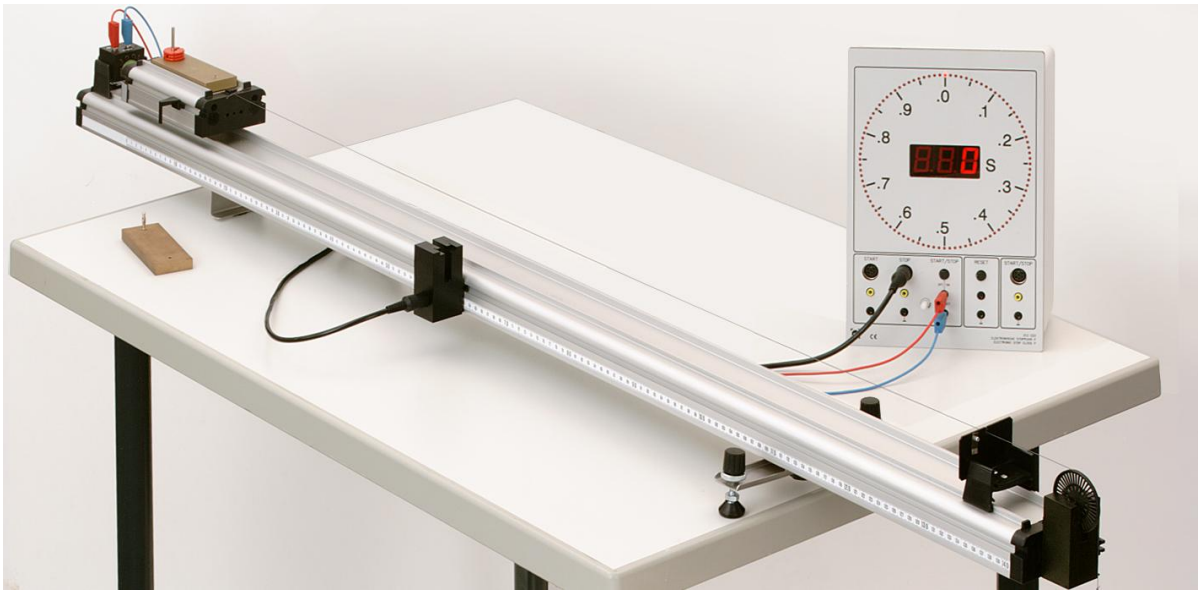
Motions
Inertia and Newton's law

Relationship between acceleration, force and mass - Measurement using an electronic stopwatch

Objects of the experiment

1. Measuring the time t required by a body of mass m_1 or m_2, respectively, to cover a certain path s if the force F acting on the body is changed
2. Calculating the acceleration a of the body
3. Representing the relation between acceleration and force in an a-F-diagram

Setup



Apparatus

1 Track, 1.5 m	337 130
1 Trolley	337 110
1 Additional weights, pair	337 114
1 Holding magnet	683 41
1 Holder for combination spoked wheel	337 463
1 Combination spoked wheel	337 464
1 Combination light barrier	337 462
1 Slotted mass hanger, 10 g, small	315 410
4 Slotted weights, 10 g, red	315 416
1 Electronic stop-clock P	313 033
1 Connecting leads, 19 A, 50 cm, black, pair	501 451
1 Multi-core cable, 6-pole, 1.5 m	501 16
1 Fishing line, set of 2	309 48ET2
1 Plug-in axles, set of 2	340 811ET2

Carrying out the experiment

- Adjust the voltage at the holding magnet so that the trolley with the additional weight is just held.
- Define the starting point with the movable interrupter flag on the trolley, and read it from the scale of the track.
- Position the light barrier at a distance of 50 cm from the starting point.
- Release the motion by pressing the START/STOP key at the stopclock.
- Wait until the interrupter flag passes the light barrier, and read the time from the stopclock.
- Reset the stopclock to zero by pressing the RESET key.
- Enhance the accelerating force step by step by putting the slotted weights 10 g from the trolley on slotted mass hanger one after another.
- Repeat the measurement for each force.
- Enhance the mass of the trolley by putting another additional weight on it.
- Repeat the experiment.
- Calculate the accelerations a from the quotients $\frac{2s}{t^2}$.

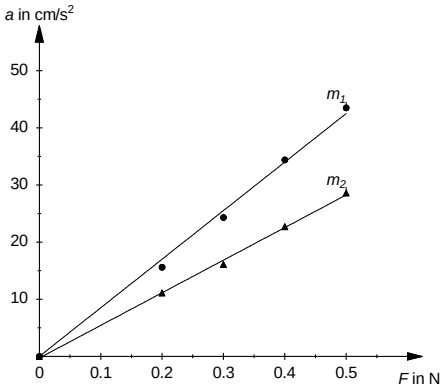
Measuring example

*m_1 = 1050 g, *m_2 = 1550 g

Path s in cm	50	50	50	50
*Force F in N	0.2	0.3	0.4	0.5
Time t_{m1} in s	2.53	2.02	1.72	1.53
Time t_{m2} in s	3.01	2.48	2.10	1.87
Acceleration a_{m1} in cm/s²	15.6	24.3	34.4	43.5
Acceleration a_{m2} in cm/s²	11.1	16.1	22.7	28.6

*Force F: round values

Evaluation



In the case of uniformly accelerated motion, the acceleration varies proportionally to the acting force: $a \sim F$.

