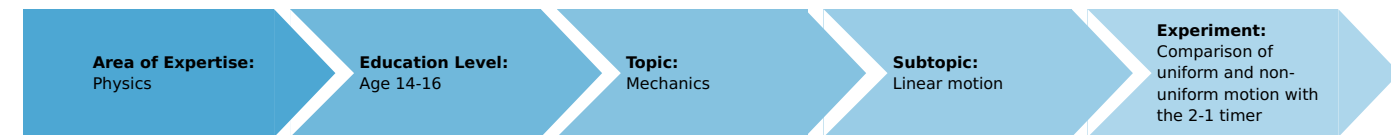


# Comparison of uniform and non-uniform motion with the 2-1 timer (Item No.: P1003605)

## Curricular Relevance



### Difficulty



Intermediate

### Preparation Time



10 Minutes

### Execution Time



20 Minutes

### Recommended Group Size



2 Students

### Additional Requirements:

### 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

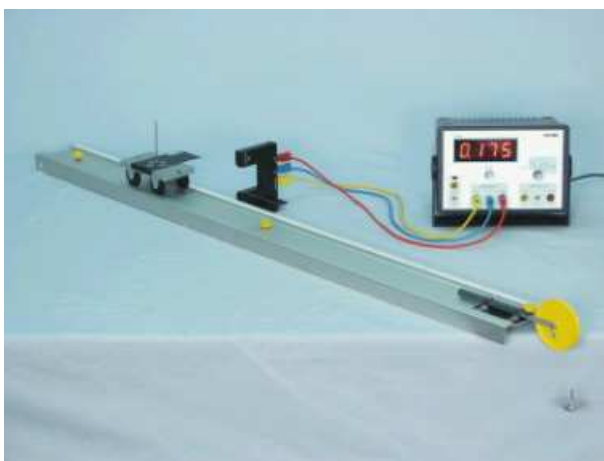
#### Application

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. In addition, they should have already gained some experimental experience concerning the handling of the Cobra4 Mobile-Link.

## Principle

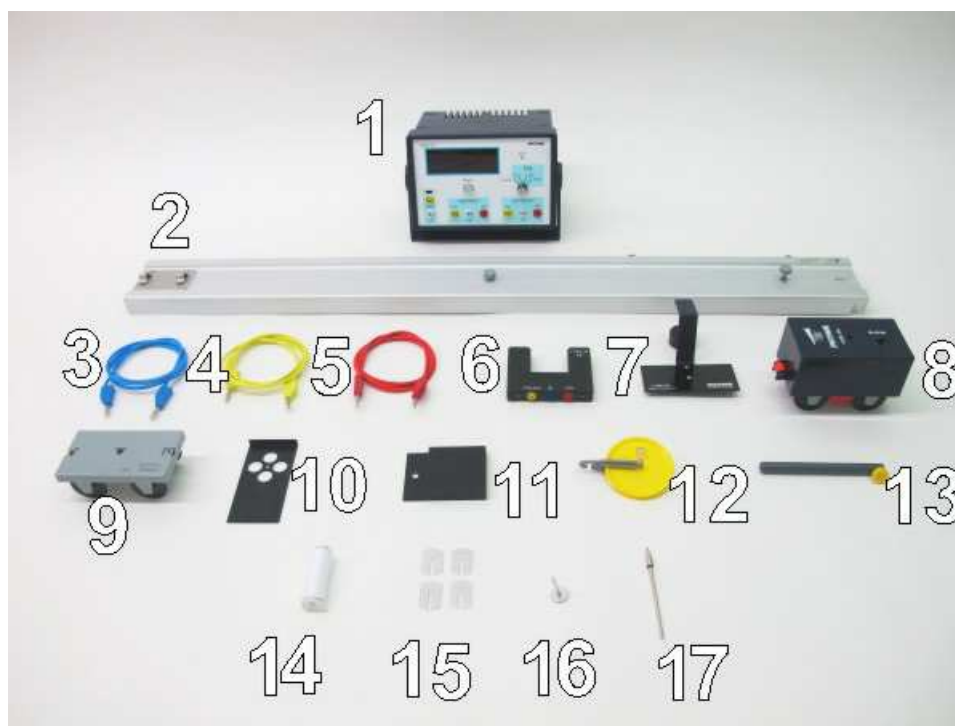
The battery-powered cart runs on the track at constant velocity. The velocity is location-independent and the motion is uniform. The unmotorised cart is accelerated up to the middle of the track so that the velocity increases as a function of the location. On the second section of the track, the cart 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.

