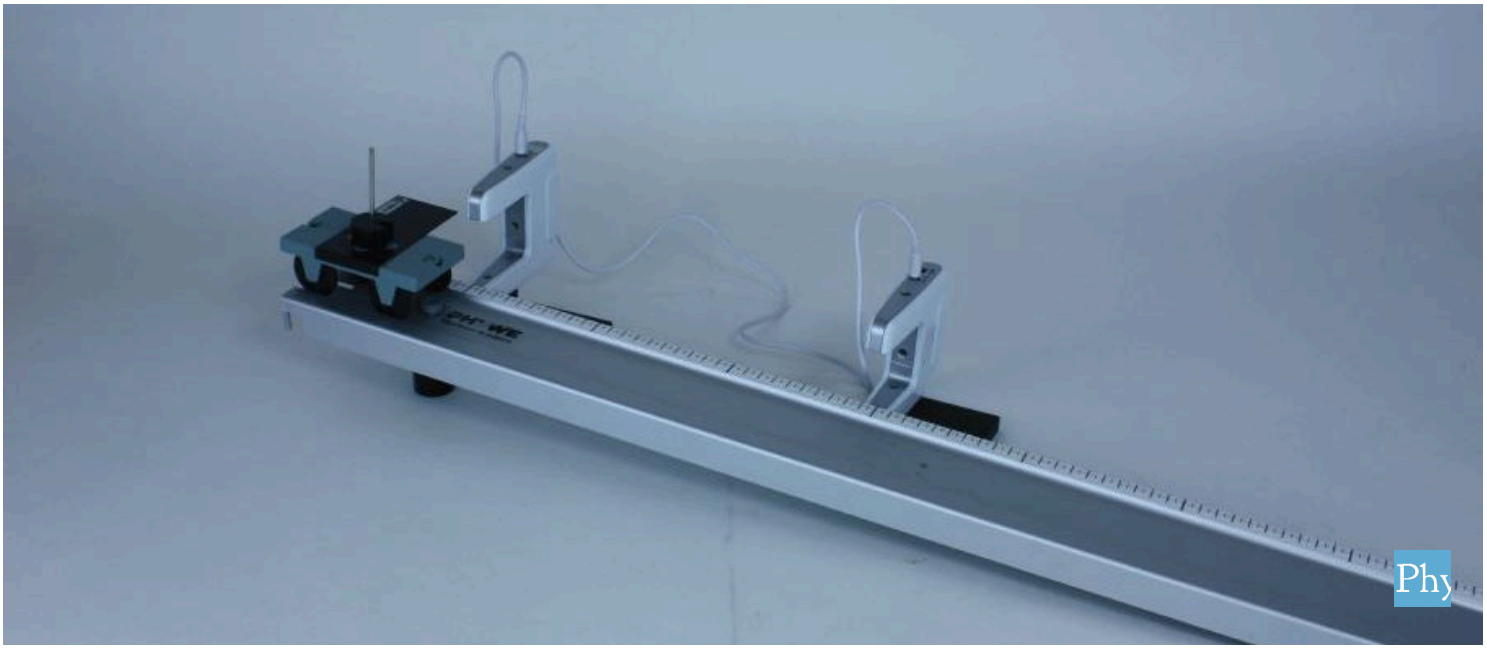
Instantaneous and average speed with Cobra SMARTsense



