Uniform linear motion with the demonstration track and timer 4 – 4 (Item No.: P1198505)

Curricular Relevance

Area of Expertise: Physik

Education Level: Klasse 7-10

Topic: Mechanik

Subtopic: Lineare Bewegung

Experiment:

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	20 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Constant velocity, frictionless motion, distance-time law

Overview

Introduction

A cart is repeatedly accelerated to a constant velocity by way of a mechanical starter system. The runtime of the cart is determined at various intervals. These values are then used to determine the average velocity.

Educational objective

If an object performs a uniform motion, the distance that is covered increases linearly over time. In accordance with the distance-time law, the velocity of the object is constant:

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

Related topics

Experiment P1199105 "Law of inertia (Newton's first law)" shows that an object with a constant velocity maintains a uniform linear motion unless an external force acts upon it.

Student's Sheet

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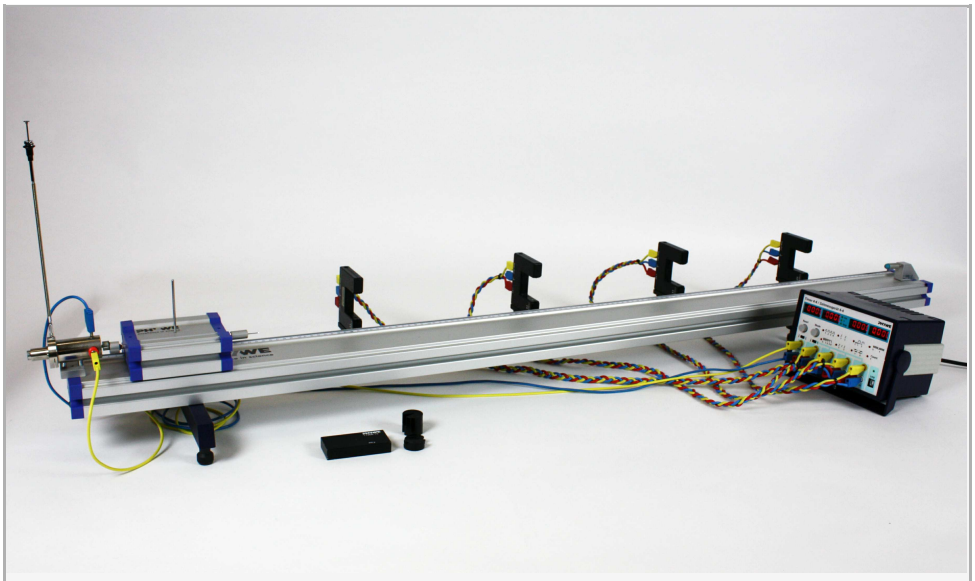

Figure 1: Experiment set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Timer 4-4	13604-99	1
2	Starter system for demonstration track	11309-00	1
3	Demonstration track, aluminium, 1.5 m	11305-00	1
4	Cart, low friction sapphire bearings	11306-00	1
5	Light barrier, compact	11207-20	4
6	End holder for demonstration track	11305-12	1
7	Magnet w.plug f.starter system	11202-14	1
8	Shutter plate for low friction cart, width: 100 mm	11308-00	1
9	Needle with plug	11202-06	1
10	Tube with plug	11202-05	1
11	Holder for light barrier	11307-00	4
12	Connecting cord, 32 A, 1000 mm, yellow	07363-02	5
13	Connecting cord, 32 A, 1000 mm, red	07363-01	4
14	Connecting cord, 32 A, 1000 mm, blue	07363-04	5
15	Plasticine, 10 sticks	03935-03	1
Option:			
	Weight (400 g) for the low-friction cart	11306-10	1
	Slotted weight, black, 10 g	02205-01	4
	Slotted weight, black, 50 g	02206-01	2

Tasks

1. Determination of the distance-time relationship based on several measured time values at different distances covered by the cart.
2. Determination and comparison of the average velocities.

Set- up and procedure

Set-up

Set the experiment up as shown in Figure 1:

1. In order to compensate for slight friction effects, the track must be slightly inclined by way of the adjusting screws at the track bases so that the cart is still just about prevented from rolling to the right.
2. Position the starter system at the left end of the track. Please note that, in order to start the cart with an initial momentum, the starter system must be installed so that the cart receives an impulse from the ram of the starter system (Fig. 2).

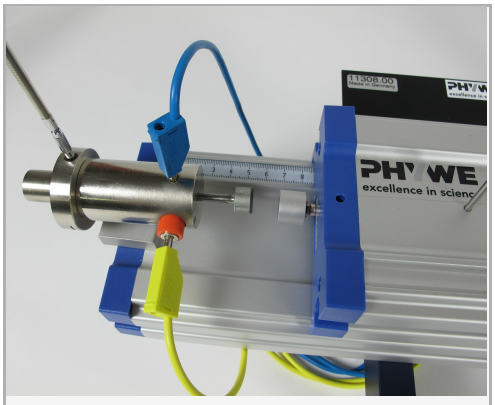

Fig. 2: Starter system for providing the necessary impulse

3. Attach a plasticine-filled tube to the end holder at the right-hand end of the track in order to stop the cart without a strong impact (Fig. 3).

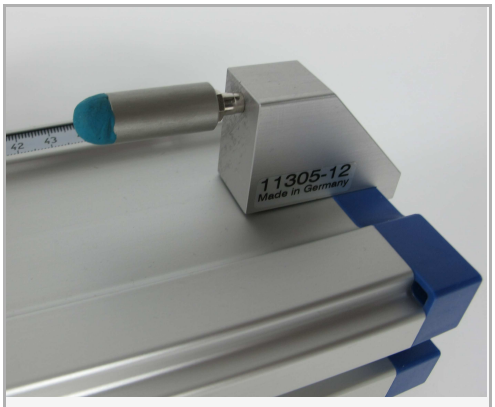

Fig. 3: End holder with plasticine

4. Equip the cart with the magnet with a plug, a needle with a plug, and the shutter plate (w = 100 mm) (see Figs. 2 and 4).

