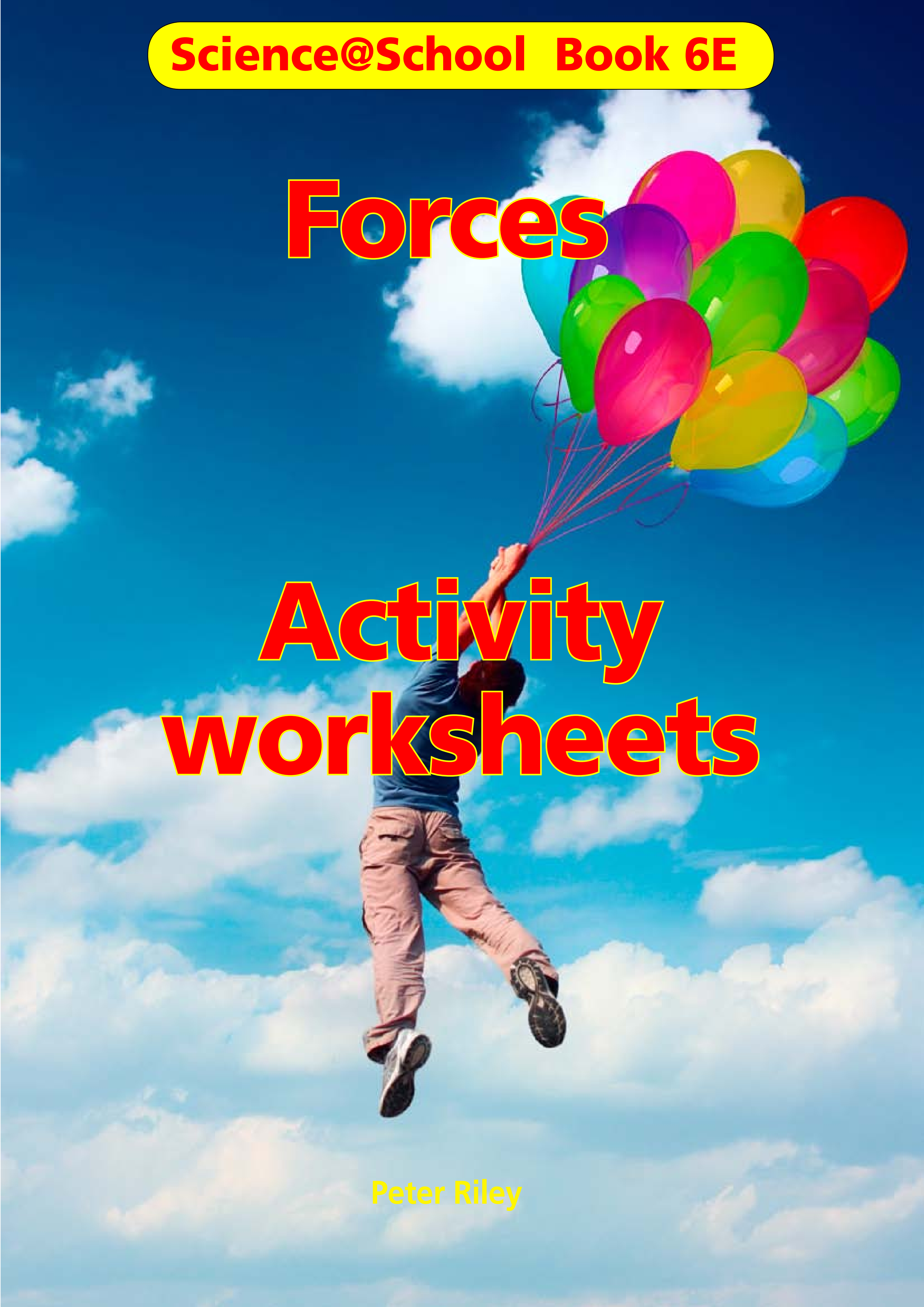
Science@School Book 6E

Forces

Activity worksheets



Peter Riley

1 Teacher's sheet: comprehension

See **pages 4 and 5** of *Forces in action*

Answers

1. **(i) A person should be rising from the trampoline. The trampoline sheet should be convex; (ii) An arrow below the person should point down in the top picture; an arrow below the person should point up in the bottom picture.**

2. **A pushing force.**

3. **A pulling force.**

4. **A force made by a magnet. A force made by electricity.**

5. **(i) Applies more force to the wheels; (ii) It goes faster/changes speed.**

6. **The rocket engine pushes a huge amount of gas downwards, and a reaction force lifts the space shuttle upwards.**

Complementary work

The children could inflate a sausage-shaped balloon, tape a straw lengthways along its top, thread a string through the straw, tie one end of the string to a door handle, pull the string tight and let the balloon go to see how the reaction force to the escaping air pushed the balloon forwards.

Teaching notes

You may like to remind the children that forces are pushes and pulls. You could perhaps begin by relating forces to their own body, and say that probably the first force they are aware of in the morning is the force exerted by muscles which open their eyes. You may then mention other muscles which pull on bones to get them out of bed.

