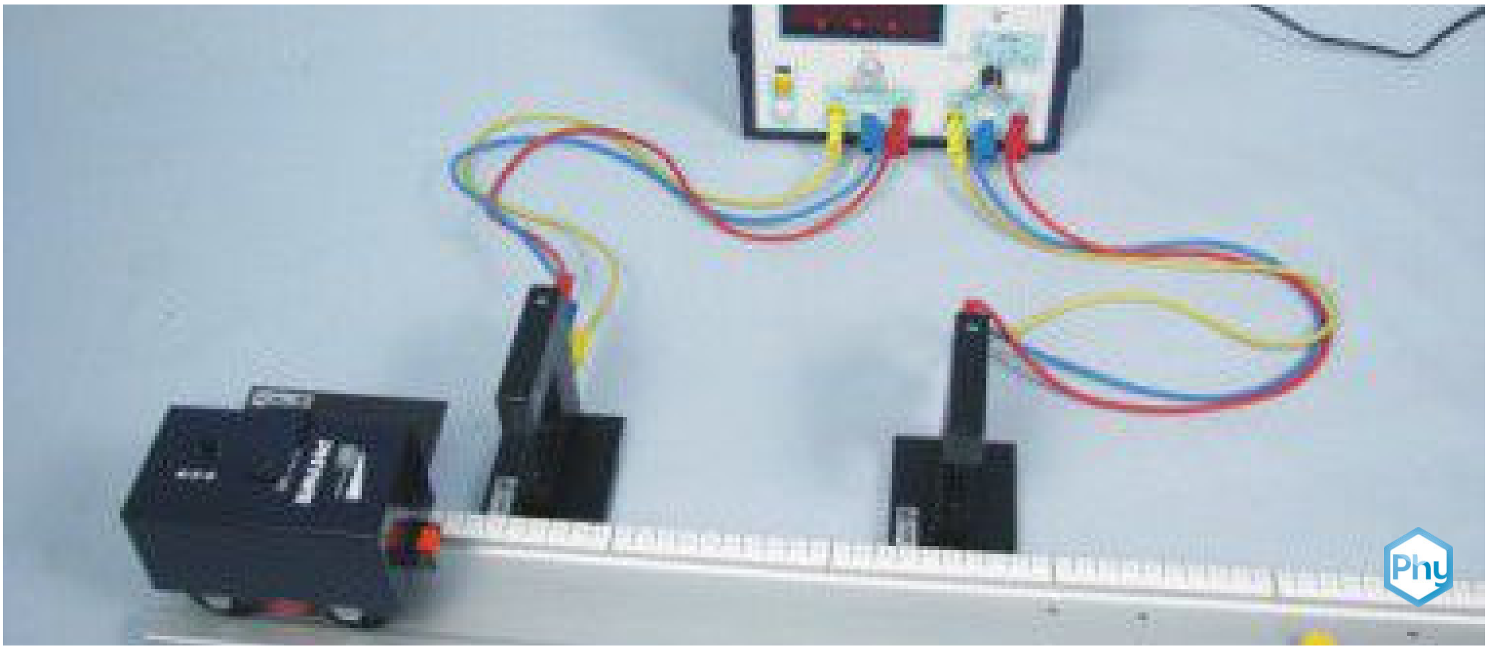
# Laws of uniform linear motion with the 2-1 timer



