Vergleich von gleich- und ungleichförmiger Bewegung mit SMARTsense (Item No.: P1003669)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Mechanics
Subtopic: Linear motion
Experiment: Comparison of uniform and non-uniform motion with SMARTsense

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

Additional Requirements:

- Tablet

Experiment Variations:

- Demonstration experiment: Uniformly accelerated motion with the demonstration track (P1198605)
- Classic student experiment: Comparison of uniform and non-uniform motion (P1003600)
- Classic student experiment: Comparison of uniform and non-uniform motion with the 2-1 timer (P1003605)

Keywords:

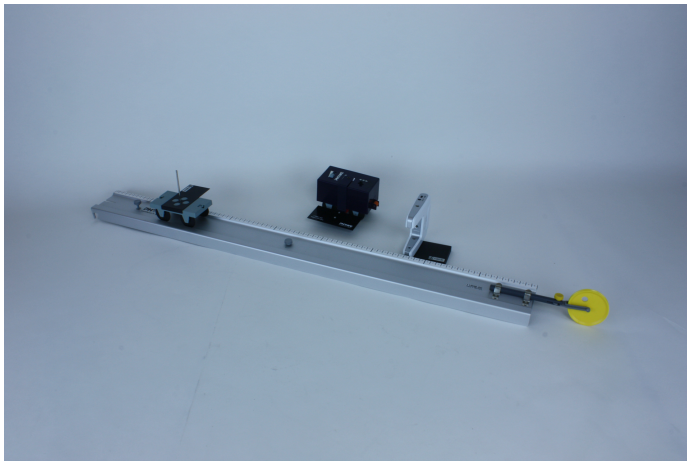
instantaneous velocity, average velocity, velocity (speed) measurement, light barrier

Information for teachers

Introduction

Application
We encounter non-uniform motion as a general case of motion in numerous situations in our everyday life. The most common example is cars that change their speed.
The instantaneous velocity is indicated by the speedometer of any type of vehicle.

Speedometer of a car


Experiment set-up.

Educational objective
The aim of this experiment is to make the students realise that non-uniform motion (and not uniform motion) of an object is the common type of motion.
They will get a feeling for the difference between instantaneous and average velocity in a subconscious manner.
The students will learn about an alternative mode of operation of the light barrier (compared to experiment P1003562).

Tasks

1. In the first part of the experiment, an unmotorised cart, which is accelerated up to the middle of the track by a weight via pulley, rolls on the track. On the second part of the track, the cart continues to roll due to its momentum while at the same time slowing down due to friction. The shutter plate on the cart interrupts a light barrier that is set up next to the track. The light barrier measures the time that the cart needs for passing through the light barrier. The students measure the shading time for different light barrier positions. They then use these values and the width of the shutter plate to calculate the velocity for the respective location.
2. In the second part of the experiment, a battery-powered cart rolls on the track at constant velocity. The students measure the shading time for different positions of the light barrier along the track and they use this value together with the width of the shutter plate to determine the velocity.
3. The students use the measurement values to determine the parts of the experiment during which the velocity of the cart is uniform or non-uniform.

Prior knowledge
The students should know what velocity means and that it can be calculated as a quotient of place and time.
Principle
The battery-powered cart runs on the track at constant velocity. The velocity is location-independent and the motion is uniform. The unmotorised cart is accelerated up to the middle of the track so that the velocity increases as a function of the location. On the second section of the track, the cart slows down due to friction. The velocity is location-dependent and thus non-uniform.

Note
The velocity of the battery-powered 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.

Safety instructions

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

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Versuch: Vergleich von gleich- und ungleichförmiger Bewegung mit SMARTsense (Item No.: P1003669)

Introduction

Application and task

What is the difference between non-uniform and uniform motion?