A force cannot be seen, but the effects of a force can be seen and felt. For example, the force of the wind can be seen moving the trees, and felt pressing against our bodies.

Some forces are called contact forces. They are exerted by one object touching another. The pushing force of the thumb on the pin is an example. Friction is a contact force that the children should have studied in some detail earlier in their science course.

Some forces do not have to make contact to produce an effect. The magnetic force, electrostatic force and gravity are examples of non-contact forces. The region in which these forces work is called a force field. For example, if you put a magnet under a piece of card and sprinkle iron filings on top of the card, the filings will line up between the ends of the magnet. These lines are called lines of force and they show the extent of the force field around the magnet, called the magnetic field.

When something exerts a force, a similar force is always generated in the opposite direction. For example, when you lean against a wall, you exert a force on the wall and, at the same time, the wall pushes back on you. If it didn't, you would fall over.

The force of the gases rushing out at the back of a rocket are balanced by a force which pushes the rocket forwards. The rocket *does not* move by the gases pushing on the air as some people believe. In space there is no air, yet the rocket engines of spacecraft still push the spacecraft along.

Teacher's sheet: activity

Based on **pages 4 and 5** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have read pages 4 and 5 in the pupil book. Remind the children about any work they have done in previous years on magnets and friction, and tell them that they are to use this knowledge to plan and carry out some investigations.

Using the sheet

(b) Give out the sheet, let the children fill in their names and form, then go through task 1 and let the children try it.

(c) Go through task 2, then let the children try it (see note (i)).

(d) Let the children try tasks 3 and 4 (see note (ii)).

(e) Go through task 5, then let the children try it.

(f) Let the children try task 6 (see note (iii)).

(g) Let the children try tasks 7 and 8.

Completing the activity

(h) Let the children compare their results.

(i) If the children have all used the same materials in the second investigation, they may like to pool their results using ICT (see note (iv)).

Conclusion

The strength of a magnet may be found by hanging paperclips from its ends, or by finding the thickness of cardboard through which the magnetic forces act. The slipperiness of a surface can be found by placing the surface on a ramp and finding the height of the ramp needed to make the surface slide.

Teaching notes

(i) The plan should show two ways in which the strength of a magnet can be tested. In one part of the plan, the strength can be tested by finding out how many paperclips will hang from each end of each magnet. In the other part of the plan, the card should be cut up and pieces of card placed between the end of a magnet and a paperclip, until the paperclip is no longer held in place.

Some plans may show tables with columns labelled magnet, north pole and south pole, and indicate how many paperclips or how many cards were used at each end of each magnet.

(ii) This should be a written statement and may refer to tables constructed in the plan and filled in during the investigation.

(iii) See if the children can relate the term 'slippery' to friction, but if they do not, remind them of the link. The plan should show similarly sized pieces of material placed, in turn, at one end of the plank, and that the end is raised to form a ramp. The height of one end of the ramp is increased until the material begins to slide. When this height is reached it is measured with a ruler. A table may be produced with the column headings – 'Material sliding' and 'Height (cm)'.

(iv) You may like to remind children that whenever a scientific investigation is being made, many tests are performed and their results are gathered to try and find a pattern in the data.

2 Teacher's sheet: comprehension

See **pages 6 and 7** of *Forces in action*

Answers

1. **A = elastic band, B = pointer, C = scale, D = pan.**
2. **(i) It stretches; (ii) It points to a place lower down the scale.**
3. **Force can make an object go faster, slower, go in a new direction or change its shape.**
4. **A forcemeter is a tube containing a spring and pointer.**
5. **Newtons.**
6. **Rest the brick on a table, put a string round it, hook the forcemeter to the string and pull the forcemeter. When the brick starts to move, look at the position of the pointer on the scale.**

Complementary work

The children could make a simple forcemeter as shown on page 6, then calibrate the scale in the following way. With an empty pan, mark the position of the pointer on the scale with a line and label this zero. They could then find the weight of a small object using a commercial forcemeter, then put the object in the pan of their forcemeter and record the new position of the pointer, marking the value in newtons taken from the forcemeter. They could then repeat this task with different objects to construct a scale which measures in newtons.

Teaching notes

There is a problem with the use of the word weight. In everyday language it is used to indicate a quantity of something, but in science, weight is a force. The term used in science to indicate a quantity of something is mass. It is a measure of the amount of matter in a substance. Weight is really a measure of the force of gravity on mass. Since most of us are only concerned with weight on Earth, we use the word weight to indicate mass. The scale for measuring mass is based on a unit called the gram (g). It is not a unit of force. So when you see something which is labelled – weight 10g – this is actually incorrect, it should say – mass 10g. You may wish to draw this to the children's attention, or some children may point out this confusion.

