & Principles – KS1 & KS2

This activity is focused on the scientific issues and principles relating to the Forces at Work that children will encounter on a visit to Killhope Museum as part of a Creative Science learning experience. It is designed to be supported and extended with reference to other relevant science books, CDs and internet resources on scientific principles written for KS1 & KS2.

Using simple diagrams drawn on a flip chart/ interactive whiteboard, the following principles can be addressed either by question and answer, discussion, experiment, direct instruction or a mixture of all. Alternatively use individual computers.

Gravity

- Initially identify we live on a planet – **PLANET EARTH**.
- Our planet has an **ATMOSPHERE** which completely surrounds it
  (At this stage it is unnecessary to get involved with planetary rotations)
- On our Planet Earth we experience a major **FORCE.** It is called:

  ******GRAVITY******
- On Planet Earth, if we jump upwards into the air, we will be **PULLED** back downwards onto the ground - towards the centre of the earth. This is called **THE FORCE OF GRAVITY.** Anything made of matter has gravity. The issue is not how heavy anything is. Everything with a mass on the planet - solids, liquids and gasses - is being pulled downwards by the **FORCE OF GRAVITY**.
- Gravity, it may also be worth noting, is more complex than simply the pull to towards the centre of the Earth. It is a force that any two objects in the universe have towards each other.
- The use of the **FORCE OF GRAVITY** was central to the lead mining industry. At Killhope both the extraction and movement of rock and lead ore – Galena – out from the underground mine and the separation of the lead ore from the rock/ stone exploited gravitational forces.

Friction

- Friction varies depending on the interaction between the surfaces of different objects
- Different materials create more (or less) friction as their two surfaces make contact
- When the same objects are moved across different surfaces with the same force they will travel a different distance
- At Killhope the tubs with iron wheels filled with *bouse* (rock and ore) ran on iron rails. The contact between the two hard smooth surfaces created little friction (or resistance). Therefore the tubs moved comparatively easily. If the same tubs were moved over rough bumpy ground (without rails) with the same force a greater amount of friction (or resistance) would be created. The tubs would be far more difficult to move

Moving Objects

- When an object is rolled or moved along a level surface it will slow down as the friction between the two surfaces slows it down
- The speed of a moving object is affected by the force used to move it
- When an object is rolled or moved down a slope its own mass makes it go faster because the force of gravity acts on it
- At Killhope the iron tubs filled with *bouse* (rock and lead ore) were moved using a combination of different forces
    - Where possible the iron rails were placed on a downward slope starting inside the mine making use of the force of gravity.
    - Additional force was provided by horses that pushed against their harnesses to pull the tubs
    - As the wheels of the tubs rotated they created less friction because there was less contact between the two surfaces and therefore less resistance to slow down the moving tub
        - The curved surface of the wheel touched less surface area of the flat rail than a flat object of the same size and weight
        - The two iron surfaces were hard and smooth (Note: the tubs and rails at Killhope that can be seen on a visit are now rusty)

Floating and Sinking

- Some materials will float and others will sink because of their density
- A piece of iron, for instance, is a lot denser than a piece of wood of the same size. A piece of stone, iron or Galena (lead ore) will sink in water but a piece of wood floats
- Materials such as iron, Galena and stone are denser than wood, plastic or cork. They are also denser than the water itself
- Therefore, the force of gravity pulls the denser materials downwards through the water, even against the force of water trying to push them upwards
- With materials that do not sink, the reverse is happening. The opposing force of the water pushing them upwards is stronger than the force of gravity pulling them down
- At Killhope you will find that although Galena and stone both sink, Galena is denser than stone. So that when they are shaken together in water during the separation processes the Galena always sinks to the bottom

1d KS1 & KS2 Discovering Forces at Killhope

Activity 1: Experiment – Gravity

Hypothesis

Gravity as a force exerts a constant downwards pull

Question

If we release different objects at the same time, will they be pulled towards the ground at the same speed and hit the ground at the same time?

