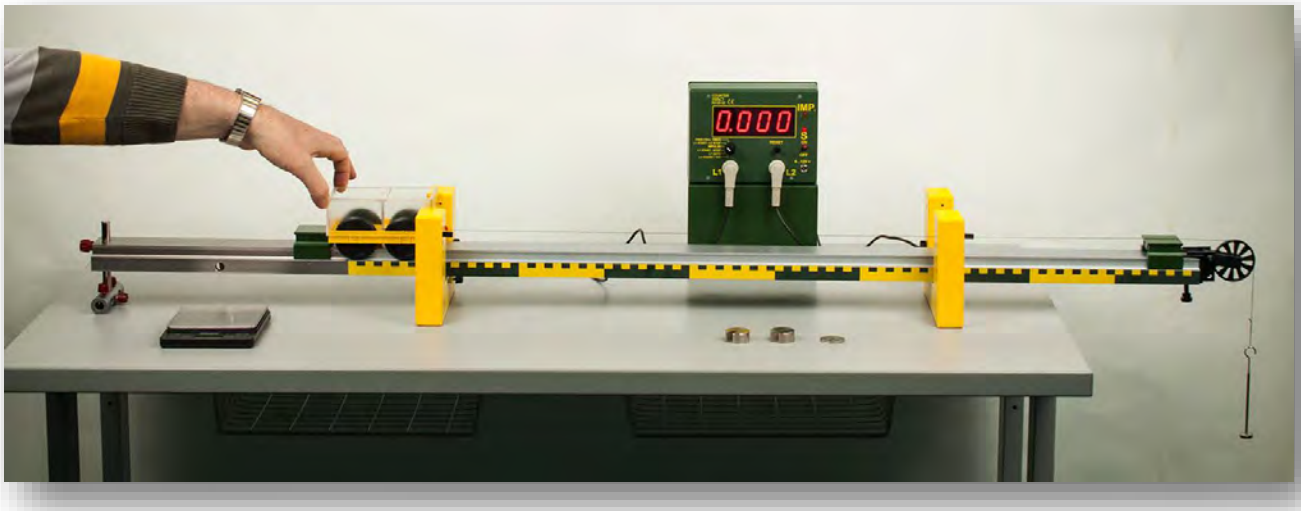
NEWTON'S BASIC LAW (LIGHT GATES)

MED 04.13a



Material

Item-no.	Qty.	Description
DS101-3B	1	Stand rail with scale, L=1000 mm
P7210-5C	1	Stand rail NTL, L=300 mm, SE
P5310-1S	1	Rail bond SE, universal
DM355-5S	1	Pulley with very low friction
DS102-2G	2	Clamp saddle
DM300-2A	1	Dynamics trolley, demo, 50 g
P1312-2A	1	Car body for trolley SE
P1120-2F	2	Slotted weight 50 g, SE
P1120-2D	4	Slotted weight 10 g, SE
P1120-2C	1	Holder for slotted weights, 10 g, SE
P1320-4A	2	Light gate "demo" 04
P3120-2Z	1	Universal timer "inno"
P3120-5B	1	S-shaped assembly platform
DS201-10	1	Support rod, round, L=100 mm, D=10 mm
P7230-1K	1	Bosshead round NTL, SE
P7100-1A	1	Cord, roll, high tensile strength
P7502-1A	1	Pair of scissors, SE
P1100-1E	1	Measuring tape, L=300 cm

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Purpose
To demonstrate that the acceleration is proportional to the driving force and vice versa proportional to the mass accelerated by the force.
This relationship serves to determine the size of a force F = m * a

Preparation
Connect the 100 cm stand rail and the 30 cm stand rail with the support of the rail bond; afterwards fix the pulley on the right end of the track.
Place the clamp saddle before the pulley.

Place the light gates at distance of 60 cm in between on the table; afterwards place the track on the light gates. Now move the right light gate to the 70cm mark and the left light gate to the 10 cm mark; make sure that the small bridges of the light gate are exactly on this mark.