Children may also ask how grams are different from newtons. You may answer in the following way. All systems of measuring (such as for time and length) have to have units which can be used by everyone. The units are obtained by using something as a standard. For mass the standard is a lump of metal (an alloy of platinum and iridium) kept in a special room. This lump is the standard kilogram – it has a mass of exactly one kilogram. All other masses are compared with this one.

By comparison, a newton is the force needed to accelerate (or speed up) a mass of one kilogram at the rate of one metre per second per second.

You may find it useful to teach the next unit straight after this one to consolidate the children's ideas about weight and mass.

2

Teacher's sheet: activity

Based on **pages 6 and 7** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied pages 6 and 7 in the pupil book. Show the children a number of different forcemeters and tell the children that each one is designed to measure a range of forces. Some measure small forces, and others measure larger forces. Tell the children that they may use different forcemeters to measure forces of greatly differing strengths (see note (i)).

Using the sheet

(b) Give out the sheet, let the children fill in their names and form, then go through task 1 (see note (ii)).

(c) Let the children try task 1 (see note (iii)).

(d) Go through tasks 2 and 3 (see note (iv)).

(e) Let the children try tasks 2 and 3.

(f) Go through task 4, then let the children try it.

(g) Go through tasks 5 and 6, then let the children try them.

Completing the activity

(h) Let the children compare their results.

Conclusion

A small object, such as a pencil case, may only need a small force to make it move, while a large object, like a school bag, may need a large force (see note (v)).

The force needed to open a door depends on the stiffness of the joints and weight of the door. The force needed to open a drawer depends on the amount of friction between the drawer and its support.

Teaching notes

(i) A forcemeter should have a device on it to prevent the spring being pulled too much, but make sure that the children get used to selecting forcemeters for appropriate strengths.

(ii) The children should have done some work on friction at an earlier stage in which string was tied around a block. They may need reminding of this now so that they can use the technique to test the pencil case and the other objects they choose in task 2.

(iii) Make sure the children have used N to signify the units in their answer.

(iv) The children may list the items they are to test in the first column. They should not list all their predictions at once. They should make each prediction after each test as the result of the previous test may help them to improve the accuracy of their predictions.

(v) Some children may note that the force needed to drag the object along is less than the force needed to get it moving. This is due to the two kinds of friction – holding, or static, friction (the stronger force) and sliding friction (the weaker force).

3

Teacher’s sheet: comprehension

See **pages 8 and 9** of *Forces in action*

Answers

1. **One arrow pointing towards the Sun, one arrow pointing along the orbit, one arrow pointing away from the Sun.**

2. **(i) The Sun; (ii) It is larger than the Earth.**

3. **(i) The weight becomes six times smaller; (ii) Gravity on the Moon is only a sixth as powerful as gravity on the Earth.**

4. **People, breakfast cereal, computer, table.**

5. **It stops athletes jumping very high. It makes it hard for planes and rockets to fly and can make things fall quickly.**

6. **Muscles and bones would become weak. Gravity is strong on the ground and muscles and bones stay strong by working against it. In space, gravity is weaker, so muscles and bones do not have to work as hard and become weaker.**

Complementary work

The children can use secondary sources to find out about Galileo’s studies on gravity.

Teaching notes

You may wish to teach this unit straight after the previous one, in order to consolidate the children’s ideas about weight.

The mass of an object is the amount of matter it contains. This does not change if an object is moved from the Earth to the Moon, or anywhere else in space. The units of mass are grams and kilograms. The mass of an object is found by using scales, or a balance, calibrated to read in grams. This calibration has been made by comparing the pull or push of a spring with the standard mass mentioned on page 25.

Weight is the pulling force of gravity on an object. The unit of weight is the newton. The weight of an object can be found by using a forcemeter. This device has a scale which measures in newtons.

It seems obvious that when two objects of different weights fall to the ground, the heavier weight will fall faster than the lighter weight. But this does not happen, for the following reason. The force of gravity acts on all objects exactly the same. Two objects that are the same shape, but which weigh different amounts, will fall at exactly the same speed. Of course, on Earth, the air can slow an object down. That is why, on Earth, objects which can trap air – a feather, a parachute – do fall more slowly than objects which do not trap air – like a book, or a person.

3

Teacher's sheet: activity

Based on **pages 8 and 9** of *Forces in action*

Introducing the activity

(a) If you do not wish to introduce the concept of mass, simply carry out the first four steps of the activity (see note (i)). The activity in Unit 2 should be done before the children try this activity. Before you start remind the children of how a forcemeter works.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 and let the children try it (see note (ii)).

(c) Go through task 2, then let the children try it (see note (iii)).

(d) Go through task 3, then let the children try it (see note (iii)).

(e) Go through task 4, then let the children try it (see note (iv)).

(f) Explain to the children that all objects have a certain amount of matter in them, and this is recorded by the units called grams and kilograms. Scales and balances are used to find mass. When a scale is used, you are comparing the mass of the object with a standard mass of a piece of special metal which is kept in a laboratory.

(g) Go through tasks 5 and 6, then let the children try them (see note (v)).

