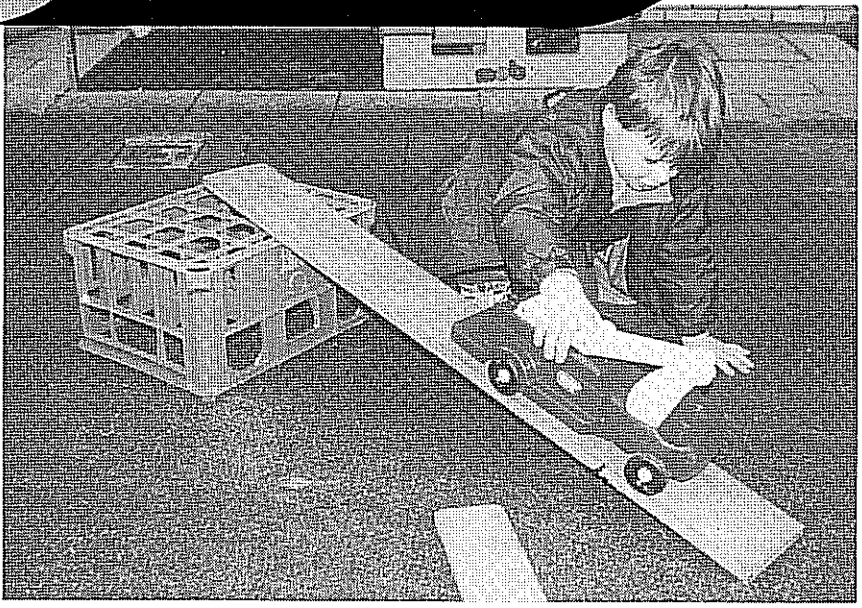
Understanding the science of classroom activities

Moving and falling objects



What forces are operating here? (Photo, North Beckton Primary School, East London)

● Paul Warwick provides background knowledge on this topic linked to activities appropriate for different age groups

At a recent in-service training day held in a large primary school in Essex the focus was on developing teachers' subject knowledge in science as *one* of the components that makes for more effective science teaching. The idea of teachers having a good knowledge of the subjects they are teaching certainly seems to be common sense and, in considering the criteria against which teaching is judged, Ofsted formalise this expectation in the inspection process.

The problem for practising teachers (apart from the perennial problem of there not being enough hours in the day!) is knowing where to gain access to the wide range of relevant background knowledge necessary for effective teaching. The aim of this article is to make some small contribution to the information available. At the end of the article I have listed some books that current trainee teachers are using to support their understanding of science ideas and which practising teachers may also find helpful.

I have chosen to focus here on moving and falling objects and have linked the information to specific activities that might be carried out with different age ranges. There is always a problem deciding on the depth of information that might be appropriate. Through my work with trainee teachers I have been struck by the fact that what is most appreciated is a clear review of what might be called 'the big ideas' in a given area of science. It is always possible in science to qualify, almost out of existence, ideas that have been fairly simplistically stated. Yet this level of explanation has an important part to play in moving teacher knowledge forward and we should be aware of qualification that begins to obscure, rather than reveal, science ideas for specific audiences. It is for this reason that, amongst other things, I have deliberately avoided formulae. I would be grateful for any feedback on the usefulness of this level of information from educators in schools and colleges.

Background knowledge for 'simple' science activities

Reception – making a vehicle move different distances

When it is standing still the forces acting on the vehicle are in balance. Gravity acts on the mass of the vehicle (the amount of substance that the vehicle has, measured in grams and kilograms) giving it weight (measured in newtons). Weight is therefore a force acting

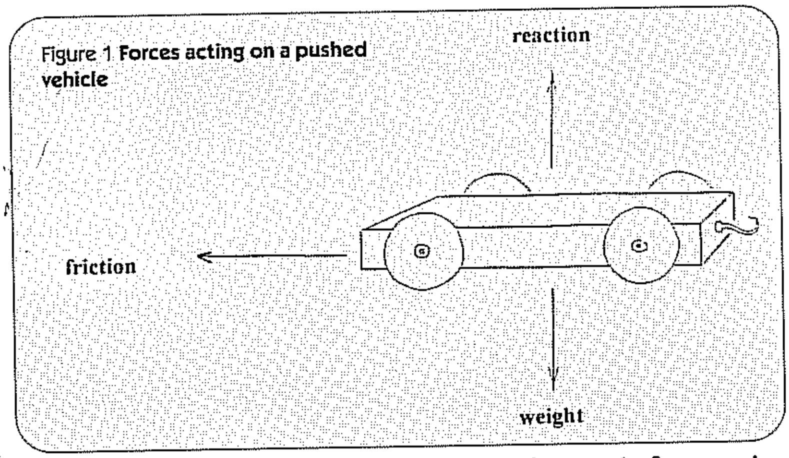


Figure 1 **Forces acting on a pushed vehicle**

downwards towards the surface – or more correctly the centre – of the Earth (if anyone doubts that weight is a force acting downwards, persuade them to hold a book out at arm's length for a while). Acting in opposition to weight is the force of reaction from the ground. The weight of the vehicle acting downwards causes the molecules of the surface on which it rests to adjust their orientation slightly and 'push back'. The greater the weight of the vehicle, the greater the push back. This is analogous to the springs in a bed, which change shape in response to weight and oppose any downward force.