Fix the 100 mm support rod in the centre hole of the round bosshead.
Insert the support rod with the attached bosshead in the hole on the left side of the track.
Attach the car body to the trolley and place the trolley on the left side of the track.

Now raise the track to balance out the friction of the trolley; when pushing the trolley slightly it has to travel with constant speed on the track. In case that the movement of the trolley becomes slower the friction has to be balanced out further (by raising the track on the left side further). Cut off a 150 cm piece of the cord and make loops at both ends, the remaining length from one loop to the other one should be 120 cm.

Tie the cord to the “tower” of the trolley, place it over the pulley and tie the cord to the holder for slotted weights on the other side; make sure that the pulley protrudes over the edge of the table.

Place the universal timer “inno” on the S-shaped assembly platform for a better visibility and connect the two light gates to the universal timer, afterwards put the switch into the “L1 START – L2 STOP” position.

Before starting the experiment make sure that the trolley can pass through the light gates without touching them.

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Experiment 1 – A & B
The mass to be accelerated consists of the car and the mass of the drive weight.
In total we want to reach 220 g.
Place two slotted weights of 50 g and one slot weight of 10 g on the tower of the trolley.
The holder for slotted weights has a mass of 10 g, the effective fore is therefore 0.1 N.

Turn on the universal timer and adjust the brightness controller of the light gate so that the diode is just not lighting up.
The trolley is placed in front of the left light gate in a way so that it just does not activate the light gate; use a clamp saddle as an indicator to find the correct position easier when repeating the experiment.

Afterwards push the “Reset”-button on the universal timer and let the trolley move down the track.

The drive weight is initially 10 g and is then increased to 20 g (by placing a slotted weight of 10 g on the holder). This doubles the effective force to 0.2 N.

With the help of the given formula determine the acceleration a.

$$a = \frac{2.s}{t^2}$$

Acceleration at a force of 0.1 N: …….. m/s²

Acceleration at a force of 0.2 N: …….. m/s²

The acceleration is proportional to the force.

Experiment 2 – A & B
The drive weight now remains 10 g (drive force 0.1 N) in both subsequent experiments, so only the holder alone is hung on the cord.

First we want to have a total mass of 220 g, so we load the trolley with the body with slotted weights with a weight of 110 g. After that we want to have a total mass of 110 g, therefore remove all slotted weights from the trolley.

Acceleration at a mass of 220 g: …….. m/s²

Acceleration at a mass of 110 g: …….. m/s²

The acceleration is indirectly proportional to the mass.

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Compile the four partial experiments and compare the force and the product of mass and acceleration:

Force F	Mass m	Acceleration a	m . a
0.1 N	0.22 kg	…….. m/s²	……..
0.2 N	0.22 kg	…….. m/s²	……..
0.1 N	0.11 kg	…….. m/s²	……..
0.1 N	0.22 kg	…….. m/s²	……..

This relationship serves to determine the size of a force F = m * a

Experiment 3
We want to determine another acceleration.
The mass of the trolley should be 180 g (Trolley + Car body + 80g slotted weights);
The force is caused by the weight of 20 g (holder + slotted weight 10 g), therefore 0.2 N.
The total mass is 0.2 kg.

Note the measurement and the resulting acceleration in the chart below.

From the 1st and 2nd experiment we take the knowledge for the following consideration:

0.2 N Force	0.2 kg Mass	…….. m/s²
1 N Force	0.2 kg Mass	…….. m/s²
1 N Force	1 kg Mass	…….. m/s²

Conclusion
The acceleration is directly proportional to the force.
The acceleration is indirectly proportional to the accelerating mass.

1 Newton is the force that gives the 1 kg mass the acceleration of 1 m / s².

Note
Because of the moment of inertia of the pulley, the occurrence of frictional forces on the trolley and the measurement inaccuracies results are expected that deviate slightly from the law.