Physics | Mechanics | Dynamics & Motion

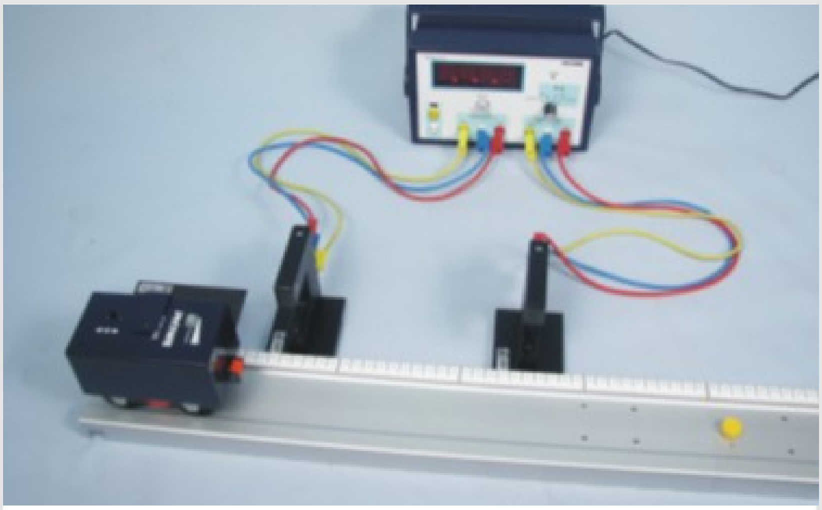
| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| hard | 2 | 10 minutes | 20 minutes |

This content can also be found online at:

http://localhost:1337/c/5fdbb8665098f00003f1ede6

# Teacher information

## Application



Experiment set-up

Uniform rectilinear movement tends to have little everyday relevance and is therefore encountered rather rarely as a rule, since we are normally exposed to constantly acting forces and thus accelerations.

Movements that are very nearly uniformly rectilinear in reality are trains traveling at constant speed on a straight line, or airliners when they have reached their cruising speed.



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## Other teacher information (1/2)

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**Prior knowledge**

Students should be able to distinguish between instantaneous and average speed and calculate these from a given distance and known time.

**Scientific principle**

The car with drive travels over the roadway at a constant speed within a series of measurements. Accordingly, the same instantaneous and average speeds are always calculated from the measured values.

## Other teacher information (2/2)

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**Learning objective**

In this experiment, the students should become more familiar with the laws of motion of uniform rectilinear motion. In particular, the students should become more confident in using diagrams to represent the laws.

**Tasks**

The students drive the car along the road first at the lowest speed and then at medium speed. The time taken by the car to cover the distance is measured. The distance between the light barriers is varied. For each distance, the students determine the respective average or instantaneous speed depending on the location.



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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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Intercity Express on straight track

Uniform rectilinear motion tends to have little everyday relevance and is therefore something we generally encounter rather infrequently, since we are normally exposed to constantly acting forces and thus accelerations. The underlying principles, however, are just as universal as for accelerated movements, but easier to reproduce.

Movements that are very nearly uniformly rectilinear in reality are trains traveling at constant speed on a straight line, or airliners when they have reached their cruising speed.

In this experiment you will deal with the principle of uniform rectilinear motion.

## Tasks

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Drive the car first at lowest speed and then at medium speed drive over the roadway.

Measure the time that the car needs to cover different distances. Vary the distance between the light barriers. For each distance, the respective average or instantaneous speed is to be determined as a function of the location.



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Car, motor driven | 11061-00 | 1 |
| 2 | Shutter plate for car, motor driven | 11061-03 | 1 |
| 3 | PHYWE Timer 2-1 | 13607-99 | 1 |
| 4 | Light barrier, compact | 11207-20 | 2 |
| 5 | Adapter plate for Light barrier compact | 11207-22 | 2 |
| 6 | Connecting cord, 32 A, 1000 mm, red | 07363-01 | 2 |
| 7 | Connecting cord, 32 A, 1000 mm, yellow | 07363-02 | 2 |
| 8 | Connecting cord, 32 A, 1000 mm, blue | 07363-04 | 2 |
| 9 | Track, l 900 mm | 11606-00 | 1 |



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## Set-up (1/4)

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Attach the shut-off orifice to the car

Attach the shade screen to the car and place it at one end on the roadway.

The speed control knob should be in the lowest position (left stop).

