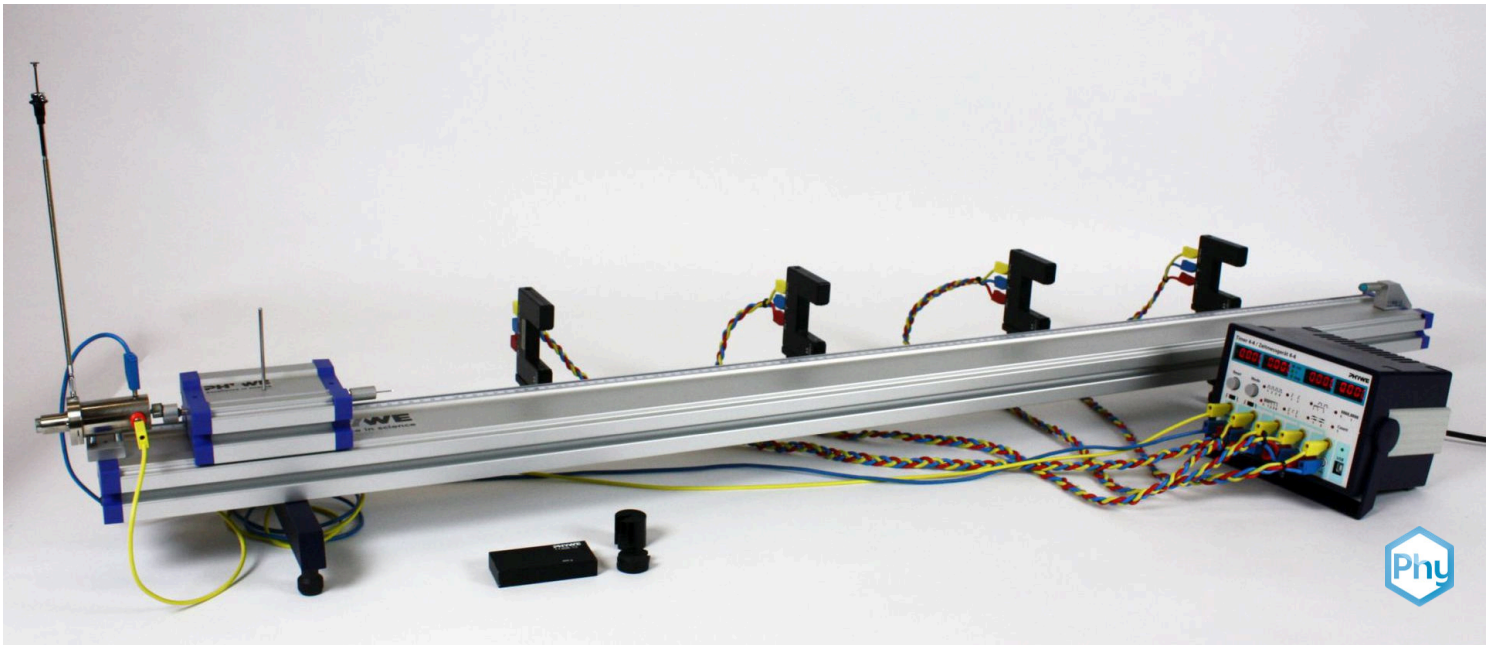
Linear uniform motion with the demonstration track and the timer 4-4



Physics > Mechanics > Dynamics & Motion

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

This content can also be found online at:

http://localhost:1337/c/60032113eefa9f0003fe61fc

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General information

Application

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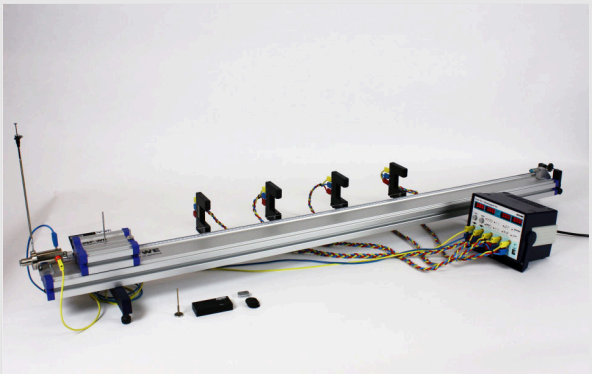

Experiment set-up

A trolley is repeatedly accelerated to a constant speed by a mechanical starting device.

