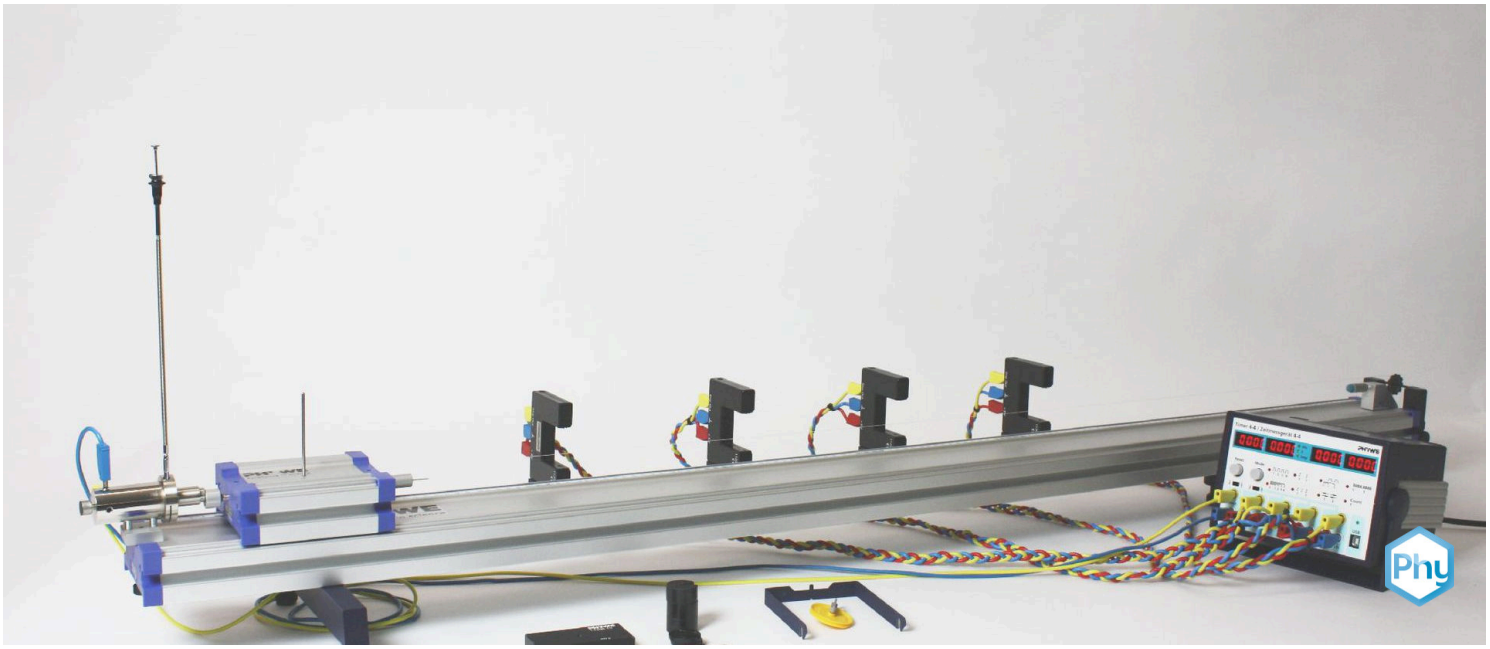
The law of inertia (1st Newton's law) with the roller track and timing device 4-4



Physics > Mechanics > Energy conservation & impulse

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

This content can also be found online at:

http://localhost:1337/c/60046b31f3052e0003c4a497

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General information

Application

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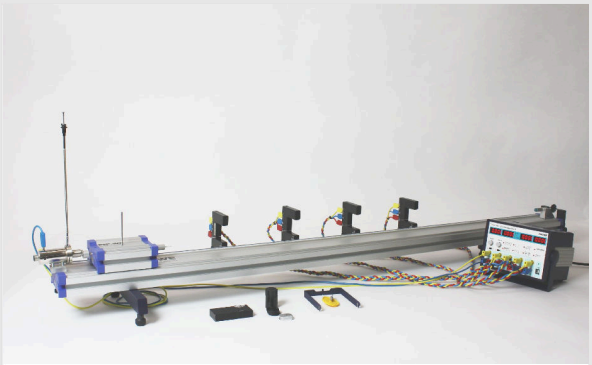

Experiment set-up

If no external force acts on a body after acceleration, it remains in a state of uniform motion. Here it is to be shown on the roller track by measuring the speed of a uniformly accelerated car that its speed remains constant after the acceleration process has ended.

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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 Newton's axioms and the classical equations of motion.

