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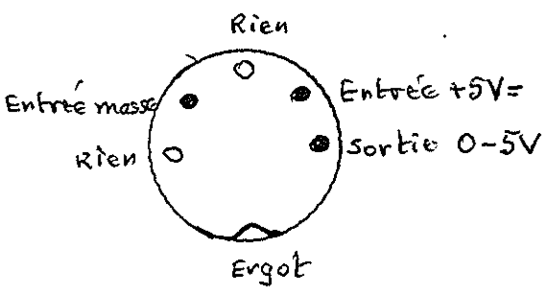

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(MEP)

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Rev. 6/27/00

Dual-Range Force Sensor

(Order Code DFS-BTA or DFS-DIN)

The Dual-Range Force Sensor is a general-purpose device for measuring forces. It can be used as a replacement for a hand-held spring scale, or it can be mounted on a ring stand. It can also be mounted on a dynamics cart to study collisions. It can measure both pulls and pushes. Forces as small as 0.01 newtons and as large as 50 newtons can be measured. The Dual-Range Force Sensor can be used for a variety of experiments, including

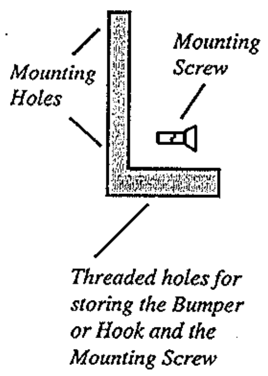
- Studying force and impulse during collisions
- Studying simple harmonic motion
- Monitoring frictional force
- Studying Hooke's law
- Monitoring the thrust of model rocket engines
- Measuring the force on a dynamics cart at the same time you monitor acceleration
- Measuring the force required to lift a known weight using simple machines
- Measuring the heat of vaporization of liquid nitrogen

The Dual-Range Force Sensor was designed by Bruce Lee of Andrews University and is manufactured by A.U. Physics Enterprises.

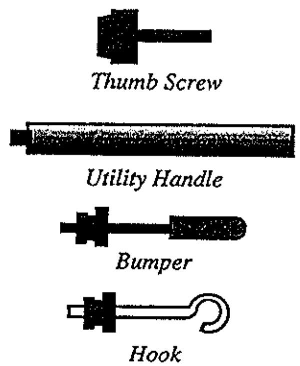
NOTE: This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

What is included with the Dual-Range Force Sensor?

Several accessories are included with the Dual-Range Force Sensor:



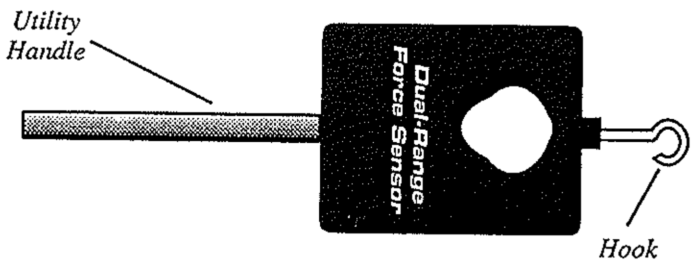
Cart Mounting Bracket



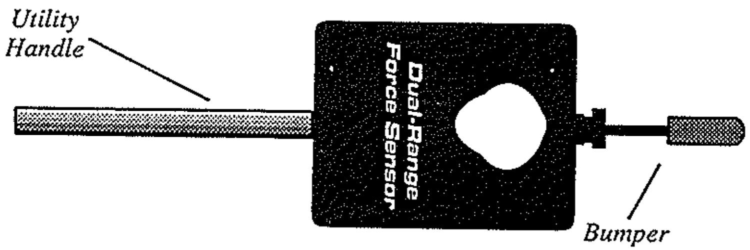
The bracket and Phillips screw are used to mount the Force Sensor to a PASCO dynamics cart.

The Utility Handle provides a convenient handle for the Force Sensor, and can also be used to mount it to various clamps.

The Bumper is used mostly for collision experiments, or any time you want to measure pushing forces.



With Hook for Connecting to a String and Measuring Pulls



With Bumper for Collision Experiments or Measuring Pushing Force

The Phillips screw and the bumper are screwed into the bracket for storage. This should make them more difficult to lose.

Using the Dual-Range Force Sensor with a Computer

This sensor can be used with a Macintosh® or PC computer and any of the following lab interfaces: Vernier LabPro™, Universal Lab Interface, or Serial Box Interface. Here is the general procedure to follow when using the Dual-Range Force Sensor with a computer:

1. Connect the Dual-Range Force Sensor to the appropriate port on the interface.
2. Start the data-collection software on the computer. If you are using a Power Macintosh or Windows® computer, run the Logger *Pro*™ software. If you are using older Macintosh, MS-DOS®, or Windows 3.1 computers, run the Data Logger program.
3. Open an experiment file in the Logger Pro or Data Logger folder, and you are ready to collect data.

Using the Dual-Range Force Sensor with Graphing Calculators

This sensor can be used with a TI Graphing Calculator and any of the following lab interfaces: LabPro, CBL 2™, or CBL™. Here is the general procedure to follow when using the Dual-Range Force Sensor with a graphing calculator:

1. Load a data-collection program onto your calculator:
   - LabPro or CBL 2 - Use the DataMate program. This program can be transferred directly from LabPro or CBL 2 to the TI Graphing Calculator. Use the calculator-to-calculator link cable to connect the two devices. Put the calculator into the Receive mode, and then press the Transfer button on the interface.
   - Original CBL - Use the PHYSICS program. This program is available free on our web site at www.vernier.com. Our programs can also be obtained on disk. (Contact us for more information.) Load the program into a calculator using TI-GRAPH LINK™.
2. Use the calculator-to-calculator link cable to connect the interface to the TI Graphing Calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
3. Connect the Dual-Range Force Sensor to any of the analog ports on the interface. In most cases, Channel 1 is used.
4. Start the data-collection program, and you are ready to collect data.