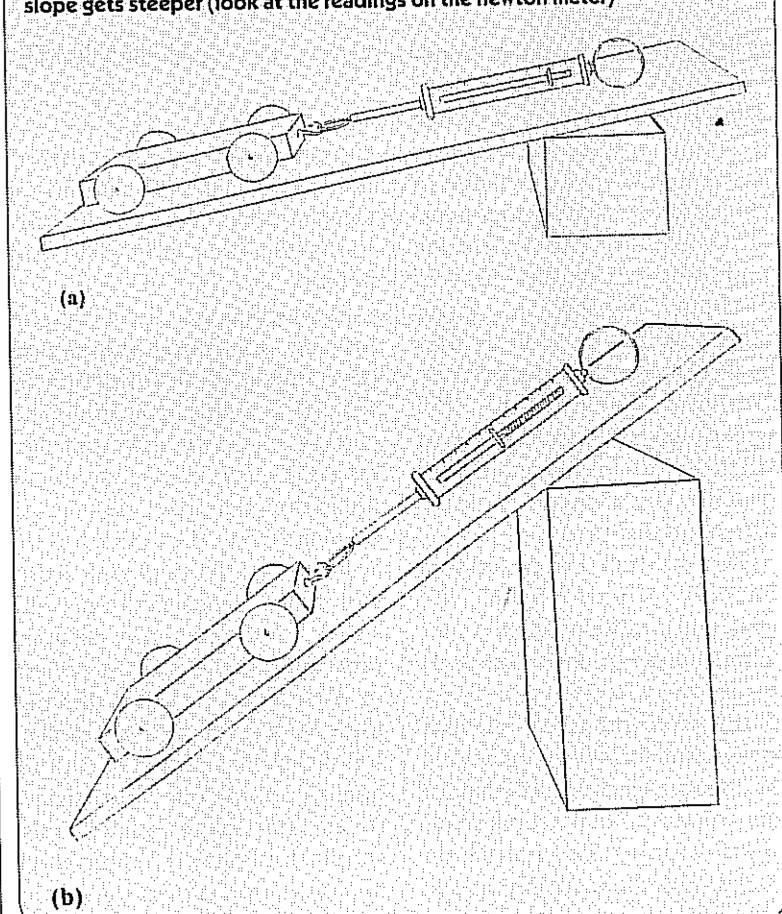
In order to get the vehicle to move a force must be applied – a push or pull. Whenever a force or forces cause an object to start, stop, accelerate, slow down or change direction then the forces are said to be unbalanced. In the case of a push, once the person pushing lets go then the force is no longer being applied – the force is not 'carried with' the object, but rather gives the vehicle a certain level of 'unstoppability'. This 'unstoppability' is the momentum of the vehicle, which is related to the velocity (speed in a particular direction) and mass of the vehicle. The harder the push the greater the acceleration. If the vehicle has more mass, and therefore weighs more, it takes a greater force to get it going at the same velocity as a light vehicle, but its momentum at this velocity will be greater – its 'unstoppability' is greater.

When the vehicle is moving there are three main forces acting on it (see Figure 1). Weight and the force of reaction continue to act and balance each other, whilst friction acts in opposition to movement. Frictional force occurs between surfaces. In the case of a simple moving vehicle, frictional force mainly occurs between the wheels and the surface on which they travel, and between the axles and the vehicle body. The heavier the vehicle, the greater are these frictional forces. Eventually the frictional force, not counterbalanced by a force acting to keep the vehicle moving forward, will cause the vehicle to stop, when all forces will once again be balanced.

Years 1 and 2 – vehicles down ramps of different heights

The forces in operation when a vehicle is on a flat surface are still appropriate here, but the slope introduces additional considerations. A vehicle on a slope is essentially a falling object that is having its fall redirected by the slope. The effect is that whilst part of the weight (force) of the vehicle acts into the slope surface and is opposed by the force of reaction (the reaction is said to be normal to the slope), part of the weight acts in the direction of the slope. You can see how big the component of force acting down the slope actually is, by attaching a newton meter to the back of the vehicle (Figure 2).

