Science@School Book 4E

Friction

Teacher's Guide

Support material for the pupil book
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1

Teacher's sheet: comprehension

See **pages 4 and 5** of *Friction*

Answers

1. **Children should draw both shoe and ground as rough surfaces with bumps and troughs.**

2. **A gritty, tearing sound.**

3. **You could never get a grip on it.**

4. **To lower the friction between the gears and chain. This makes the chain move easily over the gears.**

5. **Between the wheel and the spindle it turns on.**

6. **If it was very high, it would be difficult to pedal. If it was very low, the tyre might slip on wet ground.**

Complementary work

(a) You may wish to develop the introductory practical in the following way. Let the children rub their hands together quickly. Ask them what they can feel, and look for an answer that implies heat. You could ask the children to press their hands together harder and rub. They should find that their hands become even warmer.

(b) The children could use secondary sources to find out how friction is used to generate heat. For example, they could find out how to start a fire by rubbing pieces of wood together.

Teaching notes

As you begin work on friction, it is important to review the children's knowledge of forces in order to set friction in context. A force is a push or a pull. You cannot see a force, but you can feel it. For example, you can feel a push or a pull on your arm. You can also see the effects of a force. For example, you can see the pushing force of the wind on the branches of a tree.

Although children do not have to study gravity, and the forces involved in floating and sinking until later, many of them are already aware of these forces. This may be helpful in introducing the concept that forces act in pairs. You could introduce this by reminding children what happens when they try to sink a bottle full of air. When they push down on the bottle, they can feel the water pushing back on the bottle. When they let the bottle go, the pushing force of the water is unopposed and the bottle rises to the surface.

The pushing force of water can then lead to the study of an object at rest on the ground. Gravity is pushing the object against the ground and the ground is pushing back on the object. If the object is pulled from the side, the opposing force, which pulls in the opposite direction is friction. As long as the friction force can match the pulling force the object does not move. When the pulling force becomes larger than the force of friction holding the object, the object begins to move. A lower frictional force then acts on the moving object.

Teacher's sheet: activity

Based on **pages 4 and 5** of *Friction*

Introducing the activity

(a) Use this activity after the children have read pages 4 and 5 in the pupil book. Tell the children that there are forces of friction all around them, and that their task is to find these forces. If the children are not sure how to translate what they have read into the classroom situation, tell them that friction is holding them in place in their seats, and it occurs when they rub their pens on paper as they write.

Using the sheet

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

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

(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.

Completing the activity

(f) Let the children compare their results (see note (iii)).

Conclusion

There is a huge range of places where surfaces are in contact and friction exists between them. Examples are clothes and skin, clothes and chair, shoes and floor, any object on a table, food on a plate, nail or screw in a wall, car at rest in the car park, a log on the ground.

There are also many places where surfaces slide over each other. Examples are clothes when moving, brushing shoes on a door mat, putting on clothes, washing up, washing hands, using a paint brush, going down a slide in a playground.

The list about surfaces in contact may be longer than the list about one surface sliding on another.

Teaching notes

(i) You may let the children work in the classroom, or you could escort them round the school or take them outside to look at friction in the school grounds.

(ii) You may let the children work in the classroom, or you could escort them round the school or take them outside to look at friction in the school grounds.

(iii) You may like the children to keep their lists and refer to them later when they are studying other aspects of friction.

2

Teacher's sheet: comprehension

See **pages 6 and 7** of *Friction*

Answers

1. **A = block, B = forcemeter, C = table or other surface.**
2. **A force.**
3. **(i) Newton; (ii) Sir Isaac Newton, an English mathematician.**
4. **It would get smaller.**
5. **Another block.**
6. **It gets larger.**

Complementary work

You could bring a bicycle into the classroom and show the children the mechanism that pushes the brake pads hard against the wheel.

Teaching notes

The children should have studied the forces on springs earlier, and may have studied them in *3E Magnets and springs* in this series.

