2. Measuring the force 1

50 mins

Children compare toy vehicles with different sized front areas to discover that vehicles with a larger front have greater air resistance.

OBJECTIVES

- Identify the effects of air resistance, water resistance and friction, that act between moving surface.
- To show that air resistance slows moving objects down.
- To show that air resistance depends on the area of the object.
- Planning different types of scientific enquiries to answer questions.

RESOURCES

(Per group of 4 children)

- Activity sheets 2 and 5
- Activity sheet 3, copied onto A5 card
- Activity sheet 4, copied onto A4 card
- Toy vehicle (Corgi or Early Learning Centre variety, see page 3)
- Hair dryer (preferably with a 'cold' setting)
- 1 metre and 30 cm rulers
- 2-3 thick, large elastic bands
- Newton force meter

INTRODUCING THE ACTIVITY (10 minutes)

In the first activity, the children should have discovered that there is a force exerted by the air on the card as the children run around, which seems to be greater if the card is bigger. Activity sheet 2 can be used here to reinforce the idea of changing vehicle shapes. See Appendix 1 for further information. However, there is no measurement of that force, and thus no objective evidence which can be presented to the transport manager. Therefore, the following can be discussed with the class:

- *How can the children measure the effect of different surface areas on the distance a vehicle will travel?*
- *Using the models we have, what experiments can be set up to compare a car and lorry?*
- *Should each group use just one model car?*
  Yes. The car should always run smoothly in exactly the same way. Different cars will not necessarily do this.
- *How can we make the front surface different?*
  Card can be stuck to the front of the model to represent the front of a lorry, with nothing fastened to it to represent a car.

- *How can we give the car the same push to make it run? The test would not be fair if different pushes were used?*
  Use a 'standard force' launcher. This can be explained and demonstrated if necessary.
- *What should we measure? What would be easy to measure?* The distance travelled from the launch point is easy to measure. The more force pushing against the car, the less distance it will travel.

Safety note

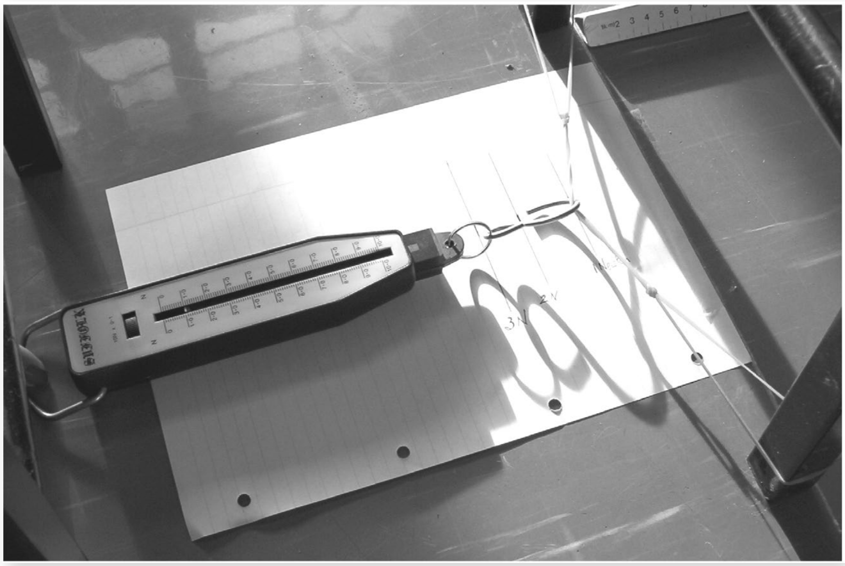
Electrical equipment brought into school must be safety-checked before use.

MAIN ACTIVITY (30 minutes)

First, each group makes their elastic band launcher, as outlined below. Activity sheet 5 provides an opportunity for children to record their predictions, and the results of their tests. The launcher is then used to test the vehicles first without a card front (representing a car) and then with Activity sheet 3 attached (representing a lorry).

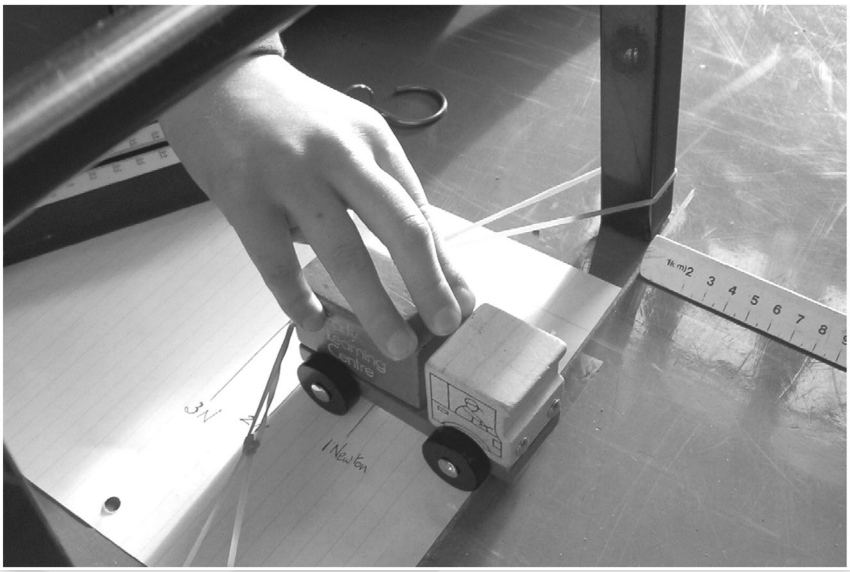
Elastic band launcher

Join 2-3 large elastic bands and stretch them between the legs of a stool or chair. Mark a line from leg to leg of the chair, and place a sheet of paper at right angles to this line. With a force-meter, pull back the elastic until a force of 1 Newton is registered, and mark the position of the elastic on the paper.



