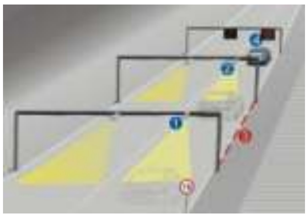
AVERAGE SPEED CONTROL – HOW TO DETECT THE SPEED OF A MOVING CAR?

(VERSION FOR SECONDARY LOWER SCHOOL)

Failure to have proper control of a vehicle in road traffic results in more or less penalty the driver has to pay.

But how do policemen find out, if somebody drives too fast?

Average speed control (also called 'section control' or 'point-to-point' control) is a relatively new speed enforcement technique. Average speed control systems measure the average speed over a road section (usually 2 – 5 km).



Source of Picture: http://neurosoft.pl/en/neurocar-section-speed-control-en

The vehicle is identified when entering the enforcement section, and again when leaving it.

Do you have an idea, how it possible to find out the average speed of an object by this method?

How can you detect the speed of a motion? What is the difference between speed and velocity?

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A. Preparation

In this activity you will use a motion detector to plot distance (position) –time graphs of the motion of your body. You will make distance-time graphs for different walking speeds and directions and explore how the related graphs differ from each other.

Place the motion detector so that it points toward an open space at least 2 m long and then connect the motion detector to an interface.

You will learn how to relate graphs of distance as a function of time to the motions they represent.

Comment: „***Distance***" is short for „***distance from the motion detector***". The motion detector is the origin from which distances are measured.

- ✓ It detects the closest object directly in front of it.
- ✓ It will not correctly measure anything closer than 0.15 meter.
- ✓ As you walk, the graph on the computer screen displays how far away from the detector you are.

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B. Observation of an experiment

1) Walk in front of the motion detector and learn how to relate graphs of position as a function of time to the motions they represent.

The motion detector sends out a sound wave to measure the distance to the nearest object by measuring the time it takes the sound wave to return to the detector after bouncing off the object.

Your computer screen will display position-time graphs. The origin is chosen to be at the motion detector. The positive x direction will be in a straight line away from the motion detector. The position displayed on the computer screen will be your location on an imaginary number line extending away from the detector.

a) How does the distance-time graph look when you move slowly?

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b) How does the distance-time graph look when you move quickly?

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c) What happens when you move toward the motion detector?

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d) What happens when you move away from the motion detector?

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Q1) Describe the difference between the graph you made by walking away slowly and the one made by walking away faster.

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Q2) Describe the difference between the graphs made by walking toward and the ones made walking away from the motion detector.

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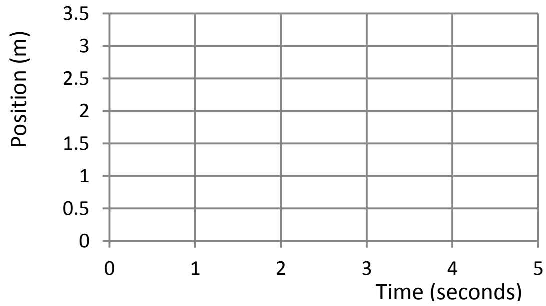
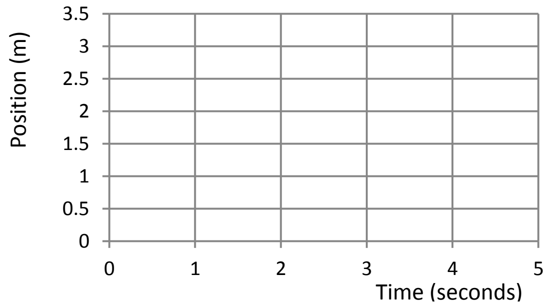
2) Making position-time graphs by walking with constant speed

Comment: It is common to refer to the distance of an object from some origin as the position of the object. Since the motion detector is at the origin of the coordinate system, it is better to refer to the graphs you have made as **position-time graphs**. From now on you will plot position time graphs.

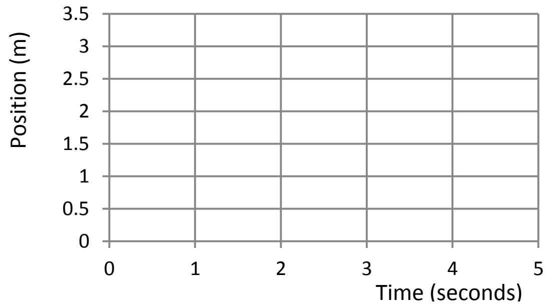
a) Start from ½ meter away from the motion detector and make a position-time graph, **walking away from the detector slowly and steadily.**



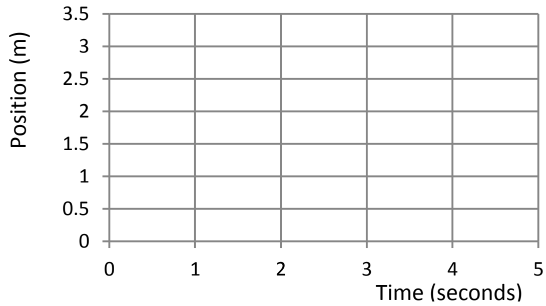
b) Start from ½ meter away from the motion detector and make a position-time graph, **walking away from the detector medium fast and steadily.**



c) Start from 3 meter away from the motion detector and make a position-time graph, **walking toward the detector slowly and steadily.**



d) Start from 3 meter away from the motion detector and make a position-time graph, **walking toward the detector medium fast and steadily.**



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3) Calculating Average Velocity by using the Position-Time Graph

Comment: Average velocity during a particular time interval can be calculated as the change in position divided by the change in time. The change in position is often called the *displacement*. By definition this is also the *slope* of the position-time graph for that time period.
As you have observed, the faster you move, the more inclined is your position-time graph. The slope of a position-time graph is a quantitative measure of this incline, and therefore it tells you the velocity of the object.

a) Calculate your average velocity from the slope of your position graph in activity 2a).

a1) Read the position and the time coordinates for two typical points while you were moving.