At various intervals, the corresponding travel time of the car is determined and then the average speed is calculated.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

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Other information (1/2)

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Prior knowledge

Students should be familiar with the basic concept and terminology of classical equations of motion.

Scientific principle

The properties of uniform rectilinear motion are studied.

For this purpose, uniform rectilinear movements are observed and the physical relationship is then derived from the results.

Other information (2/2)

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Learning objective

If a body performs a uniform movement, the distance covered increases linearly with the elapsed time.

Tasks

1. Determination of the path-time dependence from several measurement times after different distances covered.
2. Determination and comparison of the average speeds.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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Safety instructions

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

Theory

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Following Newton's first law, that any body on which no force acts is either at rest or moving at a constant speed along a straight line.

This form of locomotion is called uniform rectilinear motion.

Since the speed remains unchanged, the distance travelled is as follows $s(t)$ following the speed-time law:

$$s(t) = v(t) \cdot t$$

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Equipment

Position	Material	Item No.	Quantity
1	Demonstration track, aluminium, 1.5 m	11305-00	1
2	Cart, low friction sapphire bearings	11306-00	1
3	Shutter plate for low friction cart, width: 100 mm	11308-00	1
4	Needle with plug	11202-06	1
5	Plasticine, 10 sticks	03935-03	1
6	Magnet w.plug f.starter system	11202-14	1
7	Tube with plug	11202-05	1
8	Light barrier, compact	11207-20	4
9	Holder for light barrier	11307-00	4
10	PHYWE Timer 4-4	13604-99	1
11	Connecting cord, 32 A, 1000 mm, yellow	07363-02	5
12	Connecting cord, 32 A, 1000 mm, red	07363-01	4
13	Connecting cord, 32 A, 1000 mm, blue	07363-04	5
14	Starter system for demonstration track	11309-00	1
15	End holder for demonstration track	11305-12	1

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Set-up and Procedure

Set-up (1/6)

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Launching device for the shock

1. In order to compensate for minor friction effects, the track must be set at a slight angle using the adjusting screws on the feet so that the measuring carriage just does not start to roll to the right.

2. A launching device shall be installed at the left end of the runway.

Note that to start the trolley with initial impulse, the starting device must be mounted in such a way that the trolley receives a force impulse from the ram.

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Set-up (2/6)

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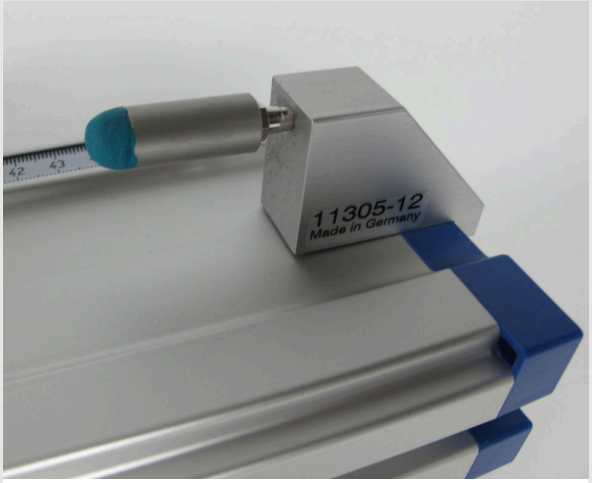

End bracket with plasticine

3. A tube filled with plasticine is attached to the end bracket at the right end of the track to slow the car down without hard impact.

