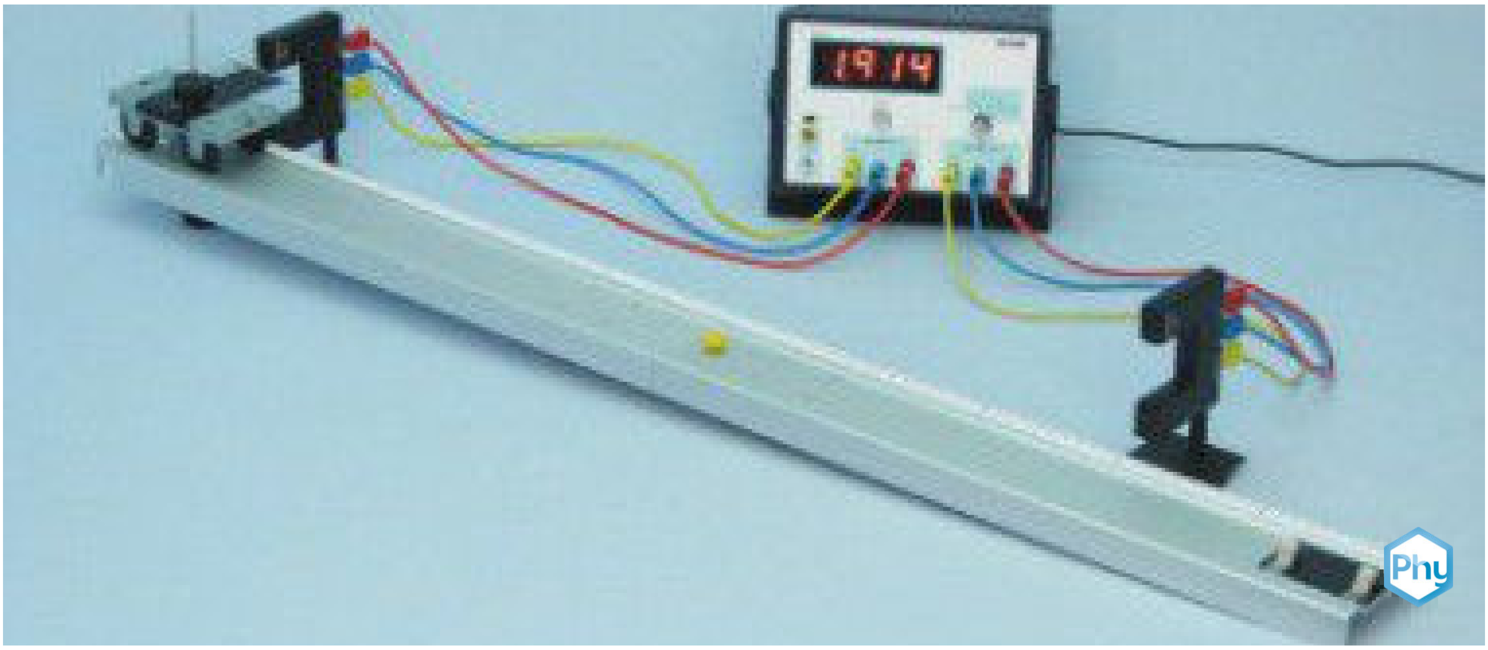
# Instantaneous and average speed with timer 2-1




Physics › Mechanics › Dynamics & Motion

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| medium | 2 | 10 minutes | 20 minutes |

This content can also be found online at:

http://localhost:1337/c/5fdbb8485098f00003f1ede2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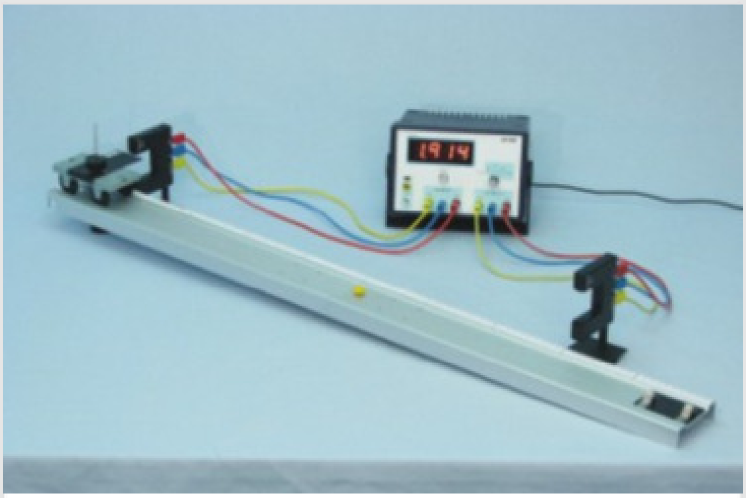
# Teacher information