(h) Go through task 7, then let the children try it (see note (iv)).

(i) Let the children try task 8.

Completing the activity

(j) Let the children compare their results.

Conclusion

Small objects generally have a smaller weight than larger objects. A heavy object has a greater weight than an object which feels less heavy.

As the mass of an object increases, so does its weight.

Teaching notes

(i) You could then relate the graph to features of the objects, such as the length or colour, and decide that these do not affect the weight. You could then let the children feel each object and link weight to the feeling of heaviness.

(ii) The objects should have a weight which the forcemeters can cope with. For example, if the forcemeter only records weights up to 10N, small objects must be selected.

(iii) Tell the children that they may like to make their table before they measure the weights. The table should have two columns, headed 'Object' and 'Weight (N)'.

(iv) Give the children a sheet of graph paper and let them choose the size to make their chart. The chart should be as large as possible for accuracy.

(v) Tell the children that they may like to make their table before they measure the masses. The table should have two columns, headed 'Object' and 'Mass (g)'.

4 Teacher's sheet: comprehension

See **pages 10 and 11** of *Forces in action*

Answers

1. **(i) Pulleys; (ii) There should be an arrow pointing down from each cup. The arrows should be the same size; (iii) Cup Y will go down and cup X will go up; (iv) The downward force acting on cup Y is now bigger than the downward force acting on cup X.**

2. **The chair pushes back with as much force as you push down.**

3. **A sharp-edged block of wood (or the balancing point of a beam or lever).**

4. **The arm carrying the apple tips down.**

5. **The apple should be moved close to the pivot and the pencil sharpener should be moved further away.**

Complementary work

The children could hang up a coat hanger and suspend a yogurt pot from each end. They could add objects to both pots until they balance. One pot can then be removed and its weight can be found by using a forcemeter. From the reading, they could then predict the weight acting on the second pot. The children can then test their prediction by finding the weight of the second pot using the forcemeter. They should find that both pots have the same weight.

Teaching notes

Force is usually associated with movement, but can also be associated with still objects. The basic particles of matter are held together by forces. For example, the particles (atoms) in a solid are held firmly together by forces which act between the atoms. In liquids, forces hold the particles together but also allow them to slide over each other. In a gas there are no forces which hold the particles together. The ways that forces act on substances can be taken further by realising that the inside of the atom is made from even smaller particles, and these are also held together by forces. One of these particles is the electron. This is held in place by electrostatic forces similar to the one that makes combed hair stand up.

Children may think that no force is at work when an object is at rest, so it may need pointing out that forces are acting all the time. The reason an object does not sink into a solid surface is due to the forces which hold the particles together and give the surface strength to push back against the weight of the object. This is an example of forces acting in pairs. The force of the object's weight is opposed by the force of the surface pushing back. If the force pushing back was weaker than the weight (as when an object lands in quicksand), movement occurs and the object sinks down.

4

Teacher's sheet: activity

Based on **pages 10 and 11** of *Forces in action*

Introducing the activity

(a) The forces acting on an elastic band or a coiled spring can be a difficult topic. So, you may like to begin by finding the forces on a person who is falling. The person is falling because there is only the downward force of gravity (ignoring air resistance). Draw a person on the board and put an arrow showing the direction of the weight force acting on the person. Now say that if the person is stood on the ground the person could not fall because there would be a balancing force. Draw in an arrow showing the force of the ground pushing on the person (see note (i)). Tell the children that they are now going to identify the forces acting on some objects.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 and let the children try it (see note (ii)).

(c) Go through tasks 2 and 3, then let the children try them (see note (iii)).

(d) Go through task 4, then let the children try it (see note (iv)).

(e) Go through task 5, then let the children try it.

Completing the activity

(f) Let the children compare their results. Make drawings on the board so the children can check their answers.

Conclusion

Both the elastic band and the spring stretch but then come into equilibrium. At this stage the force of the weight acting down is balanced by the pulling force of the band or spring acting up.

There should be arrows of equal size pointing down and up. This indicates balance.

When a paperclip is suspended below a magnet, a magnetic force pulls the paperclip upwards. This is balanced by the weight of the paperclip. So this is the same – one force down and one up of equal sizes.

Teaching notes

(i) The two arrows should be the same size to show that they balance.

(ii) Make sure that the spring is an open coiled spring like one used to make a mattress.

(iii) An arrow should point down to show the object's weight. An arrow should point up to show the stretching force of the elastic band.

(iv) You may like to assemble one set of the equipment to show the children how to do it. The children will have to find out the distance needed between the paperclip and the magnet by trial and error.

Teacher's sheet: comprehension

See **pages 12 and 13** of *Forces in action*

Answers

1. **(i) A = downward force, B = weight, C = lifting force; (ii) The plank is coloured in; (iii) The small log is labelled with an X.**
2. **It multiplies a force.**
3. **A long lever. The further you are from the pivot, the more the force is multiplied.**
4. **A pair of scissors.**
5. **To raise a car off the ground.**
6. **The snapped plank would be less powerful because it would be shorter. The hand would be closer to the pivot.**

Complementary work

The wheelbarrow and the arm are examples of levers. The children should use secondary sources to find out where the pivot is in each lever and also where the load force and effort force act.

