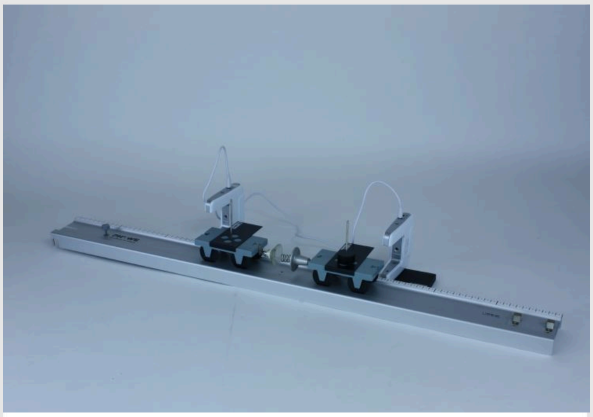
Impulse with Cobra SMARTsense

Physics | Mechanics | Dynamics & Motion

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

Teacher information

Application



Experiment set-up

The momentum is a fundamental quantity in physics and the conservation of momentum is one of the most important conservation laws. It states that the total momentum of a mechanically closed system is constant and that the change in total momentum is always zero. Mechanically closed means that the system is not in interaction with its environment. The total impulse p of a system consisting of two bodies is composed of the sum of the individual impulses:

$$p = m_1 \cdot v_1 + m_2 \cdot v_2 = const. \quad \Rightarrow \quad \dot{p} = 0$$

We find a vivid application of the conservation of momentum theorem for example in billiards.

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Other teacher information (1/2)

Prior knowledge

Students should be familiar with the concepts of speed and motion. Students should be confident in using equations and should be able to work with them independently.

Scientific principle

Before the start, both cars are at rest and the individual impulses of the cars and the total impulse of the car system are zero. The potential energy stored in the explosion device sets the cars in motion at the start. However, according to the pulse conservation law, the sum of the individual pulses remains zero even after the start.

Other teacher information (2/2)

Learning objective

In this experiment, the students should be introduced to the quantity momentum as a fundamental conservation variable and gain a first impression of the usefulness of the conservation variable for calculations. It should also be indicated that the momentum, like the velocity, has a direction (vectorial quantity).

Tasks

1. The students connect two resting cars of the same mass to each other using the starting device, so that the cars start suddenly. Both cars drive through a light barrier, which measures the respective shadowing times, from which the speed is then calculated.
2. The measurements are repeated if the total mass of the cars changes: First, both masses are increased equally and then decreased individually.

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Safety instructions

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

Further notes

To prevent the cars from skidding, it can be useful to shift the centre of gravity of the carriages more towards the middle by means of a counterweight: a 4 mm socket (11060-11) is fitted to each end of the carriage facing away from the explosion starter. A tube with plug (11202-05) is then inserted into each of these sockets. Both cars are thus extended by $12\ g$ heavier.

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Motivation

Billiard balls

When playing billiards, you hit a ball so that it hits another ball with a lot of momentum to put it in the pockets. The swing of the ball is physically called impulse and depends on the mass of the moving body as well as on its speed.

When two billiard balls collide, the directions and speeds in which they continue to roll generally change depending on the angle of impact, their masses and also the speed of impact.

In this experiment you learn what the total impulse of a mechanical system is and what role masses and speeds play in it.

Tasks

1. Connect two stationary cars of the same mass to the starting device so that the cars start suddenly. Both cars will pass a light barrier, which measures the respective shading time. Record three measured values each and use them to determine the speeds of the cars.
2. First increase the mass of both cars with a 50 g slotted weight and then remove the 50 g slotted weight from one of the two cars. Repeat the measurement each time.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Photogate, 0 ... ∞ s, two pieces (Bluetooth)	12909-00	1
2	Track, l 900 mm	11606-00	1
3	Meter scale, demo. l=500mm, self adhesive	03005-00	2
4	Cart for measurements and experiments	11060-00	2
5	Shutter plate for cart	11060-10	2
6	Holding pin	03949-00	2
7	Adapter plate for Light barrier compact	11207-22	2
8	Slotted weight, black, 50 g	02206-01	2
9	Slotted weight, black, 10 g	02205-01	1
10	Plug 4 mm, for cart, 2 pcs.	11060-11	1
11	Equiforce launcher	11311-00	1
12	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/4)

