Module 3: Energy and Movement
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Section 1: Everyday forces - investigating movement

Key Focus Question: How can we find out and build on pupils’ ideas about forces?
Keywords: force; investigation; brainstorming; floating; games; friction

Learning Outcomes
By the end of this section, you will have:

- used different methods to find out pupils’ ideas about forces around them;
- considered how to record your own and pupils’ learning in this topic;
- supported your pupils to do investigations in small groups.

Introduction
The most obvious thing about our world is the amount of movement that is happening almost all the time. What powerful natural forces drive this movement? What is force, and how do we explain its effects? How do we make use forces to make life easier or better? Here we look at different ways to find out how pupils make sense of everyday forces. As their teacher, your challenge is to help them explore and assess possible explanations for how forces cause changes.

1. Discussing Forces in everyday life

How do you, the teacher, find out what your pupils already know about forces and motion? And how can you extend these ideas and link them to current scientific understanding?

In Case Study 1, a teacher raises her pupils’ awareness of all the force events around them. From the start, she challenges their understanding by asking them to see themselves as thinkers with scientific minds.

In Activity 1, you ask pupils to identify and describe forces at work captured in photographs. By trying to make sense of what they have identified, they will be increasing their science awareness with your help.

Case Study 1: Challenging pupils to see forces everywhere

Eugenia in Abuja, Nigeria, is an experienced teacher who has learned to trust her pupils. When she did an upgrading course some years back, she realised how following traditional ‘jug and mug’ (where the teacher has the ‘jug’ of knowledge and pours it into the ‘mug’ of the waiting student) teaching had led her to underestimate her pupils. Now she tells less and challenges them more.
She began the topic of ‘force’ by suggesting to her class that they have a ‘Force Week’, where nearly everything that happens will need to be explained in relation to ideas about force and movement (motion).

First thing on Monday, as they wrote the date in their books, she told them to stop and think if any force was involved in making marks on paper. A lively discussion followed. She encouraged them to investigate by making different marks on scraps of old paper. They came up with ideas that surprised and even challenged Eugenia.

‘We pull the pencil across the paper.’

‘But I push the pencil!’ exclaimed Danladi, who is left-handed.

‘The ballpoint pen slides easier than a pencil.’ – ‘Maybe the ink is like oil for a bicycle.’

‘Rough paper scratches more colour off the point of the crayon than shiny paper.’

‘Look Ma’am, you push and you pull when you rub out. Rubbing is a different kind of force.’

How do you turn a page when you read a book? This question led to more discussion about gentle pulls, pushes and lifts, and holding up books against gravity.

Identifying forces in everyday happenings really excited the class. Soon, pupils were discussing and trying to explain all sorts of event.

Activity 1: Identifying forces in action pictures

You will need to collect good pictures from newspapers or magazines depicting force in action and effects of forces. Ask some pupils to help you cut out paper arrows of two colours (colour-coded for pulls and pushes) and three sizes. (See Resource 1: Finding forces in pictures.)

Pupils work in threes to look carefully at a picture for evidence of forces in action. Mark all the pushes and pulls with arrows that show the direction of force and prepare to discuss and share what they believe. See if they realise that different-sized arrows can be used to compare the size of the different forces they find. Do they notice that you get changes in movement when forces are not balanced?

Ask the groups to join into sixes to explain, check and challenge each other’s ideas.

Was asking the groups to assess each other’s work successful? Did it lead each group to understand the size, direction and effects of forces better?

2. Using games and brainstorming to learn about forces

Forces and motion are part of the games and sports children play.

You can use this to determine what your pupils already know and to encourage them to challenge their own thinking. By doing this, they will be extending their understanding. Case Study 2 shows how pupils can learn things about force and motion through games and competitions.
Activity 2 builds on pupils’ identification of forces from Activity 1. We integrate science and language work to help us describe forces and their effects more accurately in a brainstorm activity. (See Key Resource: Using mind maps and brainstorming to explore ideas.) There are no ‘right’ or ‘wrong’ answers in a brainstorm, but you are challenging pupils’ thinking by encouraging them to speak their thoughts. An important part of learning in science is communicating ideas and practising using scientific vocabulary.

Case Study 2: The class force Olympics

Mr Kabahizi set up a series of games and competitions one Friday. He thought carefully about how these games would show aspects of force. He realised that wrist wrestling would show how forces work in pairs and that, if opposing pushes are balanced, there is no movement. He thought how he could use blow football to illustrate forces acting on a moving object – air blown through the straws would cause movement, change of direction and slow or even stop the table-tennis ball. Tug-of-war would get the pupils thinking about balance, and being pulled off balance.

Before each game, Mr Kabahizi asked his pupils to predict what the game would teach them about force. Then, as the game took place, he took the role of commentator, describing what was happening and providing extra information about the effects of forces. In this way, they were thinking about the forces involved as they experienced the effects directly.

The next week, Mr Kabahizi and the pupils reflected on the ‘force Olympics’ and made notes and drawings to show what had been learned. (See Resource 2: Force games.)

Activity 2: Force action words

Space out the words ‘Pulls’, ‘Pushes’ and ‘Twists/Turns’ on the chalkboard (or on separate sheets of newsprint).

Brainstorm all the force action words the pupils can think of and form word spiders (word burrs) for each term. (See Resource 3: Force word spiders or burrs for examples of pupil’s work.) Encourage your pupils to use all languages they understand and use.

