Gleichförmig geradlinige Bewegung mit SMARTsense

(Item No.: P1003569)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Mechanics
Subtopic: Linear motion
Experiment: Uniform linear motion with SMARTsense

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Tablet

Experiment Variations:

- Demonstration experiment: Uniformly accelerated motion with the demonstration track and timer 4-4 (P1198505)
- Classic experiment: Uniform linear motion (P1003500)
- Classic experiment: Uniform linear motion with the 2-1 timer (P1003505)

Keywords:

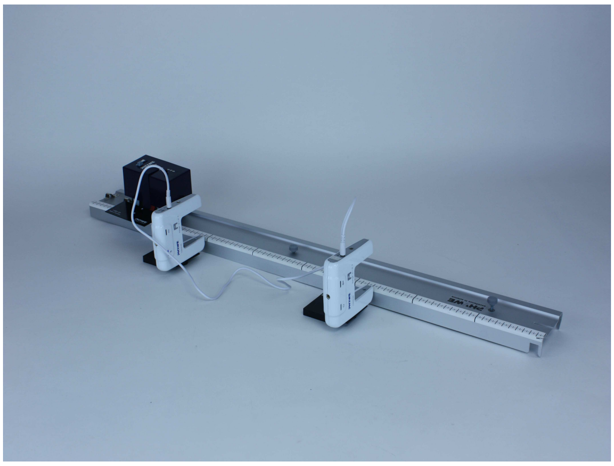
velocity measurement, linear motion, uniform motion, light barrier

Information for teachers

Introduction

Application
Uniform, linear motions can be observed in technical applications, e.g. conveyor belts: An object moves on the belt in the same direction at constant velocity.
The average velocity of an object can be measured by way of two light barriers. This method is used for traffic monitoring, for example.


Coal conveying system (picture: Robert & Mihaela Vicol)


Experiment set-up.

Educational objective
The aim of this experiment is to familiarise the students with the concepts of linear and uniform motion. At this stage, the concept of velocity is introduced in a somewhat vague manner as the ratio s/t. It will be determined by the students in an experimental manner based on the distance and time measurement of a motorised measurement cart that passes through two light barriers.

Based on the measurement data, the students should realise that the velocity remains constant within the measurement distance and that the term "uniform" is correct in this context.
In addition, the students will be familiarised with the distance-time-diagram and they will see that the gradient of the graph reflects the 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.
2. Calculation of the velocity based on the time measured between the interruption of the two light barriers and on the distance that has been covered.
3. Preparation and discussion of the associated distance-time-diagram.

Prior knowledge
The students should be familiar with the mode of operation of a light barrier.
Principle
The cart is driven by an electric motor and it rolls on the track at a constant velocity. This means that, if the speed setting of the measurement cart remains unchanged, the experiment will always lead to the same s/t ratio.

Notes concerning the set-up and execution of the experiment
The velocity of the cart depends rather strongly on the charge of the battery. In order to be able to reproduce the times of motion that have been measured by PHYWE, proper power supply of the cart must be ensured.

Notes concerning the set-up and execution of the experiment
In this experiment we will try to operate the light-emitting diode first with one and then with two solar cells, which will not work. In the evaluation the student should come to the conclusion that one must switch on four solar cells in a row in order to be successful. This hypothesis can be checked in an additional experiment. For this purpose two groups of the experiment must join their switching circuits. One group must substitute the light-emitting diode for a straight wire building block. Then, the circuit is aligned in such a way that the longer side is illuminated by the halogen lamp.

If it is possible to perform the experiment in the open air or near a window, the halogen lamp and solar cell holder do not need to be used. The sunlight sun is sufficient as an energy source.

Safety instructions

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

Versuch: Gleichförmig geradlinige Bewegung mit SMARTsense (Item No.: P1003569)

Introduction

Application and task

What is a uniform linear motion?
What does the term "velocity" mean?