## Set-up (2/4)

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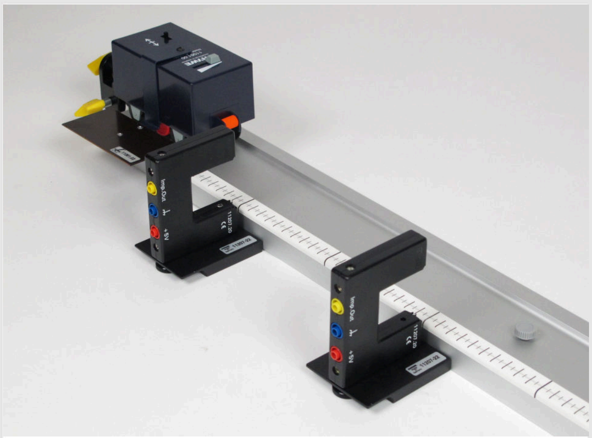

Attach forked light barriers to the adapter plates

Connect the forked light barriers to the adapter plates in such a way that the light barriers can be easily positioned along the road and the shadow shield of the car can pass through without bumping into them.



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## Set-up (3/4)

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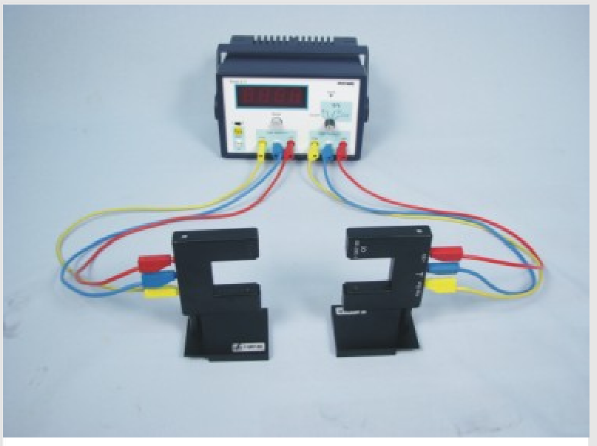

Connect the light barriers to the timing device

Connect both light barriers to the timing device.

Now set the slide switch above the field labeled "Start" on the timing device to the right position.

## Set-up (4/4)

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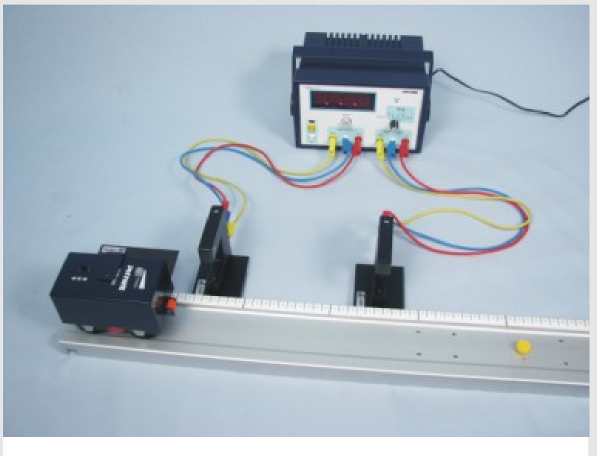

Positioning light barriers

Position the first light barrier at the 20 cm mark of the roadway and position the second light barrier at the 30 cm mark so that there is a distance of 10 cm between the two light barriers.

Set the rotary switch on the timing device to the third position from the left. The device then displays the time that elapsed between the interruption of the first and the second light barrier. In this experiment, this is the time it takes the trolley to travel the distance between the two light barriers. $\Delta s$ between the two light barriers. Press the "Reset"-button on the timing device before each measurement.