This unit provides a good opportunity to introduce the concept of technology. Technology can be considered as the application of scientific knowledge to solve human problems. You could use this to introduce the forcemeter in the following way. Remind the children of their work on springs and ask them what they discovered. Ask them how they could compare two pulling forces by using a spring and look for an answer about comparing the length of the stretched spring. Develop the idea by asking the children how they could use the spring to measure a range of pulls and look for the suggestion of a scale. Present the children with a forcemeter and show them how the features you have discussed have been incorporated into its design.

The rules of friction apply to clean, dry surfaces. Dirty, wet surfaces bring in other forces, such as the forces by which dirt adheres to surfaces and the way the layers of a liquid move over each other. This is far too complex for simple study, but serves to show that the study of forces is complicated and is a major part of the work of structural engineers.

Teacher's sheet: activity

Based on **pages 6 and 7** of *Friction*

Introducing the activity

(a) You may use this activity before the children study pages 6 and 7 in the pupil book and use the book for confirmation of their work. Alternatively, you could use the sheet after studying the unit with the whole class (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.

(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 tasks 5 and 6, then let the children try them (see note (iii)).

(g) Go through tasks 7 and 8, then let the children try them.

(h) Let the children complete tasks 9 and 10.

Completing the activity

(i) Let the children compare their results.

Conclusion

The load does affect friction. As the load is increased, the amount of friction preventing movement increases.

The amount of area in contact does not affect the frictional resistance.

Teaching notes

(i) Another alternative would be to use this sheet and the book together for a differentiation exercise. More able pupils could use the book to help them plan and carry out an experiment, while most of the others could use this sheet. The least able could simply try to assemble the equipment as shown in the diagrams and pull the blocks.

(ii) You may ask the children to explain their plan to you orally, or to write it down on a separate piece of paper. The table should have a column headed 'Number of blocks' and a column headed 'Greatest friction force (N)'.

(iii) Remind the children that in this section of the activity they are investigating the effect of the amount of area in contact on friction.

3 Teacher's sheet: comprehension

See **pages 8 and 9** of *Friction*

Answers

1. **(i) A mouse; (ii) Glides; (iii) A mouse mat.**
2. **Rough or soft, flexible materials.**
3. **(b) A heavy object.**
4. **A brick.**
5. **(a) Rubber.**
6. **Change the materials that they are made of.**

Complementary work

(a) The children could examine a range of footwear to discover the most widely used material for making soles and heels. They should discover that rubber is the most common.

(b) The children could pull a wood block over a wood surface with a forcemeter and then wrap rubber bands around the block and pull again. They should find that the block is much harder to pull when it is covered in rubber.

Teaching notes

Studies on friction allow the children to develop a range of investigative skills in a short time. During the practical work, you can reinforce this by discussing which principles of investigation they are using. For example, they could design an investigation to answer a "What if..." question, such as "What if I covered a block of wood with plastic and pulled it along the ground?"

The concept of a fair test, the need for accurate measuring and the concept of repeating experiments to establish reliable results should all be emphasised. If the children can be firmly grounded in these skills while completing this work, they could then be encouraged to apply, or discuss, these skills in other areas of the curriculum, such as in the study of materials, the body, plants and animals. In these areas of the curriculum, it is sometimes difficult to set up large numbers of tests, or measurements need to be taken over longer periods of time, so a discussion of all the skills may be more convenient than actually setting up all the experiments. The discussion can be used as part of the evaluation process, in which the children could say they could make all their results more reliable if they could repeat them, as in their studies on friction.

3 Teacher's sheet: activity

Based on **pages 8 and 9** of *Friction*

Introducing the activity

(a) Show the children a selection of mouse mats. Ask them how they could find which one is the best. Let some children try the different mouse mats at the computer. At first they may just move the mouse in a random way over the mats. Ask them how they could make their test fair. From this exercise, point out that you have to think carefully when making a scientific investigation. Tell the children that they are going to make a more thorough investigation about how different materials grip.

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 tasks 4 and 5, then let the children try them.

(f) Go through task 6, then let the children try it (see note (ii)).

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

(h) Go through task 8 (see note (iv)).

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

Completing the activity

(j) Let the children compare their results (see note (vi)).