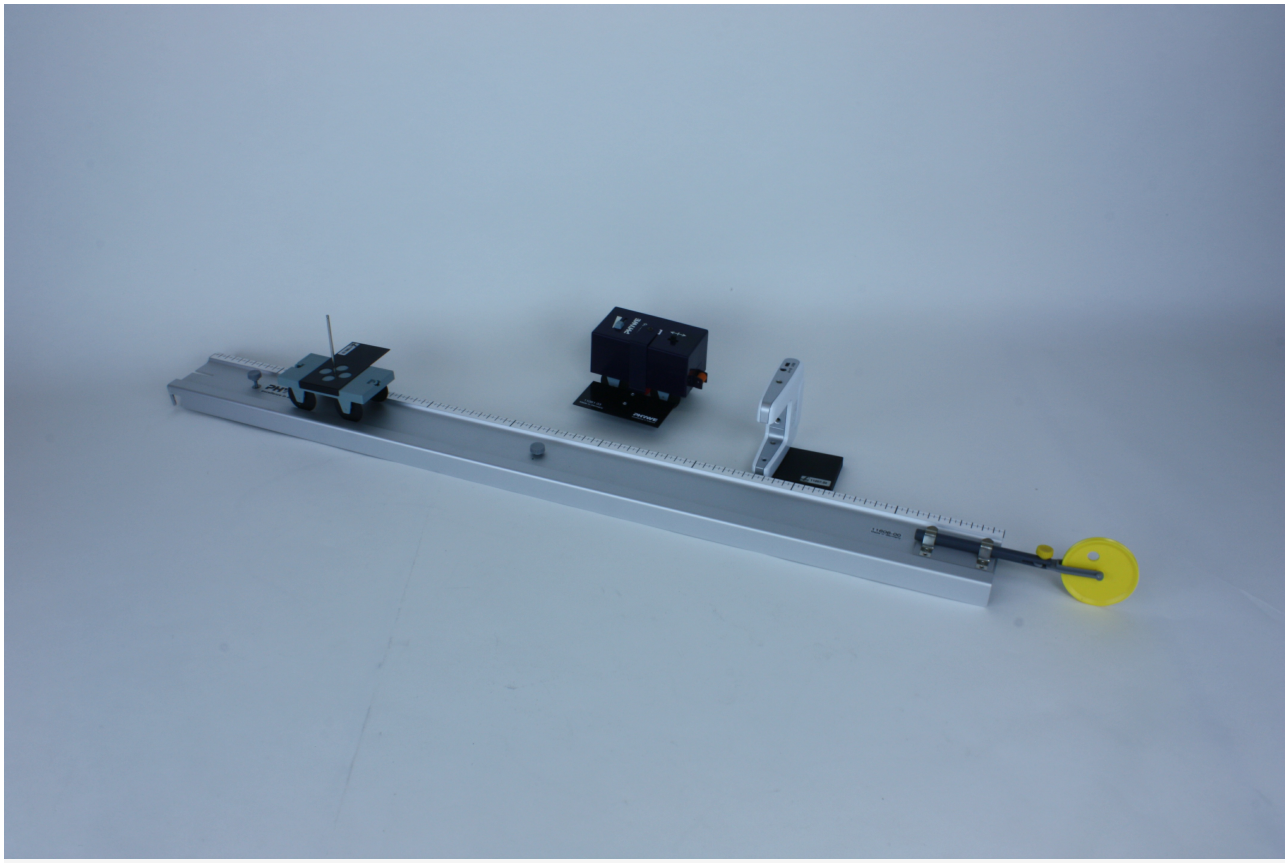
Introduction
You know what velocity (speed) is and how it can be measured.
You have already done so for a uniform motion.
But how can varying velocity be measured, e.g. the velocity of a vehicle in inner-city traffic? You will learn how to do it in this experiment.

Application
We encounter non-uniform motion everywhere in our everyday life. The typical motion of a car that travels at higher or lower speed or even stops depending on the volume of traffic and configuration of the streets and roads is a non-uniform motion. Today, this instantaneous velocity is often determined electronically, but the measurement principle is always the same as the one of this experiment.

Speedometer of a car

Tasks
The experiment is divided into two parts: In the first part of the experiment, you will work with an unmotorised cart, whereas the cart for the second part of the experiment is battery-powered.

1. Use the unmotorised cart. It will be accelerated up to the middle of the track by weights. Measure the shading times of the light barrier that the cart causes when it passes through the light barrier. Change the position of the light barrier along the track and note down the respective shading times and light barrier positions.
2. Now use the battery-powered cart. Measure the shading times of the light barrier that the cart causes when it passes through the light barrier. Once again, change the position of the light barrier along the track and note down the respective shading times and light barrier positions.
3. Calculate the velocities of the cart for both experiment parts based on the width of the shutter plate.
4. Compare the velocity development and decide which of the carts performs uniform motion and which non-uniform motion. Justify your decision based on the measurement values.