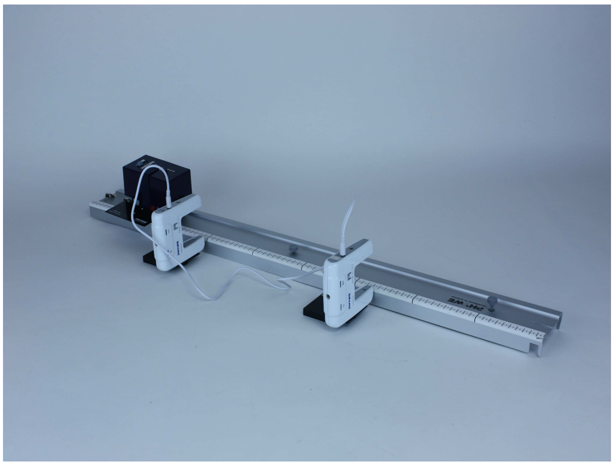
Introduction
You surely know the word "velocity" or "speed". Whether you are driving a car or riding a bike (or using any other vehicle): The velocity or speed indicates how fast you move.
How can the velocity be measured? You will learn this in this experiment based on an easy example, the so-called uniform linear motion.

Application
We find uniform linear motion, for example in brown coal strip mining where the coal is transported on long conveyor belts.

Coal conveying system (picture: Robert & Mihaela Vicol)

Tasks

1. Measure the time t that the cart needs for covering a certain distance s by way of two light barriers, with one placed at the beginning and the other at the end of the respective track segment.
2. Calculate the quotient s/t based on the time t measured between the interruption of the two light barriers and on the distance s .
3. Represent the laws that you have determined in graphical form.



Experiment set-up

Material

Position No.	Material	Order No.	Quantity
1	Track, l 900 mm	11606-00	1
2	Meter scale, demo. l=500mm, self adhesive	03005-00	2
3	Car, motor driven	11061-00	1
4	Shutter plate for car, motor driven	11061-03	1
5	Cobra SMARTsense - Photogate, 0 ... ∞ s	12909-00	1
6	Adapter plate for Light barrier compact	11207-22	2

Set-up and procedure

Set-up

Fasten the shutter plate on the cart and position the latter at the end of the track (Fig. 1).

Fig. 1

Connect the light barriers to the adapter plates so that they can be set up along the track. Put the photogate marked "B" at the second position. Ensure that the shutter plate of the cart can pass through the light barriers without touching them (Fig. 2).

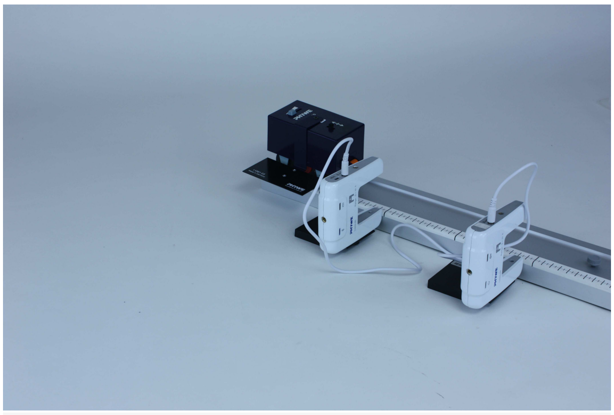


Fig. 2

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. 3).

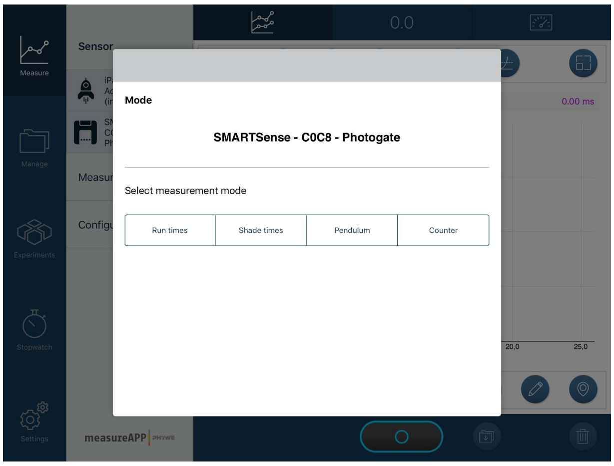


Fig. 3.

Position the starter light barrier (A) at the 20-cm mark of the track and the stop light barrier (B) at the 30-cm mark so that there is a distance of 10 cm between them.

With these settings, measureAPP measures the time that the cart needs for covering the distance between the light barriers after measurement started.

Procedure

Set the speed slider of the cart to the lowest speed setting (fig. 4).

Fig. 4.

