Momentan- und Durchschnittsgeschwindigkeit mit SMARTsense (Item No.: P1003769)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Mechanics
Subtopic: Linear motion
Experiment: Instantaneous and average speed with SMARTsense

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	2 Students

Additional Requirements:

- Tablet

Experiment Variations:

- Demonstration experiment: Uniformly accelerated motion with an inclined track with the demonstration track and the timer 4-4 (P1198805)
- Student experiment classic: Instantaneous and average speed (P1003705)

Keywords:

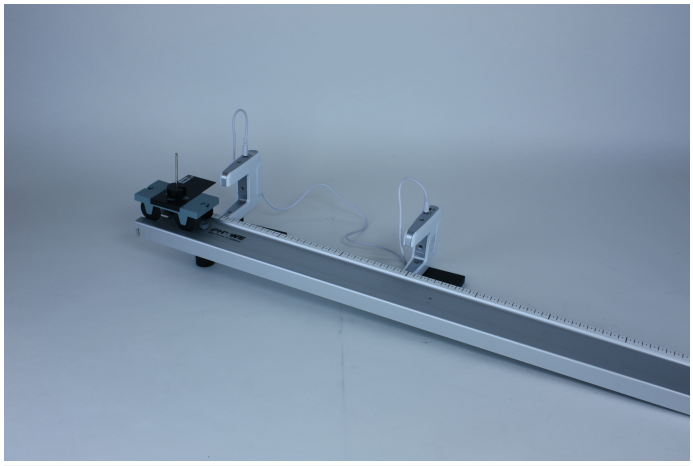
instantaneous velocity, average velocity, velocity measurement, light barrier

Information for teachers

Introduction

Application
Light barriers can be used to determine the instantaneous as well as the average velocity. The method is applied, for instance, in traffic monitoring systems.

Single-side sensor ES 3.0



Experiment set-up

Educational objective
The differences between uniform and non-uniform motion that the students have studied in a rather qualitative manner in the experiment "Comparison of uniform and non-uniform motion" will be substantiated in a quantitative manner while the concept of instantaneous velocity will be introduced. v = s/t has been introduced in the experiment "Uniform linear motion". This experiment will define more clearly that this is the average velocity. The aim is to distinguish it from the instantaneous velocity.

Tasks

1. Measurement of the time that the cart needs for covering a certain distance by way of two light barriers, with one placed at the beginning and the other at the end of the respective track segment. Calculation of the average velocity based on the time measured between the interruption of the two light barriers and on the distance that has been covered.
2. Measurement of the time that the shutter plate on the experiment cart needs for passing the light barrier after such a distance. Calculation of the instantaneous velocity based on this light barrier shading time and on the width of the shutter plate.
3. Comparison of the instantaneous and average velocity.

Prior knowledge
The students should be familiar with the mode of operation of a light barrier.

Principle
A body on an inclined track is subject to constant acceleration in parallel to the track due to the gravitational forces exerted on the body. This is why the laws of motion for a uniformly accelerated motion apply.

Note
In order to determine the position of the light barriers, the centre seam of the light barriers can be used for reference.

Safety information

For this experiment, the general notes and instructions concerning safe experimentation in science classes apply.

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Versuch: Momentan- und Durchschnittsgeschwindigkeit mit SMARTsense (Item No.: P1003769)

Introduction

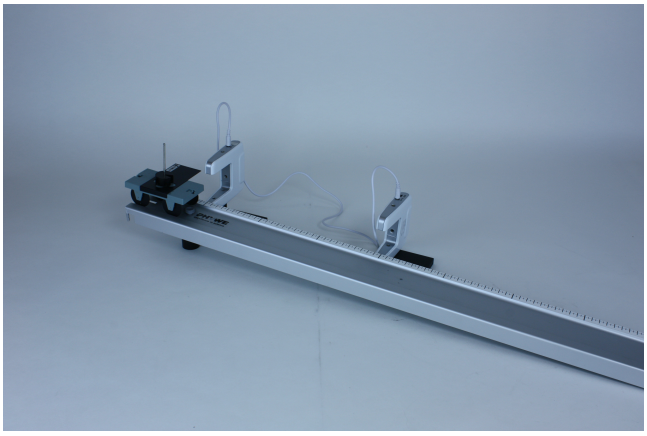
Application and task

How can the instantaneous velocity be distinguished from the average velocity?

Application
Light barriers can be used to determine the instantaneous as well as the average velocity. The method is applied, for instance, in traffic monitoring systems.

Tasks

1. Measure the time that the cart needs for covering a certain distance by way of two light barriers, with one placed at the beginning and the other at the end of the respective track segment. Calculate the average velocity based on the time measured between the interruption of the two light barriers and on the distance that has been covered.
2. Measure the time that the shutter plate on the experiment cart needs for passing the light barrier after such a distance. Calculate the instantaneous velocity based on this light barrier shading time and on the width of the shutter plate.
3. Compare the instantaneous and average velocity.



