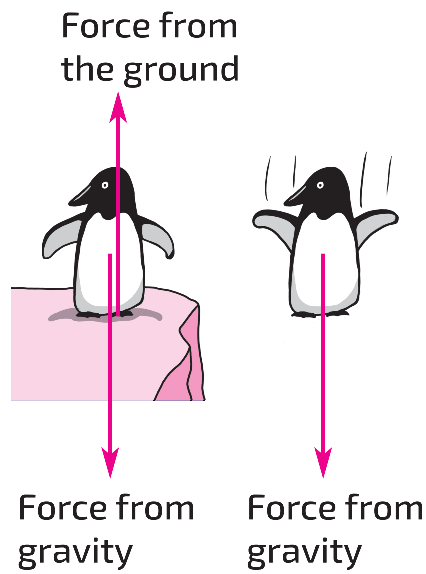
Is this object falling at constant speed or accelerating?

In this experiment we are going to drop an object, from rest, on Earth. We all expect it to fall to the ground, but does our object fall through the same distance each second (*it moves at constant speed*) or does the distance travelled in each second change (*it accelerates*)?

We will:

- Take time and distance readings from a video of a falling object and put them in a table.
- Use our table to plot a graph of the distance travelled against time.
- Look at the shape of the graph to answer our question: is the object accelerating?



Equipment

- A laptop, tablet or smartphone to watch the video
- Graph paper (in this worksheet)
- A print out of this worksheet (or copy the table)
- Pens, pencil
- Ruler
- Calculator

Method

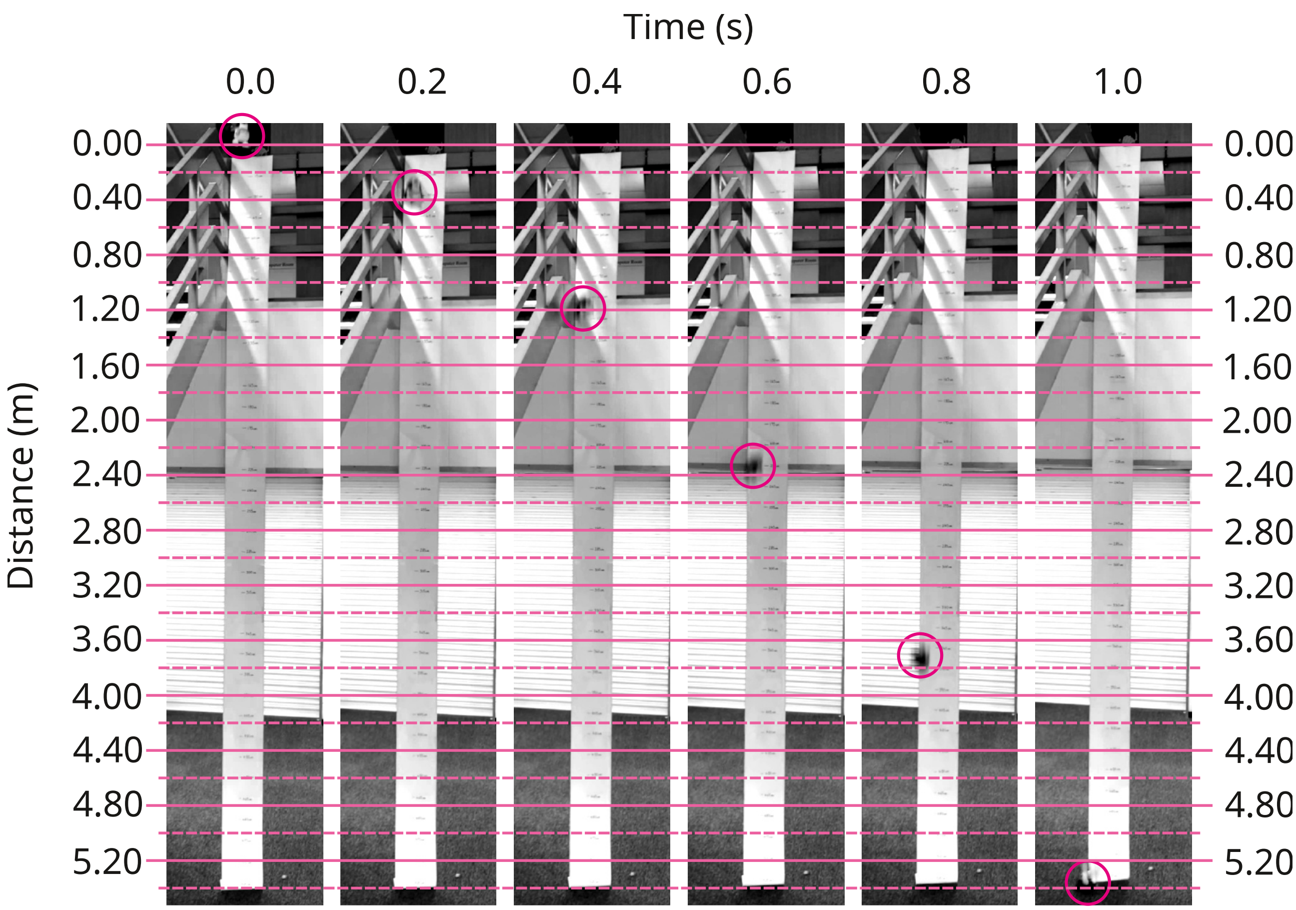
1. Watch the video of the object falling. You may wish to play it a few times as it is only a few seconds long.
2. Using each of the photographed snapshots from the video enter the corresponding times into the results table on the next page.
3. Using the distance scale on the photographs, read off the distance that the object has fallen for each time and enter your values into the results table. Write the distance fallen as a positive number to two decimal places and notice that the units are metres.
4. From the data in a table plot a graph of our dependent variable distance, against our independent variable time.
5. Look at your graph. What does it tell you about the motion of the falling object? Is it moving at constant speed or accelerating?

