3.1 Describing motion

Aims

*(a)* define displacement, speed, velocity and acceleration

*(b)* use graphical methods to represent displacement, speed, velocity and acceleration

*(d)* use the slope of a displacement-time graph to find the velocity

*(e)* use the slope of a velocity-time graph to find the acceleration

# Rolling balls down ramps

This is a version of the experiment that Galileo performed towards the end of the sixteenth century.

marble

runway

stop

Apparatus required

* wooden runway
* digital stop clock
* metre rule to measure lengths along runway
* metre rule to act as a ‘stop’.
* retort stand and clamp
* marble

Procedure

* Set the ramp at about 20o slope.
* Measure the time taken for the marble to run from the top of the slope to a rule (‘stop’) 10 cm along the slope. Repeat this measurement a sensible number of times to establish a mean value.
* Move the stop point to 15 cm from the top of the slope and repeat the process.
* Continue the process, at 10 cm intervals until the marble runs the length of the ramp.
* Results can be recorded in a table with the following headings:

|  |  |  |  |
| --- | --- | --- | --- |
| distance along ramp / m | mean time/ s | average velocity / m s-1 | final velocity =2 × average velocity / m s-1 |

Analysis

Draw graphs of final velocity against distance and final velocity against time. From the second graph deduce the marble’s acceleration.

Repeat the experiment using a different angle of slope, and find the new value of acceleration.

If you have time repeat with a marble of different mass.

# Distance, time and speed calculations

Try these calculations

Graph paper is needed for some. These questions are all based on the connection between speed, distance and time. Answer in the spaces provided:

Hints

In these questions it is useful to remember that:

– if an object is accelerating steadily from rest its average speed is half the maximum speed

– and that distance travelled = average speed time

1. You are watching a batsman hit a cricket ball. If 0.375 s passes between the time you see him strike the ball and the time you hear the sound of this, how far from the batsman are you sitting? The speed of sound in air is 340 m s–1. (The speed of light is nearly a million times bigger than this, so you see the bat hit the ball more or less at the instant it occurs.)

2. A girl diving from a 15 m platform wishes to know how fast she enters the water. She is in the air for 1.75 s and dives from rest (with an initial speed of zero). What can you tell her about her entry speed?

3. An experiment performed on the Moon finds that a feather falls 20.75 m from rest in 5 s. What is its speed as it hits the Moon's surface?

4. The sketch graph shown represents the variation in vertical height with time for a ball thrown upwards and returning to the thrower.



From this graph sketch a velocity–time graph.

5. In a Tour de France time trial a cyclist is able to reach a top speed of 100 km h–1 by starting from rest and pedalling flat out for a distance of 3 km. If the rate at which the cyclist's speed changes is uniform, how long will this take?

6. You are travelling in a car moving at 50 km h–1 (just over the 30 mph speed limit). What is this speed in m s–1? You have to brake so the car comes to rest uniformly in 1.4 s, how far will you travel? A cat runs out in front of your car and your reaction time is 0.6 s. What is the total distance the car will travel before stopping?

7. A steam traction engine speeds up uniformly from rest to 4 m s–1 in 20 s. It then travels at a steady speed for 440 m and finally comes to rest uniformly in 10 s having travelled 500 m in total. Draw a speed–time graph for its motion showing key values of speed and time. What is the total time for the journey? What is the average speed for the whole journey?

8. A tennis ball is dropped from a height of 2 m above a hard level floor, and falls to the floor in 0.63 s. It rebounds to a height of 1.5 m, rising to a maximum height 1.18 s after it was released. Draw a speed–time graph indicating speed and time at key points of the motion.