Figure 2 **The component of force acting down the slope increases as the slope gets steeper (look at the readings on the newton meter)**



As a slope gets steeper, the vertical drop for the vehicle gets bigger (remember the vehicle is a falling object). Put another way, a greater and greater component of the force acts down the slope and, as a consequence, less and less of the weight of the vehicle is counterbalanced by the force of reaction. Effectively, then, as the slope increases the force moving the vehicle down the slope increases, increasing the momentum of the vehicle and causing it to run further when it gets to the end of the slope.

Years 3 and 4 – falling paper

If we let a piece of paper fall to the ground it quickly becomes clear that something is opposing the movement downwards. The paper takes a long time to drop and is diverted to fall in a random, swirling manner. This occurs because the act of falling gives momentum to the countless billions of air molecules beneath the paper. A force of reaction is set up, which opposes the downward movement of the paper. This is a frictional force, as the air molecules are in contact with the paper and act in opposition to movement. It is a significant force because there are so many molecules under any broad falling object.

If we scrunch up an identical piece of paper and drop it, the number of molecules of air that come into contact with the paper is reduced. The force of reaction from the air molecules cannot be as great, so the paper falls more quickly.

An interesting adjunct to this idea comes from looking at how two pieces of paper fall. If their dimensions and weights are very similar then there is likely to be little *detectable* difference in their rate of drop. However, as you increase the weight of one of the pieces of paper – for example, by attaching heavier and heavier blobs of Blu-Tack to the centre – it will begin to fall demonstrably more quickly than the other piece (Figure 3). The reason for this is that increasing the weight produces a greater force downwards whilst the frictional force from the air molecules remains effectively the same. A direct comparison can be made between what is occurring here and what occurs when parachutes have different masses suspended beneath them.

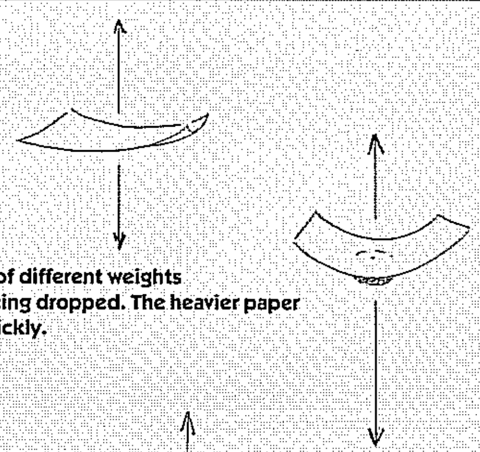


Figure 3 Two papers of different weights immediately after being dropped. The heavier paper accelerates more quickly.

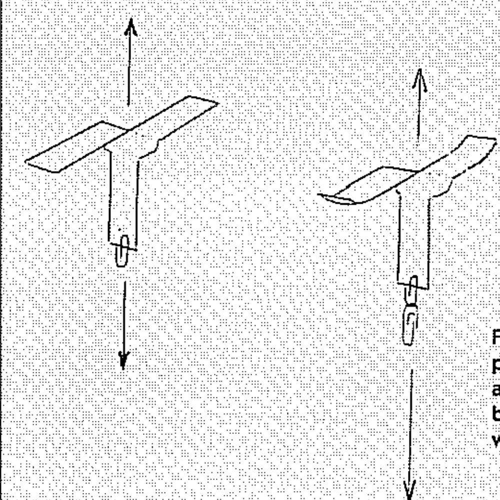


Figure 4 Rate of fall of paper helicopters is also affected by slight bending of the wings as weight is increased

Years 5, 6 and 7 – paper helicopters

There are several ways in which a paper helicopter can be regarded in a similar way to a falling piece of paper. Though the wings are small, they rotate. This means that the effective overall size of the falling helicopter is determined by the circumference of the circle described by the rotating wings. As this is the case, the frictional force from the air molecules will be significant as the helicopter falls. This means that as weight is added to the helicopter it will fall more rapidly, for the same reasons that weighted paper falls more rapidly than unweighted paper.

In addition to this, however, increasing weight has the effect of pulling the wings up slightly, effectively changing the circumference described by the wing shape, reducing the frictional force and changing the rate of drop (Figure 4).

Acknowledgement

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Further reading

Farrow, S. (1995) *The really useful science book: a framework of knowledge for primary teachers*. London: Falmer Press.

Peacock, G. (1998) *Science for primary teachers*. London: Letts Educational.

Nuffield Primary Science (1997) *Understanding science ideas: a guide for primary teachers*. Glasgow: Collins Educational.

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