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## Procedure (1/3)

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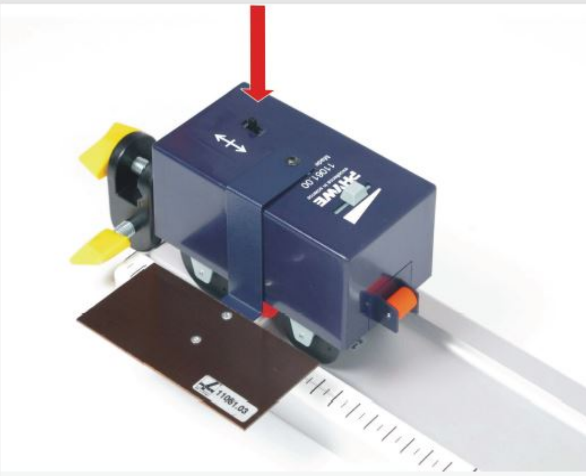

Starting the car

- Now start the car with the direction switch in the desired direction.
- Note the resulting measured value for the duration $\Delta t$ between both light barriers in the report in Table 1.
- Repeat the measurement for positions of the rear light barrier from $40\,cm,\ 50\,cm,\ 60\,cm,\ 70\,cm$(i.e. relative distances to the start light barrier of $\Delta s = 20\,cm,\ 30,cm,\ 40\,cm,\ 50\,cm$).
- The front light barrier remains at the 20 cm mark throughout the test.

## Procedure (2/3)

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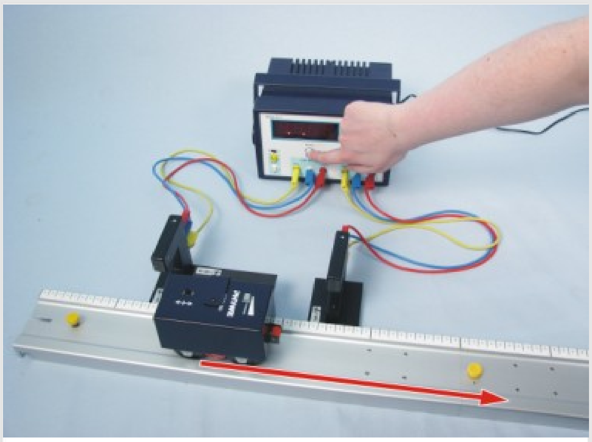

Adjusting the rotary switch

- Now set the rotary switch on timer 2-1 to the second position from the left. The device then displays the shading time. This is the time period in which the light barrier is interrupted by the shutter.
- Let the car run with unchanged speed setting, press the "Reset"-button each time before the car reaches the second light barrier and note the shadowing time $t$, the aperture with the width $b = 10\,cm$, to pass the second light barrier. Repeat the measurement for all previous positions of the rear light barrier. Note your measurements in Table 1.



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## Procedure (3/3)

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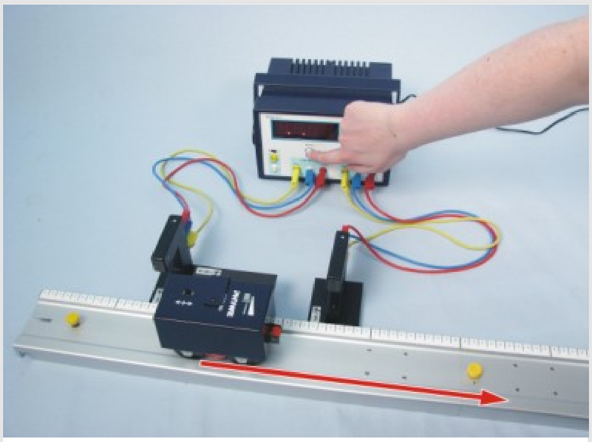

Adjusting the rotary switch

- Now set the speed control on the car to about the middle setting.
- Then repeat both series of measurements with the same distances or positions of the light barriers as before at the lowest speed.
- Record the resulting readings in Table 2 in the report.
- Note: Do not forget to select the necessary setting on timer 2-1.