	Position (m)	Time (seconds)
Point 1		
Point 2		

a2) Calculate the change in position (*displacement*) between points 1 and 2. Also calculate the corresponding change in time (*time interval*).

Then, divide the change in position by the change in time to calculate the *average velocity*. Show your calculations in the table at the right.

Change in position (m)	
Time interval (seconds)	
Average velocity (m/s)	

Repeat the procedure carried out in 3a) for the graphs 2b, 2c, and 2d.

b)

	Position (m)	Time (s)
Point 1		
Point 2		

Change in position (m)	
Time interval (s)	
Average velocity (m/s)	

c)

	Position (m)	Time (s)
Point 1		
Point 2		

Change in position (m)	
Time interval (s)	
Average velocity (m/s)	

d)

	Position (m)	Time (s)
Point 1		
Point 2		

Change in position (m)	
Time interval (s)	
Average velocity (m/s)	

Q3) Explain in your own words how the average velocity of an object can be calculated from the position-time graph.

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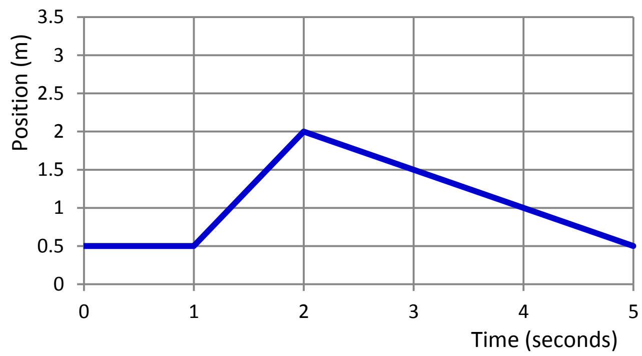
C. Modeling the situation in the laboratory: Matching graphs

1) Try to match the shape of the position-time graphs

<table>
<tr><td>a1) Write down how you would walk to produce each target graph.</td><td>
</td></tr>
<tr><td colspan="2">a2) Test your prediction as you walk in front of the motion detector and look at the displayed graph. Describe and explain your results:</td></tr>
<tr><td colspan="2">a3) If you were not successful, repeat the process until your motion closely matches the graph on the screen. Describe what you did wrong previously and how you were able to succeed?</td></tr>
</table>

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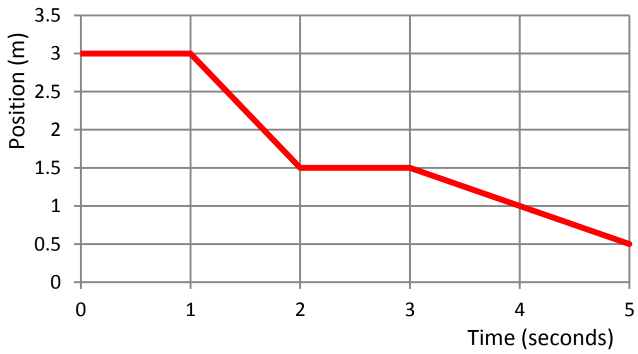
b1) Write down how you would walk to produce each target graph.



b2) Test your prediction as you walk in front of the motion detector and look at the displayed graph. Describe and explain your results:

b3) If you were not successful, repeat the process until your motion closely matches the graph on the screen. Describe what you did wrong previously and how you were able to succeed?

Q4) Explain in your own words how you managed matching the graphs. What was difficult? How you could you make it work?

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D. Evaluating the data obtained

1) Explain the significance of slope of a position-time graph. Include a discussion of positive and negative slope.

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2) What type of motion is occurring when the slope of a distance vs. time graph is zero?

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3) What type of motion is occurring when the slope of a position-time graph is constant?

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E. Show your results

1) Create a graph-matching challenge. Sketch a position-time graph on a piece of paper and challenge another student to match your graph. Have the other student challenge you in the same way. Document your activities and considerations.

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F. Write general conclusions

Returning to the main question of this activity:

Explain, how the average speed of a car can be found out? What physics quantities are needed to calculate the speed of a car?

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Questions

a) It was easy for our group to design our own experiment and find an appropriate solution to the given task. Tick a number 1, 2, 3, 4 or 5 (1: strongly agree 5: strongly disagree)

Please explain your answer……………………………………………………………………………………………………

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b) The guidance in the worksheet helped us to perform the experiment and analyze the data in order to understand the physics behind and apply physics concepts to everyday life situations. Please, tick a number 1, 2, 3, 4 or 5 (1: strongly agree 5: strongly disagree) and explain your answer: ……

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