## Material

Position No.	Material	Order No.	Quantity
1	Timer 2-1	13607-99	1
2	Track, l 900 mm	11606-00	1
3	Connecting cord, 32 A, 1000 mm, blue	07363-04	1
4	Connecting cord, 32 A, 1000 mm, yellow	07363-02	1
5	Connecting cord, 32 A, 1000 mm, red	07363-01	1
6	Light barrier, compact	11207-20	1
7	Shutter plate for car, motor driven	11061-03	1
8	Car, motor driven	11061-00	1
9	Cart for measurements and experiments	11060-00	1
10	Shutter plate for cart	11060-10	1
11	Adapter plate for Light barrier compact	11207-22	1
12	Pulley, movable, dia. 65 mm, w. hook	02262-00	1
13	Rod for pulley	02263-00	1
14	Silk thread, l = 200 m	02412-00	1
15	Slotted weight, blank, 1 g	03916-00	4
16	Holding pin	03949-00	1
17	Weight holder, silver bronze, 1 g	02407-00	1



## Safety instructions

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

# Comparison of uniform and non-uniform motion with the 2-1 timer (Item No.: P1003605)

## 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.

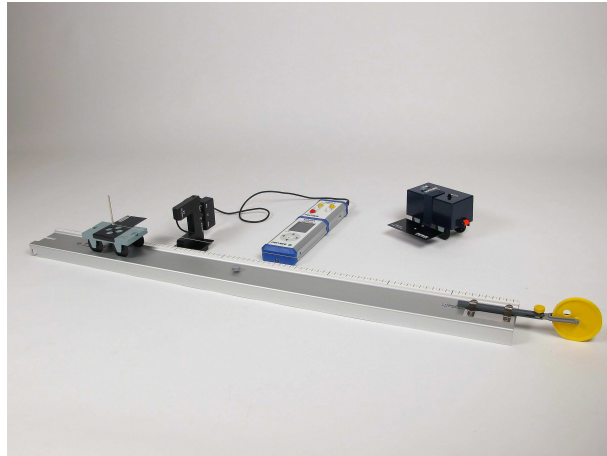


Speedometer of a car

#### Tasks

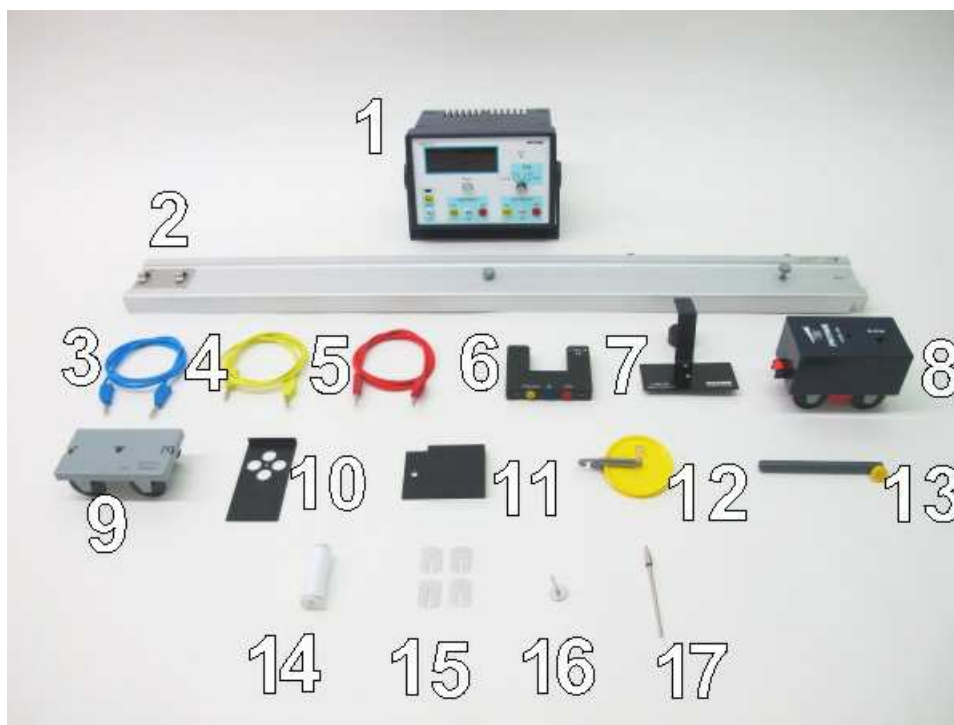
The experiment is divided into two parts: In the first part of the experiment, you will work with an unmotorised cart, whereas the cart for the second part of the experiment is battery-powered.