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	Cart for measurements and experiments	11060-00	1
6	Shutter plate for cart	11060-10	1
7	Holding pin	03949-00	1
8	Silk thread, l = 200 m	02412-00	1
9	Weight holder, silver bronze, 1 g	02407-00	1
10	Slotted weight, blank, 1 g	03916-00	4
11	Pulley,movable,dia.65mm,w.hook	02262-00	1
12	Rod for pulley	02263-00	1
13	Cobra SMARTsense - Photogate, 0 ... ∞ s	12909-00	1
14	Adapter plate for Light barrier compact	11207-22	1

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Set-up and procedure

Set-up

Connect the pulley to the associated rod (Fig. 1).

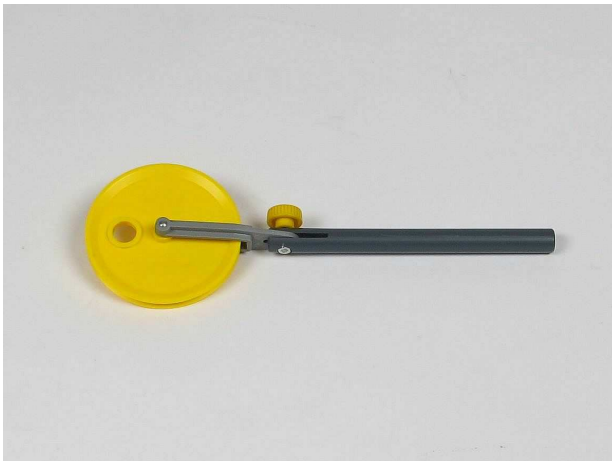


Fig. 1.

Push the rod carefully under the holding clamps located at one end of the track. To do so, slacken the holding clamps slightly with your fingers so that the plastic rod will not be damaged by the sharp metal edges. Position the track on the desktop so that the pulley is located behind the edge of the table and can be rotated freely (Fig. 2).

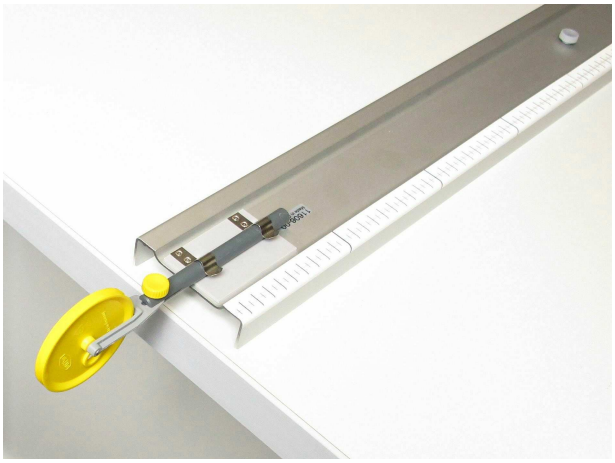


Fig. 2.

Equip the unmotorised cart with a holding pin and shutter plate and place it on the middle of the track (Fig. 3).

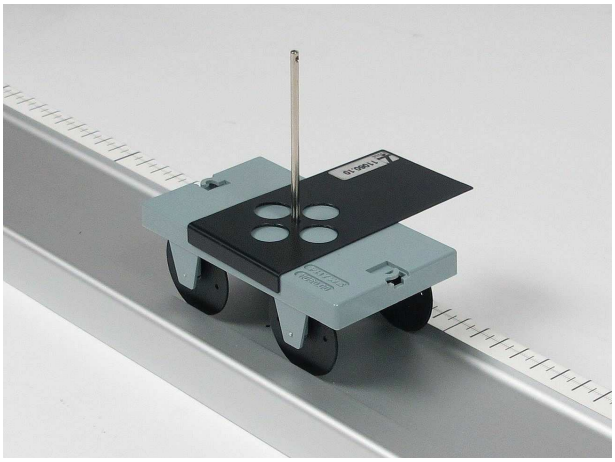


Fig. 3.