Discuss the words and actions with pupils, using mime to demonstrate (e.g. what are you doing when you ‘wring’ out a damp cloth to squeeze out the water?). Check if the words represent pushes, pulls or circular movements. Expect some healthy disagreement. Give your pupils time to discuss conflicting ideas and praise their logical contributions.

Finally, organise your pupils to display the selected words alongside pictures or objects that illustrate the force action (e.g. ‘screw’ could show a screw or screwdriver, ‘tear’ could show torn fabric, ‘crumple’ could show a crumpled drinks can).

3. Organising investigations in to friction

Resource 4: Summary of forces summarises what a teacher could be expected to understand on forces and motion.
Primary pupils need to experience a range of practical experiences and have chances to talk and think about what they have been finding out. There are many activities that would extend your pupils’ ideas about forces, for example looking at balls rolling down slopes at different angles and pushing or pulling shoes along different types of surface.

**Case Study 3** shows how Mr Kabahizi reflects on what he has achieved with his class. How do you reflect on your learning and that of your pupils? What would you record about your learning in this topic?

In the **Key Activity**, you guide the pupils through thoughtful investigations around a force that slows objects down – friction. This extends the work of **Activities 1 and 2**, where you encouraged pupils to speak their ideas. At the same time, you can assess their developing understanding by listening carefully to what they say.

### Case Study 3: Reflections of a teacher

Here are Mr Kabahizi’s notes on what he feels his pupils have gained from doing half a term’s work on force. (This involved a number of different experiments and discussions, those in this section and some based on the ideas in **Resource 6**.)

- Confident they know forces are pushes or pulls or combinations of both.
- All pupils know that forces are involved when things start and stop moving and make turns.
- Some pupils know that the forces on a stationary object are equal and opposite but many find this difficult, as they can’t see any forces acting.
- They have good experience of most forces that require actual contact – but many are not sure about forces exerted over a distance (for example repulsion and attraction of magnets and static electricity).
- The class is pretty clear about effects of gravity and most pupils have some idea that ‘weight’ is the force they exert on our planet and that this would change if they were on a different planet.
- Need more work on friction. Some pupils still puzzled that friction can be both useful and a problem.
- Need to improve our models of force meters, which show how to measure forces accurately.

### Key Activity: Reducing friction

Give your pupils opportunities to work in groups (see **Key Resource: Using group work in your classroom**) to set up their own investigations.

This investigation looks at reducing friction. Write this question on the board: Which substances are better at reducing friction? Some ideas of substances to use are chalk, cooking oil, margarine and soap, but let your pupils try their own ideas. (See **Key Resource: Using investigations in the classroom**.)

Depending on the equipment you have:

- Pupils could use a shoe with weights (heavy stones would be ideal) on a piece of wood. If they tilt the wood the shoe will slide. The more they need to tilt the wood the greater the friction. How does the angle change when they rub different substances on the wood?
Or pupils could use an elastic band to propel a coin across different surfaces. If the elastic band is pulled back the same amount each time, the coin will get the same pushing force each time. Pupils can then measure how far the coin travels on different surfaces.

Support their planning of investigations including their predictions – what they think will happen and why. How will they clean the wood in between experiments? How many times will they try each substance? Resource 5: Investigating friction provides a planning sheet to help pupils with their investigations.

Give them plenty of time to carry out the experiment. Encourage them to record their results in a table.

At the end of the investigation, ask them to what their results mean. What advice would they give to people who wanted to know how friction could be reduced? They will be behaving, talking and thinking scientifically – which is great.

Think about how your pupils could present their work: will you ask each group to present to the class? Or make a poster to show their results?

(Look at Resource 6: More ideas for experiments around forces for how to support and encourage more investigations.)

Resource 1: Finding forces in pictures

Teacher resource for planning or adapting to use with pupils
Resource 2: Force games

Teacher resource for planning or adapting to use with pupils

The standing one-hand boot throw
A competitor stands outside in the open with both feet on an agreed line with a large size boot, which they proceed to throw as far as possible, without moving their feet.

- What is the best way to measure/compare distances?
- Is this a push or a pull?
- Discuss other examples, like throwing a 1.5 m stick or heavy stone. Explain that these are like sports activities such as javelin throwing and shot put.

Wrist wrestling rules
Opponents face each other on opposite sides of a desk with left hands on laps. Their right elbows are on the table in front of them in line with the opponent’s elbow (elbows should not move). They grasp hands and at the instruction ‘PUSH!’ each tries to push the back of their
opponent's hand onto the table to score a point. First to three is the winner who then accepts further challenges. (A variation is to alternate hands.)

This is a good example of balanced forces, but as one weakens, the more powerful force results in a movement.

**Blow football**

Blow football is played on a large empty table with a ping-pong (table-tennis) ball and two or three players per team. The ball can only be moved by air blown through straws.

A goal is scored when the ball is blown over the far end of the table. A game lasts five minutes each way. If the ball goes off at the side, the opposite team has a free blow-in from the place where the ball left the table. If the ball is touched by a player or a straw, the opponents get a penalty blow and all other straws must be at least two straw lengths away.

This is an example of pushes on the ball from the air.

**Tug-of-war**

Two opponents stand sideways, foot to foot. They hook little fingers together. At the command pull, they both try to pull the other off balance. The first person to move or lift a foot is the loser.

All these games show the effects of forces clearly and give pupils a good chance to experience and think more carefully about how forces operate. Many other possible push and pull games exist and new ones are waiting to be invented.