Equipment Needed

- Chair or box to stand on
- 2 x Shallow baking trays
- Pairs of objects of a similar size but different weights e.g. ping-pong & golf ball; cricket ball & tennis ball: 0.5 roll of toilet paper and a baked bean tin and so on in increasing size. The shape is irrelevant, but do not select objects that have a large 'air-resistance' e.g. a balloon

Method

1. Create a table and record predictions of what will happen with the different pairs of objects.
2. Place the two baking trays either side of the chair or box.
3. Elect teams of people to observe the baking trays very carefully.
4. Elect one child to stand on the chair or box with one object from the pair in either hand.
5. The objects are released directly over the trays at EXACTLY the same time.
6. The observers are to identify if there is any difference in the moment each object hits the baking tray. The noise of the impact will be more noticeable than the visual information.
7. Record all findings on a chart and evaluate the test.

Conclusions

Ask each individual or team to write down the answer to the question, describe their role in carrying out the experiment and give examples of their findings as supporting evidence.

Activity 2: Experiment – Friction

Hypothesis
When the same object is moved across different surfaces with the same force there are different levels of resistance (friction) between them.

Question
If we move the same objects across different surfaces with the same force do they cover the same distance?

Equipment needed
- 1.5 metre (approx) plank of wood or similar
- Toy car/vehicle made of plastic
- Toy car/vehicle made of metal
- Tins of baked beans, peas, soup, dog food *(All tins to be the same size)*
- 0.5 litre bottle of water
- 2 – 5 metre rule/ tape
- Access to smooth wooden floor, carpeted floor, bumpy surface

Method
1. Create a chart to record your findings – *Which object moves the farthest on what surface?*
2. Discuss predictions of what you think may happen.
3. From a marked line on a level wooden floor/ plank of wood, USING EXACTLY THE SAME AMOUNT OF FORCE each time, push the wheeled vehicles; or roll the tins along the floor.
4. Observe only one at a time.
5. Measure exactly how far each has travelled from the starting point.
6. Repeat the exercise on each of the 3 different surfaces.
7. Discuss whether it a Fair Test and your earlier predictions.
8. Record your findings.
9. Prop up one end of the plank of wood on a chair with the other end resting on the floor.
10. Discuss and predict what you think may happen.
11. Observing one object at a time, release each from the top of the plank and let it roll down and along the floor. DO NOT USE ANY FORCE AT

THE POINT OF RELEASE.

12. Measure the distance travelled along the floor from the bottom of the ramp.
13. Discuss whether it was a Fair Test and your previous predictions.
14. Record your findings.

Conclusions

Ask each individual or team to write down the answer to the question, describe their role in carrying out the experiment and give examples of their findings as supporting evidence.

Activity 3: Experiment - Moving Objects

Hypotheses

The curved surface of the rotating wheels will touch less of the surface area of a flat floor and experience a comparatively low amount of friction. Therefore less force is needed to move an object.

If an inclined ramp is made steeper increased force is needed to move objects in an upward direction.

Questions

1. How much force is needed to move each object along different surfaces?
2. How much more force is needed to pull objects up steep slopes or inclines?
3. How might the movement of objects be made easier?
4. Which is the easiest object and which the most difficult object to move and why?

Equipment needed

- Force meter
- Supply of lengths of thread
- Skate board (or similar)
- Supply of objects of different shape and weight
- Length of wooden plank or similar
- Angle measurer
- Access to smooth wooden floor, carpeted floor (or grass), bumpy surface

Method

1. Attach a fixing point to each object with the thread.
2. Attach the hook of the force meter to each object in turn.
3. Use the force meter to pull each object in the same direction along the first surface and record the measurement.
4. Repeat the experiment on each different surface and record the results.
5. Attach the force meter to the skate board. Place each object on the skate board in turn and measure how much force it now takes to move the objects placed on the skate-board across different surfaces.
6. Take the wooden plank and lift one end onto blocks to create a ramp.
7. Gradually make the ramp steeper and steeper. For each 10 degrees of slope record the change in the amount of force needed to pull an object up the ramp.

8. Repeat step 7 both with and without the skateboard.
9. Discuss whether Experiment 3 was a Fair Test.
10. Discuss and compare the findings.

Conclusions

Ask each individual or team to write down their answers to the questions, describe their role in carrying out the experiment and give examples of their findings as supporting evidence for their answers.