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The Cobra SMARTsense Photogate and measureAPP are required to perform the experiment. The app can be downloaded for free from the App Store - QR codes see below. Check whether Bluetooth is activated on your device (tablet, smartphone).

measureAPP for Android operating systems

measureAPP for iOS operating systems

measureAPP for Tablets / PCs with Windows 10

Set-up (2/4)

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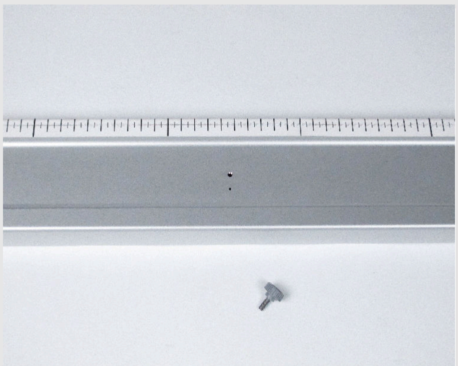
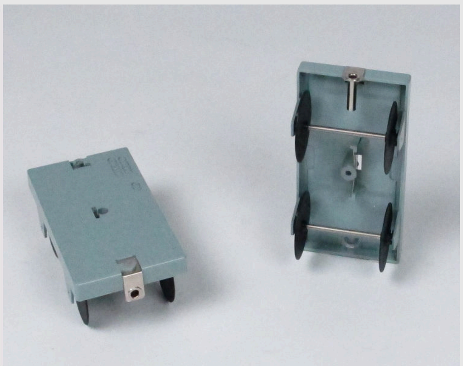
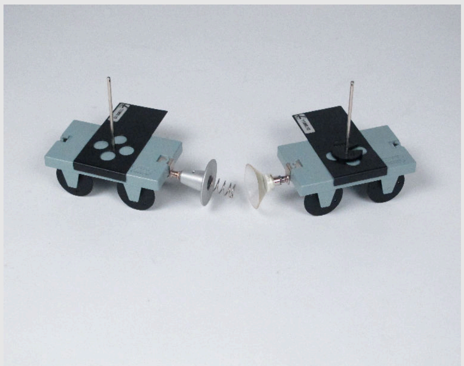
Unscrew the screw that is in the middle of the track completely and put it aside. Then attach a 4 mm socket to each of the two experimental cars, mount a part of the launching device to each of the sockets and attach a retaining bolt to each of the two cars and a shading panel to it.







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Set-up (3/4)

