FORCE SENSOR
WITH TWO RANGES

DESCRIPTION D0362BT

Figure 1. The Force sensor with two ranges.

Short description

The Force sensor with two ranges (0362bt) is a general-purpose device for measuring forces.

It can be used as a replacement for a hand-held spring scale, can be mounted on a ring stand or on a dynamics cart to study collisions. It can measure both pulls and pushes. Forces as small as 0.01 N and as large as 50 N can be measured.

The Force sensor uses strain gage technology to measure force, based on the bending of a beam. Strain gages attached to both sides of the beam change resistance as the beam bends. The strain gages are used in a bridge circuit such that a small change in resistance will result in a change in voltage. This voltage change is proportional to the change in force. The switch allows you to select either of two ranges: ± 5 N or ± 50 N. A maximal force of 70 N can be applied to the sensor, for forces above 70 N the sensor beam can bend permanently. If this happen the sensor will not work according to its specifications anymore.

As with any instrument, there is a trade off between resolution (the smallest force that can be measured) and the range of forces that can be measured. In general, you should use the ± 5 N range if you can. If the forces exceed 5 N, you need to use the ± 50 N range. Using a 12 bit AD converter (e.g., CoachLab II), the resolution with the two different switch settings will be respectively:
- 0.01 N (or 1 gram) for $\pm$ 5 N range
- 0.025 (or 2.5 gram) for $\pm$ 50 N range.

Accessories delivered with the Force sensor

Several accessories are included with the Force Sensor with the two ranges, which are shown in figure 2:
- A *bracket* and a *screw* to mount the Force sensor to a dynamics cart;
- A *thumb screw* to mount the Force sensor on a ring standard;
- An *utility handle* to provide a convenient handle for the Force sensor. It can also be used to mount it to various clamps;
- A *bumper and a hook*. The bumper is mostly used for collision experiments, or any time you want to measure pushing forces. The hook is used to measure pulling forces.

Figure 2. Accessories delivered with the Force sensor.

The sensor is delivered with a BT-plug and can be connected to the following interfaces:
- UIA/UIB through Measuring console (via 0520 adapter)
- CoachLab
- CoachLab II
- SMI (via 0520 adapter)
- Texas Instruments CBL™ and CBL2™ datalogger
- Vernier LabPro datalogger.

An optional adapter (art. 0520) can be used to connect the sensor with the BT-plug to 4-mm input.

Suggestion for experiments

The Force sensor with two ranges can be used in variety of experiments, including:
- Measuring of forces and impulse during collisions;
- Studying simple harmonic motion;
- Measuring of centripetal forces;
- Measuring of frictional forces;
- Studying Hook's law;
- Studying the second Newton's law;
- Monitoring the thrust of model rocket engine.

Calibration

When there is no force applied to the sensor the output voltage generated by the sensor is 2.5 V. This offset allows to measure positive and negative force values in the range of the output voltage between 0 to 5V.

In the range ±5 N the sensitivity of the sensor is 2.5 N/V (0.4 V/N) and the sensor is calibrated according to the formula F=2.5*V-6.25.

In the range ±50 N the sensitivity of the sensor is 25N/V (0.04 V/N) and the sensor is calibrated according to the formula F=25*V-62.5.