Results

Use the snapshots of the video that are given below to complete the table of results.

The times are measured in fractions of a second up to 1 second.

We have highlighted the object for you, but think about how you will measure the distance fallen. Where on the object is the distance zero at the start? Should you pick anywhere in the circle, or pick the same point on the object each time?



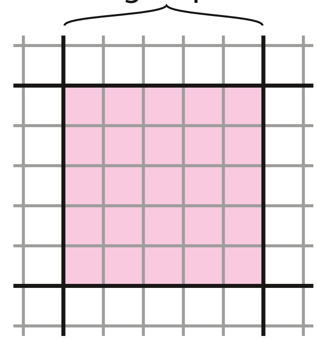
Time (s)	Distance fallen (m)
0.0	0.00
1.0	

Plotting your graph

We are going to plot a graph with the independent variable (time) on the horizontal axis and the dependent variable (distance) on the vertical axis. A sheet of graph paper is provided at the end of the handout for you to plot your graph.

1 First we need to decide on a scale for our axes.

(a) The range of our times is from 0.0 seconds to 1.0 second and we have 10 large squares on the horizontal, time-axis of our graph. If each large square represents the same amount of time, how much time does each large square represent?



We can now label each large square on our time axis (next to the small black mark). The first (0) and last (1.0) numbers have already been added for you.

(b) We now need to do the same for our distance axis. First decide on your range of values - your minimum distance fallen is 0.00 m at the start of the experiment. What is the largest distance fallen by the object?

(c) The value for each large square $= \dfrac{\text{maximum value} - \text{minimum value}}{\text{number of large squares}}$. There are 10 large squares on your distance axis. We then round this value **up** to something that is easy to use. For example, if we had an answer of 0.13 then we might round this to 0.2. You may also want to take into account the number of small squares per large square so that the size of each small square is a sensible number. For example, if there were 5 small squares per large square and you calculated a spacing of 0.90, then you may wish to round up to 1.0 so that each small square is 0.20 and not 0.18.

We can now label each large square on our distance axis.

2 Use the scales on the axes to plot each of the points in our table. To mark a point we use a '+' where the centre of the cross marks the time and distance value of that point.

(a) Take a value of time and draw a dashed vertical line to the top of your graph.