**Resource 3: Sample of pupil's work**

**Example of pupils' work**

Here are some examples of pupils’ work.
Resource 4: Summary of forces for the teacher

- **Background information / subject knowledge for teacher**

- Forces are pushes and pulls.
- A force has two characteristics: size and direction.
- When forces act, they can change the shape of the things they act on. There is a bigger change from a bigger force.
- We can use the change to provide a quantitative measure of forces.
- Forces can be measured using a spring balance or force meter (newtonmeter) in units called newtons.
- An object’s weight is the force of gravity acting on it, thus weight is a force.
- The mass of an object is a measure of the amount of matter in it. It is constant and does not change.
- All objects exert a force on each other: the size of the force depends upon their masses.
Gravity is the force that holds you down to the planet Earth. The force of gravity is smaller on the moon than on Earth because there is less matter in the moon (smaller mass) than in the Earth. On the Earth, every kilogram is pulled by gravity with a force of around 10 newtons towards the centre of the Earth. There is a distinction between mass and weight. Mass is an intrinsic property of an object – no matter where you are, you always have the same mass. Your weight is the gravitational force that acts on you. Your weight acts downwards, towards the centre of the Earth. Mass and weight have different units. Mass is measured in grams and kilograms, whereas weight (a force) is measured in newtons. Friction is a force that resists movement. A force is needed to start something moving, speed it up, slow it down or change its direction. The bigger the force, the greater the acceleration (or deceleration) on a fixed mass. When no overall force is acting on an object, it will remain stationary or continue at a steady speed in a straight line.

Adapted from: Developing Subject Knowledge – Jane Devereux

Resource 5: How can we reduce friction

Pupil use

Friction is the force that stops your shoes from sliding across the floor. This helps you not to slip over. But sometimes we want to reduce the amount of friction – how can we do this?

Work with your partners to complete this planning sheet for your investigation.

We are trying to find out:

We think that these substances will reduce friction: (give 3–5 ideas)

We predict that the substance that will be best at reducing friction is:

We think this because:
Our investigation:

We will need: (list your equipment)

What we will do:

What we will measure:

What we will change in each experiment:

What we will keep the same:

Our results:
Try to draw a table to record your results.

We found out that the best substance to reduce friction was:

Was your prediction correct?

Did you experience any problems in your investigation? What were they?

Resource 6: More ideas for experiments around
forces

Teacher resource for planning or adapting to use with pupils

1 Using springs to measure forces:
   a. Make a class list of everything the pupils have seen that includes a spring.
   b. Show how a spring stretches with a pulling force and measure how much it stretches.
   c. Use a spring to measure forces around the classroom – measure how much the spring changes in length. (You can make a spring from a 50 cm length of copper wire or you can use a strong elastic band instead of a spring.) Some forces to measure include door opening, pulling a chair along the floor, pulling a pen or pencil, opening a clothes peg.

2 Cutting down friction in water – making streamlined shapes: Ask pupils to draw the shapes of fish, boats and diving birds. Which sort of shape is best for going fast through air or water?
   Pupils make different shapes with lumps of clay or plasticine. Drop these shapes through a tall tank of water and time how long it takes each to get to the bottom.

3 Forces at a distance:
   a. Use a magnet to pick up steel pins. Ask pupils to slowly move the magnet towards the pins. What is the distance between them when the pins first start to move?
   b. Rub a plastic pen or ruler on a cloth (e.g. a duster). This gives the pen or ruler an electric charge. Now try to use the pen or ruler to pick up small pieces of scrap paper. How many will it pick up?
   Ask pupils to explain what they think is happening in each of these experiments.

4 Forces and weight: Weight is a special sort of force caused by the Earth attracting everything on it or near it.
   Ask pupils to use a spring or elastic band to make a weighing machine that measures the pull of the Earth on objects. They will need to make a scale for it.
   Then talk to pupils about how the weight of these objects would be different on other planets in the solar system or on the moon. Larger planets exert a larger force on another object and smaller planets or bodies exert a smaller force.

Section 2: Exploring sounds and music

Key Focus Question: How can you involve your pupils in assessment?
Keywords: musical instruments; assessment; local resources; game; project

Learning Outcomes

By the end of this section, you will have:
Introduction

From a very early age, we respond to familiar sounds – a baby will respond to its mother’s or carer’s voice for example – and we learn new sounds very quickly. Your pupils will have learnt to recognise a large number of different sounds. In this section, you support your pupils’ developing ideas about sounds and how they are produced. The emphasis is on practical activities and active learning. Do you play an instrument yourself? Or know someone who could visit your classroom to play to your pupils?

This section also explores ways for helping pupils to assess their own work. (See Key Resource: Assessing learning.) Being involved in assessment helps pupils understand their learning and set goals for future progress. It also builds self-confidence and enthusiasm for learning.

1. Using stories and games to introduce sound

It is always wise to start by finding out what pupils already know. Pupils will recognise many different sounds, but they probably haven’t considered different qualities of these sounds like pitch (low notes or high notes) and volume (loud or soft).

In Activity 1, you play a guessing game with your pupils, where they try to identify sounds and explain how they think the sounds were made. This involves pupils scoring their own answers, one way of involving them in assessment.

Don’t dismiss answers that seem incorrect – encourage pupils to explain their responses. You can learn much about their understanding from what they say. Afterwards, think about what they said – was there anything that surprised you?

Case Study 1 shows how one teacher used a local story as a starting point for pupils’ questions about sound. Do you know any stories from your own culture that you could use? Or could you ask a member of the local community to visit your school to tell a story? Could one of your pupils tell a story?