Example of Recording Charts
Moving Objects - Force Measurements

Create charts similar to the examples given below to plot the force measurements for moving different objects with and without the use of wheels.

Moving Objects - Force Measurements
Recording Chart: Measurements in Newtons (example numbers only)

OBJECT	SURFACE MATERIAL		
	WOOD	SMOOTH PLASTIC	CONCRETE
Wood Block	0.3	0.2	0.7
Container of earth	1.0	0.8	1.4
Piece of natural stone	2.0	1.8	2.5
Etc.			

Recording Chart: Measurements in Newtons (example numbers only)

OBJECT	ON SKATE BOARD		
	WOOD	SMOOTH PLASTIC	CONCRETE
Wood Block	0.1	0.1	0.2
Container of earth	0.5	0.6	1.0
Piece of natural stone			

Activity 4: Experiment – Floating and Sinking

Hypothesis
Whether something floats or sinks in a tank full of water depends on its density and the opposing force or up thrust of the water.

Question
Will objects made of different materials but the same size sink in a tank of water?

Equipment needed
- A water tank

- *All of the following material samples should be roughly the same size*
  - A piece of Galena
  - A piece of wood
  - A piece of stone
  - A piece of plastic
  - A piece of cork

Method
This experiment is a way of measuring the comparative density of different objects.

Carry out tests to compare a number of different materials.

1. Fill the tank with water
2. In turn, drop each of the pieces of material into the water
3. Record which materials float, which sink and how quickly.
4. Discuss the findings

Conclusion
Ask each individual or team to write down the answer to the question, describe their role in carrying out the experiment and give examples of their findings as supporting evidence.

2. On-site at Killhope - Forces in Action

Inside the Lead Mine: Extraction Processes
Outside the Lead Mine: the *GALENA* (lead ore) Separation Processes

This briefing uses the scientific language of **FORCES & MOTION** that the children should have experienced in the pre-work experiments they have done at school to describe the mine and miners' tasks at Killhope and will have reinforced during the on-site learning experience with the Information Assistants at Killhope.

You will recall that the pre-visit experiments are designed to echo both the physical shapes and practical application of tasks and activities experienced around the Lead Mine. Repetition and reinforcement of the science of **Forces and Motion** through on-site and off-site learning are key benefits of relating this area of the national curriculum science to what was a real life situation – lead mining at Killhope.

This Creative Science On-site Briefing on Forces and Motion covering the Lead Mining and Lead Separation Processes is divided into TWO Sections that relate to two separate locations on the site. **Inside the Lead Mine & Outside the Lead Mine.** The Vegetable Garden is not covered.

2a Inside Killhope Lead Mine

Keeping Killhope Lead Mine Safe & Open

Two major problems were experienced inside the underground lead mine

1. Water
2. Air

1. Water

In Killhope Lead Mine, water was both *useful* and a *problem* for the miners. Water power was used to help the miners in some places but, at the same time, in other places it got in their way.

Flood Prevention

Later in its history Killhope Lead Mine installed large hydraulic machines driven by **WATER POWER.** These machines **PUMPED** water **UPWARDS** from the lower levels of the mine. At ground level the floor of the mine was built with sloping floors leading towards the entrance. The water drained down the slopes and out of the mine.

2. Ventilation

When people worked underground, they needed good air to breathe; therefore the mine needed constant ventilation. This was done in a number of ways.

Water blasts

WATER was used to bring air into the mine. Large amounts of water were collected above the mine and released down pipes from the surface.

The **FORCE OF GRAVITY** pulled the water down the pipe. As this water moved down the pipe it sucked air into the pipe from the surface.

Fans

Large fans – *windy billies* - were installed inside the tunnels. Young boys used **MUSCLE POWER** to turn handles which drove these fans around to circulate the air.

Inside Killhope Lead Mine - Task by Task

Task 1: Drilling Holes for Gunpowder Charges

It could take up to six hours and more for a miner to 'drill' just one hole in the hard rock face using a hand held hammer and chisel.

FORCES USED

The **FORCE** of the miner using a sledge hammer to hit the end of the chisel or 'Jumper' generated energy.