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
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3	Connecting cord, 32 A, 1000 mm, blue	07363-04	1
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12	Pulley, movable, dia. 65mm, w. hook	02262-00	1
13	Rod for pulley	02263-00	1
14	Silk thread, l = 200 m	02412-00	1
15	Slotted weight, blank, 1 g	03916-00	4
16	Weight holder, silver bronze, 1 g	02407-00	1
17	Holding pin	03949-00	1

## Set-up and procedure

### Set-up

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

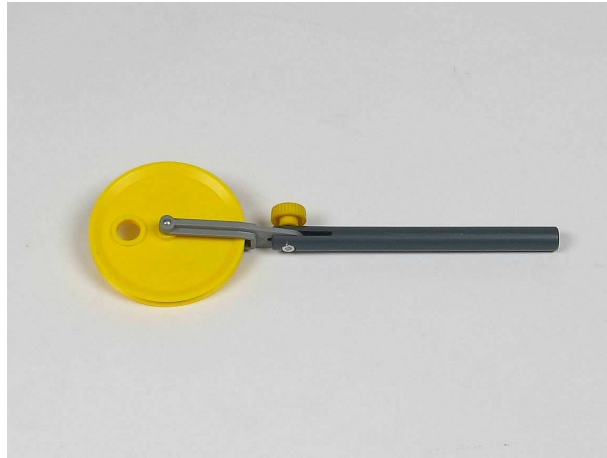


Fig. 1

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).

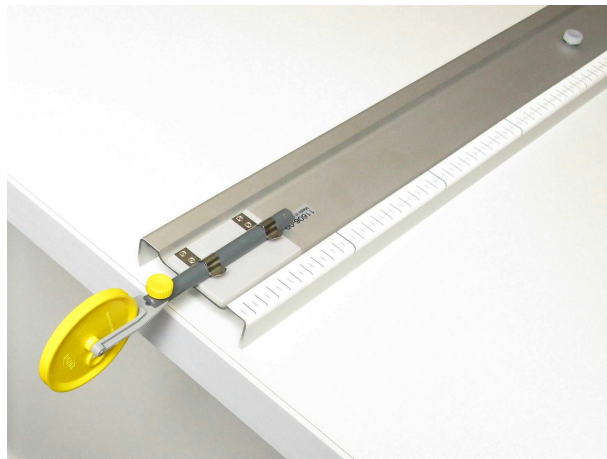


Fig. 2

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

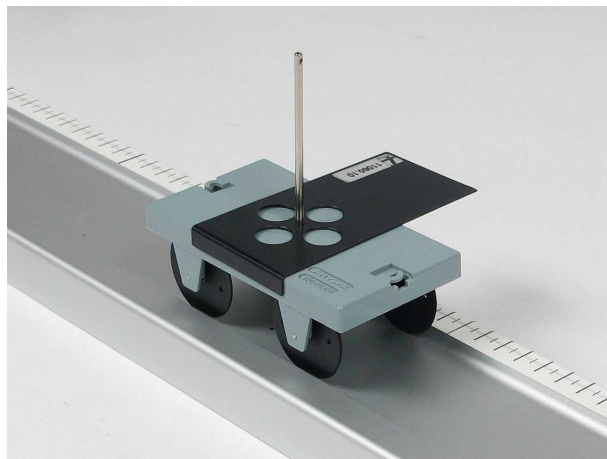


Fig. 3

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).