Conclusion

Different materials grip the same surface in different ways. Some grip strongly while others only have a weak grip.

Teaching notes

(i) Let the children choose how many materials they want to test. Some may feel confident enough to test them all while some may feel more confident with just testing a few. The materials could be different kinds of carpet, corrugated cardboard, bubble wrap and materials used to make skirts and trousers.

(ii) You may like to point out here that you are making a fair test by repeating the experiment. If the children find that they obtain different results each time, they should not worry but simply record them in the table.

(iii) You may like to remind the children that they should have the same area of material in contact with the surface in each test, in order to make the test fair.

(iv) The children may like to choose a number which typifies the four results. They may use the most frequent number, or the number which is the middle value. If appropriate, you could use this exercise to introduce the concept of averages.

(v) You may like to use this exercise to introduce the children to ways of comparing data.

(vi) You may like to tell the children that when scientists perform experiments they compare them with the results of other experiments. This serves as a double check and also provides more data. The children may also discover a pattern, such as rougher materials provide a better grip.

4

Teacher's sheet: comprehension

See **pages 10 and 11** of *Friction*

Answers

1. **Treads.**

2. **Push it out of the way.**

3. **It could aquaplane.**

4. **(i) The little troughs in the surface fill with water, so bumps in the fingers do not grip the soap so well; (ii) Rubber is a very soft material, which squashes down into the troughs and pushes the water out.**

5. **(i) In snowy and icy weather; (ii) The steel of the chains is harder than the ice and bites into it to help the tyre grip the ice.**

Complementary work

(a) The children could examine the handles on a range of sports equipment to find out about the materials and patterns used to give a good grip.

(b) Old shoes could be examined to find out which areas of the soles and heels wear down to reduce the grip.

Teaching notes

Scientists pick up ideas for experiments from other experiments they have seen. The introduction to the previous unit, and the activity in this unit, have been arranged so that some of the children may pick up on the use of the ramp in the previous unit and apply it to the investigation in this unit. If some children suggest this, point it out to the whole class that they can all get ideas for investigations from what they have learned earlier.

The tread on a tyre provides a rough surface which, in some circumstances, can provide a good grip. For example, the treads on the tyres of a mountain bike help it to grip the mud. On a flat surface, such as a road, the surface of the rubber provides the grip. The tread provides channels to remove water from wet road surfaces to allow the rubber to reach the road. This point is sometimes difficult for the children to grasp. The absence of a tread means that the water is not channelled away between the road and the tyre and so acts as a lubricant. This prevents friction between the tyre and the road, which is needed to provide movement.

As mentioned in the teaching notes in Unit 1, forces occur in pairs. The pushing force of the wheel on the road (generated by the engine) is resisted by the friction between the tyre and the road. If water on the road is not removed, the tyre loses its grip, and a skid, or aquaplaning, may occur. You may wish to discuss this in this unit and refer to it again in later units.

4 Teacher's sheet: activity

Based on **pages 10 and 11** of *Friction*

Introducing the activity

(a) Show the children a large poster of joggers and ask them how the grip of the joggers' training shoes are important. Look for answers about not letting the jogger slip, then ask the children how they could test shoes to see which gives the best grip.

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 tasks 2 and 3, then let the children try them (see note (ii)).

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

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

(f) Go through task 6, then let the children try it.

(g) Let the children try task 7.

(h) Let the children try task 8.

(i) Let the children try task 9 (see note (v)).

Completing the activity

(j) Let the children compare their results (see note (vi)).

Conclusion

The grip of an item of footwear may be tested by placing it on a surface and pulling it with a forcemeter. It may also be tested by placing it on a ramp, raising the ramp and recording the height of the ramp at which the item began to slide.

The grip will depend on the roughness of the sole and the material from which it is made.

Teaching notes

(i) They may choose a Wellington boot, hiking boot, sports shoe, plimsoll, shoe, slipper or sandal.

(ii) Some children may wish to tie a forcemeter to each item and pull it across the same surface. Children who have seen your introduction to the previous unit may wish to raise each item on a ramp and record the height of the ramp at which the item begins to move. For both experiments, the children may like to put the same weight in each shoe.