In the diagrams below F describes the force measured in Coach program and V describes the sensor voltage (see figure 3).
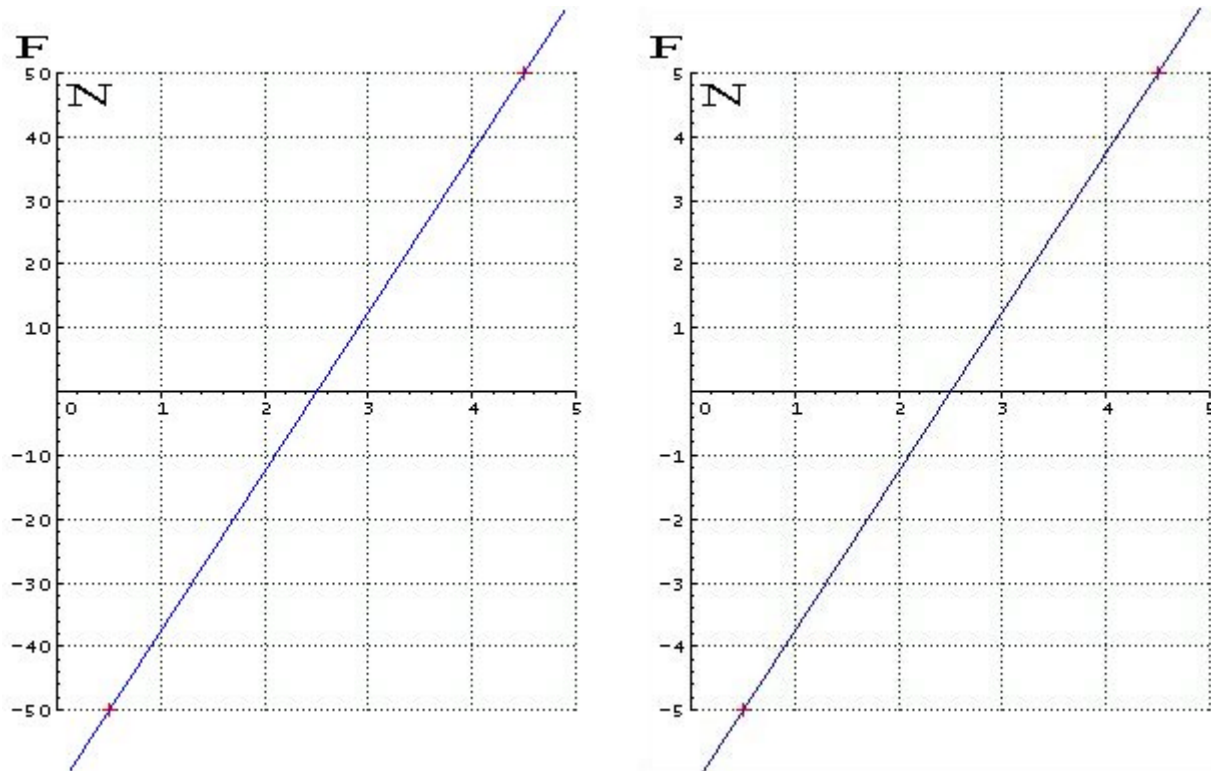

Figure 3. Calibrations of the Force sensor with two ranges: ±50 N (left) and ± 5N (right).

Remarks regarding the calibration:
- In the range ±5 N the sensor is so sensitive that the weight of the connection element of the sensor influences the calibration in the vertical direction (even more effect when the hook or bumper is mounted).
  Calibrate the sensor in this range in the horizontal position to avoid this effect.
- Because the sensor generates the output voltage of 2.5 V for the force of 0 N it can happen that the sensor does not indicate exactly 0 value. This applies especially for the ±5 N range, at which the sensor signal is internally 10 times amplified (and therefore the deviation with respect to the 2.5 V offset can appear).
  Use the 'Shift the calibration' option in Coach (see the Coach Help, search term

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'Shift the calibration') to adjust the zero point of the sensor.
- The option 'Shift the calibration' in Coach is also handy to adjust the zero level when something is attached to the sensor, for example in experiments to study oscillations of a spring attached to the sensor (the sensor oscillates around the value of 0 N).
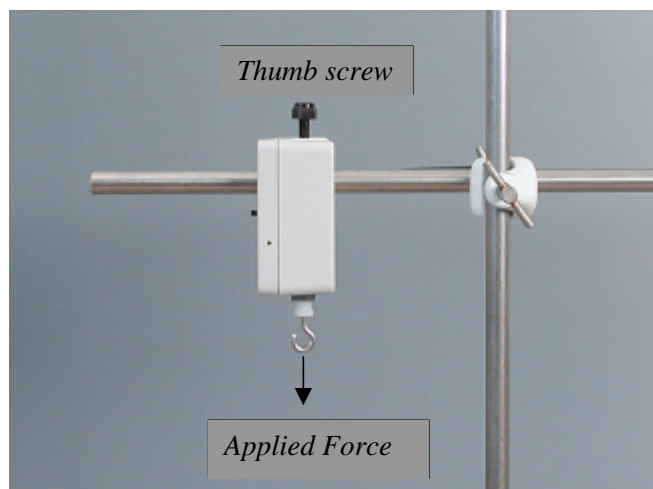
The Force sensor in the Coach sensor library

The names of the Force sensor in the sensor library of Coach 5 program are:
- Force sensor with two ranges (0362bt) (CMA) (–5..5 N)[1]
- Force sensor with two ranges (0362bt) (CMA) (–50..50 N).

Mounting of the Force sensor on a Ring Stand

The Force sensor with two ranges is designed to be mounted on a ring stand in several different ways:

For measuring vertical forces, you can use a short horizontal 13-mm rod extended through the hole in the Force sensor. Tighten down on the thumb screw (see picture →).

For measuring horizontal forces, you can use a standard 13-mm rod extended through the hole in the Force sensor. Tighten down the thumb screw (see picture →).