Case Study 1: Using a folktale to start the topic ‘Sound’

Ms Sarpong, who teaches in South Africa, but comes from Nigeria, used a Nigerian folktale about a swallowing drum to introduce the topic ‘sound’ (see Resource 1: Sound story).

When she told the story to her pupils, she beat three different-sized drums to demonstrate the ‘bim’, ‘bam’, ‘bom’ sounds of the drums in the story.

After the storytelling, they discussed the sounds in the story and how they were made.

Some groups investigated how drums make sound, by using grains of dry rice on the surface of the drums to see the vibrations. They also tried to get different sounds from the same drum.
Other groups investigated what happened when they blew air over the tops of different sizes of empty plastic bottles. They made notes of what they found out, and later they shared what they had thought about and learned.

Finally, they made a list of all the questions they had about sound and displayed it on the classroom wall. Ms Sarpong encouraged them to think of ways they could find out the answers for themselves.

Activity 1: A sound guessing game

Gather 10–12 different objects that make interesting noises – include both familiar and unusual sounds. You might include sounds recorded on a cellphone. Before pupils come to class, you will need to set up a screen to hide from view both the objects and the action that makes the sound.

Settle the pupils and explain what you have planned. Tell them that they will be expected to assess their responses honestly.

From behind the screen, make each sound in turn. Pupils need to write down how they think the sound is made.

At the end, show how each sound was made and pupils score the sounds they identified. Finally, ask the pupils if all the sounds were equally easy to identify? How did they identify the more unfamiliar sounds? What clues helped them to identify the sounds?

2. Working in groups to investigate sound

Sounds are made by vibrating objects. The vibrating object causes the air particles to move closer together (compress) and then apart in a regular pattern – this is called a sound wave (see Resource 2: Sound waves). Thus the air carries the sound to our ear.

In Activity 2, you ask your pupils to use everyday objects to make sounds and see how they can change these sounds in different ways. The pupils should carry out this investigation in small groups. (See Key Resource: Using group work in your classroom.) Spend some time at the end of the investigation talking to your pupils about how the groups worked; do they have ideas about how they could work together more effectively in the future?

In Case Study 2, a teacher uses an interesting set of questions to encourage pupils to think about their work – another way of involving them in assessment.

Case Study 2: Measuring how far sounds travel

Mrs Mukamanzi organised her multigrade class into groups of six pupils of different ages. Each group was given some wooden blocks.

She asked them to find out how far the sound of blocks clapped together travelled. Each group organised their own investigation. (See Key Resource: Using investigations in the classroom.) When they had planned their investigation and decided who would carry out each task, she let them work outside. Groups recorded results on a poster.
After they had completed their investigations, Mrs Mukamanzi gave them the following questions to discuss in their groups:

- Did they get an accurate answer to the question (results)?
- Were they happy with their data?
- What would they do differently next time?

Mrs Mukamanzi knew this was a good way of helping her pupils to reflect on their learning. The pupils came up with some excellent ideas, including that the wind varied and affected the results, not everyone’s hearing is the same and that other noises were distracting.

**Activity 2: Exploring changing sounds**

Organise your class into small groups to investigate ways to change the sounds made by a range of objects. Give each group one set of equipment – here are some ideas:

- Use different-sized upturned tin cans as drums.
- Fill five identical glass containers with different levels of water and tap them with a pencil.
- Blow air over bottles of four different sizes.
- Use four identical plastic bottles filled with different amounts of sand as shakers.

Pupils could also choose something for themselves.

Ask your pupils to think about and then carry out investigations to find out:

- How are you making the sounds?
- How can you make the sound higher? lower? louder?

Each group records their results on a poster, including any patterns that they found. They also discuss:

- how well they have worked together;
- how they might organise themselves next time;
- how happy they are with the group ideas on changing sounds.

Groups could swap equipment if they want to do more experiments, but make sure that they have first recorded their results on the poster or in their book.

You may like to use Resource 3: Ideas pupils may have about working in a group to help your pupils with their discussions at the end of the experiment.

### 3. Exploring musical instruments

For centuries, people have developed musical instruments using local materials. These all involve plucking, hitting, blowing or rubbing to create vibrations of different pitch and volume. Many instruments also have a box of vibrating air to amplify the sound (make the sound louder). Try to find out about traditional instruments in your community – is there anyone who could come into your classroom and show their instrument?
The **Key Activity** and **Case Study 3** involve pupils exploring musical instruments – either from the community or those pupils have made themselves. In both cases, pupils develop criteria to judge the instruments. In the activity, you could also ask your pupils to develop criteria to judge their presentations.

Inviting local musicians into the school to demonstrate their instruments and to hear the pupils’ instruments would be a wonderful way to end the activity. (See **Key Resource**: Using the local community/environment as a resource.)

### Case Study 3: Involving pupils – what is best to buy?

Mrs Umurerwa involved her class in the choice of a musical instrument for the school choir. She planned a research project where pupils researched locally available musical instruments, such as the inanga, icyembe, umuduri, ingoma, iningiri, ikondera and umwirongi. The class suggested the kinds of questions that would have to be asked, the points to be awarded for each answer and how they would report back. These questions were put together to form a questionnaire. (See **Resource 4**: Ideas for judging each instrument.) Children worked in small friendship groups for homework to get answers to their questions.

To analyse the scores, Mrs Umurerwa made a table on a large manila sheet (also in **Resource 4** for hints). As the different groups brought in their reports, the scores were entered into the table. These points were all totalled up and, based on the instrument with the highest total score, the class decided to find out if they could buy one.