(iii) The shoes should all be the same size. The children could provide their own shoes, or you could provide a range of shoes the same size for them to test.

(iv) The table should show that the children are going to repeat their results. The units, newtons (N) or centimetres (cm), should be shown in the column headings for each try.

(v) The children should say that there was either a good or a poor match between the prediction and the results. They should not use terms such as 'OK'.

(vi) You may like the children to present the class results using ICT. They may produce bar charts from the data.

5 Teacher's sheet: comprehension

See **pages 12 and 13** of *Friction*

Answers

1. **The diagram should have a block resting on a table. The block should be attached to a forcemeter with string. A hand could be shown holding the forcemeter.**

2. **Block, forcemeter, string, hand.**

3. **Newtons.**

4. **More force is needed to get the car moving than to keep it moving.**

5. **(i) By friction; (ii) An avalanche.**

6. **In a still object, tiny bumps on the object rest in troughs on the surface the object is resting on, so a strong force is needed to pull them out. In a moving object, the bumps are lifted out of the troughs, so the force needed to keep the object moving is less.**

Complementary work

The children can use secondary sources to find out about how people protect themselves against avalanches.

Teaching notes

It may come as a surprise to the children that there are three types of friction. The previous units have focused on the friction which holds an object in place. The correct term for this is static friction. When an object begins to move, there is still contact between the two surfaces, but the projections on the surfaces do not sink deeply into the grooves. This results in a frictional force which is less than the frictional force which held the object in place. The friction which occurs when one surface slides over another is called sliding friction. It is slightly less than static friction. In sliding friction, the objects are in contact only at their high points. When an object is rolling the friction is far less than either static or sliding friction because the projections do not have to be pulled out of the grooves, rolling simply lifts them out.

In the first unit, the point was raised about what would happen if there was no friction. At that time the discussion may have been limited to people sliding about. In this unit, it can be seen that friction also holds snowflakes together on a mountain side. When this friction is overcome by the weight of the snow mass, the snow slides away. This concept can be taken further to consider what would happen if the static friction between soil particles was lost and soil slid away.

5

Teacher's sheet: activity

Based on **pages 12 and 13** of *Friction*

Introducing the work

(a) Use this activity after the children have studied the unit in the pupil book. Remind the children that friction is a force which holds something in place but it also occurs where one surface is sliding over another.

Tell the children that when scientists perform certain kinds of experiments, such as those related to friction, they try them out in different sets of circumstances to test their ideas. Tell the children that they are going to perform a test in different circumstances to test out an idea (see note (i)).

Using the sheet

(b) Give out the sheet, let the children fill in their names and form. Go through tasks 1 to 3, then let the children try them.

(c) Go through tasks 4 to 6, then let the children try them (see note (ii)).

(d) Let the children try task 7.

Completing the activity

(e) Let the children compare their results (see note (iii)).

Conclusion

The friction which holds something in place can be measured by attaching a forcemeter to it and gently pulling the forcemeter until the object starts to move. The friction which acts on a moving object can be measured by pulling the object along and reading the scale of the forcemeter.

The static friction is always stronger than the moving friction no matter what surface the object is placed on.

Teaching notes

(i) When an investigation leads to the discovery of a relationship, such as static friction is stronger than sliding (moving) friction, the relationship is then tested in different circumstances to see if it is a general one, or one that occurs only in specific circumstances. For example, it may be found that when carpet is placed on wood, the static friction is stronger than the moving friction, but this changes when the carpet is placed on plastic. The aim of this activity is to make children think about the relationships they discover and realise that, in science, a lot of investigations are started by thinking "So we have found this relationship but what if...".

(ii) The children should suggest tying a piece of material to a wooden block, attaching a forcemeter to the block and measuring the static and moving friction on a range of different surfaces. The results may be recorded in two tables – 'Static friction' and 'Moving friction'. Each table should have a 'Material' column and four 'Try' columns with the unit N in each.