Switch the display mode in measureAPP to the "0.0" option (fig. 5) and start the measurement by pressing on
Start the cart in the desired direction by way of the direction selector switch (fig. 6).
After the shutter plate of the cart has passed through both light barriers, tA and tB indicate at which time after start the cart passed photogate A and B.
Stop the measurement by pressing on .

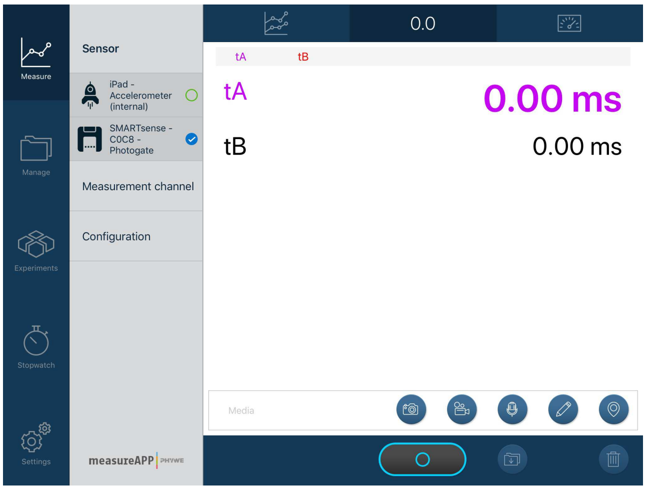


Fig. 5.

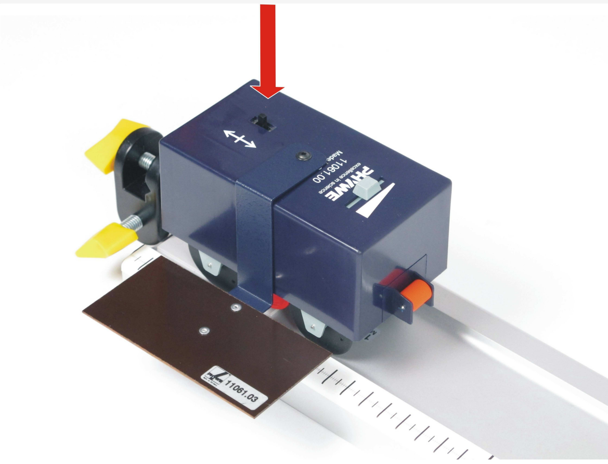


Fig. 6.

Calculate the difference between both values, convert the value into seconds, round it to a hundredth of a second (i.e. you need to have two digits after the decimal point), and enter the value into table 1 of the experiment report.

Repeat the measurement with the following positions of the stop light barrier: 40 cm, 50 cm, 70 cm, and 80 cm (the resulting distances between the start light barrier and stop light barrier are 20 cm, 30 cm, 50 cm, and 60 cm).
The start light barrier remains at the 20-cm mark during the entire experiment.

Then, set the speed controller of the cart to the middle position.
Measure the times that the cart needs for covering the following distances: 10 cm, 20 cm, 30 cm, 50 cm, and 60 cm. Enter these values also into table 1.

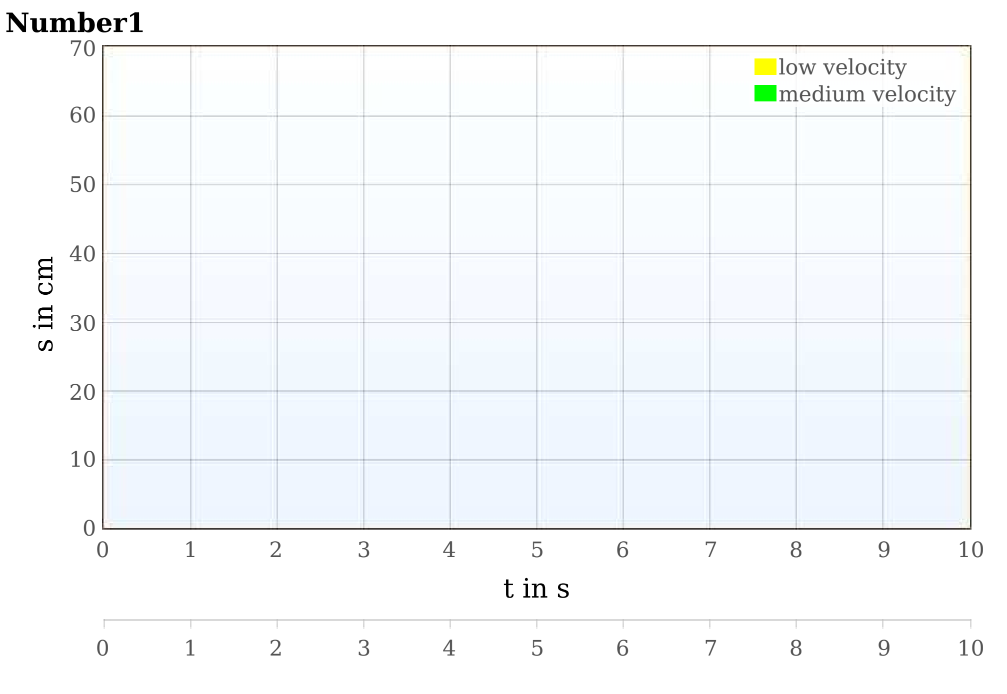
Report: Uniform linear motion with SMARTsense