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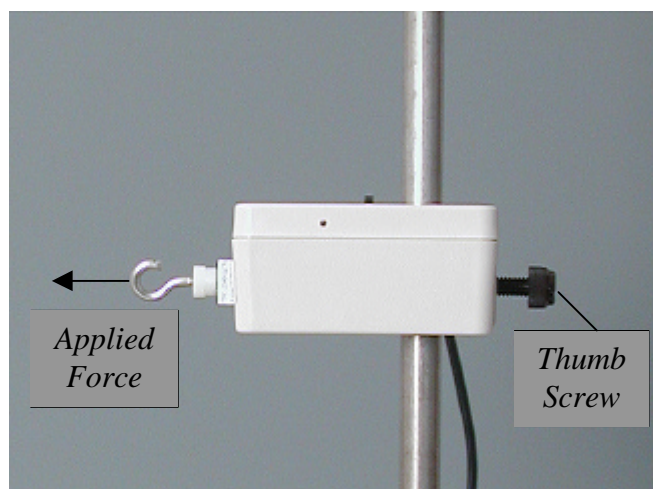
[1] If you have in the Coach library the sensor 'Dual-range force sensor (0362bt) (CMA) (-10..10N)', then you should download an update from http://www.cma.science.uva.nl/english under Support).

Mounting on a Dynamics Cart

The Force sensor was designed for easy mounting on a dynamics cart (especially designed for PASCO carts). First mount the bracket on the cart, using the Phillips screw to hold it in place. Then mount the Force sensor to the bracket, using the thumb screw.

Example of measurement results

The Force sensor with two ranges can be used to study force and impulse during collisions.
During such experiment a dynamics cart collides into the bumper of the Force sensor mounted on a ring stand.
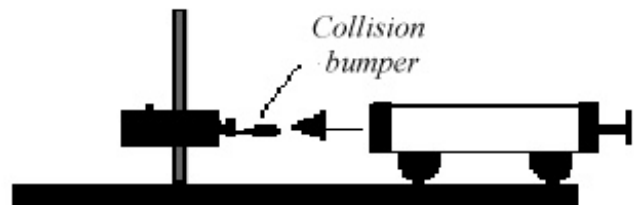

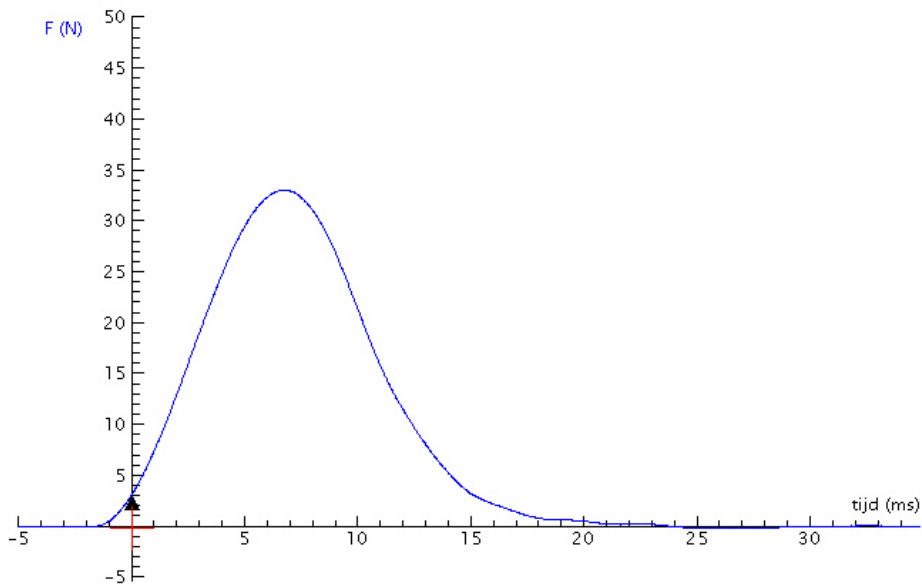**Figure 4.** Setup of the collision experiment.

Figure 5. The force measured during the collision of a cart with the bumper of the Force sensor.

If you want to compare the integral of the force vs. time graph with the change in momentum of the cart you can use a Motion Detector to make graphs of the motion and the force at the same time.

Technical data

Switch position	±5 N	±50 N
Sensitivity	2.5 N/V	25 N/V
Output voltage	0.5 – 4.5 V	0.5 – 4.5 V
Force range	10 N	100 N
Resolution using 12 bits 5V AD converter	0.0025 N (theoretical)	0.025 N
Accuracy	±0.01 N (due to noise)	0.025 N
Current	4.5 mA	4.5 mA
Power (for 5V sensor supply)	22.5 mW	22.5 mW
Maximum force	70 N (for forces above this value the beam can permanently bend and the sensor will not work according to its specifications anymore)	
Dimensions (lxwxh)	80 (box: 75) x 52 x 32 mm³	
Connection	BT (British Telecom) plug	

This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

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