This energy travelled along the length of the 'Jumper'. The repeat actions of the miner using a sledge hammer and chisel in the same place slowly formed a hole in the rock face to put the gunpowder in.

Task 2: Hacking out with Pick Axes

Miners used hand held pick axes to break into the rock and softer lead ore.

FORCES USED

Initially, the sharp end of the pick axe was **PUSHED** into the soft ore. Once embedded into the rock and ore, the **PUSH** was reversed down the pick axe handle and the rock and ore together were **PULLED** away from the rock face.

Task 3: Loading the Tubs with Rock and Ore (Bouse)

This was done in two ways:

1. Chunks of rock and ore were hacked off from the rock face or from above the heads of the miners and fell down chutes into the empty tub placed underneath where the men were working.

2. Other large and heavy chunks of rock and ore fell onto the floor of the mine. Miners using either their hands or hand held shovels lifted up the rock and ore and put it into the tubs.

FORCES USED

1. Rock and ore were **PULLED** by the **FORCE OF GRAVITY** down into the empty tub
2. **OPPOSING THE FORCE OF GRAVITY** rock and ore were **PULLED** up and away from the floor of the mine with a greater force than the **PULL OF GRAVITY** was pulling down.

Task 4: Backfilling

The waste material left on the floor of the mine was used as backfill. The heavy rubble was lifted up using hand held shovels then thrown into the empty spaces that needed to be filled to prevent the tunnels collapsing.

FORCES USED

OPPOSING THE FORCE OF GRAVITY rubble was **PULLED** away from the floor of the mine with a greater force than the **PULL OF GRAVITY** was pulling down. Then **CHANGING THE DIRECTION OF THE FORCE** a **PUSHING FORCE** was used to throw the waste material to the place where it could be used as backfill.

Task 5: Rolling the tubs full of Bouse (rock & lead ore) out of the mine

On their journey out of the mine the tubs were full and very heavy. A great **FORCE** was needed to move them. Sometimes miners **PUSHED** the tubs out. More often horses were harnessed to **PULL** them out of the mine.

FORCES USED

The tubs had metal (iron) wheels and ran in and out of the mine on metal (iron) rails to reduce **FRICTION** and so make them easier to move.

The mine tunnel had a slight downward slope towards the outside. So the **FORCE OF GRAVITY** also helped to make it easier to roll the heavy tubs out of the mine.

Horses **PUSHED** against their harnesses and this **FORCE** was then used to **PULL** the tub**.**

2b Outside Killhope Lead Mine

Lead Ore (*Galena*) Separation Task by Task

Task 1: Rolling the tubs full of Bouse from the Horse Level entrance to the Teems

The full heavy tubs were moved further on rails from the Horse Level entrance to the Teems. Once they arrived over the Teems, the tubs were emptied from the higher level of the Tub Track to the lower level of the Washing Rake where the next process took place.

FORCES USED

At the Teem where the tubs were emptied of their cargo the **FORCE OF GRAVITY** assisted in transferring the *Bouse* from the higher level of the Tub Track to the lower level of the Washing Rake.

Task 2: Moving, Breaking up and Sorting the Chunks of Bouse The Washing Rake and Knock Stone

1. The *bouse* (mixed rock and lead ore) had to be broken up into smaller pieces - either by hand or machine - before the main separation process could begin.

2. Teams of young boys lifted the largest lumps of *bouse* into wheel barrows and moved their loads away from the Teem to the sizing gratings, crushing rollers or the knock stone.

3. Other younger boys filled their shovels with heavy pieces of mixed rock and lead ore (*bouse*) and carried this directly over to the washing rake (grating). Here they tipped out the contents.

4. Another team washed and 'agitated' the *bouse* using hand held rakes to begin to separate the Galena from the unwanted rock/ stone.

5. The running water from the stream below the grating (washing rake) was used in two different ways. First to carry away the unwanted mud leaving only lumps of rock and ore. Second to carry away smaller stones/ grains of both unwanted rock and the dense Galena.

6. Tiny pieces of Galena and rock/ stone slipped through the grating into the stream of running water below and were carried down to the next separation stage. Here the aim was to recover even the smallest pieces/ fragments/ grains of Galena.