Knot one end of the thread onto the weight holder. Knot the other end of the thread onto the holding pin and adjust the length of

the thread so that the weight holder reaches the floor when the cart is located on the middle of the track. Lay the thread over the pulley (Fig. 4).

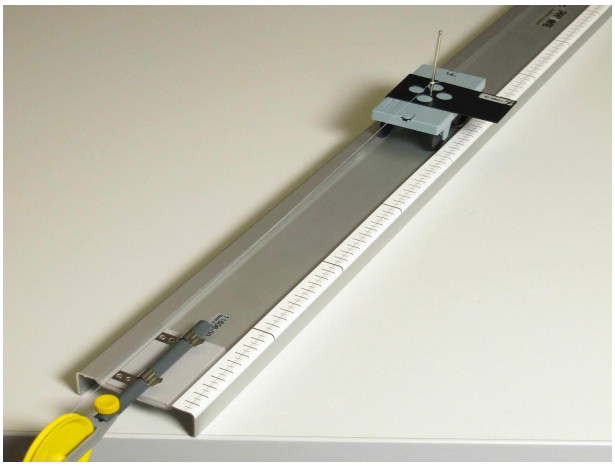


Fig. 4.

Push the cart to the starting end of the track so that it is flush with the end (Fig. 5).
Then, release the cart, which is pulled by the weight holder, without pushing it.
Ensure that the thread runs over the pulley and that the pulley can rotate freely.
The cart should roll approximately up to the end of the track (the weights only pull it up to the middle of the track). You may have to place some additional slotted weights of 1 g (1 to 3) on the weight holder in order to provide the cart with sufficient momentum.
However, do not use more weights than absolutely necessary. Otherwise, your measurement values would deviate too strongly.

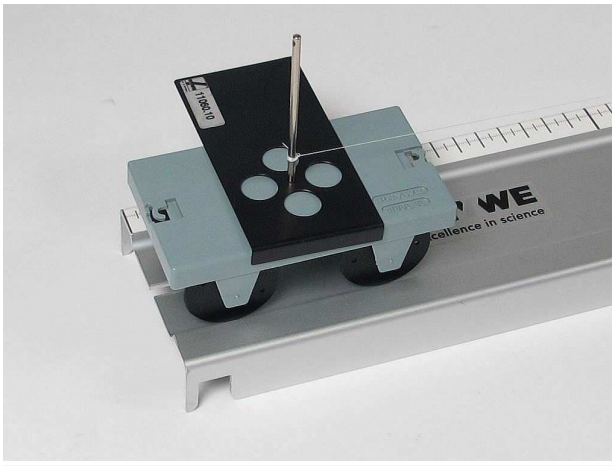


Fig. 5.

Connect the adapter plate to the light barrier A so that it can be set up next to the track and that the shutter plate on the cart can pass through the light barrier without touching it (Fig. 6). Switch the light barrier on and connect it to measureAPP by selecting "photogate" in the menu "sensors". In the then upcoming dialogue select the option "Shade times" (fig. 7).

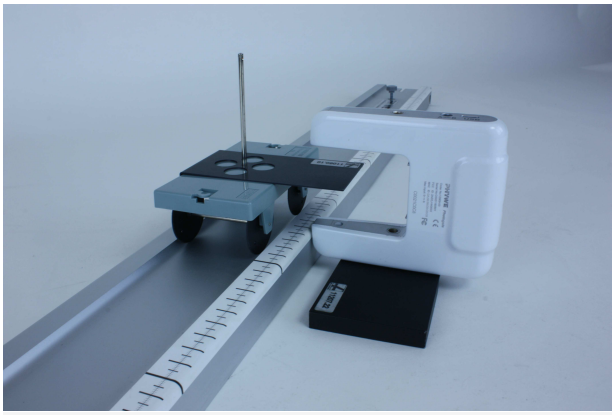


Fig. 6.