(iii) The results could be used in an ICT exercise.

6

Teacher's sheet: comprehension

See **pages 14 and 15** of *Friction*

Answers

1. **Oil particles should be drawn coating the bumps and resting in the troughs.**
2. **There is a lot of friction between the working parts.**
3. **Because oil clings to most surfaces.**
4. **The oil fills in the troughs and makes it harder for the bumps to sink in.**
5. **It is thinner and flows more easily. Its layers glide much more easily over each other.**
6. **Oil sticks to itself less than water, oil evaporates much more slowly than water, oil does not combine with metals or make some metals rusty.**

Complementary work

If you can find an object which is in need of oiling, show it to the children and demonstrate how difficult it is to move the parts. Oil the object and show how oiling the parts has made them easier to move.

Teaching notes

If the children have studied book *4D Solids and liquids* in this series they will already have been introduced to the concept that solids and liquids are made from particles of matter. The word particle in this context does not refer to tiny particles such as grains of sand or specks of dust. It refers to particles which can only be seen by very powerful electron microscopes. Particles, in this sense, are made from atoms or groups of atoms called molecules. For simplicity, particles are often represented as spheres. These can be seen in the diagram of oil on page 14.

In a solid, the particles are held tightly together and cannot move. In a liquid, the particles are free to move over each other. In the evaporation process mentioned on page 15, some particles at the surface of a liquid escape into the air and form a gas.

Because it reduces friction, oil also reduces wear on surfaces which rub against each other. By reducing friction, oil also reduces the amount of heat produced when two surfaces rub against each other.

Teacher's sheet: activity

Based on **pages 14 and 15** of *Friction*

Introducing the activity

(a) Tell the children that a lubricant is a liquid which allows surfaces to slide over each other more easily (see note (i)). If the children have done Unit 5 in *4D Solids and liquids* in this series, you may tell them that sometimes things that they learn in one area of science can have a use in other areas of science (see note (ii)).

Using the sheet

(b) Give the children the sheet, let them write their names and form on it, then go through tasks 1 and 2 with the children.

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

(d) Let the children try task 2.

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

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

(g) Go through tasks 5 to 7, then let the children try them.

(h) Go through task 8, then let the children try it (see note (v)).

(i) Let the children try task 9.

Completing the activity

(j) Let the children compare their results.

(k) Ask the children how the results may be more reliable, and look for the answer that each experiment should be repeated a number of times.

(l) Read about water as a lubricant on page 15 of the pupil book. Ask the children to devise a test to compare water and oil as lubricants and let them try it.

Conclusion

Syrup is less runny than oil. It is not as good a lubricant as oil.

Teaching notes

(i) You may use this activity before studying the pages in the pupil book, if you wish.

(ii) Children usually compartmentalise their knowledge and seldom use it in other contexts. This activity provides an opportunity to see how an investigation in runniness can be used to make a prediction about loss of friction.

(iii) Small amounts of the liquids should be poured down a wooden ramp. The children should find that they run at different speeds.

(iv) Make sure the children do not use too much liquid and keep their table tidy.

(v) The children only need to make one try with each lubricant at this stage.

Teacher's sheet: comprehension

See **pages 16 and 17** of *Friction*

Answers

1. **(i) The children should draw a playground slide;**
   (ii) Mirror-shiny metal and plastic.

2. **Fills them in.**

3. **It flakes easily.**

4. **Use wax on their skis, and ski over a ski-run because it is smooth.**

5. **The skate blade takes all the skater's weight and presses it on the ice. The high pressure melts some of the ice and the skater slips over a film of water.**

Complementary work

If there is a playground close by, the children could coat the bases of blocks with different materials, including waxes, and let them go down the slide. They could count, or use a stop clock, to record how fast the blocks slid, or they could let the blocks slide in pairs to work out a rank order of slippery surfaces.

Teaching notes

Sliding, or dynamic, friction provides us with an exciting but sometimes dangerous way of moving. It is exciting because of the speed of the movement. This association of sliding and moving may give the impression that this type of friction is the only one that provides movement, but this is not the case.