## Application




Experiment set-up

By using light barriers, both the instantaneous and the average speed can be determined.

This technology is used, among other things, in traffic monitoring. Here, for example, the speed of road users can be determined using the difference in travel time of transmitted radar waves or light pulses. For correct scaling, there are often standardized markings on the road.



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## Other teacher information (1/2)

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**Prior knowledge**

Students should know how a photoelectric sensor works.

**Scientific principle**

A body experiences a constant acceleration in an inclined path due to the component of gravity acting on it parallel to the path. Therefore, the laws of motion apply to a uniformly accelerated motion.

## Other teacher information (2/2)

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**Learning objective**

In this experiment, students will quantitatively investigate the differences between uniform and non-uniform motions. Specifically, the average velocity $v = \Delta s / \Delta t$ should be differentiated from the momentary speed $v = \dot{s}$.

**Tasks**

1. Determine the average speed: measure the time taken by the car to cover a given distance using two light barriers at the beginning and end of the respective distance.
2. Determine the instantaneous velocity: Measure the time it takes for the aperture on the car to pass the light barrier after such a distance.



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## Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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# Student Information



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## Motivation

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Measuring device for radar control

Since everyday movements are particularly non-uniform, it is important to distinguish between the so-called instantaneous and average speeds. In road traffic, the instantaneous speeds are generally determined with radar traps as average speeds for very short periods of time. The longer this time span is, the more the average speed can deviate from the intermediate instantaneous speeds.

In this lesson, you will learn the difference between these two quantities by using two photoelectric sensors in different measurement modes.

## Tasks

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1. Measure the time taken by the cart to travel a certain distance using two light barriers at the beginning and end of the respective distance. Calculate the average speed from the time measured between the interruption of one and the other light barrier and the length of the track.
2. Measure the time required for the diaphragm on the cart to pass the light barrier after such a distance. Calculate approximately the instantaneous velocity with this shading time of the light barrier and the aperture width.



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Cart for measurements and experiments | 11060-00 | 1 |
| 2 | Shutter plate for cart | 11060-10 | 1 |
| 3 | Holding pin | 03949-00 | 1 |
| 4 | Slotted weight, black, 50 g | 02206-01 | 3 |
| 5 | PHYWE Timer 2-1 | 13607-99 | 1 |
| 6 | Light barrier, compact | 11207-20 | 2 |
| 7 | Adapter plate for Light barrier compact | 11207-22 | 2 |
| 8 | Connecting cord, 32 A, 1000 mm, red | 07363-01 | 2 |
| 9 | Connecting cord, 32 A, 1000 mm, yellow | 07363-02 | 2 |
| 10 | Connecting cord, 32 A, 1000 mm, blue | 07363-04 | 2 |
| 11 | Track, l 900 mm | 11606-00 | 1 |



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## Set-up (1/3)

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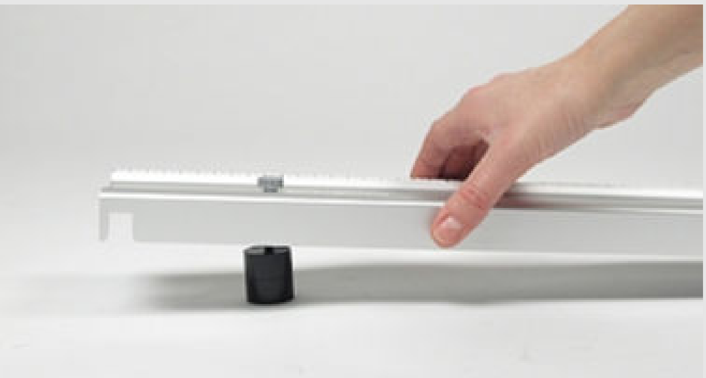
To tilt the carriage, screw the adjustable foot of the carriage all the way down and place it on two stacked 50 g slotted weights. Then attach the shade screen to the cart using the holding pin and weigh it down with a 50 g slotted weight.