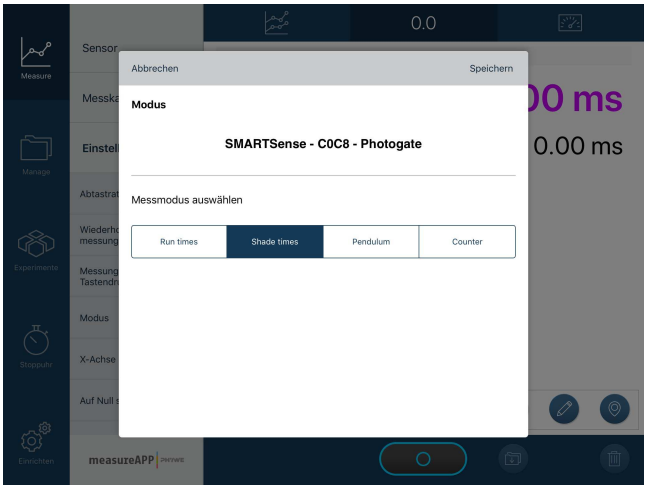


Fig. 7.

With this setting, the light barrier measures the so-called shading time, i.e. the time during which the light beam is interrupted when the shutter plate passes through the light barrier.

Then, take the battery-powered cart and equip it with the associated shutter plate. Place the cart on the desk. Set the speed slider to the lowest speed setting (fig. 8).

Fig. 8.

Procedure

First part of the experiment: unmotorised cart
Position the light barrier at the 15-cm mark and push the cart to the starting end of the track (fig. 9).

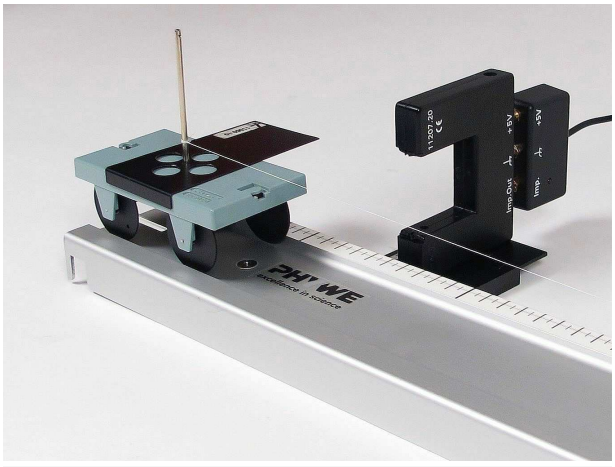


Fig. 9.

Check whether the thread runs over the pulley and whether the pulley can rotate freely. Ensure that the cart is flush with the

edge of the track (fig. 10).
Change the display to numerical mode 0.0 (fig. 11).
Start the measurement by pressing on .
Release the cart without pushing it.

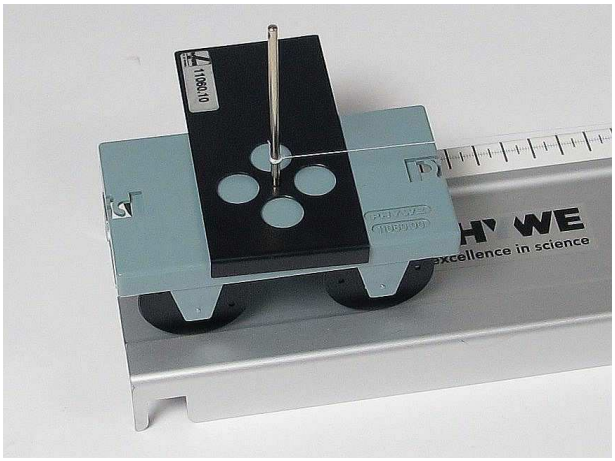


Fig. 10.

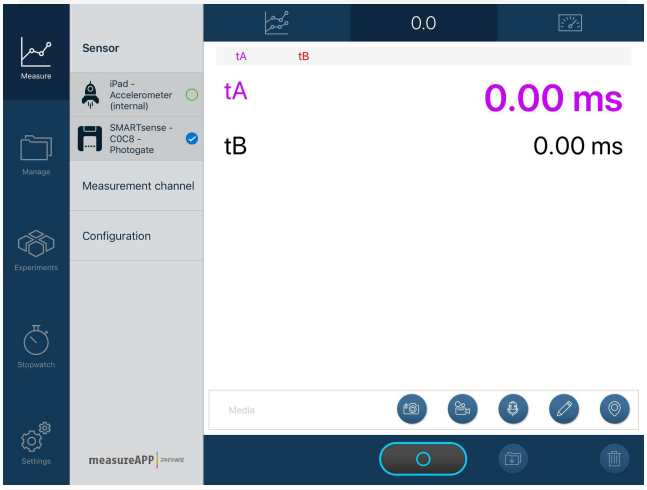


Fig. 11.