Most movement is due to limiting or static friction, but the way in which this provides movement is less obvious. When you take a step, your foot pushes downwards and backwards on the ground. The force pushing backwards is matched by the holding, or static, friction between your foot and the ground. When you raise your other foot, the fact that the foot on the ground is not moving allows you to move your body forwards. By comparison, when you try to walk over a slippery surface, the static friction is soon lost. It cannot provide the balancing force needed to allow you to release one foot from the ground. The sliding friction is weaker than the static friction and cannot match the force of your foot pushing backwards, so your foot moves backwards in the direction it is pushing.

When an ice skater moves on, the film of water that was created by the pressing ice skate turns back into ice. This is due to the reduction of pressure on the water.

Children may mention water chutes at swimming pools as a slippery place. Here, a slippery surface is combined with water, which acts as a lubricant to provide rapid movement.

You may use the activity in this unit to provide a link to the next unit – rolling friction.

7 Teacher's sheet: activity

Based on **pages 16 and 17** of *Friction*

Introducing the activity

(a) Tell the children that when we walk, our feet push on the ground. A friction force between our shoes and the ground pushes back and holds our foot in place. This is what we mean by grip. Explain to the children that when someone tries to walk on an icy surface, such as frozen water on a pavement, there is little friction between the shoe and the ground, so the shoe cannot grip and the person slides around. Tell the children that the same thing happens with a wheel. It pushes on the ground, and the friction between the wheel and the ground grips the ground and allows the wheel to turn. On ice the friction is so low that the wheel spins.

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) Let the children try task 1.

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

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

(f) Go through tasks 4 and 5, then let the children try them.

(g) Go through tasks 6 and 7, then let the children try them.

(h) Let the children try task 8.

(i) Let the children try task 9.

Completing the activity

(j) Let the children compare their results.

(k) You could let the children put water or oil on a shiny surface and see how that affects movement at all three ramp heights.

Conclusion

The car may move most quickly down the smoothest slope. It may travel in a straight line, with its wheels turning, on all but the smoothest and highest slope.

The results can be made more reliable by repeating the experiments.

Teaching notes

(i) There should be three ramps. One should be very shiny – either highly polished or shiny metal, one should be wood and the third should be covered in sandpaper. Aim to have the shiny surface so slippery, that when the ramp is set at its highest position, the car wheels do not turn and the car slides down the ramp, maybe turning as it slides.

The three height settings for the ramps could be 10cm, 20cm, and 30cm, but this will depend on the length of the ramp and how high the slippery one has to be set to make the car slide. Try this yourself before the children try it.

(ii) The children may make a table for each height setting. The table columns could be 'Ramp surface', 'Time', 'Straight direction', 'Wheels turning'. The last two columns could be filled in by writing 'yes' or 'no'.

The children may use a stop watch or count quickly as a means of timing the car.

8 Teacher's sheet: comprehension

See **pages 18 and 19** of *Friction*

Answers

1. **(i) Rolling friction; (ii) Sliding friction.**
2. **(c) Less than a thousandth as much force.**
3. **A log from a tree.**
4. **Stonehenge – England, Pyramids – Egypt.**
5. **Tie a string around the brick and attach the string to the forcemeter. Pull the brick along a table with the forcemeter and record the force. Put rollers under the brick, pull again and record the force.**

Complementary work

The children could explore how the pushing movement on the pedals of a bicycle is transferred through the chain to the back wheel. They could first examine how the push makes the wheel turn in the air. Then they could lower the wheel to the ground and see how the friction makes the wheel roll forwards. The wheel should not be turning at great speed, so that only a slight push is experienced.

Teaching notes

When you move on roller skates, roller blades or a skateboard, you move faster, just like when you are sliding. However, the friction which occurs in rolling is not sliding friction. It is the same kind of friction, called static friction, that develops between your feet and the ground to provide the push to move you forwards when you walk.

