CONSERVATION OF MOMENTUM AND ENERGY IN CASE OF DIFFERENT MASSES

MED 08.07

Material

Item-no.	Qty.	Description
DS101-3B	1	Stand rail with scale, L=1000 mm
DM300-2A	2	Dynamics trolley, demo, 50 g
P1312-2A	2	Car body for trolley SE
P1120-2F	2	Slotted weight 50 g, SE
P1311-2D	1	Spring bumper
P3120-2Z	1	Universal timer "inno"
P3120-5B	1	S-shaped assembly platform
P1320-4A	2	Light gate "demo" 04
P1321-3K	2	Block for light gates
DS103-1H	1	Holder for guide rail
DM362-1E	1	Baffle block
DM344-1S	1	Projectile launcher 02

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Purpose
To bring the experimental evidence of the conservation of momentum and energy conservation at different masses.

Preparation
Position the two blocks for light gates at a distance of 90 cm on the table and place the light gates in between the blocks as shown on the image to the left.
Now place the stand rail on the blocks for light gate.

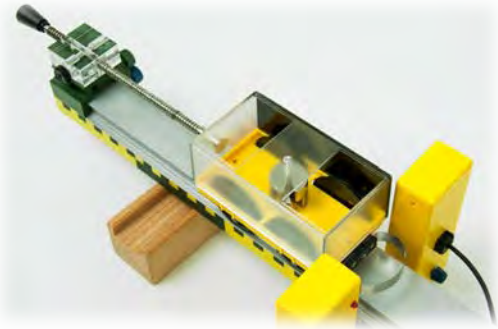
Mount the projectile launcher on the left end of the stand rail.
Afterwards mount the holder for guide rail on the right end of the stand rail and fix the baffle block on the holder.

Two 50g weights are attached the vertical axis of the left dynamics trolley.

Place the car bodies on the dynamics trolleys; make sure that the small rod of the trolley points through the hole of the car body.

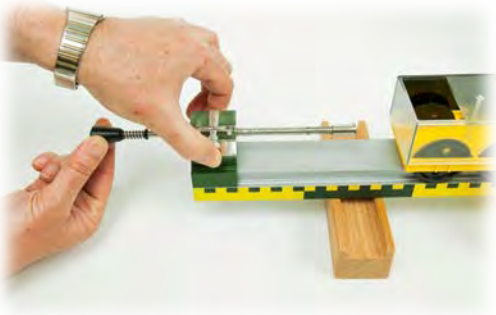
Attach the spring bumper to the left trolley.

Initially the launching piston of the projectile launcher is fully extended; place the dynamics trolley at the end of the launching piston.



Position the left light gate so that the diodes of it are just in front of the dynamics trolley (approximately at the 32 cm mark).

The right light gate is placed at the 70 cm mark.



Push the launching button of the projectile launcher in and pull up the launching piston, fix the piston at the 4th notch.

Place the universal timer on the S-shaped assembly platform.

Connect the light gate with the “L1”-socket of the universal timer and set the switch on the universal timer to “L1 Gate”; afterwards turn the timer on.

Move your finger through the light gate to check if it is working properly.
When passing through with the finger the red LED has to flash up – this time of darkening is measured by the timer. In case that this is not working properly the luminosity has to be adjusted (check at the end of this experiment how this can be done).

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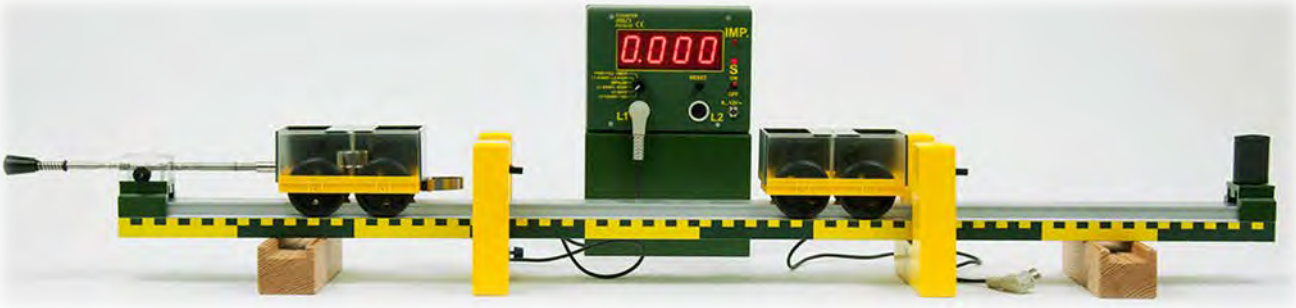
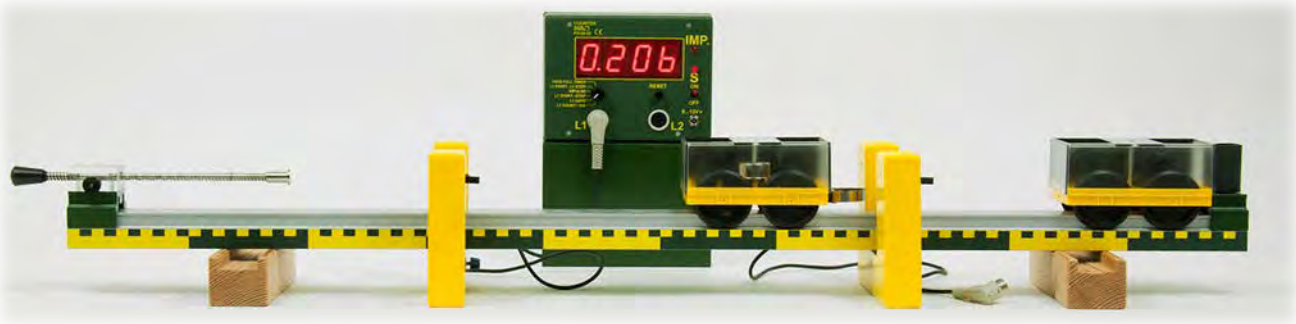
Experiment 1 - A