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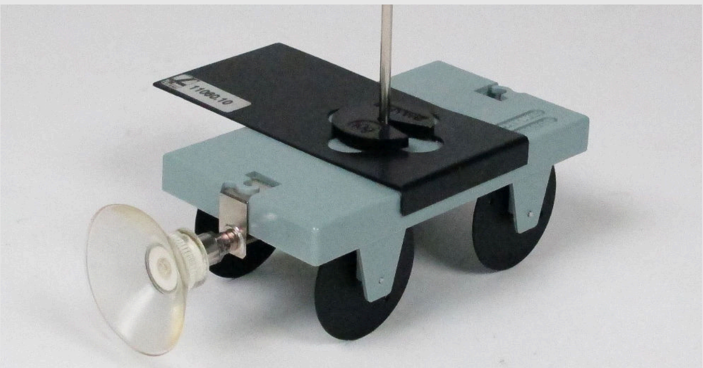
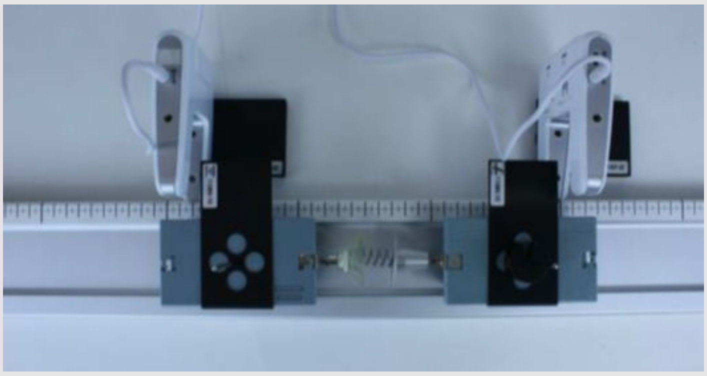
The suction cup weighs $10\,g$ less than the plate with the spring: put a 10 g slotted weight on the car with the suction cup accordingly, so that the masses of the two cars are equal. Place the photogates so that they are passed by the panels of the cars immediately after the start but are not interrupted before.





Set-up (4/4)

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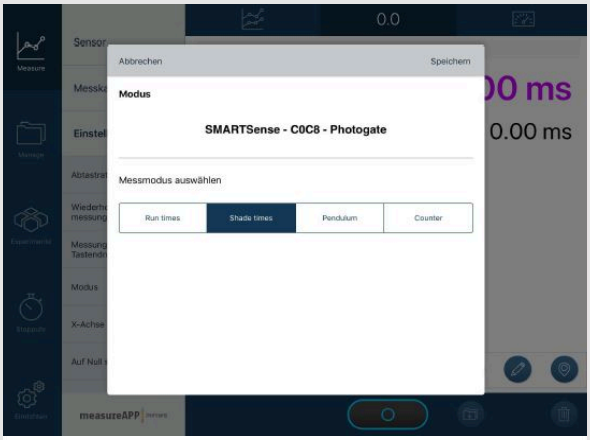

Extract from measureAPP

Connect both light barriers with the jack cable and switch them on. Select the light barriers in measureAPP under "Sensor" and select "Shading times" in the menu which then appears.

Then select the digital measured value display.

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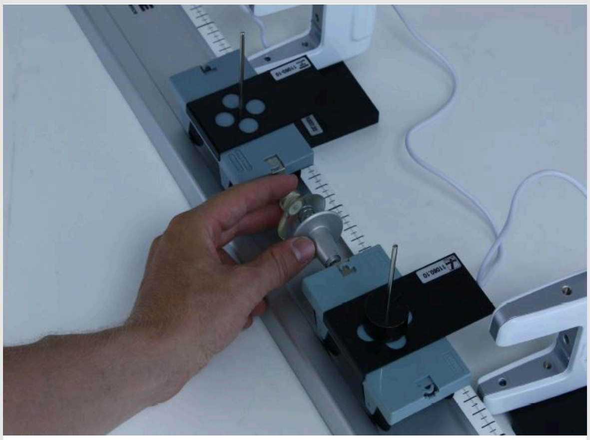
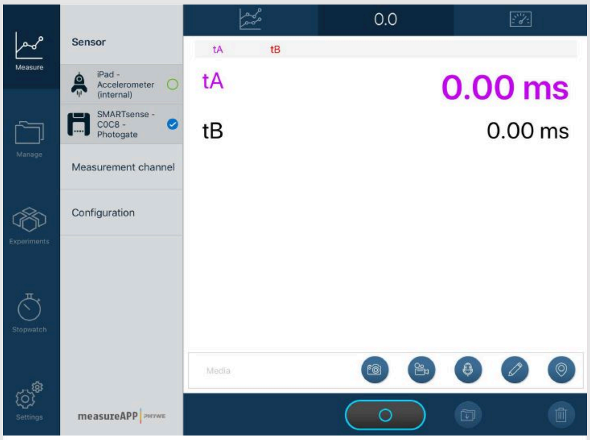
Procedure (1/2)



Compressing the starting device

- Start the measurement in the measureAPP.
- Press the starter as shown in the picture. Avoid pressing the ends of the car together. The spring should be exactly in the middle of the suction cup.
- Release the starter. When you squeeze the starter all the way together, it will release after about $5\ s$ off.
- Catch the cars before they roll off the road and note the shading times Δt_1 and Δt_2 in Table 1 of the Report.