7. Galena is the first material to be pulled to the stream bed whilst the other materials are carried further down the stream by the water, separating the valuable lead ore from the waste.

FORCES USED

Boys transferred chunks of *bouse* into wheel barrows by **PULLING** against the **OPPOSING FORCE OF GRAVITY** that was holding them on the ground. Then again **PULLING** against the **OPPOSING FORCE OF GRAVITY** they lifted the wheelbarrow legs up off the ground and **PUSHED** the load away on the one wheel.

Other boys filled shovels with smaller pieces of the heavy *bouse* and **PULLING** upwards against the **OPPOSING FORCE OF GRAVITY** carried them over to the washing grating (washing rake). Here they tipped the shovel over allowing **THE FORCE OF GRAVITY** to **PULL** the loose rock/ stone and lead ore down towards the grating ready for washing.

Another team **PULLED** and **PUSHED** the rake across the piles of *bouse*.

THE FORCE OF GRAVITY PULLED the very small pieces/ grains of Galena and rock/ stone through the grating down into a stream of running water below and the next stage of the separation process.

Galena - lead ore - has a greater density than most other minerals and materials found with it. Therefore, being **PULLED** down by the **FORCE OF GRAVITY** and working against the **UP THRUST OF THE WATER**, the Galena was the first material to be **PULLED** to the bottom of the stream. Other materials were carried further down the stream by the water, separating the valuable lead ore from the waste fragments/ grains of rock/ stone and mud.

Task 3: The Hotching Tub

Piles of the smaller rock and ore from the Washing Rake and Knock Stone were shovelled into a large basket with a metal sieve at the bottom suspended in a wooden tub full of water. This was called a 'Hotching Tub'.

The 'Hotching Tub' had a long wooden handle that was also attached to the frame. This handle allowed the basket to be shaken up and down.

As the basket was shaken or agitated by moving the long handle up and down water flowed through it. The valuable Galena was separated from the other materials and gathered at the bottom of the basket.

FORCES USED

When the handle of the Hotching Tub was **PUSHED** upwards, the basket was **PULLED** downwards by the **FORCE OF GRAVITY**.

When the handle was **PULLED** downwards, the basket was **PULLED** upwards opposing the **FORCE OF GRAVITY**.

The action of the **LEVER** being quickly **PUSHED** and **PULLED** up and down continually shakes or agitates the small pieces of rock and ore in the tub full of water. This allows the Galena to move downwards by the **FORCE OF GRAVITY**.

As mentioned already, Galena – lead ore - has a greater **DENSITY** than most other natural rocks and ores.

Task 4: Park Level Water Mill - Water Power – The Major Force

The Mill Wheel

The Killhope mill wheel is driven around by the **FORCE of GRAVITY** acting on numerous buckets of water.

The wheel is called an 'Overshot' wheel because it is powered by water flowing down the hillside from mill ponds above on higher ground. The water is poured over the wheel from a channel at the top.

The water flows from the channel onto the wheel and is caught in a series of buckets. As each bucket fills up, it becomes very heavy. The **FORCE of GRAVITY** then **PULLS** the bucket down towards the 'centre of the earth'. At the bottom of the wheel's cycle the bucket is emptied out, making the bucket lighter once more. It is then taken round to the top to be filled up all over again. Each bucket is filled and emptied in turn continuously, therefore, the wheel is kept turning continuously.

The water wheel was used to provide power to work the machines that carried out the processes of separating the lead ore, processes that had previously been done by the muscle power of men and boys.

On-site Activity:
The Force of Gravity and Working of the Water Wheel

The force of gravity and working of the wheel can be easily demonstrated near the bottom of the wheel by using the large weighing scales on the loading platform.

1. Place empty buckets on either side of the scales

2. Fill one full of water – observe it being 'pulled' down towards the 'centre of the earth' in exactly the same way as the buckets on the wheel are pulled down. This is the weight of water and force of gravity at work!

3. Tip the water out and it will rise up again

Task 5: The Jigger House Machinery

The **FORCE OF GRAVITY** was used to turn the Water Wheel. The power of the wheel was transmitted by shafts and belts and used to drive the machinery housed within the Jigger House.