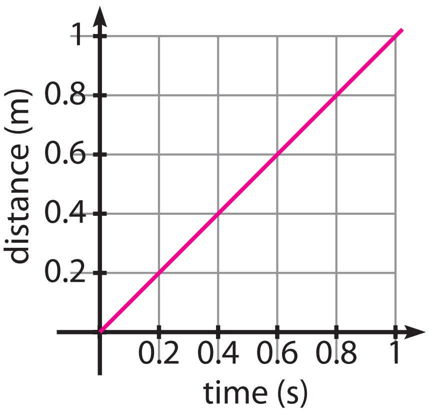
(b) Use the distance measurement for this time and draw a horizontal dashed line.

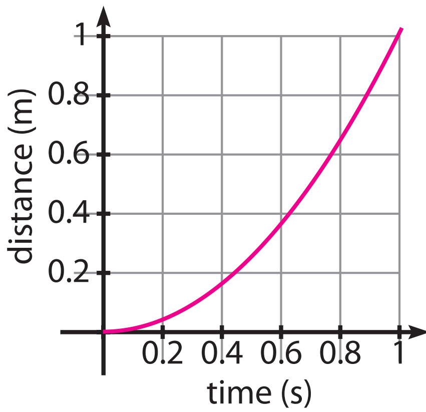
(c) Where these two lines meet is where you mark your point.

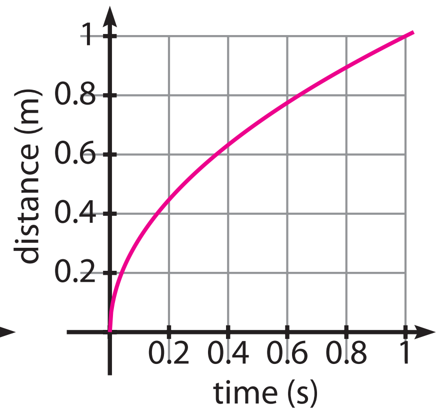
3 Once you have plotted all of your points, draw a smooth line through the points. This is not a dot-to-dot, you must not connect each point to the next one but instead in one smooth motion draw a line that goes through the points as best you can. If your line only passes through some of the points, you should have equal numbers of point above and below the line.

Discussion

4 Which of the following shapes is most similar to the graph that you have drawn?



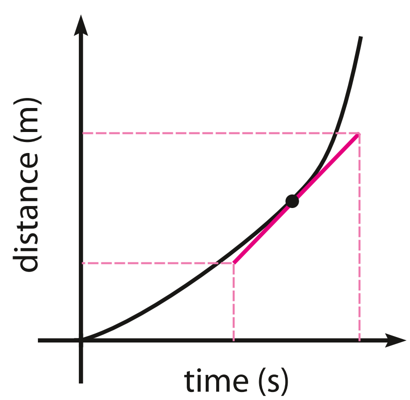




5 Which of the 3 graphs above show equal distance in equal time?

If an object is travelling at constant speed then it travels equal distance in equal time. If an object has an acceleration then the speed of the object is either increasing or decreasing. The definition of speed is:

$$\text{speed} = \frac{\text{distance}}{\text{time}} \quad \text{or in symbols} \quad s = \frac{d}{t}.$$



We can measure the speed of our falling object by measuring the slope (or gradient) of our graph. If our graph is curved we draw a tangent to the curve at the point we wish to measure the gradient. If at different points the tangents have the same slope then the object is travelling at constant speed. If the slope of the tangents gets steeper for larger values of time then the object is travelling a greater distance each second and is therefore accelerating. If the slope gets smaller the object is decelerating.

6 For each of the 3 graphs at the top of the page is the object at rest, at constant speed, accelerating, or decelerating?

7 For the graph you have drawn for your data is the object at rest, at constant speed, accelerating, or decelerating?

Conclusion

8 Write a conclusion for your experiment, this should answer the initial question. From this experiment and the analysis of the data, I conclude that the object is ...

Use this graph paper to plot your data for the falling object. Remember you will have to work out your scale for both axes.

Title: A graph of the distance fallen by the object against time