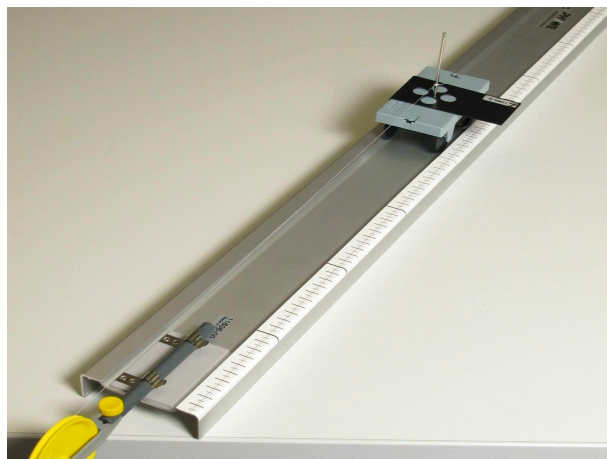


Fig. 4

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.

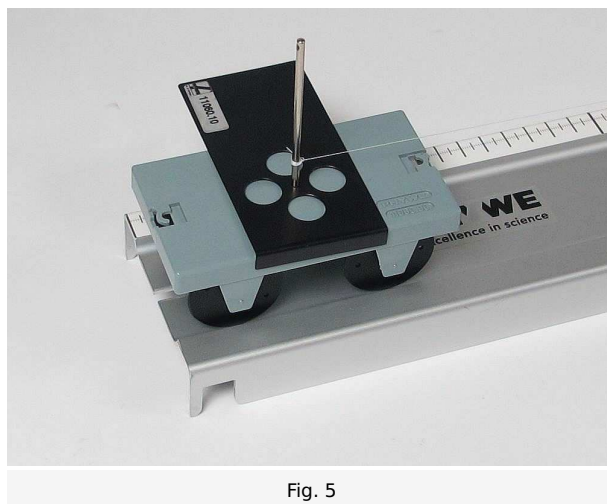


Fig. 5

Connect the adapter plate to the light barrier 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).

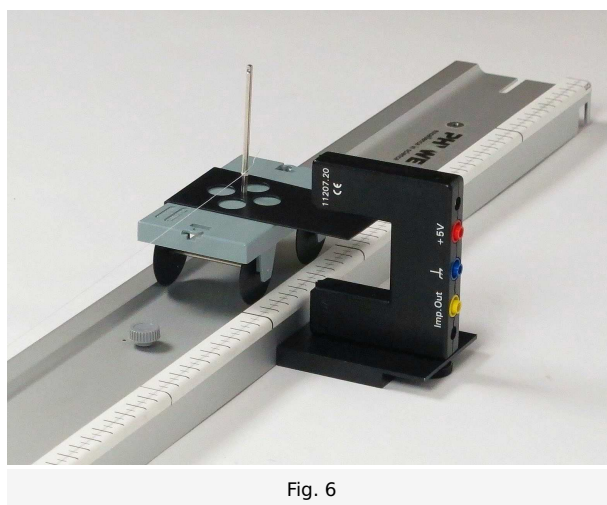


Fig. 6

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. 7).





Fig. 7

Connect the "Timer Counter" Sensor-Unit to the Mobile-Link (Fig. 8).



Fig. 8

Connect the light barrier to the Cobra4 adapter and connect it to the TC1 socket of the "Timer Counter" Sensor-Unit (Fig. 9).

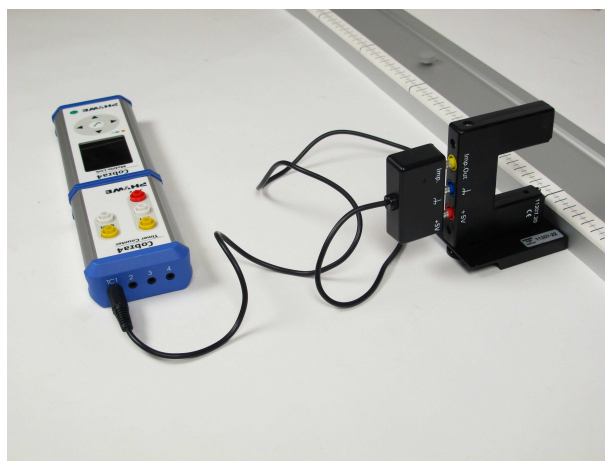


Fig. 9

Switch the Mobile-Link on. The connected "Timer Counter" Sensor-Unit will be recognised automatically. Pressing the right-hand arrow button will open the main menu. Select the menu item "Sensor" and press the confirmation button (green tick) to enter this submenu. Then, open the "Range" menu and set the unit to milliseconds (ms) by way of the arrow buttons (Fig. 10).