Teaching notes

A lever is a simple machine. Machines are devices that help us to do work. You can think of a lever as a bar, with a place on which the bar turns. This place is called the pivot. There are three kinds, or classes, of levers. The plank on page 13 of the pupil book is an example of a first class lever. This kind of lever has a pivot between the force that is to be overcome (called the load) and the force which is applied to the lever (called the effort). In the example in the pupil book the weight of the log is the load, and the force exerted to push down the plank is the effort. The crowbar and scissors are further examples of first class levers.

In a second class lever, the pivot is at one end of the bar, the downward force (the load) is close to the pivot and the force acting upwards against the load (the effort) is further away. The bottle opener, wheelbarrow and the car jack are examples of second class levers.

In the third class lever, the pivot is at one end of the bar with the upward force (the effort) close to it and the load further away. The arm is a third class lever. The elbow is the pivot, the bicep muscle provides the effort and the load is in the hand. Sugar tongs and chopsticks are also third class levers. The effort is applied where the hand grips the tongs or sticks and the sugar lump or food (the load) is at one end.

Teacher's sheet: activity

Based on **pages 12 and 13** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied pages 10 to 11 and pages 12 to 13 in the pupil book. Tell the children that they are going to make a simple investigation on levers, then plan and carry out a more complicated one.

Using the sheet

(b) Give out the sheet, let the children fill in their names and form. Go through tasks 1 and 2, then let the children try them (see note (i)).

(c) Go through tasks 3 and 4, then let the children try them (see note (i)).

(d) Go through tasks 5 and 6, then let the children try them (see note (i)).

(e) Let the children try tasks 7 and 8.

(f) Go through tasks 9 and 10, then let the children try them (see note (ii)).

(g) Let the children try task 11.

Completing the activity

(h) Let the children compare their results.

Conclusion

The setting which needed the least pushing force to lift the wooden block is shown in Diagram 1. The setting which needed the most pushing force to lift the wooden block is shown in Diagram 3. As the length of the lever opposite the block gets shorter, the force needed to lift the block becomes larger.

Teaching notes

(i) Tell the children to remember what it is like to push down on the lever.

(ii) The children should realise that they can assemble the lever near the end of a table and tie a piece of string at point X. They could then connect a forcemeter to the lever and pull down gently until the lever is horizontal. In their plan, they may show drawings of the three diagrams on the page and also diagrams of levers set up in different positions between Diagrams 1 and 2 and between Diagrams 2 and 3.

Teacher's sheet: comprehension

See **pages 14 and 15** of *Forces in action*

Answers

1. **(i) The plumb line hangs from the top of the letter; (ii) The plumb line hangs from the top of the letter; (iii) The X is near the centre of the letter.**
2. **They are the same (equal).**
3. **Gravity.**
4. **Keep balancing the spoon at different places on your finger by trial and error until it stays at rest.**
5. **(i) A dune buggy; (ii) It stops the vehicle rolling over when it turns a corner.**
6. **(i) High up; (ii) It would be dangerous to drive because it would be in danger of toppling over easily.**

Complementary work

(a) The children can use secondary sources to find out why a tightrope walker uses a long pole to help keep their balance.

(b) If the children have done the second part of the activity about the centre of gravity of half empty bottles, they could be asked why in busy times passengers on a double decker bus may stand downstairs but not upstairs. (The extra weight of the standing bodies downstairs lowers the centre of gravity. If people stood upstairs their weight would raise the centre of gravity and the bus would be more likely to topple over.)

Teaching notes

The centre of gravity is the point in an object through which its weight seems to push downwards. Imagine a rectangular block standing on end. The surface in contact with the table is called the base. The centre of gravity is in the middle of the block and the weight acts straight down through the middle of the base. If the block is tipped a little, its weight still acts through the base, so when the block is released, the weight pulls all of the base back down to the table. If the block is tipped a long way, the weight pushing down from the centre of gravity now acts through the side of the block, not the base. This means that when you let go of the block, the weight pulls the side down to the table and the block topples over.

Objects which are short have a low centre of gravity and must be tipped a long way before the weight acts through a side and pulls them over. Objects which are tall have a high centre of gravity and need only be tipped a small amount before their weight acts through a side and pulls them over.

The centre of gravity is also called the centre of mass. The mass is the amount of matter in the object. When a bottle is half-emptied, most of its mass is concentrated in the bottom half of the bottle and its centre of gravity becomes lower. This means the bottle is less likely to topple over. It is more stable.

Teacher's sheet: activity

Based on **pages 14 and 15** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied the unit in the pupil book. Show the children some bottles and ask them which would be easiest to knock over. Ask them for an explanation (see note (i)).