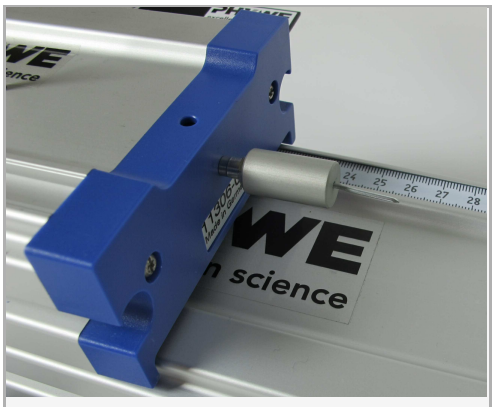

Fig. 4: Front of the cart

5. The mass of the cart can be varied by way of the weights.

6. Install the four light barriers on the track by way of the light barrier holders (Fig. 5). The intervals between the light barriers can be selected freely. However, the light barriers should be distributed over the entire track.

Fig. 5: Installation of the light barriers on the demonstration track

7. Connect the four light barriers from the left to the right to the sockets in the fields "1" to "4" of the timer as shown in Fig. 6. In doing so, connect the yellow sockets of the light barriers to the yellow sockets of the measuring instrument, the red sockets to their red counterparts, and the blue sockets of the light barriers to the white sockets of the timer.

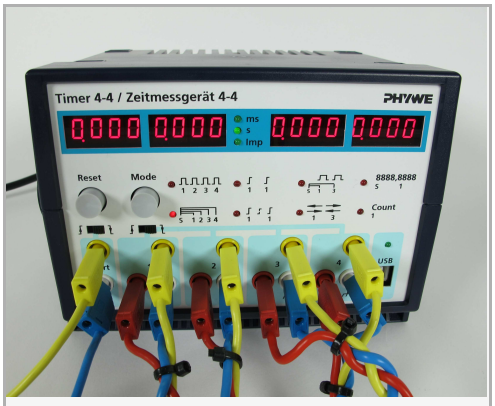

Fig. 6: Connection of the light barriers and starter system

8. Connect the starter system to the two "Start" sockets of the timer. Ensure that the polarity is correct. Connect the red socket of the starter system to the yellow socket of the timer.
9. In order to select the triggering edge, push the two slide switches of the timer to the right, i.e. to "falling edge" ( )

Procedure

1. Measure the distances $s_1 \ldots s_4$ of the light barriers with regard to the start position of the cart. In doing so, it must be taken into consideration that the light barriers will be interrupted by the front edge of the shutter plate that is installed on the cart, and not by the cart itself. The exact determination of the distances can be performed as follows:
   - Bring the cart to the start position and read the value (x_0) off the tape measure at the right-hand side end of the cart.
   - Move the cart to a position where the right-hand side end of the shutter plate just about interrupts the light beam of the light barrier i and then read the value (x_i) off the tape measure at the right-hand side end of the cart (see Fig. 7).

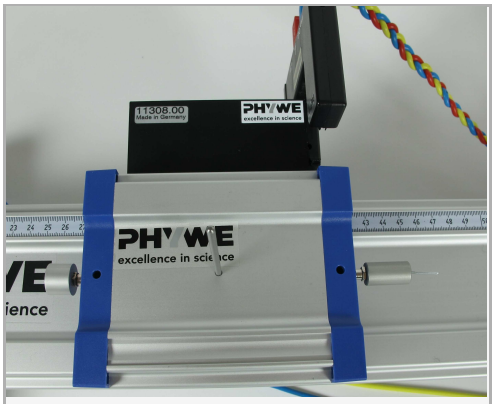

Fig. 7: Interruption of a light barrier by the shutter plate

   - $s_i = x_i - x_0$ is the distance that the cart has covered from the start up to the corresponding light barrier.
2. The cart receives an impulse from the starter system and moves at constant velocity.
3. Determine the times $t_1 \ldots t_4$ for covering the distances $s_1 \ldots s_4$ from the start position up to the respective light barrier in mode 2 (s 1 2 3 4).
4. Record the times for up to five repetitions. Prior to every recording process, press the "Reset" button in order to reset the display.
5. In order to increase the number of measuring points, the light barriers can be repositioned and another series of measurements can be performed as described hereinabove.

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Observation and results

Observation

Observation

The cart passes through the light barriers in an unbraked manner and it reaches the end holder with the same velocity as the one it had when it was started. It can be observed that the runtime differences t_i are proportional to the distances s_i of the light barriers.

Evaluation

Evaluation

1. Determine the mean values $t_{1m} \ldots t_{4m}$ based on the five measurements of $t_1 \ldots t_4$.
2. Determine the average velocity for every distance by way of $v_m(t) = s(t)/t_m$ and enter these values into a table (see Table 1). It becomes clear that the average velocities for any random distance are constant within the scope of the measuring accuracy.

Table 1: Measurement example: mass of the cart mc = 900 g

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	1.370	1.328	1.358	1.337	0.39
0.828	2.101	2.079	2.177	2.110	2.169	2.127	0.39
1.128	2.893	2.863	2.863	3.000	2.908	3.004	0.38

Note

Note

The experiment can be performed more quickly if the time that is needed by the shutter plate for passing through the light barriers is used instead of the runtime of the cart. In this case, the timer must be set to mode 1 (). A comparison of the measured times shows that the cart always needs the same time for passing through the light barriers regardless of the position of the light barriers, i.e. that it moves at constant velocity.