### Key Activity: Making musical instruments

Organise your class into groups of three (or more if you have a very large class).

Tell them that each group will make their own musical instrument, using what they know about changing sounds.

Ask each group to draw a rough diagram, showing their instrument and a list of what they will need to make it.

Ask each group to organise themselves to bring in materials from home.

The next day, give time for each group to make their instrument and prepare a three-minute presentation to:

- show the different sounds the instrument makes (louder/softer, higher/lower);
- try to explain how the instrument makes the different sounds.

Depending on the size of your class, bring groups together or into four larger groups.

With the class (or large group), develop a set of criteria to judge the instruments. Make a list of these criteria on the board. Discuss whether they are all of equal importance. (See **Resource 4** for hints.)

### Resource 1: Sound story

Teacher resource for planning or adapting to use with pupils
The swallowing drum

A small girl, an only child, lives with her parents in a certain village. Because of a terrible unspoken local danger, she is never let out of her parent’s sight nor allowed to go and play with other children. She feels like a prisoner in her own home and longs to be independent like the other children.

One day, she gets a chance to slip away when her father falls asleep after lunch. The mother has gone to work in the fields and the girl hopes to surprise her there. She is not certain of the way and when the path splits into two, she chooses the cool path by the river rather than the hot path over the hill.

After a while she comes across a small little drum, beating itself …

‘Bim! Bim! Bim! Little Girl! Little Girl, go back home.’

But the little girl is curious and she carries on regardless. Around another corner she comes across a middle-sized drum beating itself …

‘Bam! Bam! Bam! Little Girl! Little Girl, go back home.’

But the little girl is curious and she slips past the drum and carries on. Further on, what do you think she finds? Yes, a big drum beating itself …

‘Bom! Bom! Bom! Little Girl! Little Girl, go back home.’

Really curious, the little girl ignores this warning too. The path comes to the edge of the forest and as she enters the dark forest the trees close behind her.

She can only go on now – but there is a terrible drumming noise in the forest. She comes to a clearing and faces a truly enormous drum. It is the swallowing drum – the terrible danger that her parents were so terrified might get her. She gets swallowed by the drum and, as she falls to the bottom, other people and animals rush up asking her if she has anything sharp with her. But she hasn’t. All she can see as she looks up from her new prison is the slit of the mouth of the drum and a huge wooden heart beating …

Ba-boom! Ba-Boom! BA-BOOM!

Back home her parents are devastated when they discover her missing and see where her footprints lead. The father weeps and cries and covers himself with ashes from the fire. But her mother doesn’t rest – she goes around the village borrowing sharp things and she stays up the whole night stitching them carefully into the inner lining of her cloak.

The next day she sets out for the forest. She sees no drums but as she enters the forest, the trees close behind her.

She comes to the clearing and faces the terrifying swallowing drum, who asks, ‘Yes fat woman! What do you want!’ Before she can answer, she too is swallowed and the people rush to her asking if she has sharp things. But she first asks to see her daughter and then she shows them the sharp things. The men in the drum stand against the wall of the drum and the women stand on their shoulders. The young boys climb up with the sharp things and begin to chop away at the wooden heart…

BA-BOOM! Ba- boom! Ba-boom, b-bm

When the heart stopped beating, they chopped their way out of the drum, ran back to the village to fetch help and the dangerous swallowing drum was chopped into pieces. The people in that village had good firewood for more than a year.
Resource 2: Sound waves - teacher notes

**Background information / subject knowledge for teacher**

**What is sound?**
Sound is produced whenever an object vibrates. The object could be a string on a guitar, a flat surface such as a drum skin, the diaphragm in a loudspeaker or even the vocal cords. Sound transfers energy away from the vibrating object, and it needs something to travel through. Sound cannot travel through a vacuum – in space, no one can hear you scream!

**Speed of sound**
Sound travels at different speeds through different substances. In general, the denser the substance, the faster sound travels through it. Sound travels at 5,100 m/s through steel, 1,480 m/s through water and 330 m/s through air. This is much slower than the speed of light.

Light travels nearly a million times faster through the air than sound does. This is why you hear the thunder clap after you see lightning in a thunderstorm, and why the sound of someone hammering some distance away does not match the hammer blows.

**Echoes**
Sound can reflect from the surface of an object. This is called an echo. Hard surfaces reflect sound better than soft surfaces.

**Loudness**
The loudness of a sound depends upon the size of the vibrations. Big vibrations transfer more energy than small vibrations, so they are louder.

**Pitch**
A sound can range from a high to a low pitch (high to low note). The pitch of a sound depends on how fast the original object is vibrating. If there are lots of vibrations per second, the frequency is high and the sound has a high pitch. If there are few vibrations per second, the frequency is low and the sound has a low pitch.

**Checkpoint**
The table summarises some features of sound waves and vibrations.
Hearing
We hear because sound waves enter the ear and cause the eardrum to vibrate. Three small bones in the inner ear carry these vibrations to the cochlea (pronounced ‘kok-lee- a’). The cochlea contains tiny hairs, which send messages to the brain when they vibrate.

A diagram of the ear

Hearing damage
Our hearing is easily damaged and as we get older we find it more difficult to hear very low or very high sounds. The three small bones may join together as we age, so they are not so good at passing along the vibrations from the eardrum to the cochlea.
Loud sounds can eventually damage our hearing. If the eardrum is damaged, it may repair itself again, but if the cochlea is damaged, the damage is permanent. People with damaged hearing may find it difficult to follow conversations and may need a hearing aid. 