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# Report



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## Table 1

Enter the measured values for the travel times $\Delta t$ and the shading times $t$ for the respective routes $\Delta s$ for the lowest speed 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 $b = 10\,cm$.

| $Distance\ \Delta s\ [cm]$ | $\Delta t\,[s]$ | $v_d\,[cm/s]$ | $t\,[s]$ | $v_m\,[cm/s]$ |
|---|---|---|---|---|
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |
| 50 | | | | |


## Table 1

Enter the measured values for the travel times $\Delta t$ and the shading times $t$ for the respective routes $\Delta s$ for the lowest speed 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 $b = 10\,cm$.

| $Distance\ \Delta s\ [cm]$ | $\Delta t\,[s]$ | $v_d\,[cm/s]$ | $t\,[s]$ | $v_m\,[cm/s]$ |
|---|---|---|---|---|
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |
| 50 | | | | |




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## Table 2

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Enter the measured values for the travel times $\Delta t$ and the shading times $t$ for the respective routes $\Delta s$ for the lowest speed 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 $b = 10\,cm$.

| $Distance\ \Delta s\ [cm]$ | $\Delta t\,[s]$ | $v_d\,[cm/s]$ | $t\,[s]$ | $v_m\,[cm/s]$ |
|---|---|---|---|---|
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |
| 50 | | | | |

## Task 1

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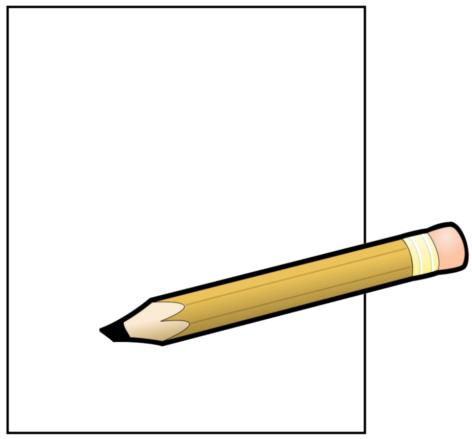
Now take a sheet of paper and create a diagram on it. In this diagram, you represent the distance traveled $\Delta s$ and the instantaneous speed $v_m$ ($y$-axis) as a function of the maturities $\Delta t$ ($x$axis) for both speed settings.





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## Task 2

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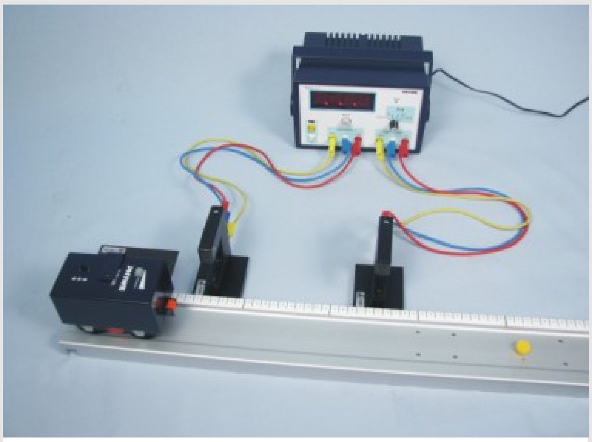

Experiment set-up

Which curve shapes result for the $s/t$- d and $v/t$-diagram?

$s/t$-Diagram: ______ function.

$v/t$-Diagram: ______ function.

linear constant

Check

## Task 3

PHYWE

Look at the path-time diagram and mark the correct statements!

- [ ] The flatter the line, the faster the car.
- [ ] The steeper the line, the faster the car.
- [ ] The slope reflects the speed of the measuring carriage.
- [ ] The gradient reflects the acceleration of the measuring carriage.

Check



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# Task 4

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Mark the correct statements!

- ☐ Since the velocity curves in the velocity-time diagram have a slope of zero, it is a uniform motion.
- ☐ The instantaneous speeds are very different from the average speeds.
- ☐ The average speeds agree well with the instantaneous speeds.
- ☐ The flatter the course in the path-time diagram, the higher the course of the speed.
- ☐ The slight kinks in the velocity-time diagram are due to measurement errors.

Check



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