## Set-up (2/3)

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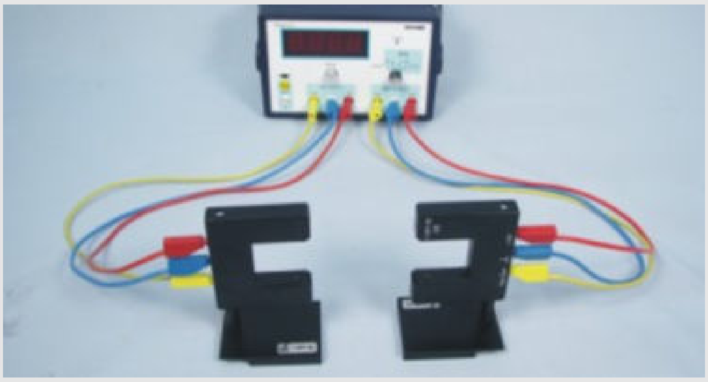
Screw the spacer bolts and adapter plates to the forked light barriers in such a way that they can be easily positioned next to the carriageway and the aperture on the cart fits through the respective light barrier without hitting it. Connect both light barriers to the timing device. Set the slide switch above the field labelled "Start" on the timing device to the right position.





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## Set-up (3/3)

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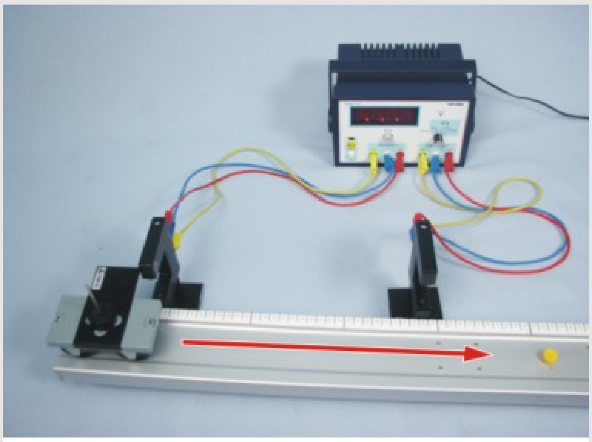

Direction of travel of the cart

Position the cart so that the end of the cart is flush with the end of the track. Position the first light barrier so that the screen on the cart interrupts it as soon as the cart is released.

Position the second light barrier at a distance of 20 cm from the first one.

## Procedure (1/2)

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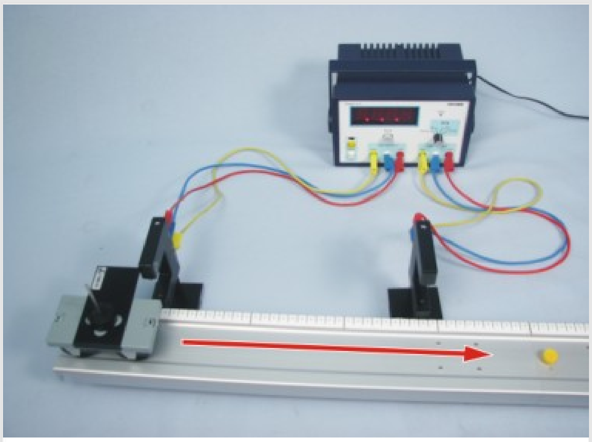

Direction of travel of the cart

- Set the rotary switch on the timing device to the third position from the left. The device then displays the time that elapses between the interruption of the first and the second light barrier. In this experiment, this is the time that the cart takes to pass through the distance $\Delta s$ between the two light barriers.
- Press the "Reset"-button on the timing device before each measurement.
- Let go of the car without nudging it and note the time $t$ required for the distance by the car $\Delta s = 20\,cm$ in Table 1 in the report. Repeat the measurement for the distances $\Delta s = 30,\ 50,\ 70 cm$.