Set-up (3/6)

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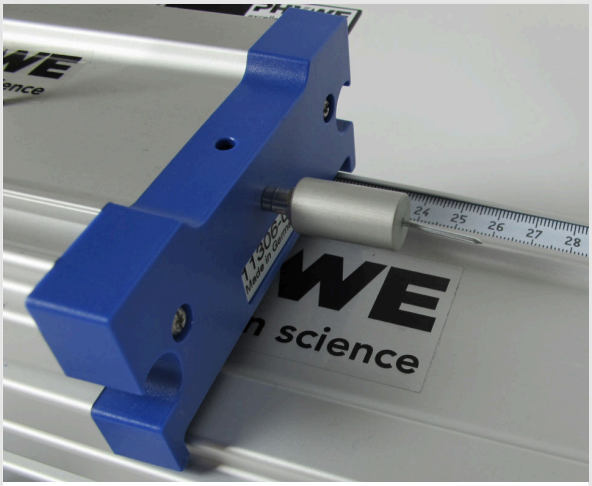

Front of the measuring carriage

4. The measuring carriage is equipped with the holding magnet with plug, a needle with plug as well as the cover for measuring carriage (b = 100 mm).

5. The mass of the trolley can be varied by means of the weights.

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Set-up (4/6)

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Mounting of the light barriers

6. The four forked light barriers are mounted on the roadway with the light barrier holders.

The distances are freely selectable, but they should be distributed over the entire roadway.

Set-up (5/6)

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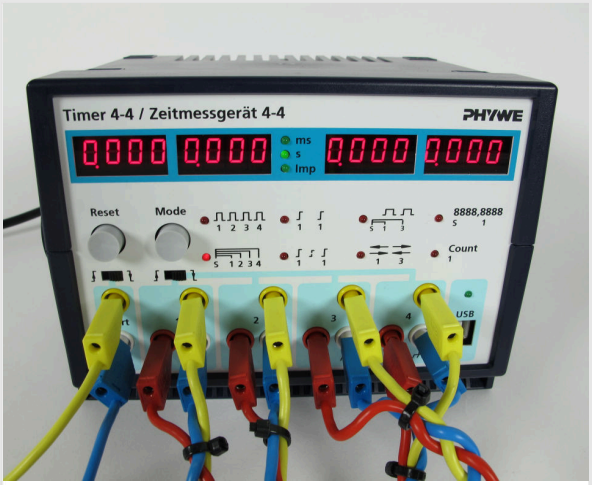

Connecting the light barriers and the starting device

7. The four forked light barriers are connected in sequence from left to right to the sockets in fields "1" to "4" of the timing device as shown in Fig. 6.

The yellow sockets of the light barriers are connected to the yellow sockets of the measuring device, the red sockets to the red sockets and the blue sockets of the light barriers to the white sockets of the time measuring device.

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Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
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Set-up (6/6)

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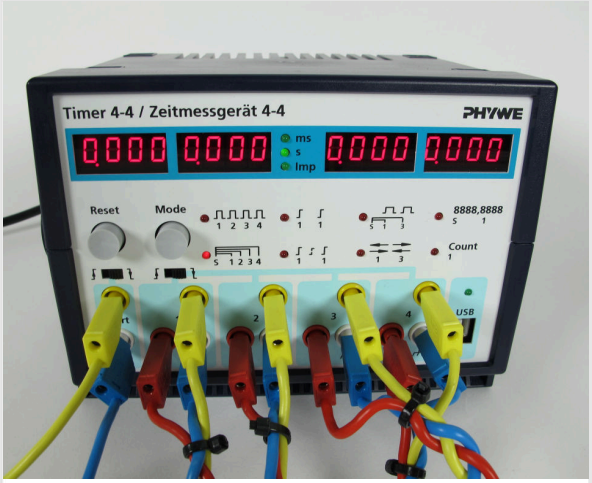

Checking the settings

8. The starting device must be connected to the two "Start" connection sockets of the timing device.

Make sure that the polarity is correct.

The red socket of the starting device is connected to the yellow socket of the timing device.