**Adapted from: www.bbc.co.uk**

**Resource 3: Ideas pupils may have about working in a group**

- Teacher resource for planning or adapting to use with pupils

Choose one of these methods to help your pupils talk about how they worked together in a group.

1. Write each of the following words on to a card, or on the board. Give each group of pupils a set of cards to help them develop three sentences to describe how they worked. They should try to use some of these words in their sentences:
   - decide, persuade, tell, ask,
   - argue, describe, agree, opinion,
   - listen, share, organise, lead,

2. Write these statements onto a set of large cards (keep these for different group work activities). Display the statements around the room and ask each group to choose the statements that describe the way they worked. Encourage your pupils to add further statements.
   - Everyone in the group had a chance to speak.
   - Everyone in the group was encouraged to speak.
   - Not everyone spoke during the activity.
   - We reached agreement in our group.
   - We listened carefully to each other.
   - Sometimes we found it hard to listen to others without interrupting.
   - Not everyone in the group agreed with our way of drawing the poster.
   - Not everyone in the group contributed to the poster.
   - Everyone in the group was able to add to the poster.

3. Choose one or more of these questions. Read it/Them out to your class and ask each group to discuss the question(s) in their group for five minutes. Ask for feedback from some of the groups.
   - How did sharing your ideas help you?
   - Did everyone have a chance to speak?
   - Did you encourage each other to share your ideas?
   - Did you listen carefully to each other?
Resource 4: Ideas for judging each instrument

Teacher resource for planning or adapting to use with pupils

1 These are some questions pupils could ask about each instrument. Brainstorm a list of questions with your class.

<table>
<thead>
<tr>
<th>What is it made of?</th>
<th>How do you make the note higher? lower?</th>
</tr>
</thead>
<tbody>
<tr>
<td>How old is it?</td>
<td>How do you make a quiet sound? loud sound? Is this easy to do? Can you hear the quiet sound?</td>
</tr>
<tr>
<td>How robust (not easily broken) is it?</td>
<td>What is vibrating?</td>
</tr>
<tr>
<td>Does it need to be kept in a special place?</td>
<td>How easy is it to learn to play?</td>
</tr>
<tr>
<td>How easy is it to carry around?</td>
<td>How much does it cost?</td>
</tr>
<tr>
<td>How do you make a sound?</td>
<td></td>
</tr>
</tbody>
</table>

2 Decide which of these questions are important when judging the instrument. We suggest that pupils in your class choose a maximum of five criteria/questions to judge each instrument.

3 For each of the five criteria or questions your class has chosen, develop a scoring scale out of 5. The maximum for each instrument would then be 25.

4 As each group presents their instrument, the class gives them scores for each criterion.

5 These scores could be recorded on the chalkboard or a large sheet of newsprint on the wall.

Each group should summarise their work by saying:

The final score for our instrument is:

Our instrument is a good choice because … (strengths)

Our instrument might not be a good choice because … (difficulties and problems with the instrument)

Resource 5: Traditional musical instruments

Background information / subject knowledge for teacher

The teacher him/herself will try to describe the following Rwandan traditional musical instruments

- inanga,
- icyembe,
- umuduri,
- ingoma,
- iningiri,
Whenever possible he/she will bring them to learners and if possible some one could come into the class and play them.

Resource 6: Traditional musical instruments

**Background information / subject knowledge for teacher**

The balafon (or ‘bala’) is a resonated frame xylophone (Accessed 2008) of West Africa (Accessed 2008). It is a lamellophone with wooden keys. There are many different balafons in Africa. They fall into two main categories: the free-key type, in which the keys are independent of one another and of their supports, and those with fixed keys, in which the keys are permanently strung together and attached to their support. In the free-key balafons, the loose keys are assembled on temporary supports; for example, the player’s legs, banana-tree trunks, straw bundles or logs padded with grass. The fixed-key balafons are generally mounted on or suspended from a frame, with or without calabash resonators.

![Balafon Image]

The keys themselves are suspended over the resonators by means of two lines of twisted leather cord, which pass through two ‘vibration knots’. Each key has its own particular length, width and thickness. The keys are struck with two beaters with rounded ends, formed by winding the tips with rubber strips.

**Playing techniques** The section below mentions ‘2’ techniques but only lists 1 clearly, may need checking

There are two main playing techniques for the balafon:

1) The balafon reproduces the timbres and tonalities of the spoken language. A tonal language is one expressing difference of meaning by variation of tone. Thus, the same word pronounced at different pitches will have a different meaning.
   
   If the musician plays and sings:
   
   - the balafon repeats a phrase that has been sung; or
   - the singing repeats a phrase that has been played; or

   ikondera,
   umwirongi.
the same phrase is played and sung simultaneously. In this case, as the balafon playing is faster than speech, the musician performs melodic phrases to fill in. For this, each interpreter develops his own particular formulas. These formulas may sometimes be as simple as the repetition of a single note.

If the musician plays without singing, he expresses himself in a coded manner by transferring his speech to the balafon.

Balafons are played alone or in pairs, with or without accompaniment from other instruments. Some pieces may be played by two, or even three or four players on the same instrument. One or two of the keys of the balafon are sometimes struck rhythmically with the handle of the beater or with wooden sticks.

Section 3: Investigating electricity

Key Focus Question: What sorts of practical activities with electricity can you do in your classroom?