Using the sheet

(b) Give the children the sheet, let them write their names and form on it, then go through task 1 (see note (ii)).

(c) Let the children try task 1.

(d) Let the children try task 2 (see note (iii)).

(e) Let the children try task 3 (see note (iv)).

(f) Go through task 4, then let the children try it.

(g) Go through task 5, then let the children try it.

(h) Go through tasks 6 to 8, then let the children try them.

(i) Go through task 9, then let the children try it.

(j) Go through tasks 10 to 12, then let the children try them (see note (v)).

(k) Let the children try task 13.

Completing the activity

(l) Let the children compare their results.

(m) Ask the children to predict how removing half the water from a tall bottle affects the ease with which it can be tipped over.

(n) Let the children test their predictions and offer an explanation for the result.

Conclusion

The centre of gravity of a bottle may be found by making a bottle shape on card and using a plumb line.

Tall bottles are more easily tipped over than short bottles because their centre of gravity is higher.

Removing water from a tall bottle lowers its centre of gravity.

Teaching notes

(i) The children may identify tall bottles as being easier to knock over than small, squat battles, but they may give a vague explanation. This is fine at this stage but return to it at the end of the activity and ask them to explain again. This time they should use some scientific knowledge to make a satisfactory explanation.

(ii) Give the children the option of using the pupil book if they wish. Some children may need help in adapting what they see in finding the centre of gravity of the 'A' to finding the centre of gravity of a bottle shape. Make the bottle shape easy by using a squat, almost square, small pickle jar.

(iii) This gives you an opportunity to check the children's work and see that they can locate the centre of gravity.

(iv) You may wish to use only plastic bottles with some children.

(v) The children should carefully tip the bottle to one side and use a protractor to measure the angle at which the bottle will no longer fall back and stand upright. Alternatively, the bottle could be put on a ramp, with a rough surface to prevent sliding, and the ramp raised until the bottle tips over.

Teacher's sheet: comprehension

See **pages 16 and 17** of *Forces in action*

Answers

1. **Top liquid = oil, middle liquid = water, bottom liquid = syrup.**
2. **Its weight decreases.**
3. **The brick pushes some of the water out of the way, but the water pushes back against the space it was pushed out of.**
4. **The brick pushes down more than the water pushes back.**
5. **Form it into a boat shape.**
6. **(i) Syrup; (ii) Oil; (iii) Top object; (iv) Bottom object; (v) Either of the two middle objects.**

Complementary work

The children could use secondary sources to find out how lifeboats keep afloat in stormy seas.

Teaching notes

When something is placed in water, two forces act on it. They are the weight of the object acting downwards, and the push of the water acting upwards. This push of the water is called the upthrust. The weight of an object depends on the size of the particles from which it is made, and how tightly the particles are packed together. For example, if a solid has large particles packed tightly together it is said to have a high density, and has a large weight. If the solid is made from small particles which are packed less closely it is said to have a low density, and has a small weight.

When an object is immersed in water, it pushes water out of the way to make a space for itself. The water pushes back and creates the upthrust. The size of the upthrust depends on the density of the water and the amount of water pushed away by the object. If a small object with a density higher than water is immersed, the upthrust is too small to stop the object sinking. If the object is large and has a density less than water, the upthrust is stronger than the weight and the object floats.

7 Teacher's sheet: activity

Based on **pages 16 and 17** of *Forces in action*

Introducing the activity

(a) You may use this activity before or after the children read Unit 7 in the pupil book. It may be used as an introduction to the topic or to consolidate the work in the pupil book. The children should have done the activity in Unit 4 'Identifying forces' to help them with steps 7 and 8 in this activity. Tell the children that they are going to make their own investigation about the forces at work on an object that is immersed in water.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 and let the children try it (see note (i)).

(c) Go through task 2, then let the children try it.

(d) Go through task 3, then let the children try it.

(e) Go through task 4, then let the children try it.

(f) Go through task 5, then let the children try it.

(g) Let the children try task 6.

(h) Go through tasks 7 and 8, then let the children try them (see note (ii)).

Completing the activity

(i) Let the children compare their results and diagrams.

Conclusion

When an object is weighed in air and then in water, it is found that the weight of the object in water is less than the weight of the object in air. This can be explained by the fact that, in water, there is a force which pushes upwards on the object, and this opposes the force of gravity which is pulling down on the object. In air, there is no strong force to oppose the pull of gravity. The largest objects appear to lose the most weight in water because they have pushed the largest amount of water out of the way and this water pushes strongly upwards on the object.

Teaching notes

(i) None of the objects should float. They should all sink when placed in water.

(ii) The children may need reminding of their work in Unit 4. When something is sinking, the arrow showing the action of gravity should be pointing down and be larger than the arrow pointing upwards showing the buoyancy of the water. If the arrow pointing upwards was larger this would mean that the object would shoot out of the water! Floating, or submerged but stationary objects have arrows the same size.

