Go safe – science class activities

The physics:

What is a force?

You can't see a force, only its effects. Forces can produce changes in

- Speed
- Direction
- Shape

Many people think that if something is moving, there must be a force acting on it. In fact, all we can say is that if something is changing speed, shape or direction, there must be a force on it.

Strictly speaking, we should say "there must be an unbalanced force acting on it". For example, there can be large forces on a tug-o-war rope, but if each team exerts the same force in opposite directions, the rope does not change speed, shape or direction. The forces balance.

It's counter-intuitive, but if there are no unbalanced forces on an object, it will keep going in a straight line at a steady speed forever. This is known as Newton's First Law of Motion, after Isaac Newton. Isaac Newton built on the work of Galileo, though Muslim scientists almost certainly got there first.

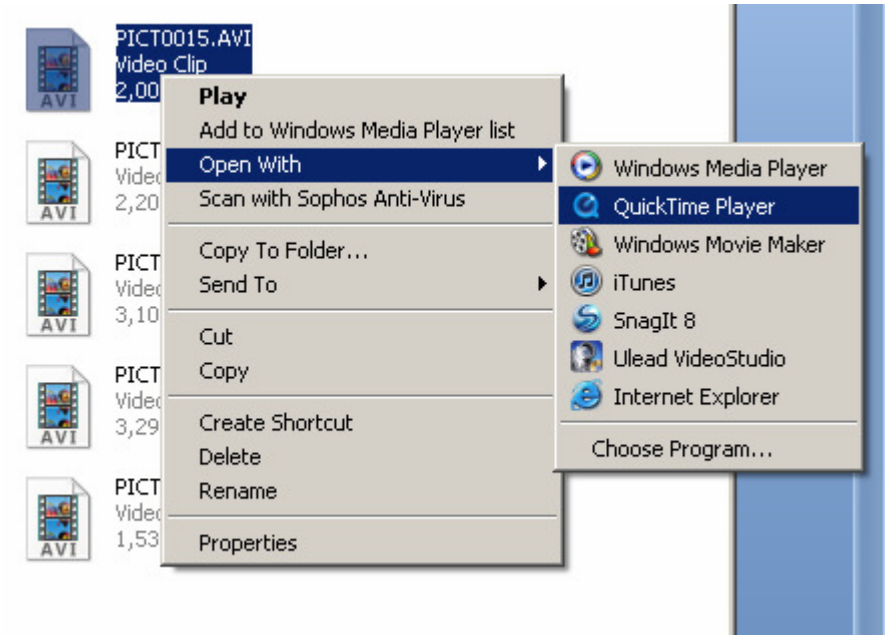
In deep space, a rocket can switch off its engines and continue travelling at huge speeds, neither slowing down, speeding up nor changing direction.

Newton's First Law explains the need for seat belts.

- If you are travelling in a car that is doing 60 mph, you are doing 60 mph too.
- You will keep doing 60 mph until a force changes your speed.
- If the car is involved in a collision, the force from your seat belt will bring you to rest.
- If you are not wearing a seatbelt, the force that brings you to rest could come from the windscreen, steering wheel, dashboard or the head of the person in front of you.

You can demonstrate this by filming a toy car or physics trolley with something sitting on it. Allow it to crash. The object on top will keep going at a steady speed in a straight line until something stops it.

Tip: Open the film clip with QuickTime. Right click on the clip and choose QuickTime as shown below:

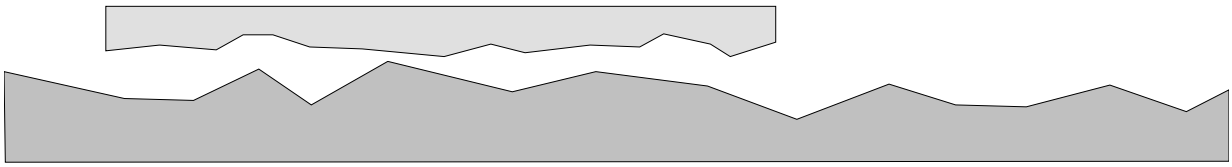


QuickTime allows you to step through the clip a frame at a time, using the arrow keys.

The force of friction

The reason that a lot of work with forces is counter-intuitive is that in all real situations that people are likely to meet, there is a force called friction opposing motion.