Physics | Mechanics | Dynamics & Motion

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

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Teacher information

Application

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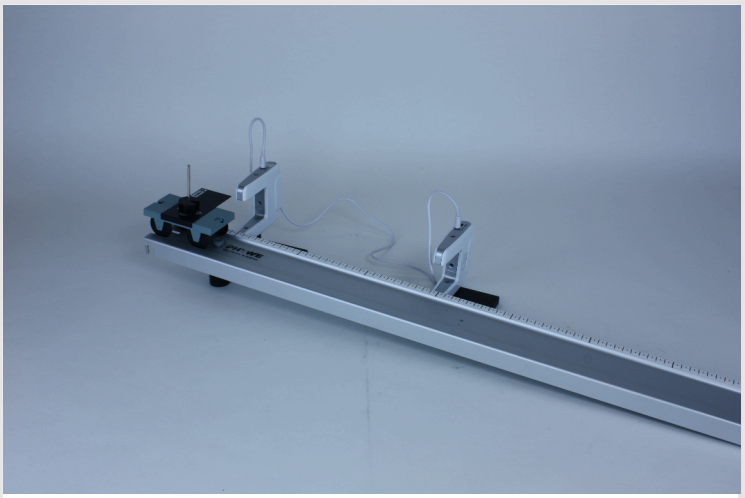

Experiment set-up

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

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

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Other teacher information (1/2)

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Prior knowledge

The students should know how a light barrier works.

Scientific principle

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

Other teacher information (2/2)

Learning objective

In this experiment, the students should quantitatively investigate the differences between uniform and non-uniform movements. In particular, the average speed $v = \Delta s / \Delta t$ from the instantaneous speed $v = \dot{s}$ be delimited.

Tasks

1. Determination of the average speed: Measurement of the time required by the experimenting cart for a certain distance using two light barriers at the beginning and end of the respective distance.
2. Determining the instantaneous speed: Measuring the time required for the aperture on the experimenting cart 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.

Student Information

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Motivation

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Measuring device for radar control

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

In this you will learn the difference between these two quantities by using two light barriers in different measuring modes.

Tasks

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1. Measure the time required by the experimenting cart for a certain distance with the help of two light barriers at the beginning and end of the respective distance. Calculate the average speed from the measured time between the interruption of one and the other light barrier and the length of the distance.
2. Measure the time it takes for the aperture on the experimenting cart to pass the light barrier after such a distance. Using this shadowing time of the light barrier and the aperture width, calculate the approximate instantaneous speed.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Photogate, 0 ... ∞ s, two pieces (Bluetooth)	12909-00	1
2	Cart for measurements and experiments	11060-00	1
3	Shutter plate for cart	11060-10	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
9	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/4)

The Cobra SMARTsense Photogate and measureAPP are required to carry out the experiment. The app can be downloaded for free from the App Store - QR codes see below. Check whether Bluetooth is activated on your device (tablet, smartphone).

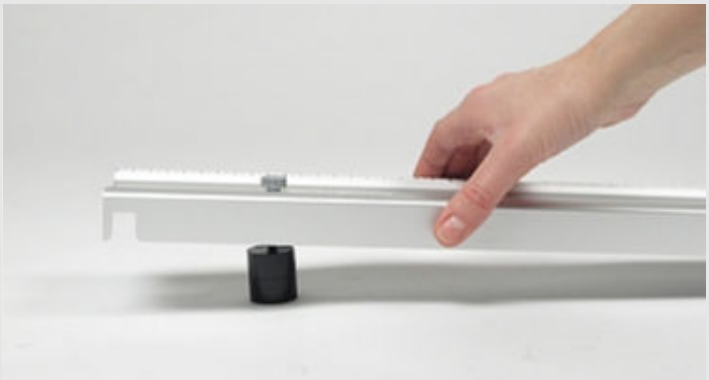
measureAPP for Android operating systems

measureAPP for iOS operating systems

measureAPP for Tablets / PCs with Windows 10

Set-up (2/4)

To tilt the track, screw the adjustable foot of the track all the way down and place it on two stacked 50-g slotted weights. Then attach the shading screen to the experiment cart using the retaining bolt and weigh it down with a 50-g slotted weight.