Equipment

Position No.	Material	Order No.	Quantity
1	Cobra SMARTsense - Photogate, 0 ... ∞ s	12909-00	1
2	Shutter plate for cart	11060-10	1
3	Cart for measurements and experiments	11060-00	1
4	Slotted weight, black, 50 g	02206-01	3
5	Holding pin	03949-00	1
6	Track, l 900 mm	11606-00	1
7	Meter scale, demo. l=500mm, self adhesive	03005-00	2
8	Adapter plate for Light barrier compact	11207-22	2

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Set-up and procedure

Set-up

In order to incline the track, completely extend the adjustable mounting foot of the track and position it on two stacked slotted weights (50 g) (fig. 1).

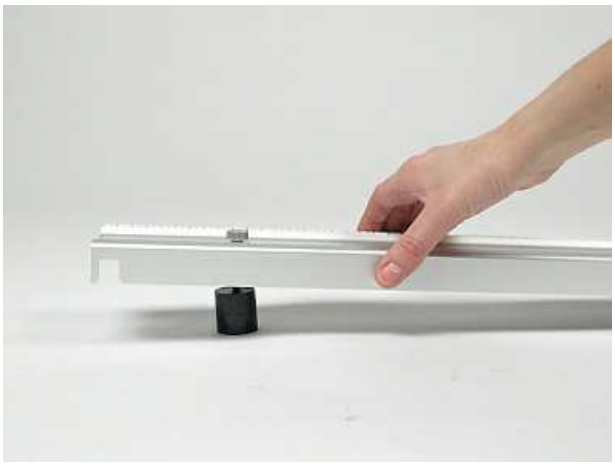

Fig. 1.

Fasten the shutter plate to the experiment cart by way of the holding bolt and place a slotted weight of 50 g on the cart (fig. 2).

Fig. 2.

Position the cart on the track so that its end is flush with the end of the track. Position the first light barrier next to the track so that the shutter plate on the cart will interrupt it as quickly as possible when the cart is released (fig. 3). Position the second light barrier at a distance of 30 cm from the first one (fig. 4).

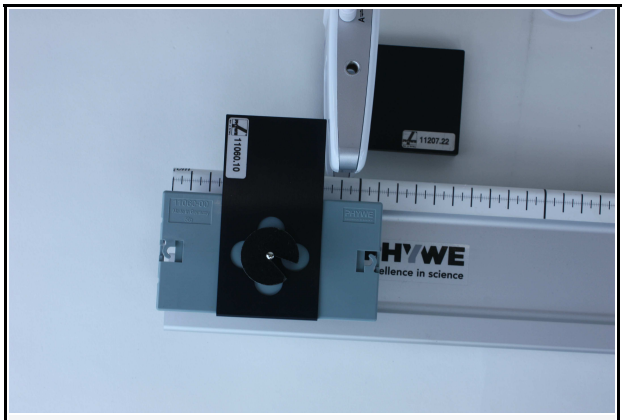

Fig. 3.

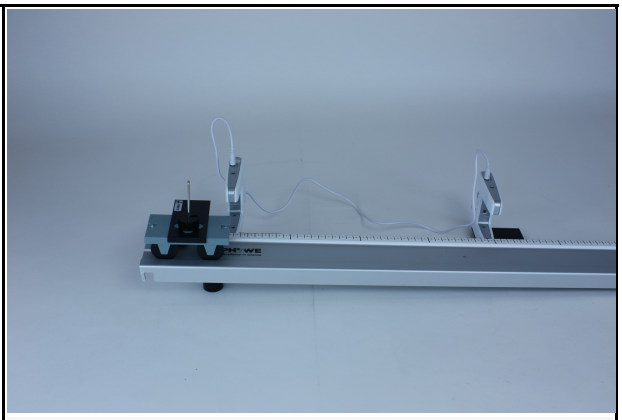

Fig. 4.

Connect the light-barriers with the stereo jack-cable and switch both of them on. Select then the photogate in measureAPP in the

menu "sensor". Pick the option "Run times" in the menu that opened. (fig. 5).