Friction occurs when surfaces move over one another (or when an object moves through air or a liquid). Even apparently smooth surfaces look like mountain ranges when magnified.



So, the reason that something doesn't keep going at a steady speed when you stop pushing it is that friction slows it down.

Friction is important in road safety because it is the force between the road and tyres, or the pavement and feet, that is responsible for grip. It is the force behind braking.

If a road surface is wet or, worse still, icy, the force of friction will be much smaller and skidding or sliding may happen. Stopping distances will increase.

Ideas for demonstrating friction

Make a balloon hovercraft (right). Children can push it and let it go. It comes to rest quickly. Then, they can repeat the activity, opening the air hole. This time, because friction is low (a cushion of air is keeping surfaces apart), it will go much further.

A launcher can be built using elastic bands so that fair comparisons can be made on the distances gone.

Another idea is to make a clockwork toy attempt to climb a slope made of shiny material. Make the slope just steep enough for it to struggle.

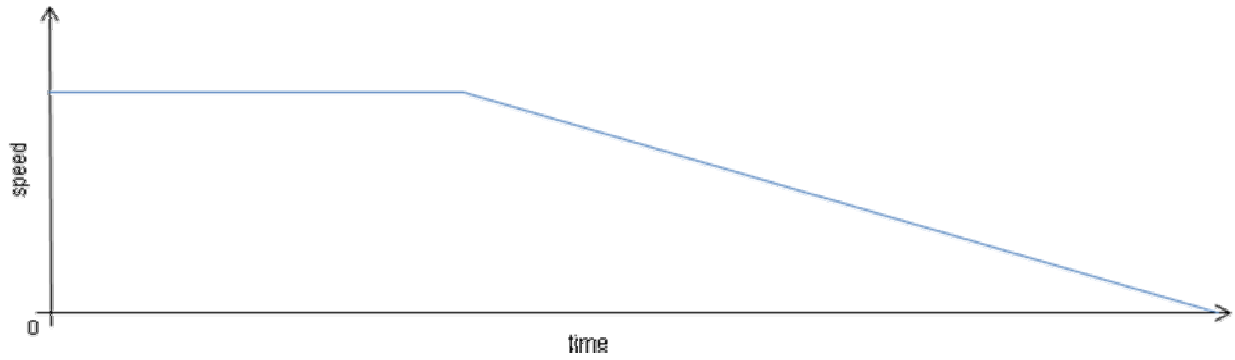
Now fit sandpaper or rubber boots to the toy. You increase the friction and hence grip and the toy climbs the slope.

Note that when a vehicle is travelling at a steady speed, the engine force and the force of friction acting against it are balanced (most of the force acting against it comes from air resistance).

The engine force is trying to speed the car up. The frictional force is trying to slow it down. If they are equal (balanced), the car will go at a steady speed in a straight line, behaving as if there was no force on it at all.

Reaction Time

The diagram below shows how a driver's speed changes with time from the moment the driver sees a hazard.



At first, the speed doesn't change. Signals are travelling to the driver's brain, the driver's brain decides what to do and then sends signals to the leg muscles to operate the brake.

This time is called **Reaction Time**. The distance travelled during this time is often called **Thinking Distance**.

Thinking distance depends on:

- Your reaction time
- Your speed

When the driver brakes, the car's speed decreases. The distance travelled from the moment the brake is pressed until the car stops is called the **Braking Distance**.

Braking distance depends on:

- Your speed when you start braking
- Road conditions

Of course, it depends on the condition of your brakes, how hard you press them and so forth as well. The Highway Code assumes that you slow down by about 11 mph every second.

Overall stopping distance = thinking distance + braking distance

The Reaction Timer

Sequence:

Reset

Clears away any previous measurements, ready to start again.

Start

Makes the light flash for a random number of times, after which it stays on.

Stop

Causes the time between the light staying on and the user pressing this button to be displayed.

The device can pick up cheats!