The water power of the mill wheel kept a number of mechanical Hotching Tubs – Jiggers - working. Machine power had taken over from the physical exertion of manually pulling and pushing handles up and down to separate the Galena.

Jiggers worked in the same way as the earlier Hotching Tub. **GRAVITY PULLED** the dense Galena to the bottom of the tub when the mixed *bouse* was agitated in water.

3. Post-visit Follow Up – Creative Forces

3a KS1: Forces and Fairy Stories Link to Literature

If you are planning to make strong links to literature you can extend this activity either before, during or after a visit to Killhope using **1a KS1 Fairy Tale Forces: The Vegetable Garden, Activity 1: Story Telling – The Gigantic Turnip**

Activity: Forces and Fairy Stories

- Invite children to create their own stories based on the 'Forces' they have studied during pre-visit sessions on Folk Tales.
- Fairy Stories are part of an oral tradition which is why there are so many versions. So, children could tell each other their stories, practising speaking aloud, and make recordings.
    - These stories could relate to enormous vegetables, like The Gigantic Turnip
    - Or, they could be about giants with huge strength hiding in the mine and hewing silver and gold – not lead – and making all the Killhope miners and their families very rich
- The class can then create two murals – one Fantasy and one Factual.
    - The Fantasy Mural can include forces portrayed in traditional fairy stories and in the ones the children have created
    - The Factual Mural can cover the story of Killhope

3b KS2: Design Make & Test a Water Wheel
Link to Art & Design

This activity also links to

1c Forces at Work at Killhope Lead Mine Activity 1: Scientific Issues & Principles – KS1 & KS2 – Gravity

1d KS1 & KS2 Discovering Forces at Killhope Activity 1: Experiment – Gravity

2. On-site at Killhope - Forces in Action 2b. Outside Killhope Lead Mine Task 4: Park Level Water Mill - Water Power – the Major Force: On-site Activity: The Force of Gravity and Working of the Wheel

Here you are given the design to make a simple water wheel which produces power.

- Carry out a series of power or force tests.
- Record the results on a bar chart on the computer.

Activity: Design for Making a Simple Water Wheel

Equipment

2 litre plastic drink bottle
Flexi-straw
Round margarine tub
Hand drill
Bobbins (cotton reels)
Dowel (20cm) to fit the centre of a bobbin
Correx or balsa wood
Glue
Sellotape
String
Hook

Method

Drill a hole in the side of the plastic bottle near the bottom

Glue a flexi-straw through the hole

Drill holes through the margarine tub to take an axle
(The holes should be in line to allow the axle to turn)

Glue the bottle to the up-turned margarine tub
(The holes should be directly underneath the flexible straw coming out of the bottle)

Glue paddles made of Correx/ balsa wood to the bobbin

Glue dowel into the bobbin

Fit the bobbin/ dowel arrangement through holes in the margarine tub (with the paddles underneath the flexi-straw from the bottle)

3c KS2: Killhope Theatre without Words
Link to Movement & Dance

Note: this creative session can be adapted for KS1 pupils but will need to be simplified and exclude reference to the Killhope underground lead mine.

Introduction

When we discuss **FORCES** in science, to describe how they work is a complex issue, but when we come to describe what they actually are, the language that we use is full of active, descriptive, vibrant words e.g. **PUSH, PULL, LIFT, HEAVY, LIGHT, STILL, MOVING, FAST, SLOW** etc. etc.

With creative activity, these types of simple words, often verbs, are the very essence of movement. They contain non-verbal information easily understood by a child. They give texture to the quality by which something can be identified, described and re-created. Forces, and the words associated with them, become translated into the 'energy' of creative dance and 'Theatre without Words'.

Activity 1: Theatre without Words -The Mining Processes - Movement

If we asked children to 'act out' the mining processes which they will have observed at **Killhope** they will have gathered rich resources from their visit to recall and use. The **FORCES** the children have observed being harnessed by the machines or descriptions of the manual activities of the historic miners are examples.