Teacher's sheet: comprehension

See **pages 18 and 19** of *Forces in action*

Answers

1. **(i) A swim bladder; (ii) Air; (iii) They are about the same.**
2. **(i) Shark; (ii) It sinks.**
3. **(i) Air; (ii) Water is allowed into the space, air is allowed to escape; (iii) The amount of air and water is adjusted so the submarine has the same density as the water; (iv) Air is pumped into the space and water is pushed out.**

Complementary work

The children could use secondary sources to find out about how the vessels which explore the depths of the oceans work.

Teaching notes

A shark does not have a swim bladder. The density of a shark's body is greater than the density of water, so a shark sinks if it does not move forwards. As long as a shark moves forwards its fins can use the water flowing over them to generate an upward force. This force is greater than the shark's weight and makes the shark rise up in the water. Sharks in deep water circle round prey at the surface to gain height so they can attack.

Some fish swim to the surface and gulp air into their swim bladder. This helps their bodies attain the same density as water so they can stay submerged, but not sink all the way to the floor of the pond, lake or sea. A fish of this type can let air out of the bladder through its mouth if it wants to sink deeper.

Many fish do not gulp air. They release an air-like gas into their swim bladder from their blood when they wish to rise in the water and absorb the gas back into their blood (where it dissolves) when they want to sink.

A submarine carries tanks of compressed air. In these tanks a large amount of air is squashed into a small space under a high pressure. When a submarine needs to rise, the air is released from the tanks. The pressure of the air pushes the water out of the spaces in the submarine's hull. With its hull spaces full of air, the submarine is much less dense than the water around it and rises.

Teacher's sheet: activity

Based on **pages 18 and 19** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied the unit in the pupil book. Tell the children that they are going to make a model submarine and make a report on how to operate it.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then let the children perform task 1 (see note (i)).

(c) Go through task 2, then let the children try it.

(d) Go through task 3, then let the children try it.

(e) Go through task 4, then let the children try it (see note (ii)).

(f) Go through task 5, then let the children try it (see note (iii)).

(g) Go through task 6 with the children, then let them try it (see note (iv)).

Completing the activity

(h) Let the children compare their instructions and see if they can use someone else's instructions to operate their submarine.

Conclusion

A model submarine can be made from a washing-up liquid bottle with holes cut in its sides and with coins stuck to its outer surface. Air is supplied by a person blowing down a tube into the bottle. The submarine sinks by letting water flow in through the holes in its side. The submarine is raised by blowing air into it which pushes the water out. A strong blow can raise the submarine quickly and make it float on the surface. Some air can be trapped in the submarine by covering the end of the pipe. This can be used to allow the submarine to float just beneath the surface.

Teaching notes

(i) Depending on the ability and the attitude of the children, you may let them bring in a washing-up liquid bottle from home and make the holes in the bottle themselves.

(ii) The submarine may take a little time to sink.

(iii) The submarine should start to rise. Eventually some bubbles of air may escape too.

(iv) You may like the children to write down their account in the form of a set of instructions to sink and raise the submarine, let it float at the water surface or just below the surface.

Teacher's sheet: comprehension

See **pages 20 and 21** of *Forces in action*

Answers

1. **(i) A diagram of a person suspended from an open parachute; (ii) The arrow points upwards; (iii) The arrow points downwards; (iv) The weight is always greater than the air resistance.**
2. **It moves out of our way.**
3. **The air does not move out of the way fast enough and acts as a force which holds back the object.**
4. **A hovercraft.**
5. **Lift or lifting force.**
6. **Air builds up pressure under the wing to make it rise.**

Complementary work

The children could be set the task of answering the question, "What effect does a hole in a parachute have?" They should make normal parachutes and test them, then put holes of different sizes in different places and test the parachutes again.

Teaching notes

The children may have studied air resistance earlier in their course so it may be worth testing their knowledge about parachutes, and the streamlined shape of vehicles, while they study this unit.

When an object falls through the air, it may seem to the children that only one force is acting – gravity. However, air resistance also acts on all falling objects, although its effect is only easily seen with objects which offer a large surface to the air.

A wing has a special shape called an aerofoil shape. The upper surface of the wing is a convex curve and the lower surface is flat. When the wing moves through the air, a stream of air flows over both the upper surface and the lower surface. The two airstreams meet at the same time at the back of the wing (called the trailing edge). For this to happen, the stream of air over the upper surface must move faster than the stream over the lower surface, because it has a greater distance to cover due to the upper surface being curved and the lower surface flat. When a stream of air moves over a surface, it pushes on the surface. However, a faster moving stream pushes with less force than a slower moving stream. This means that the air above the wing pushes down less strongly than the air below the wing pushes up. This difference in force due to the strong pressure underneath the wing causes the wing to lift into the air.

Teacher's sheet: activity

Based on **pages 20 and 21** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied Units 7 and 8, and pages 20 and 21, in the pupil book. Remind the children about how water pushes up on objects that sink through it, and tell the children that they are going to investigate how a simple object sinks through the air.