Push the „Reset“-button on the timer; afterwards push the dynamics trolley completely against the launching piston. By pressing the launching button the dynamics trolley gets pushed away.

The universal timer measures the "darkening time" - the time in which the trolley moves through the laser barrier of the light gate.



Based on the length of the dynamics trolley (125 mm) and the darkening time the current speed of the dynamics trolley can be calculated:

0.125 m / ..... s = ... m/s

The left trolley (the pushing trolley) has a mass of 200g;
The right trolley (the pushed trolley) has a mass of approx. 100 g.

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Experiment 1 - B
Again the launching piston is pulled up and fixed at the 4th notch as before; the dynamics trolleys are placed in their original position again.

Instead of the left light gate connect the right light gate now to the “L1”-socket of the timer.

Push the „Reset“-button on the timer again.
Push the dynamics trolley completely against the launching piston. By pressing the launching button the dynamics trolley gets pushed away.

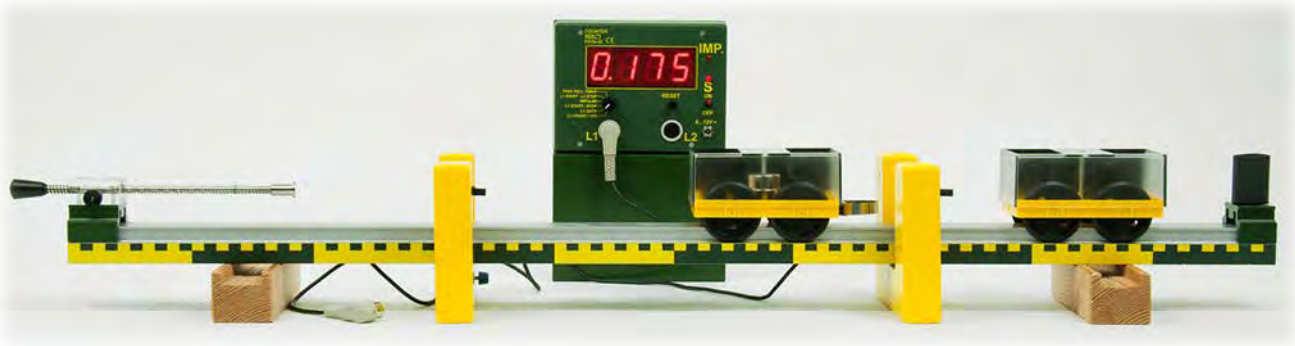
Now the universal timer measures the "darkening time" at the right light gate.

As before the current speed of the dynamics trolley is calculated again:

0.125 m / ..... s = ... m/s

Result
The speed of the right (lighter) trolley is higher.

Experiment 2



By changing the two trolleys we change the relation of the weight in comparison to the 1st experiment; the spring bumper has to be changed too.

How do the instantaneous speeds relate to each other?

Adjusting the sensitivity of the light gate
Turn the regulator clockwise until it does not go any further; the LED must light up now.
Afterwards the regulator is slowly turned counter-clockwise until the LED no longer lights up.
The sensitivity is at the highest in this setting.
The adjustment must be carried out especially when experimenting with very high or very low room brightness.

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Quantitative evaluations
The trolleys form a closed system, thus the principle of energy and linear momentum applies.

The following equations for the speeds can be derived:

$$v_1' = \frac{v_1\,(m_1 - m_2) + 2m_2 \times v_2}{m_1 + m_2}$$

$$v_2' = \frac{v_2\,(m_2 - m_1) + 2m_1 \times v_1}{m_1 + m_2}$$

The following applies for the 1st experiment: $m_2 = 0{,}5\,m_1$ und $v_2 = 0$

Thus we receive for $m_2 = 2m_1$ and $v_2 = 0$: $v_1' = -1/3\ v_1$ and $v_2' = 2/3v_1$

The total momentum before was $m_1 \,.\, v_1 + 2m_1.0$ and is afterwards $2m_1.\ 2/3v_1 - m_1.1/3v_1$; means that it is equal.

Note
At quantitative evaluations the friction and the energy losses at the impact have to be considered in the calculation.

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