**ACTIVITY: An investigation of motion**

**Investigation idea**

In this investigation, students will measure distance and time to calculate speed and acceleration.

By the end of this investigation, students should be able to:

* describe ways to measure the speed of an object
* use a formula to measure average speed
* estimate the speed of everyday motion
* calculate the speed of everyday motion
* distinguish between speed and acceleration
* describe acceleration.

# For teachers

This investigation uses the term ‘speed’ rather than ‘velocity’. Velocity refers to both speed and direction. Because this investigation examines velocity in one direction, the term ‘speed’ is appropriate.

## Background

This investigation gives students an opportunity to develop an understanding of speed and introduces acceleration. By measuring distance and time, they will calculate the speeds of moving objects. They will also learn to convert from metres per second to kilometres per hour for everyday motion such as walking, running and riding a scooter, skateboard or bicycle. An understanding of speed provides a foundation for the concept of acceleration (changing speed) and ultimately the concept that a force is needed to change the speed of an object.

***Calculating speed***

Example: A person runs 3.25 metres in 2.5 seconds.

speed = distance ÷ time

= 3.25 m ÷ 2.5 s

= 1.3 m/s

Depending on the students’ numeracy ability, you may also explore converting from metres per second to kilometres per hour.

To convert metres to kilometres, divide by 1,000.

3.25 m ÷ 1,000 km/m = 0.00325 km

To convert seconds to hours, divide by 3,600.

 2.5 s ÷ 3,600 s/h = 0.000694 h

 0.00325km ÷ 0.000694 h = 4.68 km/h

Note: The conversion from metres per second to kilometres per hour can be done in one step by pre-calculating the conversion factor: 3600 s/h ÷ 1000 m/km = 3.6. Therefore, a speed in metres per second multiplied by 3.6 is converted to a speed in kilometres per hour.

1.3 m/s x 3.6 = 4.68 km/h

***Average speed versus instantaneous speed***

When you calculate speed by measuring the distance travelled divided by the time taken to travel the distance, you are measuring average speed. The object could slow down or speed up between the start and end points. Instantaneous speed is the speed an object is travelling at a specific time. For example, if a ball is dropped, the initial speed is 0 m/s, and it speeds up steadily until it reaches the floor. The average speed can be calculated (distance ÷ time), but the instantaneous speed will be constantly changing.

***Acceleration***

When speed changes, it is called acceleration. When something gets faster, it is positive acceleration. If it slows down, it is negative acceleration or deceleration.

acceleration = speed change ÷ time

In this investigation we won’t be calculating an acceleration, but the process is relatively simple.

Example: If a drag racing car starts from rest and travels the 304.8 m track reaching a final speed of 150 m/s (current world record) in 4.06 seconds, what was its acceleration?

 speed change: from 0 m/s to 150 m/s in 4.06 seconds

acceleration: 150m/s ÷ 4.06 s = 36.9 m/s2

The speed increased by 36.9 metres per second each second.

## What you need

* Heavy sports ball
* Tape to mark the starting and finishing lines

For each student group:

* Distance measuring device (metre stick or measuring tape)
* Timing device (stop watch or cell phone with timing application)

***Teaching suggestions***

You may wish to begin by rolling a ball in the classroom or gym. Ask the students how fast the ball is moving and how its speed could be measured. You could roll the ball again across a known distance (two marks on the floor) and ask the students to record the time it takes the ball to go the distance. Many schools have a very slow speed posted in the parking lot (5 km/h to 15 km/h). Is the ball breaking this speed limit?

Measuring the speed of everyday events can be interesting to students. Some examples:

* How fast can you run 20 metres?
* What is the average speed of walking?

In groups of 3–4, have students measure out a distance and measure the average speeds of walking and running.

If your school is near a well travelled street, you could set up a ‘speed trap’ by having students measure out a distance on the road (the distance between two poles works well) and position one student at each end of the distance to signal their partner to start the time when a car passes the first pole and stop the timer when the car gets to the second pole. The maximum speed limit in a school zone is 40 km/h. How many cars were speeding?

Mark out a 20 metre distance. Have one student run the 20 metres while the others calculate the average speed. Then have the student start from 5 metres back. Start the timing when they cross the beginning mark, and stop timing when they pass the 20 metre mark. The first run will be slower, because for part of the running time, the student will be accelerating from rest (0 m/s). In the second run, the student has 5 metres to accelerate before they hit the starting line and will already be at nearly full speed.

***Scientific emphasis***

Understanding motion (speed and acceleration) is a necessary precursor to understanding the laws of motion described by Sir Isaac Newton. These laws describing motion and forces are at the heart of many concepts in physical science.

By participating in this investigation, students are also investigating in science. You can support them to think about why some results might vary (such as different students doing the running) and what the implications of this might be. For example, how would you calculate the average walking distance across the class? Does this vary for children and adults? How are average walking times calculated for public walks?

Students can also learn about the importance of repeating measurements:

* Why do the results differ? (Runners getting tired, human subjectivity about stopping the timer, delays between seeing the runner go past the stop line and your brain telling your hand to stop the timer, where the person doing the timing is standing relative to the start and finish post etc.)
* How do you calculate the average across multiple measurements?
* Why is calculating an average important?

Through this investigation, students can develop the [science capabili](http://scienceonline.tki.org.nz/Science-capabilities-for-citizenship/Introducing-five-science-capabilities)ty ‘Gather and interpret data’.

## Extension ideas

* Have a student start from rest and accelerate for 20 metres (either running or on a bicycle). Calculate their average speed. If their initial speed is 0 m/s, how might they calculate their final speed and acceleration?
* Use the ability to measure speed to investigate whether speeding is a problem in the local area. This would give students opportunities to develop the [science capability](http://scienceonline.tki.org.nz/Science-capabilities-for-citizenship/Introducing-five-science-capabilities) ‘Engage with science’, in which they could bring together the skills of gathering and interpreting data, using evidence, critiquing evidence and interpreting representations (for example, graphs of the average speed of cars at different times of day or in different locations near the school boundaries, proportion of cars shown to be speeding).

## A common alternative conception

The concepts of speed and acceleration are often confused by students. Speed is a *change in location* in a certain amount of time whereas acceleration is a *change in speed* in a certain amount time.