Keywords: electricity; circuit; electromagnets; models; investigation; group work

Learning Outcomes
By the end of this section, you will have:

- gained confidence to do practical activities in your classroom involving electricity and improved your understanding of the dangers associated with electricity;
- used rotating group work;
- supported your pupils in undertaking investigations in small groups.

Introduction
This section deals with electricity. This topic often frightens teachers – you may think it is complicated, difficult or even dangerous. But there are straightforward, practical activities that help pupils make sense of an important aspect of modern life.

We suggest you use small group demonstrations and investigations to help pupils understand two key ideas:

- Energy cannot be created or destroyed, only changed from one form to another. What can we change electrical energy into?
- An electric device will only work when there is a complete circular path for the electric current.

1. Working in groups

It is very important that pupils are given opportunities to think and behave scientifically. This can only happen with practical, hands-on activities. Pupils will be challenged and enjoy working in groups to discuss and discover things for themselves. It often helps their thinking if they use models as well as real items.

Activity 1 uses cut-out shapes to help pupils understand the need for a complete circuit in an electrical device. Case Study 1 shows how one teacher extended this activity and supported her pupils in their own investigations about electric circuits. This type of encouragement and recognition is very important to pupils.

Resource 1: A careful look at the torch bulb shows you how you can extend this work and lead pupils to a clearer understanding that electricity travels in a complete circuit inside a torch bulb.

You may also find it helpful to read Resource 2: Safe ways to investigate electricity, which explains the dangers of electricity but encourages you not to be frightened by the topic.
Case Study 1: Pupil-led investigations

When teacher Kanakuze in Kacyiru Primary School tried Activity 1 with her class, she found that some pupils took the investigation further. They noticed that the metal tip of a ballpoint pen will also allow the bulb to light when it is placed between the top of the battery and the bottom of the bulb. She watched as they investigated other materials; a wooden pencil did not light the bulb, nor did a piece of cardboard, but the end of a metal spoon worked.

Kanakuze gave them the chance to report on their own investigations and encouraged them to repeat and do further investigations. Later, she took the activity further to explore circuits and switches.

She asked her pupils to use their bulbs and cells (and other bits of scrap materials) to design a circuit so that when a visitor presses a switch a light comes on. Her pupils used paperclips, small pieces of wood, card and metal from cans to make really imaginative switches.

Then, some of the older pupils made model rooms from cardboard boxes and scraps of material and put two or even three lights in the room with a switch. One group even managed to add a warning light, which came on when a thief opened the door of the model room. Kanakuze displayed all these models in her classroom and encouraged other teachers to come and look at them while her pupils explained how they worked. Her colleagues were very impressed at what the pupils had achieved and everyone enjoyed the afternoon.

Activity 1: Lighting a torch bulb

Each group of pupils needs one live torch cell, one working torch bulb, two 15-cm lengths of plastic-coated thin copper wire, at least five life-size cut-out shapes of a torch cell and five cut-out shapes of a live bulb. (See Resource 3: Lighting a bulb – templates and discussion – it is quite time consuming to cut out the shapes; you could ask older pupils to do this for you before the lesson.) They also need a blank sheet of card or paper and a small amount of glue. (Make sure all cells and bulbs are working before the lesson.)

Hand out a bulb and a cell to each group. Ask: ‘What do we get from these?’ Can they show this? What else do they need?

Hand out the cut-out shapes and the wire. Ask pupils to investigate different arrangements to see if they can light the bulb. Successful arrangements are recorded by gluing the shapes down and drawing in the position of the wire.

Tell them: ‘There is more than one arrangement that will light the bulb.’ Encourage them to find five possible different arrangements.

The groups report back at the end. (Resource 3 discusses this activity in more detail and shows you the five possible arrangements).
2. Rotating group work

Electricity provides more than light. Think of the modern electrical appliances we use. We get heat from electricity (stoves, irons, etc.). We get movement (electric razor, fan etc.). Radios and TVs give us sound. Some pupils may even know that magnetism is also involved in some way with electricity.

You need to think about how you can show these electrical effects to pupils. One way would be to get pupils to be investigators in their local community; they draw up lists of all the effects and uses of electricity that they see around them. Or they could cut out pictures of appliances from adverts in old magazines and newspapers to make a display. Can you think of other ways to make pupils aware of different uses for electricity?

In Activity 2, your pupils move round a number of workstations in your classroom to find out about the effects of electricity; this is an example of rotating group work. You will need to think about how you ask the pupils to record what they have learned in this activity – will they create a poster in each group? Will you ask each group to present their ideas about one workstation? Read Case Study 2 to see how one teacher carried out this activity.

After the activity, ask yourself if your pupils enjoyed this way of working. How could you improve it next time?

Case Study 2: Reflecting on rotating group work

Mrs Kayitesi, an experienced primary science teacher, decided to try rotating group work using a double period and ten groups of five pupils. She planned ten workstations to show the effects of electricity: two for the ‘heat’ activity, two for ‘movement’, two for ‘sound’, two for ‘magnetism’ and two for ‘light’.

The day before the lesson, she made ten workcards (see Resource 4: Workcards) and packed the apparatus for each workstation in a shoebox. She appointed a group leader for each group and arranged a meeting with the leaders before the lesson so they were well prepared.

Reflecting on the lesson, Mrs Kayitesi was very pleased with the way it went. The groups moved from station to station every ten minutes, and the leaders ensured that everyone took part. She had asked the pupils to write their own notes on what they had learned from the lesson and to comment on their experience of rotating group work. She was impressed with how much the pupils gained, but she was even more impressed with the mature way they talked about the approach she had used.