Scientific principle

The statements of Newton's first axiom are derived from observations of the motion behavior of bodies.

Other information (2/2)

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Learning objective

An accelerated body maintains a rectilinear uniform motion when no force is applied to it.

Tasks

Determination of the velocity from the shadowing time measurement of the light barriers at different positions after different acceleration distances.

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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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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	Weight for low friction cart, 400 g	11306-10	1
5	Slotted weight, black, 10 g	02205-01	4
6	Slotted weight, black, 50 g	02206-01	2
7	Slotted weight, blank, 1 g	03916-00	20
8	Weight holder, silver bronze, 1 g	02407-00	1
9	Needle with plug	11202-06	1
10	Tube with plug	11202-05	1
11	Plasticine, 10 sticks	03935-03	1
12	Silk thread, l = 200 m	02412-00	1
13	Magnet w.plug f.starter system	11202-14	1
14	Starter system for demonstration track	11309-00	1
15	Holder for light barrier	11307-00	4
16	Light barrier, compact	11207-20	4
17	End holder for demonstration track	11305-12	1
18	Pulley for demonstration track	11305-10	1
19	Holder for pulley	11305-11	1
20	PHYWE Timer 4-4	13604-99	1
21	Connecting cord, 32 A, 1000 mm, red	07363-01	4
22	Connecting cord, 32 A, 1000 mm, yellow	07363-02	4
23	Connecting cord, 32 A, 1000 mm, blue	07363-04	4

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Theory

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Newton's 1st law states that a force-free body at rest remains in a state of rest, and moving bodies remain in exactly that motion.

If a body is accelerated by a force and the accelerating force no longer acts, the body will continue to move uniformly and in a straight line (with the current direction and speed) in this force-free state.

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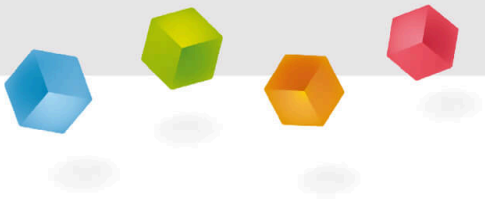

Set-up and Procedure

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Set-up (1/6)

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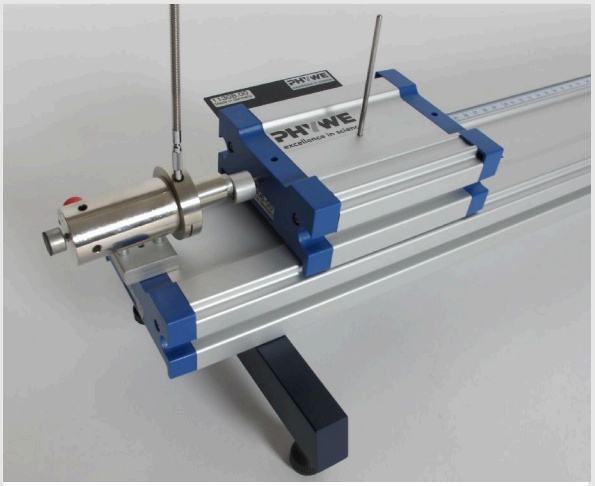

Launching device without shock

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 pulse, the starting device must be mounted so that the punch moves away from the measuring trolley when triggered.

Set-up (2/6)

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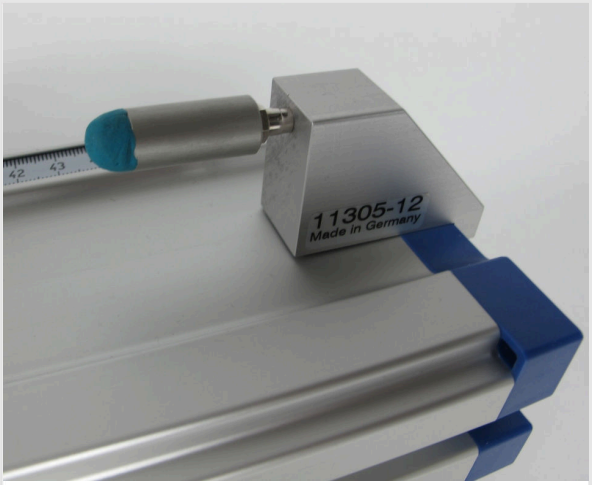

End bracket with plasticine

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.

4. The deflection roller is attached to the right end of the track with the holder for deflection roller and the incremental wheel is inserted.