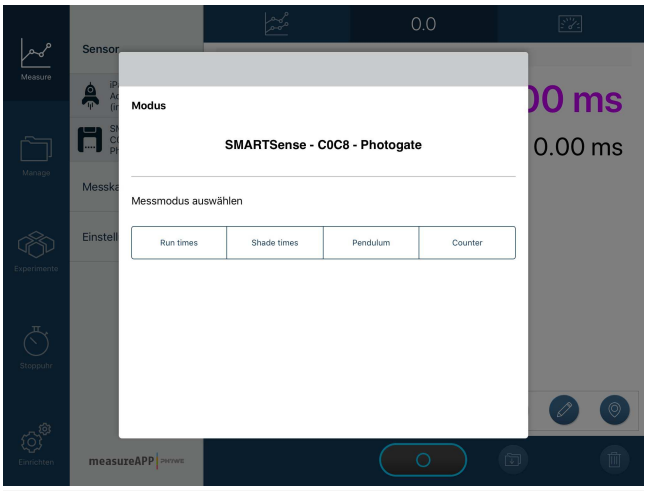

Fig. 5.

Procedure

First part of the experiment

Switch the display to numerical mode 0.0 (fig. 6).
Start the measurement by pressing the button and let the cart roll down the track. Calculate the difference between the two times that are indicated and enter the value in milliseconds into the table in the experiment report.
Repeat the measurement for the track segments s = 20, 50, and 70 cm.

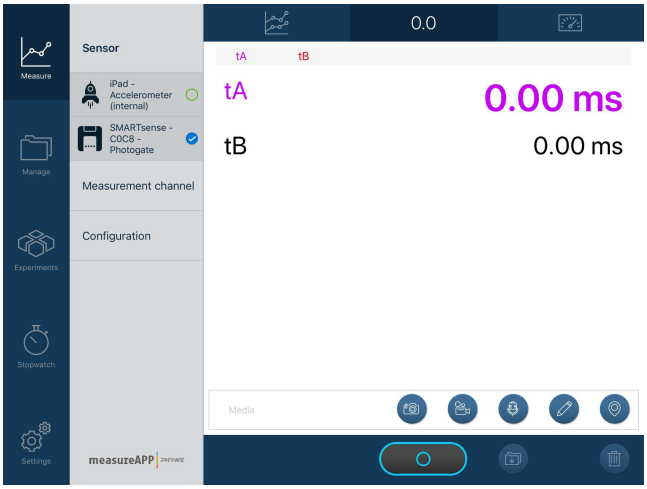

Fig. 6.

Second part of the experiment

Open the menu "sensors" > "configuration" > "mode" and change the measurement mode to "shade times" as shown in fig. 7 in order to measure the shading time.

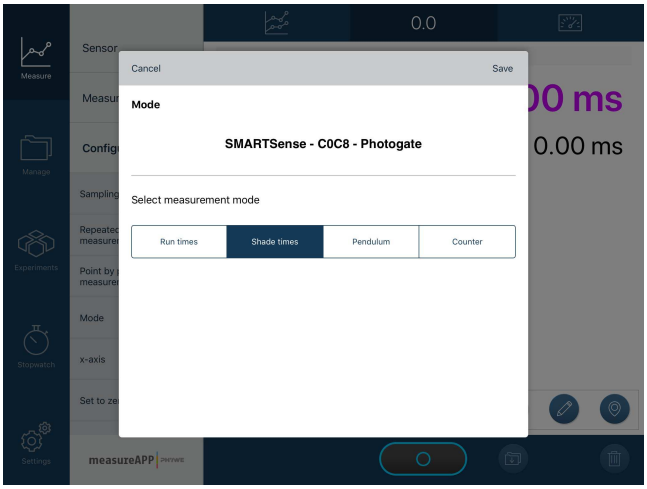

Fig. 7.

Push the first light barrier away from the track so that it will no longer be interrupted by the shutter plate of the cart.
Start the measurement and let the cart roll down the track once again. Enter the measured time into the table in the experiment report in milliseconds. Repeat the measurement for all of the positions of the second light barrier from the first part of the experiment.

Report: Instantaneous and average speed with SMARTsense

Result - Table 1

Enter the values measured for the in-motion times t and shading times Δt (converted into seconds) for the various segments s into the table. Then, calculate the average velocity v_a (v_a = s / t) and the instantaneous velocity v_i (v_i = Δs /Δt; Δs = plate width = 5 cm).

s [cm]	*t* [s]	*Δt* [s]	v_a [cm/s]	v_i [cm/s]
20	1 ±0	1 ±0	1 ±0	1 ±0
30	1 ±0	1 ±0	1 ±0	1 ±0
50	1 ±0	1 ±0	1 ±0	1 ±0
70	1 ±0	1 ±0	1 ±0	1 ±0

Evaluation - Question 1

What is the relationship between the velocities v_i?

- ☐ The velocities are identical.
- ☐ The velocities increase when the length of the track increases.
- ☐ The velocities decrease when the length of the track increases.

Evaluation - Question 2

The instantaneous velocity v_i at the end of the segment s is always ..... than the average velocity v_a over the same distance. This means that the velocity ..... along the track.

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Evaluation - Question 3

Is it correct to use the term "uniform motion" in this case? Justify your answer.

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