Activity 2: Rotating group work

Read the workcards (Resource 4), which give details of workstations, each to demonstrate one effect of electricity. Look at the equipment needed, and decide how many workstations you will have for each card. Prepare the equipment and label it clearly.

Divide your class into groups to match the total number of workstations. (If you have a large class and only one workstation for each effect, you may need to do the activity with half your class and then repeat it with the other half).

Explain to your class how to set up each workstation and read through the workcard for each workstation with the pupils.
In each group choose a leader. Gather the leaders round you and tell them they are responsible for making sure that their group works in an orderly way at each workstation and that everyone in the group joins in. When you call ‘stop’ the leaders will move their group to the next workstation until they have completed all five.

Tell the leaders to return to their groups and to start working.

After ten minutes call ‘stop’. Each group puts the equipment back neatly and moves to another workstation. Do this again after another ten minutes, and so on, until everyone has looked at all five workstations.

Make sure that each group records their observations at each workstation.

At the end, ask each group to present their observations and ideas from one of the workstations.

3. Planning investigations

The **Key Activity** builds on the ideas of energy change and the need for complete circuits. In it, pupils work in small groups to explore one effect of electricity – electromagnetism. This type of activity encourages pupils to think about different scientific processes – planning, observing and recording. After the activity, pupils could think of uses for their electromagnets (see **Resource 5: Electromagnets** for ideas).

**Case Study 3** shows how a teacher with very limited resources encouraged her pupils to think through the processes involved in an investigation like this.

**Case Study 3: Investigating electromagnetism with limited resources**

Mrs Murekateteworks in a rural school with little equipment. She likes doing practical demonstrations with her pupils and is always searching through broken devices in the village to find equipment to use with them.

One day, she took apart an old buzzer to use as an example of an electromagnet. She set it up on her table and gathered her pupils around her. She showed them that she was using electricity to make a magnet. She then asked them each to discuss with their partner ideas for how she could make the magnet stronger – what could she change? How could they measure the strength of the magnet?

After a few minutes, Mrs Murekatetetasked pupils to share their ideas and she recorded the different suggestions on the chalkboard. Some pupils thought that if she used more torch cell batteries the magnet would get stronger. Others suggested using a different material in the core. Other ideas included longer wire, more coils round the core and using two strands of wire. Mrs Murekatetetethen asked pairs of pupils to come out and try one of the ideas. They recorded the results in a table on the board. The next pair tried a different idea, and so on, until they had tried all the ideas. Her pupils copied down the table with the results and then, working with their partner, tried to write a sentence to summarise what they had found out.

Mrs Murekatetetewas very pleased with the way her class listened to each other but she realised that next time she needed to make sure that equal numbers of boys and girls came out to do the experimenting.
**Key Activity: Investigating electromagnets**

Gather your class around you and brainstorm the concept of ‘magnetism’. (See Key Resource: Using mind maps and brainstorming to explore ideas.) Where have they seen magnets being used? What sorts of substances are magnetic? Can we make magnets from electricity? This is called an ‘electromagnet’. Record their thoughts on the chalkboard or on large newsprint on the wall.

Organise your class into small groups of between four and six pupils. Give each group: a steel pin; a working 1.5V torch cell; some small pins or paperclips; and 50 cm of thin insulated copper wire.

Tell the groups you are setting them a problem. They have to use the equipment to make an electromagnet that will pick up as many pins as possible. (See Key Resource: Using investigations in the classroom.)

Encourage pupils to investigate how to make an electromagnet with the equipment.

When they have solved the problem, ask pupils to draw a diagram to show their solution.

If you can only get hold of a limited amount of material you could divide the class into groups. Give them some written work to do but call each group out one at a time to have a go at the activity under your guidance.

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**Resource 1: A careful look at the torch bulb**

- Teacher resource for planning or adapting to use with pupils

First make your teaching aid – a model torch bulb, and read this information about a torch bulb.

With younger pupils, we suggest that you draw in the features of a face to explain what we mean by features.
Now tell them that the class will do the same thing with the torch bulb. Organise your class into groups of three/four: Give each group of pupils a torch bulb and ask them to look at it carefully.

- What are the ‘features’ or parts of a bulb?
- Give them a few minutes to observe carefully.
While they do this, draw the outline of a torch bulb on the board. (Or you can have a ready prepared drawing, which you put up at this point. You can also have labels, written on cards, ready for when they tell you what they observe.)

When they seem ready, ask them to tell you what they see. You can be open to any suggestions and fill in the picture in a random way. Or you can decide to be systematic and guide their reporting by pointing to a place on the drawing and asking a specific question. As they answer, draw in and label the part – the notes below show you how to do this.

Recording observations in an ordered way
• Point to the round glass part. What do we see here?
  Answer: Glass ball
• What do we see inside the glass ball?
  Answer: Two thick wires
• What do we see between the two thick wires?
  Answer: A thin wire, like a curly hair, called a filament.
• What do we see between the two thick wires near the base/at the bottom?
  Answer: A small glass bead
• What is below the glass bulb?
  Answer: A metal drum/case/cylinder
• What can we observe on one side of the metal case, near the top?
  Answer: A little lump of metal
• What do we observe right at the bottom of the torch bulb?
  Answer: A metal/lead tip
• What do we observe between the metal case and the metal tip?
  Answer: Black plastic
• Is there anything else you have observed?
  Answer: Some may notice writing on the metal case.

Making a teaching aid