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Set-up (3/6)

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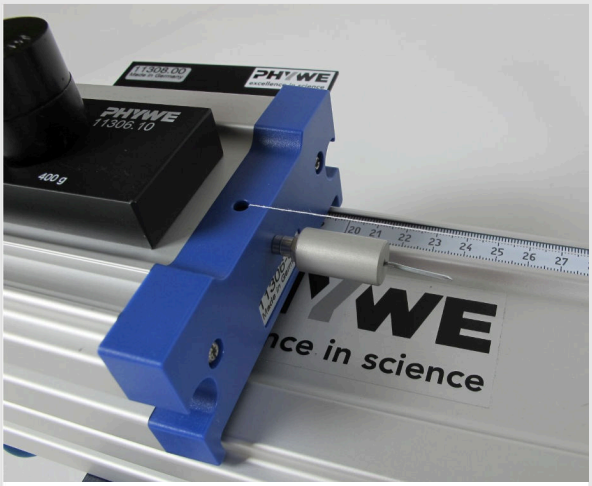

Fastening the thread to the trolley

5. The measuring trolley is equipped with the holding magnet with the plug as well as the cover for measuring trolley (b = 100 mm).

6. The beginning of the thread is inserted from above into the vertical hole of the carriage end cap and fixed by inserting the needle with plug from the front.

Set-up (4/6)

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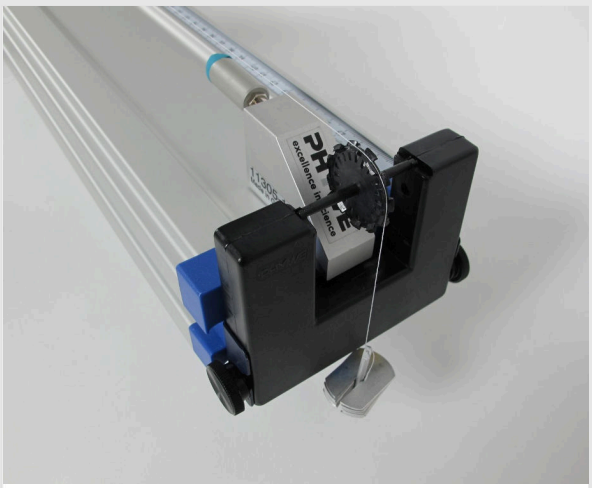

Positioning of the weight plate

7. The thread is placed over the incremental wheel of the deflection pulley and knotted at the end to the weight plate so that it hangs freely directly below the wheel, as shown in the illustration. The weight plate together with the 5-20 slotted weights (1g each) lying on it serve as a constant accelerating force. The thread must run parallel to the track.

8. The mass of the car can be varied by means of the black painted weights.

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Set-up (5/6)

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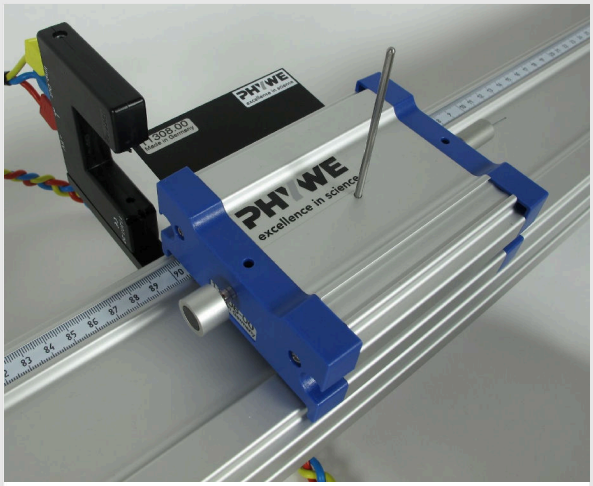

Release of the light barrier after trolley passage

9. The weight plate should come to rest at different heights during the experiment before it touches the ground, so that the acceleration distance is shortened.

To do this, have some random objects from your environment ready to place on the floor under the weight plate.

10. The four forked photoelectric sensors are mounted on the roadway with the photoelectric sensor holders and distributed evenly over the measurement section.

Make sure that all light barriers can be passed through by the rear part of the aperture when rolling the carriage.

Set-up (6/6)

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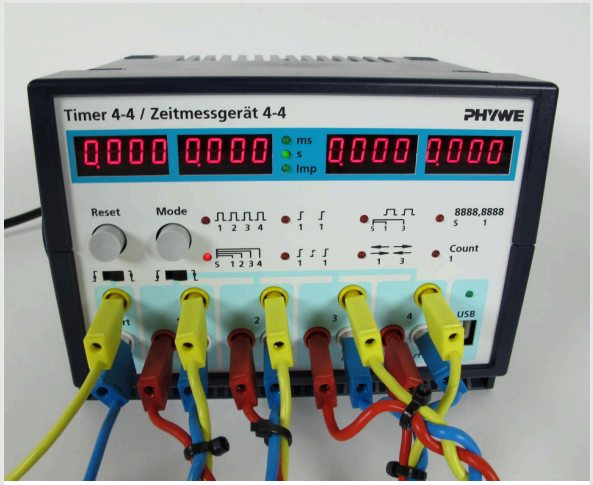

Connecting the light barriers and the starting device

11. The forked light barriers are connected from left to right in sequence to the sockets in fields "1" to "4" of the timing device.