It displays (from the left)

- Reaction time in milliseconds (1000 ms = 1 second)
- Thinking distance in metres
- Braking distance in metres

The speed control:

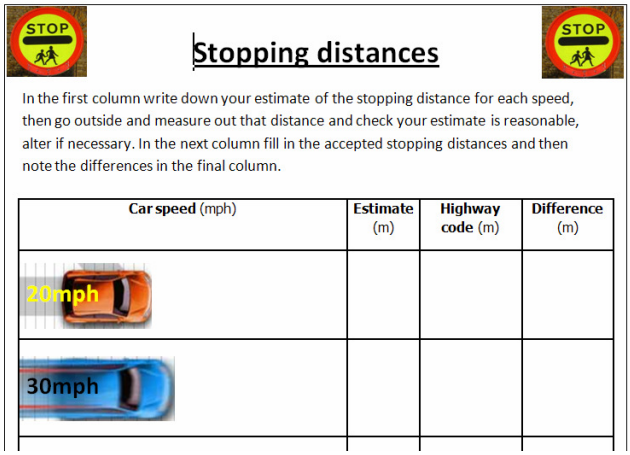
- Can be adjusted to show thinking and braking distances at different speeds.
- Has no effect on reaction time – this depends only on the person and any distractions.
- Can be altered after reaction time has been found.

The road condition control:

- Can be adjusted to show braking distances in different road conditions.
- Has no effect on reaction time or thinking distance.
- Can be altered after reaction time has been found.
- Assumes twice the distance for wet, ten times for icy.

Suggested approach:

Work cards and help cards are available.



Stopping distances

In the first column write down your estimate of the stopping distance for each speed, then go outside and measure out that distance and check your estimate is reasonable, alter if necessary. In the next column fill in the accepted stopping distances and then note the differences in the final column.

Car speed (mph)	**Estimate** (m)	**Highway code** (m)	**Difference** (m)
20mph			
30mph			

Ask pupils to estimate the stopping distances for cars at different speeds. This could be done by asking pairs of them to stand the distance apart they think corresponds to the stopping distance at a particular speed.

If space is not available for this, get them to fill in the table with their estimated stopping distances at different speeds. The table has a column for the Highway Code stopping distance. They can research this.

Pupils, working in groups, then find their reaction times with the timer. If time permits, they could be allowed a “best time out of three”.

Some schools have used a Top Gear-style leader board for reaction time.

If the pupils can handle graphs, they could, for a particular reaction time, plot a bar chart of overall stopping distance for different road conditions. More able pupils could plot a line graph for either thinking distance, braking distance or overall stopping distance at different speeds.

Find some pupils with good reaction times – say around 600 milliseconds. Get them to try again whilst being distracted –

- On the phone
- Texting
- Trying to change a CD – there is space under the timer to do this

It is very important that pupils can relate the distances on the timer to real life. It is strongly suggested that for one of the higher speeds, the corresponding stopping distance is measured or paced out.

Curriculum for Excellence Experiences and Outcomes

Science

- **SCN 1-07a** By investigating forces on toys and other objects, I can predict the effect on the shape or motion of objects.
- **SCN 2-07a** By investigating how friction, including air resistance, affects motion, I can suggest ways to improve efficiency in moving objects.
- **SCN 3-07a** By contributing to investigations of energy loss due to friction, I can suggest ways of improving the efficiency of moving systems.
- **SCN 4-07b** By making accurate measurements of speed and acceleration, I can relate the motion of an object to the forces acting on it and apply this knowledge to transport safety.

The SSERC activity Pimp My Trolley, also available from Road Safety Scotland, is suitable for the last of the above. **Topical Science** can also be covered by all of these activities.

Health and Well Being

- **(HWB) 2-18a, 3-18a,4-18a** I know and can demonstrate how to travel safely.
- **HWB 2-16a, 3-16a, 4-16a** I am learning to assess and manage risk, to protect myself and others, and to reduce the potential harm where possible.

The curriculum for excellence requires all teachers to promote the development of **numeracy** and one of the experiences and outcomes identified is that the pupil's learning should enable them to:

- Interpret numerical information appropriately and use it to draw conclusions, assess risk, make reasoned evaluations and informed decisions.

All teachers are teachers of literacy. Pupils could be asked their opinion on 20 or 80 mph speed limits

- **LIT 3-29a** I can persuade, argue, explore issues or express an opinion using relevant supporting detail and or evidence.
- **LIT 3-09a** When listening and talking with others for different purposes, I can:
    - communicate information, ideas or opinions
    - explain processes, concepts or ideas
    - identify issues raised, summarise findings or draw conclusions.