Setting up the force scale

Repeat with forces of 2, 3 and 4 Newtons. When a vehicle is placed in front of the elastic and drawn back to the marked points, the force being used to push the vehicle is known.



A vehicle about to be launched with a force of 2 Newtons

Encourage the children to repeat their test 2-3 times, to obtain a pattern of results. Depending on their ability, the average can be calculated either by choosing the middle result (median) or by calculating the mean (adding the three results and dividing by 3).

PLENARY (10 minutes)

The results[1] obtained will have shown that the vehicle with no added 'lorry front' (the car) travels further than the one with a lorry front. Ask the children:

- *Why does the car go further than the lorry?*

The children should appreciate that the larger frontal area of the lorry is creating greater resistance to the air, similar to that which they felt when they ran around the playground holding large sheets of card.

However, the children may raise other potential 'reasons' for the difference. These might include:

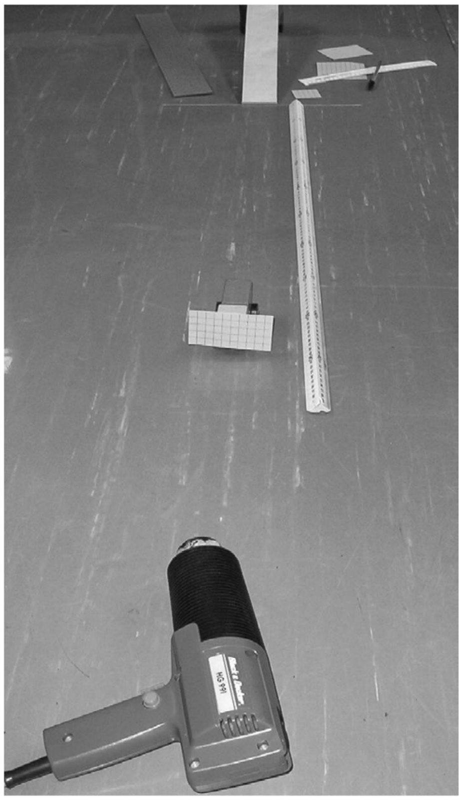
- Cars are quicker than lorries
- Cars/lorries have bigger engines
- Cars have less friction on their wheels.

It is therefore worth emphasising the controlled 'fair' nature of the tests, and that only the front of the vehicle was altered by the addition of a card 'lorry front'[2]; the same starting force and vehicle were used.

1 A sample set of results, using an Early Learning Centre vehicle and a launch force of 2 Newtons, sends the 'car' approximately 1.5 metres.

2 If a child raises the point that we have changed the weight of the vehicle as well, by adding card, then they can find out the weight of the card, and add an equivalent weight made from Blu-tack to the top of their 'car.'

The launcher is used to investigate the effect of air resistance on moving vehicles. Stick varying sizes and shapes of card to the front of the vehicle, and use a hair dryer to simulate a head wind. In this way, the effect of the front area on the distance travelled by the vehicle can be measured. The photograph below illustrates the type of set- up envisaged.



A hair dryer being used to set up wind resistance

The hair dryer could be laid on the floor, but it may be more convenient for it to be held by a child. As long as it is always held at the same position, probably around 2 metres from the launcher, the results will be 'fair' and consistent.

Using this method of measuring the distance travelled by the vehicle removes the need to make calculations of speed (distance divided by time) which could distract from the main objective of the work, particularly at Year 4. However, if groups of children, perhaps in Year 6, are capable of being extended by doing these calculations, then they should be encouraged to do so.

There are also opportunities in the work for links to technology. Years 5-6 pupils may already make simple vehicles using strip wood joined with triangles of card, to which wheels are attached. These would make excellent examples for testing purposes, if varying sizes and shapes of card are fastened to them. All such links are valuable, for they reinforce the ways in which science and technology are interlinked in industry, where an idea from science is put to use to make some part of everyday life better.

Appendix 1

THE INDUSTRIAL CONTEXT

Air resistance on moving vehicles can raise the energy costs significantly, for extra energy is needed to overcome the resistance and merely maintain speed. Back in the 1930s the National Physical Laboratory conducted tests for the London North Eastern Railway (LNER) to discover how much power was needed to overcome the air resistance at various speeds for an ordinary flat fronted engine.

They then tested the new streamlined engines being produced, and discovered how much power (and thus fuel) was saved with a streamlined shape. Some sample results from the work are quoted below.

Horsepower needed to overcome head-on air resistance

Speed (mph)	Standard engine	Streamlined type	Horsepower saved
60	97	56	41
70	154	89	65
80	231	134	97
90	328	190	138
100	451	261	190
110	599	347	252
120	779	451	328

The speeds quoted in the table are relative speeds. The engine could, for instance, be travelling at 60 mph in still air, or doing 50 mph against a 10 mph head wind. It is no accident that since the introduction of those first streamlined engines in 1935, all subsequent high speed trains like the Intercity 125s, 225s, Eurostar and the Japanese 'Bullet Train' have had carefully designed fronts and backs to minimise air resistance, and are all remarkably similar in shape.