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Set-up (3/4)

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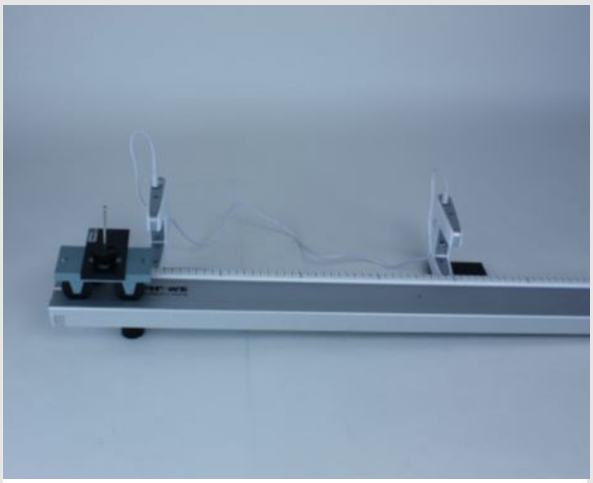

Experimental setup with experimenting carts

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

Position the second light barrier 20 cm away from the first.

Connect the photoelectric sensors to the adapter plates and spacers so that the photoelectric sensors can be easily positioned along the track and the shading screen of the measuring cart can pass through without hitting it.

Set-up (4/4)

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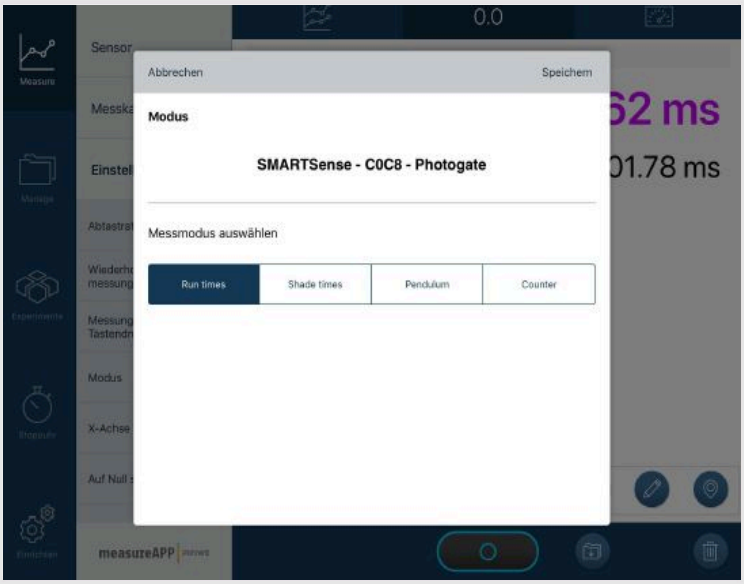

Make sure that the light barrier marked "B" is the rear one. Then connect both light barriers with the jack cable and switch them on.

Select the light barriers in measureAPP under "Sensor" and select "Runtime" in the menu which then appears. In this way, the time can be determined which elapses from the interruption of the first photoelectric sensor to the interruption of the second photoelectric sensor.

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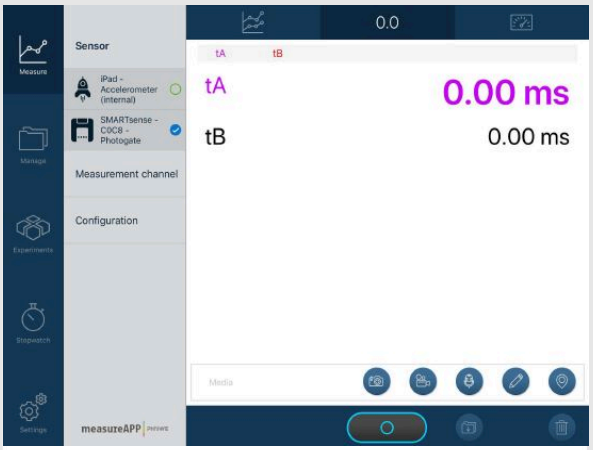
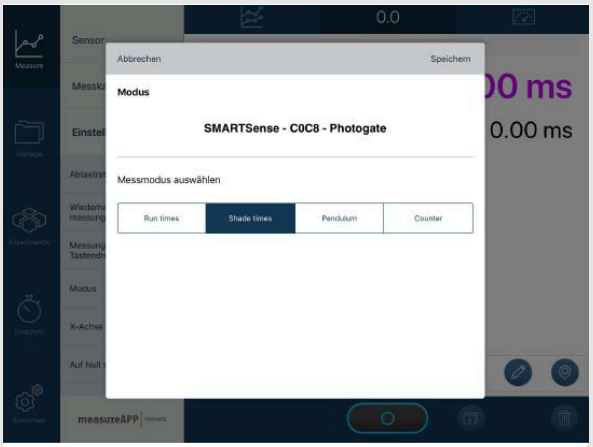
Procedure (1/2)



