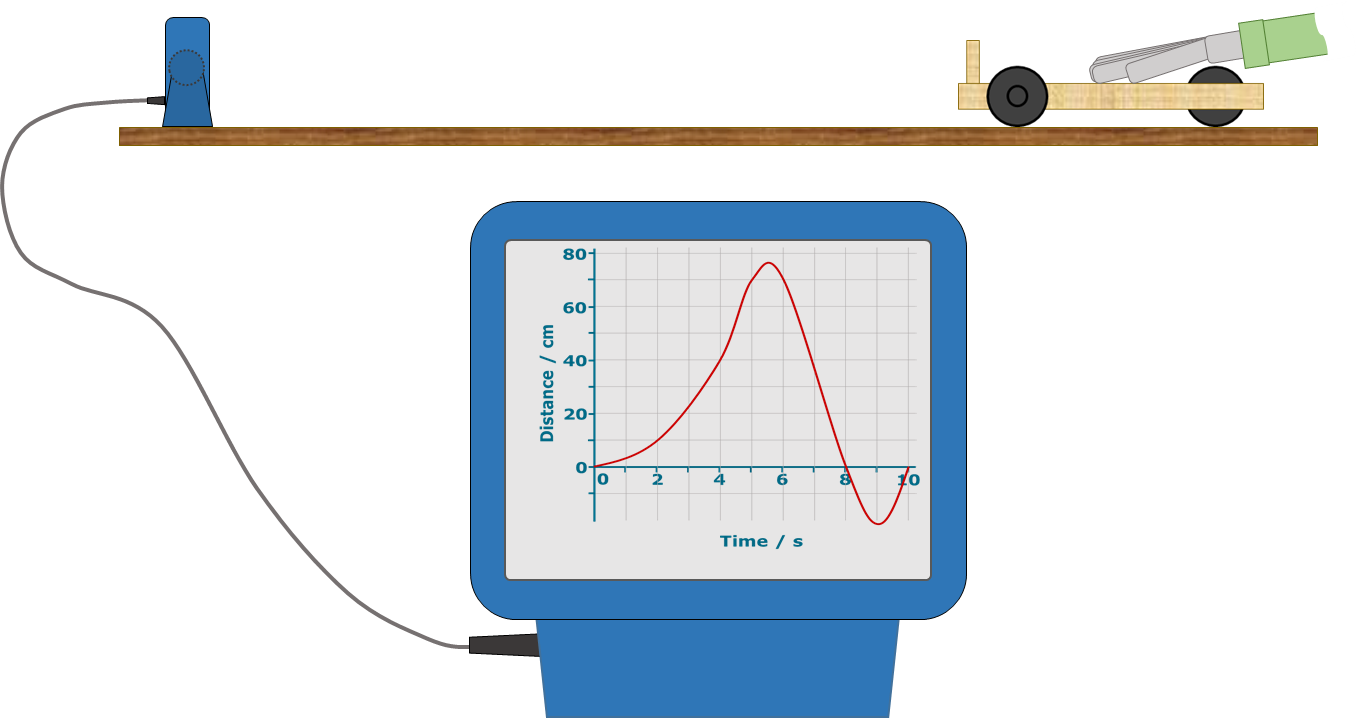
**Speedy graphs**

We can use a motion sensor and data-logger to plot graphs in real time.



**Apparatus and materials**

* Motion sensor
* Data-logger
* Connecting cables
* Dynamics trolley

**Procedure**

Set up the equipment and practise making your own graphs.

What does the graph look like when:

1. The trolley is moving at a steady speed?
2. The trolley is moving at a faster steady speed?
3. The trolley is not moving?
4. The trolley starts slowly and speeds up?
5. The trolley starts quickly and slows down?

|  |  |
| --- | --- |
| 1. Can you move the trolley to make this graph? | 2. How do you move the trolley differently to make this graph? |
|  |  |
| 3. You need two kinds of motion to make this graph. | 4. What is the trolley doing when the line on the graph is level? |
|  |  |
| 5. Can you move the trolley to make this graph? | 6. For this graph think carefully about how to start. |
|  |  |
| 7. Why is this a more realistic graph? | 8. Draw your own distance-time graph to try |
|  |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force > Key concept PFM2.2: Motion graphs*

|  |
| --- |
| **Response activity** |
| **Speedy Graphs** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Information about the motion of an object can be summarised on a distance-time graph: the plot shows the object’s distance from the start at a given time and the slope (gradient) at that point shows its speed. |
| Observable learning outcome: | Describe the changes to an object represented by a move from one point on a distance-time graph to another  Describe motion of an object represented by straight lines on a distance-time graph  Explain how a distance-time graph shows the changing position of an object  Explain how a distance-time graph shows the changing speed of an object |
| Activity type: | Application and practice - practical |
| Key words: | Distance, time, graph |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Plot story
* Diagnostic question: Line story
* Diagnostic question: Two slopes
* Diagnostic question: Where’s Sally?
* Diagnostic question: The speed of Dwight

**What does the research say?**

When interpreting graphs students must be able to determine which features of a graph correspond to particular physical concepts. With distance-time graphs there is often confusion between the slope (speed) and height (distance) of a graph (Clement, 1986; McDermott, Rosenquist and van Zee, 1987). One strategy to overcome this is to use motion sensors and data-loggers to plot real-time graphs of motion. Students can practise predicting the shape of graph for different descriptions of motion and also reproduce the shape of given graphs by moving in front of a motion sensor. A study of 17- to 18-year-olds (n=75) showed this approach significantly improved students ability to interpret distance-time graphs (Brasell, 1987).

There are several possible explanations that may explain why real-time graphing of motion improves learning: it allows students to process information about the event and the graph simultaneously; the dynamic display of the data-logger focuses attention on one feature at a time; and frequent repetition of graphing events supports consolidation. Further investigation by Brasell (1987) suggests even a short delay of 20-30 seconds between observing a motion and seeing a graph limited students ability to link aspects of motion to features on a graph.

**Ways to use this activity**

This practical activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should complete the practical in pairs or small groups if there are sufficient motion sensors and data-loggers to allow this.

An alternative strategy is to set up one motion sensor connected to a projector so that the whole class can observe. The motion sensor could be set to allow students to walk up and down in front of it to produce graphs.

The practical work divides into three distinct phases.

1. Students familiarise themselves with the equipment.
2. Students move the trolley in prescribed ways and observe the lines that are produced on a graph that represents the motion.
3. Students move the trolley to reproduce given graphs. It is helpful to include thinking time to plan the motion before trying it out. This can encourage social construction of new ideas through dialogue.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to report their findings at end of the practical work is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

**Equipment**

For each student/pair/group:

* Motion sensor
* Data-logger
* Connecting cables
* Dynamics trolley

For the class (optional):

* Motion sensor
* Data-logger or computer
* Projector
* Connecting cables

**Technician notes**

There is a wide variety of motion sensors and each type needs to be tested in order that settings are adjusted to obtain the best results.

It can sometimes help the motion sensor detect the position of a trolley if a flat piece of cardboard is taped to the front of it.

**Health and safety**

There is likely to be a significant amount of movement during this practical.

Dynamics trolleys can easily be damaged if they fall onto the floor.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

Students should be able to achieve graphs that are approximately the same as those shown.

It is not expected that exact times or gradients will be achieved.

In graphs 3-6 there is an instantaneous transition between the different motions represented. The curves in graph 7 more accurately represent how the changes are more gradual and happen over a period of time.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on the research of Heather Brasell (1987).

Images: Peter Fairhurst (UYSEG).

**References**

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