Procedure (2/2)



Digital measured value display in measureAPP

- Check both times Δt_1 and Δt_2 by repeat measurements. If necessary, correct the values in the table.

Tip: To improve the accuracy of the measurement you can also use the average of three measurements.

- Place an additional 50 g slotted weight on each of the two retaining bolts and repeat the entire measurement.
- Now remove the 50 g from the second car and repeat the entire measurement again.

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Report

Table 1

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Carry your measurements for the shadowing times Δt_1 and Δt_2 in the table.

Calculate from the shading times and the aperture width $b = 5\,cm$ the speeds $v = b/\Delta t$ of the cars and thus subsequently the respective impulses p according to $p = m \cdot v$.

m_1 $[g]$	m_2 $[g]$	Δt_1 $[s]$	Δt_2 $[s]$	v_1 $[m/s]$	v_2 $[m/s]$	p_1 $[mNs]$	p_2 $[mNs]$
82	82						
132	132						
132	82						

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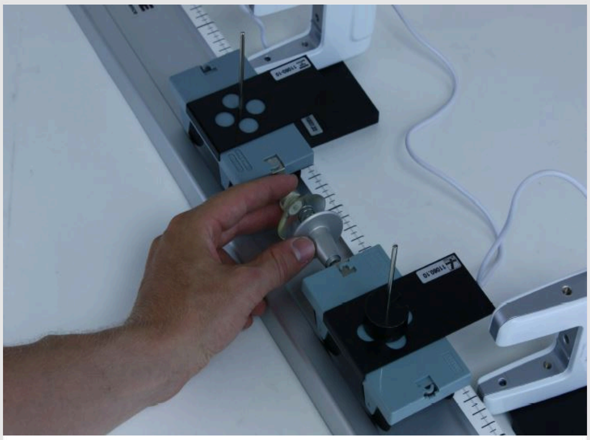
Task 1

What statements can you confirm?

- All pulses have the same magnitude, since the same starting device is always used.
- No statement about the impulses is possible.
- Independent of the car masses, the impulses p_1 and p_2 within one line of the table are equal within the scope of the measuring accuracies.

Check

Task 2



Experiment set-up

Assuming that the amounts of the impulses p_1 and p_2 are the same size: what is the difference between the movement of the two cars?

- Nothing distinguishes the cars from each other.
- The direction of the speeds v_1 and v_2

Check

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Task 3

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Which statement can you confirm with this knowledge and the table of values?

- The sum of the directed impulses p_1 and p_2 is in principle always negative.
- The sum of the directed impulses p_1 and p_2 the car is highly dependent on the car masses.
- The sum of the directed impulses p_1 and p_2 the car always lifts to zero, regardless of the car mass.

Check

Task 4

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If mass m_1 and speed v_1 of one body have been measured and the mass m_2 of the other body is known: how can the speed of the other body v_2 of the other body?

- $v_2 = m_1/(v_1 \cdot m_2)$
- $v_2 = (v_1 \cdot m_1)/m_2$
- $v_2 = (v_1 \cdot m_2)/m_1$

Check

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Slide	Score / Total
Slide 18: Impulse	**0/1**
Slide 19: Direction of the pulses	**0/1**
Slide 20: Sum of the directed pulses	**0/1**
Slide 21: determination of v_2	**0/1**

Total amount **0/4**

Solutions Repeat Exporting text

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