Lesson 9.4 Graphs of linear motion – constant velocity

Recommended teaching time for this lesson: 1 x 60 minute period

• 35 minutes of explicit teaching

• 25 minutes of suggested classroom activities

• 45 minutes homework

Getting started

Key ideas

* Linear motion graphs show data about objects moving at constant (uniform) velocity.
* The gradient of a displacement–time graph is a measure of the instantaneous velocity.
* The area under a velocity–time graph is a measure of displacement.

Curriculum links

Science understanding

* Interpret linear motion graphs to describe the motion of an object, referring to the
  + intercepts, gradients and uncertainties (using minimum and maximum lines of best fit) of displacement–time and velocity–time graphs
  + areas under velocity–time and acceleration–time graphs using simple geometry.

Advice for teaching this lesson

Things to know before you start teaching

Linear motion graphs are where students start to be introduced to the concept of having two subject variables at the same time. Most students tend to approach physics problems as an attempt to solve for ‘one’ variable, however the simultaneous use of displacement-time and velocity-time graphs means that they will have to start considering two things simultaneously. The next lesson chapter will require three simultaneous variables as acceleration is introduced. It is worth the time to get students to consider that the graphs they will be examining over the next two lessons (9.4 and 9.5) do not exist in isolation, but instead tell a narrative together from different points of view.

Common misconceptions

* Students often have problems reading graphs and constructing understanding of what is happening. Explicit demonstration of this and having students construct their own based on simple narratives can be excellent practice.

Differentiation strategies

Encourage students who struggle with graphs to practice reading and interpreting with a more capable peer.

You could develop graph templates for students in Excel to speed up the creation of simple displacement-time and velocity-time graphs as practice as well as giving students an exemplar to refer to for their lab work.

Starter activity: How far have you gone?

Approximate time: 10 minutes

**Activity placement:** Place directly after Lesson overview

**Activity summary:** An introduction to graphs of distance and displacement comparing their features and recapping previously taught content.

Notes for the teacher

You could potentially run this activity as a group discussion.

Emphasise to students to recall the definitions previously covered in Lesson 9.2.

Instructions for students

The graph below shows the distance and displacement of a dog running along a fence line. Use it to answer the following questions. Note that the displacement and distance of the dog are equal for the first 9 seconds.

Graph of the movement of a dog for 20 seconds

* 1. Describe observations about the displacement and distance of the dog.
  2. Try to describe a story that matches the movements of the dog over the 20 seconds.

Helpful hints

* There are no wrong answers when trying to observe features about data. Even simple statements can open up deeper understanding.

Answers

1. Student answers will vary. Some important features are: Displacement will go up and down at varying points, while distance only goes up. The distance and displacement are the same for the first 9 seconds, then mirror each other until 14 seconds. The change in displacement is always the same size change in distance, no matter if displacement increases or decreases.
2. Example story, however, the details should line up with the displacement line. The dog began at a middle point and slowly moved to the right over 4 seconds before stopping for 2 seconds. It then ran faster for 2 seconds and paused for a second, before running back left for 3 seconds and then pausing for another 2 seconds – perhaps it was barking at something that went past. It walked left for 2 seconds, then back right for 1 second, then back left for 2 seconds, before dashing back right for 1 second again.

Classroom activity: Reading a graph

Approximate time: 10 minutes

**Activity placement:** Place directly above “What are velocity−time graphs?”

**Activity summary:** A practice activity to put narrative to graphical expression.

Notes for the teacher

Understanding the ‘story’ of what is happening in a question is a vital skill for exam literacy. This activity is designed to help get students getting meaning from graphs.

Instructions for students

Step 1: The graph below shows the displacement of a person from their home as they drive around the neighbourhood to complete their weekend errands. Time = 0 is equivalent to 9 am.

Graph of displacement through a day

Step 2: Use the graph to answer the following questions.

1. When did the person stop moving?
2. When were they stationary for the longest time period?
3. When did they make the longest journey between stops?
4. What happens when the line crosses the x-axis (goes from positive to negative)?
5. When did the person move the fastest?

Helpful hints

* Consider features of the graph that could help you answer each question.

Support activity

Notes for the teacher

This version involves two supporting questions to get students to consider what features of the graph are important.

Instructions for students

Step 1: The graph below shows the displacement of a person from their home as they drive around the neighbourhood to complete their weekend errands. Time = 0 is equivalent to 9 am.

Graph of displacement through a day

Step 2: Use the graph to answer the following questions.

1. What does a horizontal stretch on a displacement-time graph indicate?
2. What feature of a line segment tells you how fast something is moving?
3. What was the longest period they were stationary?
4. When did they make the longest journey between stops?
5. When did the person move the fastest?

Challenge activity

Notes for the teacher

This activity will have students attempt to create a v(t) graph from the s(t) graph provided.

Students may feel a bit uncertain as to how to represent an instantaneous change in velocity e.g. at the 1 hour mark the velocity goes from 0 to -40 km/h.

Instructions for students

Step 1: The graph below shows the displacement of a person from their home as they drive around the neighbourhood to complete their weekend errands. Time = 0 is equivalent to 9 am.

Graph of displacement through a day

Step 2: Use the graph to answer the following questions.

1. When did the person stop moving?
2. What happens when the line crosses the x-axis (goes from positive to negative)?
3. When did the person move the fastest?
4. Use the information from the above graph to construct a velocity-time graph of the same time interval. Note this is easier to sketch on paper or in a drawing program rather than using Excel.

Answers

1. Multiple answers: 0.5-1 hr. 2-3 hr. 4-5 hr. 7.5-9hr.
2. 7.5-9 hr.
3. 5-7.5 hr.
4. They passed by their home – displacement = 0 km.
5. 1-2 hr.

Support activity

1. That they are not moving.
2. The gradient.
3. 7.5-9 hr.
4. 5-7.5 hr.
5. 1-2 hr.

Challenge activity

1. Multiple answers: 0.5-1 hr. 2-3 hr. 4-5 hr. 7.5-9hr.
2. They passed by their home – displacement = 0 km.
3. 1-2 hr.
4. Student answers will vary. Two graphs are provided.  
   Using dot points only:  
     
   Using small line segments

Classroom activity: Hikers on a trail

Approximate time: 10 minutes

**Activity placement:** Place directly above “Check your learning 9.4”

**Activity summary:** A puzzle that will require students to represent the narrative using graphs in order to solve it.

Notes for the teacher

This could easily be run as a class discussion instead of individual work. If you need to reword it to work with your school population please do.

The solution is not hard when considered, however students often do not consider using graphing as a tool to solve problems.

A useful follow up question is: What condition would have to be met for the hiker to not be in the same place and time at least once? Answer: They would have to leave after 3 pm.

Instructions for students

Consider the following narrative:

“A hiker leaves from the bottom of a mountain at exactly 9 am and arrives at their camping destination at 3 pm to stay the night. When the hiker decides to leave the camp to return to the bottom of the mountain, they again set out at exactly 9 am – coincidentally arriving at the bottom at exactly 3 pm.”

1. Does the hiker reach the bottom of the mountain without being in the exact same spot at the exact same time as when they hiked up, at least once?

Helpful hints

* You learnt a particular skill this lesson, can you apply it to this puzzle?

Answers

1. No. It’s impossible to get to the bottom without being in the same spot at the same time. No matter how you vary your speed you will be at the same time/place once and only once. In the graph below consider the red line representing the distance/time for the ascent, and the blue line representing the distance/time for the descent. If both start/stop at the same time, it is impossible for the blue line not to intersect the red line once.