The greater the mass of a body, the smaller its acceleration if the force is the same.

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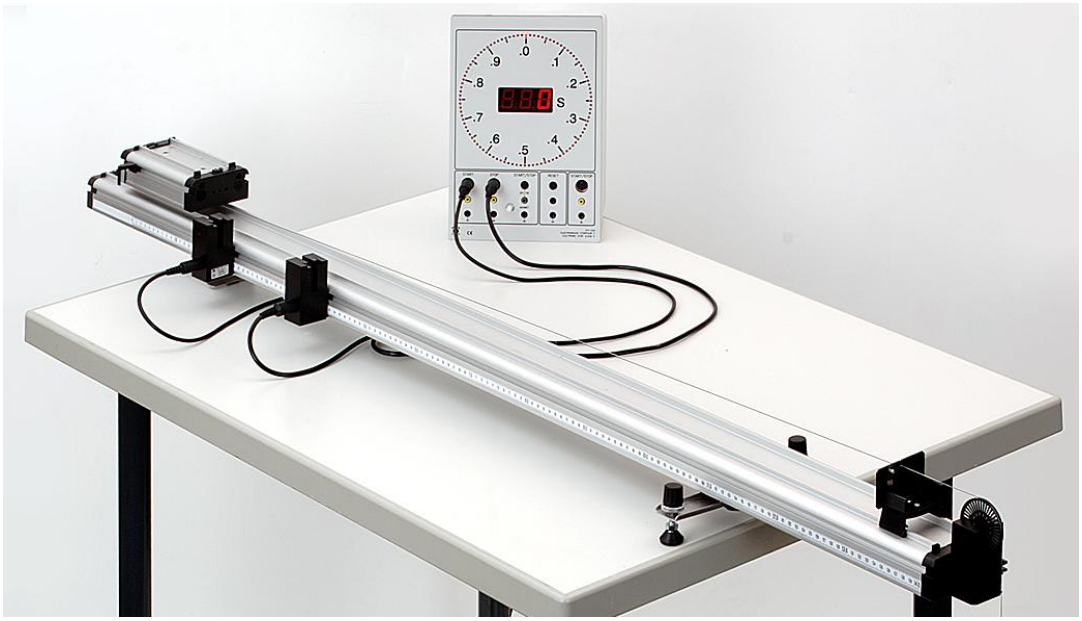
Straight motion
Uniform motion

Relationship between displacement, time and velocity - Measurement using an electronic stopwatch

Objects of the experiment

1. Measuring the time *t* required by a body for covering a given path *s*
2. Calculating the velocity of the body

Setup



- Align the track horizontally.
- Choose the length of the fishing line so that the hanger with the slotted weights hangs over the ground at a height of 10 cm.
- In order that the fishing line hinders the motion of the trolley as little as possible, guide the line under the trolley and fasten it at the back side of the trolley.
- Attach a support clip at the back end of the track and another one at the end of the trolley so that the trolley can be held in its starting position by a loop of line.

Apparatus

1 Track, 1.5 m	337 130
1 Trolley	337 110
1 Holder for combination spoked wheel	337 463
1 Combination spoked wheel	337 464
2 Combination light barriers	337 462
1 Slotted mass hanger, 10 g, small	315 410
2 Slotted weights, 10 g, red	315 416
2 Support clip, for plugging in, set of 5	314 04ET5
1 Electronic stop-clock P	313 033
2 Multi-core cables, 6-pole, 1.5 m	501 16
1 Fishing line, set of 2	309 48ET2

Carrying out the experiment

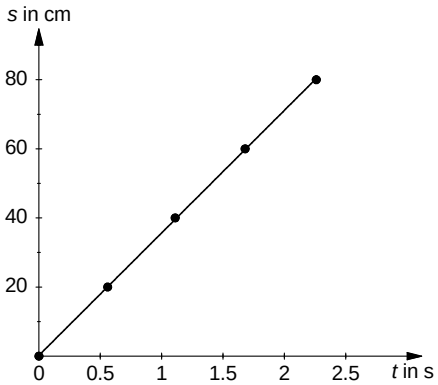
- Mark the starting point with the interrupter flag attached to the trolley.
- Position the light barrier 1 20 cm behind the starting point of the trolley.
- Place the light barrier 2 at a distance of 20 cm from the light barrier 1.
- Make the trolley move by releasing the loop of line from the support clip.
- Read the time for the motion between the two light barriers, and enter it into the table.
- Position the light barrier 2 at distances of 40 cm, 60 cm, and 80 cm from the light barrier 1.
- Repeat the measurement for each distance.
- Calculate the velocity of the trolley form the path and the time.

Measuring example

Path *s* in cm	time *t* in s	velocity *v* in m/s
20	0.56	35.7
40	1.11	36.0
60	1.68	35.7
80	2.26	35.4

Evaluation

1. In the case of uniform motion, the path and the time are proportional to each other: $s \sim t$.



2. The velocity of a body in uniform motion can be calculated from the covered path and the required time: $v = \frac{s}{t}$. If a body moves uniformly, its velocity is equal at all times.

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