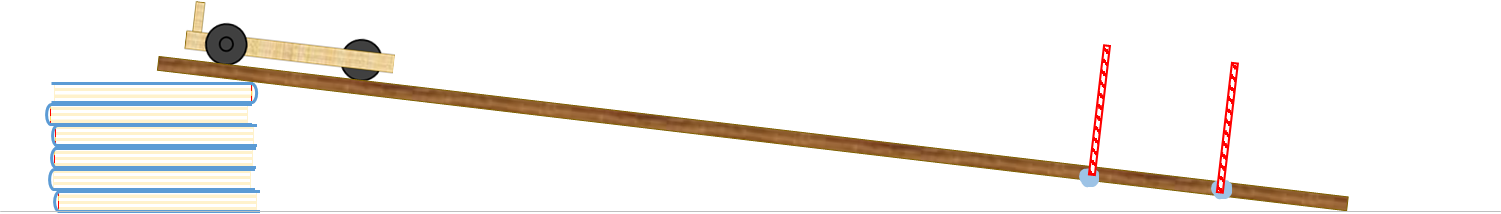
**Timing problems**

What is the speed of the trolley at the bottom of the ramp?

How can you measure it?



**Observe a demonstration**

*Talk about the answers to these questions*

1. Why can’t you measure the speed of the trolley at the bottom of the slope with a stopwatch?
2. How can you measure the speed of the trolley accurately?
3. How can you make sure the speed you have measured is correct?

Use these statements to describe **how to measure the speed of the trolley at the bottom of the ramp.**

Some of the statements are *not* needed.

|  |  |  |
| --- | --- | --- |
| Use a 30 cm ruler |  | Divide the time taken by ten |
|  |  |  |
| Repeat three times to get an average |  | Use a stopwatch |
|  |  |  |
| Use a straw to mark where to release the trolley from |  | Measure a distance of ten centimetres and mark with a straw |
|  |  |  |
| Divide the distance by time taken |  | Mark where to start timing with a straw |
|  |  |  |
| Measure the time taken for the trolley to go the last 10 cm |  | Give the trolley a good push |
|  |  |  |
| Use a data-logger |  | Use a light gate |

Sort cards for: **Timing problems**

|  |  |
| --- | --- |
| Use a 30 cm ruler | Divide the time taken by ten |
| Repeat three times to get an average | Use a stopwatch |
| Use a straw to mark where to release the trolley from | Measure a distance of ten centimetres and mark with a straw |
| Divide the distance by time taken | Mark where to start timing with a straw |
| Measure the time taken for the trolley to go the last 10 cm | Give the trolley a good push |
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*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force > Key concept PFM2.1: Describing speed*

|  |
| --- |
| **Response activity** |
| **Timing problems** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Speed is a measure of how fast an object travels: how far it goes in a given time |
| Observable learning outcome: | Explain why the average speed may be different to the instantaneous speed of an object |
| Activity type: | Sequencing process - demonstration |
| Key words: | Average speed, instantaneous speed, trolley, ramp, data-logger, light gate |

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

* Diagnostic question: 100m world record

**What does the research say?**

Practical work gives students the opportunity to measure distance and time in order to calculate average speeds of moving objects and to observe their motion in detail. Introducing and rehearsing vocabulary that allows them to describe observations accurately is an essential first step towards understanding motion (Kibble, 2011; Driver et al., 1994).

This activity investigates students’ understanding of measuring instantaneous speed by measuring the average speed over a short distance. The demonstration may introduce students to experimental equipment and methods that are new to them.

**Ways to use this activity**

Students should be shown a demonstration of measuring the speed of the trolley at the bottom of the slope in two ways. First using a stopwatch or manual timer. Asking two or more students to do this at the same time typically gives results that are quite different because of reaction time errors. Follow this by demonstrating how using a data logger connected to a light-gate can be used to give a more accurate measure of time taken.

NB motion sensors could be used instead of a light gate, but these tend to give a less direct way of measuring time over a fixed interval and may add a layer of complexity that is perhaps best avoided.

You should use carefully selected questions throughout the demonstrations to check your students’ understanding of the measuring process.

After the initial teaching, students should discuss the questions and then complete the sequencing activity in pairs or small groups. The focus should be on the discussions. The statements are also provided as cut-out cards for students to physically organise.

Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to explain why the statements were put in the chosen order. Once this activity has been completed it may be helpful to challenge students to independently write down their own description of the investigation, or explanation of when it is better to measure speed using data-logging equipment.

*Differentiation*

You may choose to use simplified statements for some students, or give them the starting statement to start them off. In some situations it may be more appropriate for a teaching assistant to read the statements with one or two students.

**Equipment**

For the demonstrations:

* Ramp
* Pile of books (or similar) to prop up the ramp
* Dynamics trolley
* Three straws and Blu-Tack
* Timer
* Light gate(s)
* Data-logger
* Stand(s) and clamp(s) to hold the light gate(s)

**Technician notes**

The slope of the ramp should be sufficient for the speed of the trolley at the bottom to be too fast to measure accurately with a manual timer.

A buffer may be needed to stop the trolley safely near to the bottom of the ramp.

Either two light gates can be placed ten centimetres apart to measure the time over ten centimetres, or a ten centimetre long piece of card can be fixed to the trolley and one light gate used to measure the time this takes to pass one point (in the centre of the original marked out length of 10cm).

**Health and safety**

The trolley may fall onto the floor.

People may move quickly around the apparatus which risks tripping or knocks.

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**

An approximate order is:

1. Mark where to start timing with a straw
2. Use a 30 cm ruler
3. Measure a distance of ten centimetres and mark with a straw
4. Use a straw to mark where to release the trolley from
5. Use a light gate
6. Use a data-logger
7. Measure the time taken for the trolley to go the last 10 cm
8. Repeat three times to get an average
9. Divide the distance by time taken

~~Divide the time taken by ten~~

~~Use a stopwatch~~

~~Give the trolley a good push~~

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Driver, R., et al. (1994). *Making Sense of Secondary Science: Support Materials for Teachers,* London: Routledge.

Kibble, B. (2011). Forces. In Sang, D. (ed.) *Teaching secondary physics.* London: Hodder Education.