Digital measured value display in the measureAPP

- Select the digital measured value display in measureAPP. Then the program displays the times at which the two light barriers are interrupted after the start of the measurement. From this, the time can be calculated, which the cart needs to pass the Δs between the two light barriers.
- Start the measurement for $\Delta s = 20\,cm$ and let go of the cart without pushing it. Calculate the difference between the two times displayed and enter the value in Table 1 in the log. Repeat the measurement for the distances $\Delta s = 30,\ 50,\ 70 cm$.

Procedure (2/2)



Changing the measuring mode in the measureAPP

- Now remove the first light barrier from the track so far away that it is not interrupted by the aperture of the cart.
- In the "Settings" menu, press "Mode" and select "Shading" to change the mode accordingly, so that the light barriers now measure the shading time, from which you can later approximately calculate the instantaneous speed.
- Repeat the measurement for all positions of the second light barrier from the first test part. Start a new measurement each time and let the cart roll down the track. Enter the measured times t is also entered in Table 1 of the Report.

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Report

Table 1

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Carry the calculated values for the travel times Δt and the shading times t for the respective routes Δs 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 $b = 5\,cm$.

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

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Task 1

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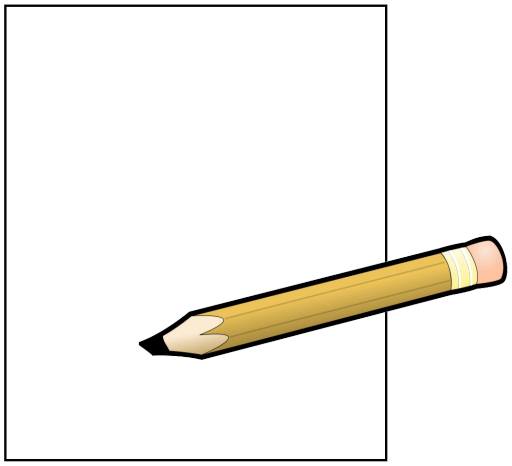
Now take a piece of paper and create a diagram on it. In this diagram you set the two speeds v_d and v_m (y-axis) depending on the distance travelled Δs (x-axis).

Draw both curves in a diagram.



Task 2

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experimenting cart

How do the speeds behave v_m to each other?

- ○ The speeds fall with increasing distance.
- ○ The speeds are all equal.
- ○ The speeds increase with increasing track length.

Check

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Task 3

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Drag the words to the right places.

The _____ v_m at the end of the segment s is always _____ than the _____ v_d over the same segment. So the speed _____ over the distance.

Not needed: _____ (adjective), _____ (noun)

- maximum speed
- greater
- lower
- average speed
- momentary speed
- increases

Check

Task 4

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experimenting cart

Can we speak obout a uniform movement here?

- ○ No, there is no uniform movement, because the cart is continuously accelerated.
- ○ Yes, there is a uniform movement because the cart is moving at a constant speed.

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Slide	Score/Total
Slide 19: settlement of v_m	0/1
Slide 20: Forms of speed	0/6
Slide 21: Type of movement	0/1

Total amount 0/8

Solutions | Repeat | Exporting text

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