Read the time value, round it to a hundredth of a second, convert the value into seconds (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 light barrier positions: 30 cm, 45 cm, 55 cm, 65 cm, and 75 cm.
Prior to starting the cart, ensure that the thread runs over the pulley and that the pulley can rotate freely.

Second part of the experiment: battery-powered cart

Replace the unmotorised cart with the battery-powered cart.
Position it at the starting end of the track and the light barrier at the 20-cm mark.

In order to activate the measurement once again, press and release the cart by way of the direction selector switch (fig. 12).
Convert the time in seconds, round it to two decimal places, and enter the value into table 2.

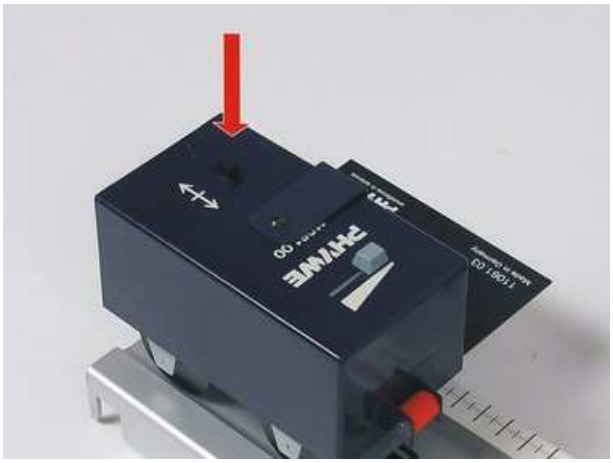


Fig. 12.

Repeat the experiment with the following light barrier positions: 30 cm, 40 cm, 50 cm, 60 cm, and 70 cm.

Report: Comparison of uniform and non-uniform motion with SMARTsense

Result - Table 1

Enter the shading times Δt of the unmotorised cart that is pulled by the weight here.

Calculate the associated velocities v based on the width of the shutter plate Δs=5 cm.

Distance s in cm	15	30	45	55	65	75
Shading time Δt in s	1 ±0.08	1 ±0.07	1 ±0.06	1 ±0.07	1 ±0.08	1 ±0.1
Velocity $v=\Delta s/\Delta t$ in cm/s	1 ±8	1 ±14	1 ±16	1 ±16	1 ±14	1 ±14

Result - Table 2

Enter the shading times Δt for the battery-powered cart here.

Calculate the associated velocities v based on the width of the shutter plate Δs=10 cm for this cart.

Distance s in cm	20	30	40	50	60	70
Shading time Δt in s	1 ±0.07	1 ±0.07	1 ±0.07	1 ±0.07	1 ±0.07	1 ±0.07
Velocity $v=\Delta s/\Delta t$ in cm/s	1 ±0.5	1 ±0.5	1 ±0.5	1 ±0.5	1 ±0.5	1 ±0.5

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Evaluation - Question 1

You have calculated the velocities in table 1 and table 2.

Which of the following statements can you confirm based on the measurement values?

- [ ] The longer the shading time is, the higher the velocity will be.
- [ ] The shorter the shading time is, the higher the velocity will be.

Evaluation - Question 2

Select the correct statement(s).

The cart that is pulled by the weight becomes ..... in the beginning until it reaches its ..... velocity approximately at the middle of the track. From there on, the ratio $\Delta s/\Delta t$ becomes .....

Evaluation - Question 3

Select the correct statements while taking the measurement values into consideration.

- [ ] The velocity of the battery-powered cart is nearly constant over the entire distance.
- [ ] The velocity of the unmotorised cart depends on the location.
- [ ] The motion of the unmotorised cart must be considered as non-uniform.
- [ ] The motion of the unmotorised cart can still be considered as uniform.
- [ ] The motion of the battery-powered cart can be considered as uniform.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com