Intermediate/Secondary educator lesson plan

Physics: Physics in the real world

Lesson overview

This lesson will look at how average speed can be calculated from the distance travelled and the time taken, and how that equation helps police to work out whether a vehicle is driving too fast.

Aim

To teach students about motion, and the relationship between speed, distance and time.

Preparation

Print out the worksheets on pages 3 and 4, with enough copies for each student. Students can also work in small groups to complete the worksheets.

Lesson outline

The exercises below cover (i) simple calculations of speed, distance and time; (ii) higher ability calculations of average speed to show how average speed cameras calculate whether a vehicle is travelling within speed limits; and (iii) how to use the gradient of a distance-time graph to calculate the distance an object has travelled.

i Speed calculations

You can calculate average speed using the equation
speed = distance ÷ time

This equation can be shown as:

$$\text{speed (velocity)} = \frac{\text{distance travelled}}{\text{time for the journey}} \quad (1)$$

$$s = \frac{d}{t} \quad (2)$$

$$\text{distance} = \text{speed} \times \text{time} \quad (3)$$

$$\text{time} = \text{distance} \div \text{speed} \quad (4)$$

Question 1: Christiano leaves home at 06.45am and arrives for early morning training at 07.10am. The swimming pool is 15km from his house. Calculate his average speed in m/s.

Calculation:
Travelling time = 25 minutes = 25 x 60 seconds = 1500s
Distance = 15km = 15 x 1000m = 15000m
Use equation (1)
Average speed = 15000m ÷ 1500s = 10m/s

Answer: Christiano travels at an average speed of 10m/s to reach the swimming pool.

Extension to Question 1:
1m/s is equivalent to a speed of 3.6km/h (kilometres per hour).
What is Christiano's average speed in km/h?

Answer: He travels at an average speed of 36km/h.

Question 2: Stephanie is a driver for Betterfood supermarket home deliveries. She has been asked to deliver to two different customers on opposite sides of a city. The customers' houses are 12km apart and Stephanie's schedule allows 15 minutes for her to get from one to the next. The speed limit on the roads she drives on is 50km/h (13.9m/s). Will Stephanie be able to complete her deliveries without breaking the speed limit? Show all calculations and give your answer to two decimal places.

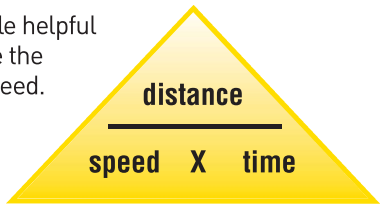
Calculation:
Time = 15 minutes = 15 x 60 seconds = 900s
Distance = 12km = 12 x 1000m = 12000m
Use equation (1)
Average speed = 12000m ÷ 900s = 13.33m/s

Answer: Yes, Stephanie will be able to complete her deliveries without breaking the speed limit (but only just!) In a real-life situation, with traffic, traffic lights, road junctions, etc., Stephanie would almost certainly not be able to make this journey without breaking the speed limit.

ii Average speed cameras (higher ability)

Speed cameras are used to find out if a motorist is travelling faster than the speed limit for the road. Average speed cameras are set a certain distance apart so that the time taken for the vehicle to travel between the two cameras can be worked out, and from that the vehicle's speed can be calculated.

You may find this triangle helpful if you need to rearrange the equation for average speed.



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Question 1: The speed limit on a road is 50km/h (13.9m/s). Calculate the distance travelled by a car in 2s at this speed.

Calculation:
Use equation (1): Average speed = distance ÷ time
Rearrange to give equation (3): Distance = average speed x time
Distance = 13.9 x 2 = 27.8m

Answer: A car travelling at a speed of 50km/h for 2s will cover a distance of 27.8m.

Question 2: Calculate the time taken for the car to travel 50m at this speed.

Calculation:
Use equation (1): Average speed = distance ÷ time
Rearrange to give equation (4): time = distance ÷ average speed
time = 50 ÷ 13.9 = 3.6s

Answer: It will take 3.6s for a car travelling at a speed of 50km/h to cover a distance of 50m.

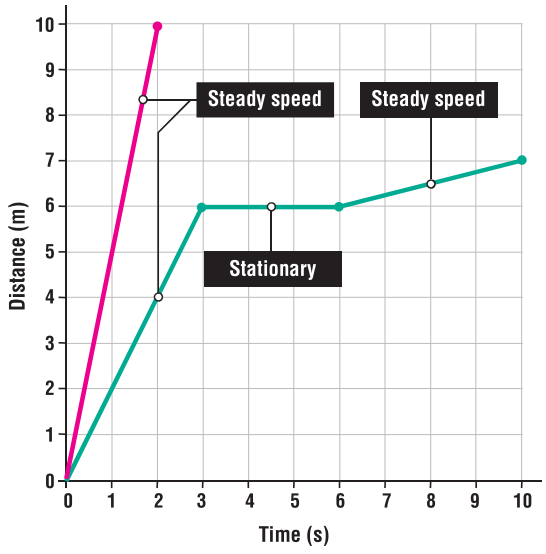
Question 3: The speed limit on a road is 60km/h (16.7m/s). A pair of speed cameras is placed 200m apart along a stretch of the road. It takes a car 10s to travel between them. Calculate the average speed of the vehicle and say whether or not the driver is exceeding the speed limit.