On a wheel or ball, the speed of movement is due to the curved surface. When a wheel pushes against the ground, static friction pushes back to match it, and allows the wheel to turn. When a wheel is made to turn on a slippery surface, sliding friction occurs. This is less than the pushing force of the wheel and cannot provide a strong enough force to allow the wheel to grip. When this happens, the wheel simply spins round in a stationary position.

Teacher's sheet: activity

Based on **pages 18 and 19** of *Friction*

Introducing the activity

(a) If the children have tried the activity in Unit 5 you may like to remind them of how it was an example of how something can be studied in different ways. Tell the children that in this activity they are going to study rolling friction by looking at rollers and marbles (see note (i)).

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through tasks 1 and 2 with the children (see note (ii)).

(c) Let the children try tasks 1 and 2.

(d) Go through tasks 3 and 4 with the children, then let the children try them.

(e) Let the children try task 5.

(f) Go through task 6, then let the children try it (see note (iii)).

(g) Go through task 7, then let the children try it.

(h) Go through task 8, then let the children try it.

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

(j) Go through tasks 10 and 11, then let the children try them (see note (iv)).

Completing the activity

(k) Let the children compare their results and the accuracies of their predictions.

Conclusion

When a block is slid along a surface, a large pulling force is needed. When rollers are used to move the block a smaller force is needed.

When a block is moved on a marble mover, a smaller pulling force is needed than when the block is slid along the surface.

When the number of blocks on the roller or marble mover is increased, the pulling force needed to move them also increases.

Teaching notes

(i) Remind the children that scientists like to study the same thing in different ways to make sure that they thoroughly understand it.

(ii) You may also like to use page 19 in the pupil book.

(iii) You may need to remind some children to use the marbles only for the tasks in this activity and not for mischief.

(iv) You may like the children to use Unit 2 in the pupils book to help them explain their result.

9 Teacher's sheet: comprehension

See **pages 20 and 21** of *Friction*

Answers

1. **The marble in the water should be lower than the marble in syrup.**
2. **Syrup is thicker and stickier than water. It is harder for anything to move through it so the marble moves slower.**
3. **(i) Streamlined; (ii) Viking longship.**
4. **Marlin.**
5. **Paddle.**
6. **The fish pushes the flat of its tail and fins from side to side. They push on the water and the water pushes back to make the fish move.**

Complementary work

The children could pull toy boats across the water in a sink and compare the forces needed to move them forwards.

Teaching notes

When an object moves through water, its surface comes into contact with the water, and friction occurs between the object's surface and the water surface touching it. This force acts in the opposite direction to the pushing force of the object, and slows down the object.

Animals which need to move quickly through the water to catch prey or escape from predators have shapes which allow the water to flow over their surfaces easily. These animals have gently flowing curves, and their overall shape may be like that of a spindle or tear drop. Shapes like these reduce the push of water resistance on the body as it moves and are called streamlined shapes.

Boat hulls have a streamlined shape to reduce water resistance. Some boats have two hydrofoils attached to them. These are strong loops of metal at the front and back of the hull. As the boat moves forward, the hydrofoil lifts the hull out of the water. This reduces the area of the boat in contact with the water, and so reduces water resistance. A boat with hydrofoils is also called a hydrofoil. It can move quicker than other boats.

A hovercraft can travel over water without being slowed by water resistance. The hovercraft rides over the water on a cushion of air.

9 Teacher's sheet: activity

Based on **pages 20 and 21** of *Friction*

Introducing the activity

(a) Ask the children if they think that all liquids behave the same way when you pour them. Look for answers that some, such as water, flow quickly while others, such as syrup or bubble bath, flow more slowly. Tell the children they are going to investigate how two liquids flow, then use this information to plan an experiment to see how differently shaped objects fall through a liquid.

Using the sheet

(b) Give out the sheet and let the children write their names and form, then go through tasks 1 and 2 (see note (i)).

(c) Let the children try tasks 1 and 2.

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

(e) Go through tasks 4 and 5, then let the children try them.

(f) Go through task 6 with the children (see note (iii)).

(g) Let the children complete task 7.

(h) Let the children complete task 8 (see note (iv)).

Completing the activity

(i) Let the children compare their results.