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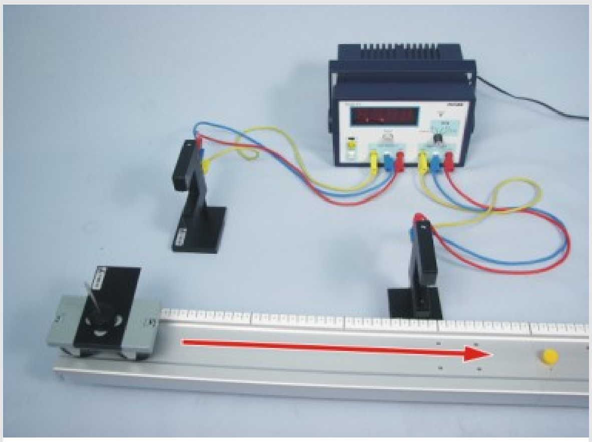
## Procedure (2/2)



Removing the first light barrier

- Now remove the first light barrier from the track far enough away so that it is not interrupted by the aperture of the car.
- Set the rotary switch to the second position from the left. The device then displays the shading time. This is the time period in which a light barrier is interrupted by an aperture.
- Repeat the measurement for all positions of the second light barrier from the first part of the experiment. Start each measurement with the "Reset" button and let the car roll down the track. Enter the measured times $t$ also in Table 1 in the report.

# Report



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## Table 1

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Enter the calculated values for the travel times $\Delta t$ and the shading times $t$ for the respective distances $\Delta s$ into the table. Then calculate the average speed $v_d = \Delta s / \Delta t$ and the instantaneous speed $v_m = b/t$ with the aperture width $b = 5\,cm$.

| $Distance\ \Delta s\ [cm]$ | $\Delta t\,[s]$ | $v_d\,[cm/s]$ | $t\,[s]$ | $v_m\,[cm/s]$ |
|---|---|---|---|---|
| 20 | | | | |
| 30 | | | | |
| 50 | | | | |
| 70 | | | | |

## Task 1

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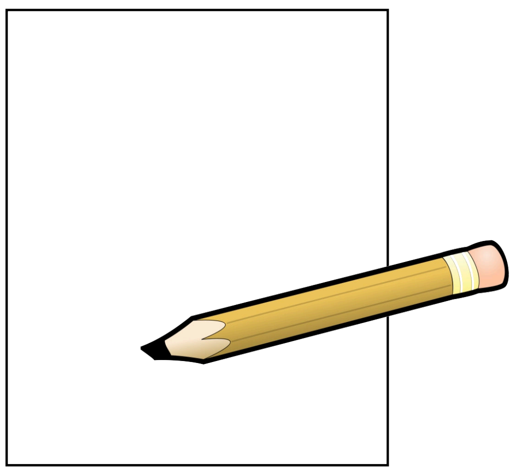
Now take a sheet of paper and draw a diagram on it. In this diagram you place the two velocities $v_d$ and $v_m$ ($y$-axis) as a function of the distance travelled $\Delta s$ ($x$axis).

Draw both curves in a diagram.





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## Task 2

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Cart

How do the speeds compare $v_m$ to each other?

- The speeds are all the same.
- The speeds increase as the length of the route increases.
- The speeds drop with increasing distance.

Check

## Task 3

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Drag the words to the right places.

The ______ $v_m$ is at the end of the line $s$ is always ______ than the ______. $v_d$ over the same distance. Thus, the speed ______ over the course of the distance.

not needed: ______ (adjective), ______ (noun).

- increases
- maximum speed
- greater
- instantaneous speed
- average speed
- smaller

Check



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## Task 4

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Cart

Can we speak of a uniform movement here?

- Yes, there is uniform motion because the car is moving at a constant speed.
- No, there is no uniform movement, because the car is continuously accelerating.

Check

| Slide | Score / Total |
|---|---|
| Slide 18: Comparison of \(v_m\) | 0/1 |
| Slide 19: Shapes of the velocities | 0/6 |
| Slide 20: Nature of the movement | 0/1 |

Total 0 / 8

Solutions Repeat Export text



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