9. The two slide switches on the timing device are set to the right-hand position "falling edge" ( ) to select the trigger edge.

Procedure (1/3)

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1. The distances $s_1 \ldots s_4$ of the light barriers to the start position of the trolley are measured.

It should be noted that the light barriers are only interrupted by the front edge of the panel mounted on the trolley.

For an exact determination of the distances, the following procedure can be followed:

- Put the car in starting position and set the value x_0 on the measuring tape at the right end of the trolley.
- Move the carriage to a position where the right end of the diaphragm just interrupts the light beam of the forked photoelectric sensor i and the value x_i on the tape measure at the right end of the car.
- $s_i = x_i - x_0$ is the distance the car has travelled from the start to the corresponding light barrier.

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Robert-Bosch-Breite 10
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info@phywe.de
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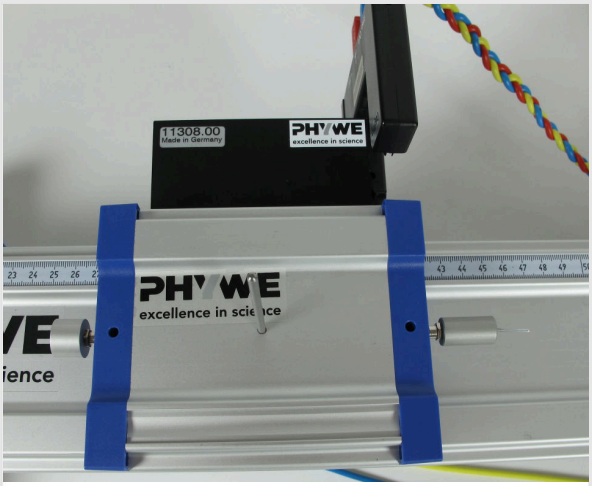
Procedure (2/3)



Interruption of the light barrier

2. The measuring trolley receives a force impulse from the starter and moves at a constant speed.

3. These are the times $t_1 \ldots t_4$ which are used to cover the distances $s_1 \ldots s_4$ from the start position to the respective light barrier must be determined in mode 2 (S 1 2 3 4).

Procedure (3/3)

4. The measuring times are recorded for up to five repetitions. Before each execution, press the "Reset" button to reset the displays.

5. In order to obtain a larger number of measuring points, it is now possible to reposition the light barriers and carry out another series of measurements as described above.

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
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Evaluation (1/2)

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Observation

The trolley passes through the light barriers unbraked and reaches the end holder with the same speed as it had at the start. It can be observed that the differences of the running times t_i are proportional to the distances s_1 of the light barriers.

Evaluation (2/2)

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1. From the five measurements each of $t_1 \dots t_4$ determine the mean values $t_{1m} \dots t_{4m}$.
2. For each route over $v_m(t) = s(t)/t_m$ the average speed is determined and entered in a table (see Table 1). It can be seen that the average speeds are constant for any driving distances within the measurement accuracy.

Table 1

s in m	$t_{i,1}$ in s	$t_{i,2}$ in s	$t_{i,3}$ in s	$t_{i,4}$ in s	$t_{i,5}$ in s	t_m in s	v_m in m/s
0,228	0,549	0,543	0,569	0,551	0,561	0,555	0,41
0,528	1,323	1,308	1,37	1,328	1,358	1,337	0,39
0,828	2,101	2,079	2,177	2,11	2,169	2,127	0,39
1,128	2,893	2,863	2,863	3	2,908	3,004	0,38

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Notes

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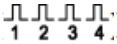
The experiment can be performed faster by determining the time required for the shutter to pass the respective light barrier instead of the travel time of the car.

To do this, operate the timing device in mode 1 (

).

A comparison of the measurement times shows that the car always takes the same time to pass, regardless of the position of the light barriers, i.e. it moves at a constant speed.

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Robert-Bosch-Breite 10
37079 Göttingen

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Fax: 0551 604 - 107

info@phywe.de
www.phywe.de