Therefore acting out the mining process, which would include demonstrating the 'size of effort and energy' contained within each element of each task from Killhope in their performances, would be quite a creative challenge for them and reinforce the **FORCES** debate.

Their brief could be to start at the beginning of the mining processes and physically describe each task in the order they remember them, putting in effort and energy as they do so.

- If they were to demonstrate and become the lead miners themselves underground, what kind of energy does it take to swing a pick axe, pull rock and ore from a rock face or lift a large chunk of rock and ore into the tub?

- If they were to demonstrate and become the process of getting the full heavy tubs out of the mine, what kind of **FORCE** would be needed to move the tubs by the horses or the men?

- The washing rake holds many opportunities for re-creation especially the process of raking the rock and ore over the metal grating.

- At the Knock Stone if they were to become not just the miner with the hammer breaking the rocks apart, but the actual rock itself breaking apart, what movement and what energy could they use to describe that?

- If they were to demonstrate the actual working of the machines themselves: the water wheel, the hotching tubs, the crushing rollers, the jigger house tubs, they would be able to recreate these things with a physical quality which contains the energy and **FORCES** they actually observed.

Activity 2: One Small Step for Killhope - Creative Dance

If you take the activity described above, or a discussion with the children of what they remember from the visit you can reduce the whole sequence of activities used in the lead mining process down to a series of ‘energy specific’ movements. This is the essence of Creative Dance.

Stand the class in two lines or just spread out randomly. You can choreograph the dance from the front or middle of the group, it doesn’t matter.

Start at the beginning of the process: the miners hacking their pick axes into the rock face and pulling the rock and lead ore away. That breaks down into just two simple movements, but all the time using the assumed real energy:

- Hands together and an energetic swing starting from over the shoulder from right to left ending in a sudden stop for both hands

- A long strong slow pull backwards ending in a quick jump backwards.

The next steps may also be quite logical taken from the sequence of mining tasks:

- Big circle with both arms(one each side) to finish at the bottom of the circle

- Bend to the floor
- Straighten up slowly as if lifting the heavy rock
- Slow turn to the left
- Exaggerate dropping the heavy rock into the imaginary tub
- Step to the right and turn to push the tub or to the left and turn to pull the tub
- Push or pull the tub out of the mine slowly and with great exaggerated effort
- An so on and so on

This process can carry on through the whole of the sequence of mining tasks. Just pick out energy specific movements taken from actual activities, exaggerate them, and join them together.

Repetition of steps as you build up the ‘story’ will enable the children to learn the dance better and also appreciate more the **FORCES** used in each step of the actual process.

The above process defines human activity, but your dance need not be so literal. Take the individual movements contained within some of the machines and the effort and energy of the forces that the children observed. Discuss with them what the most conspicuous movements were and what they remember most about them. You can exaggerate and recreate these movements in dance as well.

Activity 3: The Water Wheel – Creative Dance

The Water Wheel is the most conspicuous and impressive machine at Killhope.

For creative dance work for small groups:

- Discuss, identify and improvise movements to define the different elements contained within the water wheel. These may be different mechanical parts e.g. the wheel going around or the different elements in the whole operation e.g. the fast running water splashing onto the wheel.
- Fit the different movements together into a continuous dance routine (which needn't be completely logical) which contains all the elements and reflects all the different energies being used and possibly counter-pointed.

You may want to try different groups recreating different machines. Each group can then move around to each machine developing different ideas. This process will progressively improve confidence to try more complex routines.

You could also develop a hybrid movement and dance activity between human and object, similar to the 'acting without words' exercise.

Activity 4: The Knock Stone – Creative Dance

The actual activity of a number of miners breaking rocks apart on the Knock Stone - for creative dance work in pairs (a & b):

- For dancer (a) discuss, identify and improvise the dynamic movement used in swinging a hammer, both heavily and lightly, with one hand or both – now exaggerate it.
- For dancer (b) discuss, identify and improvise the dynamic movement of a rock being broken apart; either a large rock, a small one or both. Now exaggerate that (but not too much).
- Find out where the two sets of movements may be synthesized together into a performed duet.

If you wish, you could get the children to add simulated noises into their dance to accompany the movements.