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.

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

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Procedure (1/3)

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1. The trolley should be accelerated by the weight and then perform a uniform movement, which is detected by the forked photoelectric sensors. Place an object under the weight plate so that it is caught as soon as the measuring carriage is immediately before entering the light path of the first light barrier.

The acceleration track Δs corresponds to the distance that the carriage travels from the start until the weight plate touches down. If necessary, vary the position of the light barrier.

2. The measuring carriage is released by the starter and experiences a constant acceleration until the weight plate touches the table. It then continues to roll at a constant speed.

Procedure (2/3)

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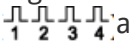
3. To determine the instantaneous speeds of the wagon when passing through the respective light barriers, a measurement of the shadowing times $\Delta t_1 \ldots \Delta t_4$ in operating mode 1 () are to be made.

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

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Procedure (3/3)

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5. The acceleration distance is now varied by changing the catch height of the weight plate by another object placed underneath.

As described above, the position of the first light barrier is also adjusted and, if necessary, that of the following light barriers in the case of longer acceleration distances. A second series of measurements is then recorded.

This step can be repeated for further acceleration distances.

Evaluation (1/4)

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Observation

For increasing acceleration distances Δs, the shading times Δt_i become smaller and smaller due to the longer acceleration of the car.

After the weight plate has been placed on the carriage, the carriage continues to travel at a constant speed, as all shading times Δt_i are approximately equal.

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Evaluation (2/4)

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Measurement example

Δs in m	Δt_1 in s	Δt_2 in s	Δt_3 in s	Δt_4 in s
0,555	0,229	0,231	0,233	0,232
0,555	0,231	0,234	0,237	0,238
0,555	0,233	0,235	0,238	0,24
0,555	0,233	0,236	0,239	0,24
0,555	0,232	0,235	0,237	0,238
0,425	0,261	0,266	0,274	0,288
0,425	0,261	0,264	0,267	0,267
0,425	0,264	0,27	0,273	0,276
0,425	0,262	0,266	0,271	0,273
0,425	0,265	0,269	0,272	0,272
0,2	0,395	0,404	0,415	0,426
0,2	0,395	0,403	0,413	0,421
0,2	0,4	0,416	0,435	0,457
0,2	0,399	0,415	0,433	0,452
0,2	0,398	0,413	0,432	0,454

Evaluation (3/4)

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Mean values of the measurement example

Δs in m	Δt_{1m} in s	v_{1m} in m/s	Δt_{2m} in s	v_{2m} in m/s	Δt_{3m} in s	v_{3m} in m/s	Δt_{4m} in s	v_{4m} in m/s
0,555	0,232	**0,432**	0,234	**0,427**	0,237	**0,422**	0,238	**0,421**
0,425	0,263	**0,381**	0,267	**0,375**	0,271	**0,368**	0,275	**0,363**
0,2	0,397	**0,252**	0,41	**0,244**	0,426	**0,235**	0,442	**0,226**

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Evaluation (4/4)

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1. For each acceleration distance, calculate the averages $\Delta t_{1m} \ldots \Delta t_{4m}$ from the five measurements sets $\Delta t_1 \ldots \Delta t_4$.

2. From the mean values of the shading times, the mean velocities $v_{im} = b/t_{im}$ can be determined with the aperture length b= 0.1 m.

3. The previous tables indicate a measurement example. If the velocities at each light barrier are compared, it can be seen that, within the limits of measurement accuracy, the carriage retains the velocity it has reached after the acceleration process has ended. To change the state of motion of a body, a force must act on it. If no external force acts on it, it remains in a state of rest or rectilinear uniform motion.

Notes

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Table to catch

1. A height-adjustable table such as the one in Fig. 8 is particularly suitable for catching the weight plate. If you use the optional items listed in the material list, place the long stand rod in the tripod base and attach the table to the short stand rod it, using the two double sockets.

2. This test can be performed with different cars and accelerating masses.

3. To reduce the distance between the weight adjuster and the incremental wheel, the thread length can be shortened by turning the needle with plug several times on the carriage, thus winding up the thread.

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