Fig. 10

Press the confirmation button in order to exit this menu. This will save the current setting and lead you to the previous menu where you can now select the "Setup" menu.

Select the operating mode and start mode by way of the arrow buttons as shown in the screenshot (Fig. 11).

Press the confirmation button once and the left-hand arrow button twice in order to return to the recording mode.



Fig. 11

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.

## 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. 12).

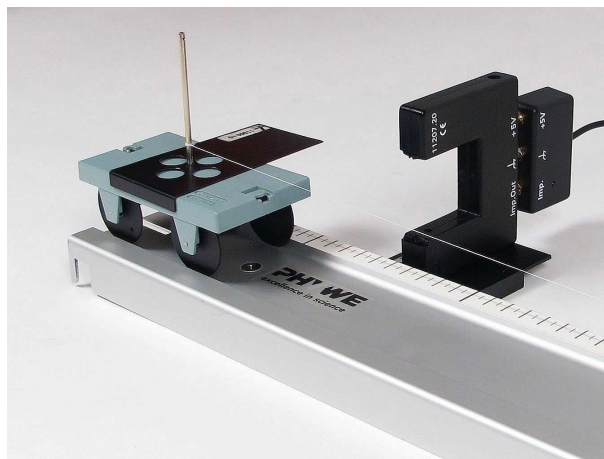


Fig. 12

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. 13).  
In the measurement window of the Mobile-Link, press the confirmation button so that "TC wait for trigger..." is displayed. The device can now perform a measurement.  
Release the cart without pushing it.

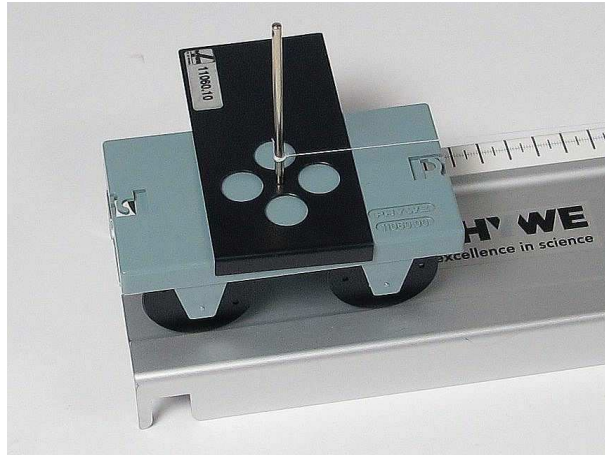


Fig. 13

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 (Fig. 14).

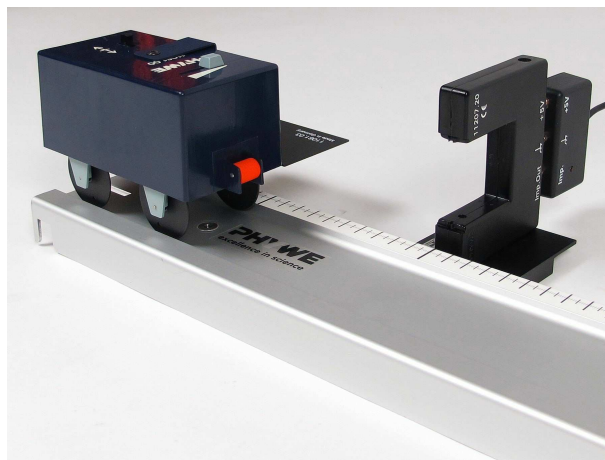


Fig. 14

In order to activate the measurement once again, press the confirmation button of the Mobile-Link and release the cart by way of the direction selector switch (Fig. 15).  
Convert the time in seconds, round it to two decimal places, and enter the value into table 2.



Fig. 15

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 the 2-1 timer

## Result - Table 1

Enter the shading times  $\Delta t$  of the unmotorised cart that is pulled by the weight here.

Calculate the associated velocities  $v$  based on the width of the shutter plate  $\Delta s = 5$  cm.

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

## Result - Table 2

Enter the shading times  $\Delta t$  for the battery-powered cart here.

Calculate the associated velocities  $v$  based on the width of the shutter plate  $\Delta s = 10$  cm for this cart.

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

**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.