(j) If the children have not already made any fish shapes, let them do so now and compare how they fall.

Conclusion

Water pours more easily than wall paper paste. Wallpaper paste puts up more resistance to objects falling through it because it is thicker than water.

The sinking speed of objects can be compared by letting them fall through wallpaper paste.

A pancake-shaped object will sink slowly when its flat surface is facing down, but will sink quickly if it tips on its side. A cube may turn as it sinks. A tear-drop shape sinks faster than the other two shapes.

Teaching notes

(i) Make sure that the wallpaper paste is non-allergenic.

(ii) You may wish the children to try and explain their answer, either orally or by writing it down on the sheet. They may explain that wallpaper paste will put up more resistance because it is thicker – this is sufficient.

(iii) The children are given a list of the equipment and materials that they can use. The focus here is to see if they can relate their work in tasks 3 and 5 to the problem of observing falling objects. They should pick the thicker liquid because objects move more slowly in it, and this gives them more time to compare how they fall. All objects should be the same weight. The children do not need to produce a table for this. A report saying that one object fell faster than another is sufficient

(iv) The children may place the objects in order of speed of falling, starting with the fastest.

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Teacher's sheet: comprehension

See **pages 22 and 23** of *Friction*

Answers

1. **(i) The air comes from underneath the parachute and goes up;**
   (ii) It brings the parachutist safely to the ground by slowing down the speed of falling.

2. **The air does not move aside fast enough, so we become aware of it pushing back.**

3. **They are blades on seeds which catch the air and slow down the rate of falling.**

4. **It 'cuts' through the air with as little resistance as possible.**

5. **Peregrine falcon.**

6. **They use less fuel and can carry goods more cheaply.**

Complementary work

The children could make a parachute out of a square piece of cloth and four pieces of string. They could attach the parachute to a small toy, throw the chute and toy up in the air and see if the toy is brought slowly back to the ground by air resistance.

Teaching notes

The children may think that air is 'nothing' and should not impede movement. You could demonstrate simply that air is 'something' by taking two balloons and balancing them on either end of a metre rule. You should then blow up one balloon and replace it on the metre rule. It will pull down the side of the metre rule, showing that it does contain 'something'. If you have talked about particles in Unit 8 you may say that the air is also made of particles, but that they can move about freely. However, when any object moves through air, the particles push on its surfaces. The power of the push only becomes noticeable when something is moving fast, or if it has a large surface pushing on the air.

Shooting stars are really pieces of rock which enter the Earth's atmosphere at high speed. The air particles rub against the rock so strongly that the friction causes the rock to become so hot that it gives out light. The space shuttle has heat resistant tiles on it so that it can enter the air from space at high speed without burning up.

10

Teacher's sheet: activity

Based on **pages 22 and 23** of *Friction*

Introducing the activity

(a) If the children have done the activity in Unit 7 remind them of it now and tell them that they are going to try an investigation to see if air resistance can slow down a toy car.

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) Let the children try task 1.

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

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

(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 task 6 then let the children try it (see note (iv)).

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

Completing the activity

(j) Let the children compare their results.

Conclusion

When testing to see how far a toy car moves across the floor, the test should be repeated several times.

When a toy car is fitted with a piece of card it does not travel as far. This is due to air resistance which pushes on the card and does not allow the car to travel so far.

Teaching notes

(i) Make sure the ramps are all facing the same way so the paths of the cars do not cross and cause collisions.

Check that all the cars to be used can travel in a straight line as some damaged ones may turn to the left or right.

(ii) Make sure the children measure the distance travelled from the bottom of the ramp to where the vehicle stops and record the unit used (eg cm).

(iii) if the children have tried some of the other activities in this book they should be thinking about repeating experiments. Some, however, may need reminding of this. From the results the middle value or the most frequent value may be used to indicate the distance travelled or if appropriate an average could be used.

You may like the children to explain their plan to you orally, or to write it down on a separate piece of paper.

(iv) You may like the children to explain their plan to you orally, or to write it down on a separate piece of paper. Their plan should have the same number of entries as the plan in task 3.