Calculation:
Use equation (1): Average speed = distance ÷ time
Average speed = 200 ÷ 10 = 20m/s

Answer: The vehicle is driving at an average speed of 20m/s. Yes the driver is exceeding the speed limit.

(**Note:** A speed of 20m/s is equivalent to 72km/h)

iii Distance–time graphs



Bottom left is a distance-time graph. The gradient of the line is equal to the speed. This means that the line is: horizontal for a stationary object (because the distance stays the same); a straight diagonal for an object moving at a constant speed.

The steeper the line, the greater the gradient and the greater the speed.

Question 1: From the distance-time graph above, calculate the speed represented by the green line between 6s and 10s.

Calculation:
Distance travelled = 1m; time taken = 4s
Speed = 1 ÷ 4 = 0.25m/s

Answer: The green line between 6s and 10s represents an object travelling at a speed of 0.25m/s.

Question 2: Calculate the average speed represented by the pink line between 0s and 2s.

Calculation:
Distance travelled = 10m; time taken = 2s
Speed = 10 ÷ 2 = 5m/s

Answer: The pink line between 0s and 2s represents an object travelling at a speed of 5m/s.

Question 3: From the graph, calculate the average speed represented by the green line between 0s and 10s.

Calculation:
Overall distance travelled = 7m; time taken = 10s
Speed = 7 ÷ 10 = 0.7m/s

Answer: The green line between 0s and 10s represents an object travelling at an average speed of 0.7m/s

Additional activity – Representation of a journey on a distance-time graph

Ask students to draw an additional coloured line on the distance-time graph for a vehicle of their choice and work out their own questions and answers for the rest of the class.

Using data to help improve road safety

Working individually, in small groups, or as a whole class discussion, look at how the data from these calculations can be used to help make roads safer. Discussions may include:

- How speed cameras calculate speed and how police use this to enforce speed limits.
- How stopping distances increase exponentially with an increase in speed, and the impact forces involved in crashes.
- How this data can be translated into road safety messaging through road safety advertising.

WORKSHEET

Lesson 1: Physics

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$$s = \frac{d}{t} \quad (2)$$

distance = speed x time (3)

time = distance ÷ speed (4)

Question 1: Christiano leaves home at 06.45am and arrives for early morning training at 07.10am. The swimming pool is 15km from his house. Calculate his average speed in m/s.

Extension question:
1m/s is equivalent to a speed of 3.6km/h (kilometres per hour).
What is Christiano's average speed in km/h?

Question 2: Stephanie is a driver for Betterfood supermarket home deliveries. She has been asked to deliver to two different customers on opposite sides of a city. The customers' houses are 12km apart and Stephanie's schedule allows 15 minutes for her to get from one to the next. The speed limit on the roads she drives on is 50km/h (13.9m/s).
Will Stephanie be able to complete her deliveries without breaking the speed limit? Show all calculations and give your answer to two decimal places.

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Speed cameras are used to find out if a motorist is travelling faster than the speed limit for the road. Average speed cameras are set a certain distance apart so that the time taken for the vehicle to travel between the two cameras can be worked out, and from that the vehicle's speed can be calculated.

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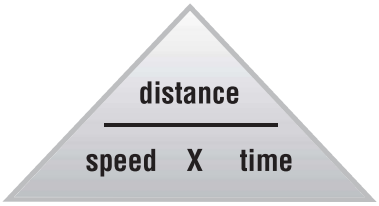

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Question 2: Calculate the time taken for the car to travel 50m at this speed.

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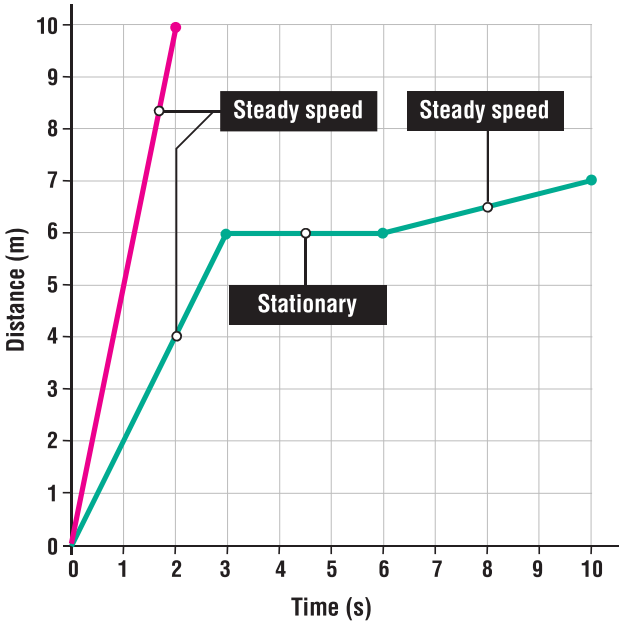
Lesson 1: Physics

iii Distance–time graphs



Above is a distance-time graph. The gradient of the line is equal to the speed. This means that the line is: horizontal for a stationary object (because the distance stays the same); a straight diagonal for an object moving at a constant speed.

The steeper the line, the greater the gradient and the greater the speed.

Question 1: From the distance-time graph above, calculate the speed represented by the green line between 6s and 10s.

Question 2: Calculate the average speed represented by the pink line between 0s and 2s.

Question 3: From the graph, calculate the average speed represented by the green line between 0s and 10s.

Additional question: Describe how the data from these calculations could be used to help make roads safer.