Using the sheet

(b) Give out the sheet and let the children write their names and form, then go through task 1 and let the children try it (see note (i)).

(c) Go through task 2, then let the children try it.

(d) Go through task 3, then let the children try it (see note (ii)).

(e) Go through task 4, then let the children try it.

(f) Go through task 5, then let the children try it (see note (iii)).

(g) Let the children try tasks 6 and 7 (see note (iv)).

(h) Let the children try task 8.

Completing the activity

(i) Let the children compare their results.

(j) Challenge the children to investigate the effect of the blades of the spinner on the time it takes the spinner to fall.

Conclusion

A spinner with a load of only one paperclip fell more slowly than a spinner with a load of many paperclips. As the load on the spinner was increased, it fell more quickly (see note (v)).

The blades of the faster-falling spinners turn more rapidly.

A spinner with large blades will take longer to fall than a spinner with small blades due there being more air pushing upwards on the larger blades.

Teaching notes

(i) You may wish to prepare some sheets already marked out for some children.

(ii) Make sure the children bend the blades of the spinner so they stick out at right angles to the rest of the spinner.

(iii) Make sure the children follow the school safety policy for dropping things from a height. For example, they may not stand on classroom furniture, but may stand on PE equipment or equipment in a playground.

(iv) The children may begin their plan with a prediction. The plan should show that the spinner will be dropped a number of times from the same height and with the same load – such as one paperclip, two paperclips etc. The time taken for each fall should be recorded. The children should produce an appropriate table on a separate piece of paper.

(v) The air pushes on all objects falling through it, but its push affects the lightest spinner most strongly and slows it down a little.

Teacher's sheet: comprehension

See **pages 22 and 23** of *Forces in action*

Answers

1. **(i) The path should be higher at first than the path shown on the diagram and the ball should fall more vertically to the ground; (ii) The path should be lower than the first path but the ball should strike the ground farther from the cannon than the ball from the cannon tilted upwards. Both paths would be shorter than the one in the diagram.**
2. **A projectile.**
3. **Gunpowder.**
4. **Air resistance.**
5. **45°.**
6. **You could fasten the elastic band to the top of the ramp. Put an object inside the band and pull it back while resting it on the ramp. When you let go, the elastic band would shorten and push the object into the air.**

Complementary work

The children could use secondary sources to find out how athletes throw the javelin, putt the shot, throw a baseball and a cricket ball.

Teaching notes

We usually think of the natural state of an object as at rest. However, there is a second natural state – an object will move at a constant speed in a straight line if no other forces are acting on it. This may seem strange, but out in space where there is no pull of gravity or push of air pressure, a space probe or a piece of rock can keep moving in a straight line at constant speed forever unless acted on by the gravity of a star or planet.

It is important to consider this second natural state here on Earth, because when an object is given a push, it tries to maintain a constant speed in a straight line. There is no continuous force pushing it along. For example, the ancient Greeks correctly believed that a bow string gave the push to an arrow, but incorrectly believed that the air took up the push and dropped the arrow when it got tired!

As soon as a projectile begins its journey, it is tugged down by gravity and pushed against by the air. These two forces deflect the object from travelling in a straight line and moving at a constant speed, so eventually they bring it to the ground.

10 Teacher's sheet: activity

Based on **pages 22 and 23** of *Forces in action*

Introducing the activity

(a) Use this activity after the children have studied pages 22 and 23 in the pupil book. Tell the children that there is a simple way to test the power of an elastic band to throw something and the children have to work out how to do it.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 (see note (i)).

(c) Go through tasks 2 and 3 with the children and let them try them (see note (ii)).

(d) Go through tasks 4 and 5, then let the children try them (see note (iii).

(e) Let the children try task 6.

Completing the activity

(f) Let the children compare their results.

Conclusion

The power of an elastic band can be tested by stretching it different amounts. A small amount of stretch will send the projectile a small distance, but a large amount of stretch will send the projectile a long distance. The distance the projectile travels increases as the amount of stretch of the elastic band increases.

The power of different elastic bands can be compared by stretching each one the same amount and measuring the distance travelled by the projectile.

Teaching notes

(i) Depending on the ability and attitude of the children, you may like them to assemble the equipment using two nails, a hammer and piece of wood. The nails must be hammered in firmly, but must not go all the way through the wood. Alternatively, you can prepare the equipment before the lesson.

(ii) The plan may start with the prediction. The plan should show that a scale is drawn on the piece of wood, or the distances the elastic band is stretched is marked and measured from a line between the two nails. The elastic band should be stretched different amounts in each trial and released. A small paper ball made from a piece of kitchen roll may be used as the projectile. The equipment must not be pointed at anyone. The distance moved by the projectile should be measured. A table should be constructed on a separate sheet of paper. The elastic band may be tested several times at each amount of stretch. The plan should show a consideration for safety and mention not stretching the elastic band too much.

Check your school policy to see if the children should wear eye protection.

(iii) Indication of a fair test must be shown. Each band should be tested for the same amount of stretch several times.