Result - Table 1

Enter the times of motion for the distances covered by the cart into the measurement value table. The times of motion with the lowest velocity must be entered into the second column ("t_1 in s") and the times of motion with medium velocity into the fourth column ("t_2 in s").

Calculate the quotient $v=s/t$ based on the distance s and associated time t and enter it into column 3 (or in column 5 for the medium velocity).

s in cm	t_1 in s	s/t_1 in cm/s	s in cm	t_2 in s	s/t_2 in cm/s
10	1 ±0.1	1 ±1	10	1 ±0.1	1 ±8
20	1 ±0.2	1 ±0.9	20	1 ±0.2	1 ±7
30	1 ±0.3	1 ±0.8	30	1 ±0.3	1 ±7
50	1 ±0.5	1 ±0.8	50	1 ±0.5	1 ±6
60	1 ±0.6	1 ±0.8	60	1 ±0.6	1 ±5



Evaluation - Question 1

The values that you have entered into table 1 have been automatically entered into a diagram and connected.

In science, the aim is to describe the relationships between quantities (here: time *t* and distance *s*) in a mathematical form that is as simple as possible.

What is the resulting, approximate shape of the graph?

State the reasons why this shape has been measured only in an approximate manner.

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Evaluation - Question 2

Which of the statements is true for the distance-time-diagram?

Tick the correct answer.

- [ ] The distance s that is covered increses in a square manner as a function of the time t.
- [ ] There is no relationship between the distance s and time t.
- [ ] The distance s is proportional to the time t.

Evaluation - Question 3

In table 1, you have calculated the *s/t* ratio. This ratio is the velocity *v*. As a result, the following applies: *v=s/t*.

Which of the statements are true for this experiment?

- [ ] The longer the distance is, the higher the velocity will be.
- [ ] The velocity within a run of the cart can be considered as constant.
- [ ] The velocity depends on the time.
- [ ] The higher the velocity is, the less time will be needed for the same distance.
- [ ] The shorter the distance is that is covered within a specific period of time, the higher the velocity will be.

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Result - Table 2

This table refers to the experiment part with the higher velocity of the cart.

Enter the times that the cart needs for covering the various track sections (distances) Δ*s*, which are listed in the table, into the second column. To do so, look at table 1, find the times that the cart has needed up to the respective distance, and form the corresponding time difference Δ*t*.

Enter the velocity of the track section (*v*=Δ*s*/Δ*t*) into the third column.

Δ*s* in cm	Δ*t* in s	*v*=Δ*s*/Δ*t* in cm/s
	1 ±0.2	1 ±8
	1 ±0.2	1 ±8
	1 ±0.3	1 ±8
	1 ±0.2	1 ±8

Evaluation - Question 4

What is the relationship between the diagram sections (for the cart with higher velocity in graph 1) and the calculated track section velocities (in table 2)?

Evaluation - Question 5

Which statement is true?

- ☐ The track section velocities are (approximately) identical. It is a uniform motion.
- ☐ The track section velocities strongly differ from one another. Therefore, it is a uniform motion.
- ☐ The term "uniform" has nothing to do with the track section velocities.