The DFS-BTA version of this sensor is equipped with circuitry that supports auto-ID. When used with LabPro or CBL 2, the data collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. This greatly simplifies the setup procedures for many experiments. Auto-ID is required for the Quick Setup feature of LabPro and CBL 2 when the unit operates remotely from the computer or calculator.

The Two Switch Settings - Resolution and Range

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 ±10 N range if you can. If the forces exceed ten newtons, you need to use the ±50 N range. In normal use, the resolution with the two different switch settings will be

±10 N range	0.01 N (or 1 gram)
±50 N range	0.05 N (or 5 grams)

How the Dual-Range Force Sensor Works

The Dual-Range 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: ±10 N or ± 50 N.

Do I Need to Calibrate the Dual-Range Force Sensor? "No."

We feel that you should not have to perform a new calibration when using the Dual-Range Force Sensor in the classroom. We have set the sensor to match our stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier in any of these ways:

1. If you ordered the DFS-BTA version of the sensor, and you are using it with a LabPro or CBL 2 interface, then a calibration (in N) is automatically loaded when the Dual-Range Force Sensor is connected.
2. If you are using Logger *Pro* software (version 2.0 or newer) on a Power Macintosh or Windows computer, open an experiment file for the Dual-Range Force Sensor, and its stored calibration will be loaded at the same time. **Note:** If you have an earlier version of Logger *Pro*, a free upgrade is available from our web site.
3. If you are using Data Logger software (version 4.6 or newer) on an older PC or Macintosh computer, open an experiment file for the Dual-Range Force Sensor, and its stored calibration will be loaded at the same time. **Note:** If you have an earlier version of Data Logger, contact us about a free upgrade.
4. Any version of the DataMate program (with LabPro or CBL 2) has stored calibrations for this sensor.
5. Any version of the PHYSICS or PHYSCI programs (for CBL), version 4/1/00 or newer, has stored calibrations for this sensor. Go to our web site, www.vernier.com, to download a current version.

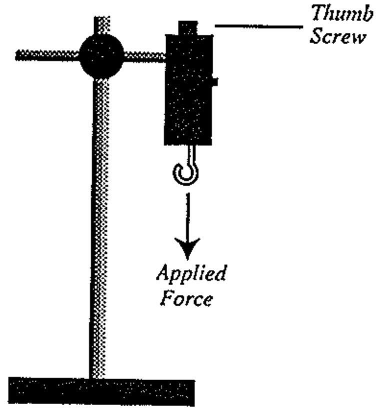
In many cases, you can simply load an experiment file that is designed for use with the Dual-Range Force Sensor and you are ready to collect data. You need to select the correct file (10 N or 50 N) to match your selected range setting on the sensor. If you do not have these calibration files, contact Vernier and we will send them to you. Be sure to specify which interface and software you are using.

If you want to improve the calibration, it is easy to recalibrate. Simply follow the same procedure used in calibrating most Vernier probes—a two-point calibration. One of the points is usually with no force applied. Select the calibration option of the program you are using and remove all force from the Dual-Range Force Sensor. Enter 0 as the first known force. Now apply a known force to the Dual-Range Force Sensor. The easiest way to do this is to hang a labeled mass from the hook on the end of the sensor. Enter the weight of the mass (note: 1 kg weighs 9.8 newtons). For calibration using the ±10 N range, we recommend using 300-grams of mass (2.94 newtons) for the second calibration point. For calibration using the ±50 N range, we recommend using a kilogram mass (9.8 newtons) for this second calibration point. Be careful not to exceed the selected range setting during calibration.

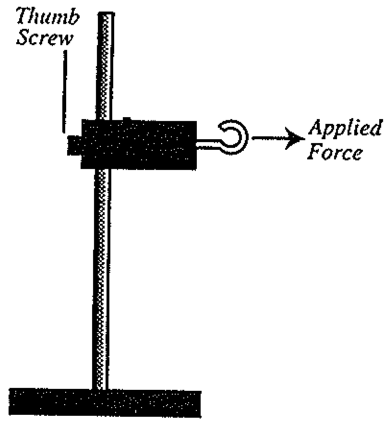
Mounting on a Ring Stand

The Dual-Range Force Sensor is designed to be mounted on a ring stand in several different ways:

- For measuring vertical forces, you can use a horizontal 13-mm rod extended through the hole in the Dual-Range Force Sensor. Tighten down on the thumb screw.

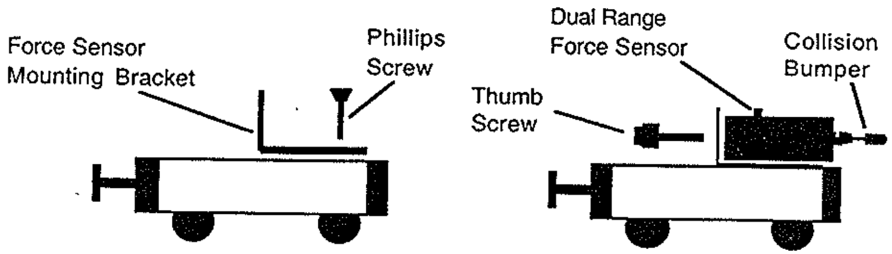


- For measuring horizontal forces, you can use a standard 13-mm rod extended through the hole in the Dual-Range Force Sensor. Tighten down the thumb screw.



Mounting on a Dynamics Cart

The Dual-Range Force Sensor was designed for easy mounting on a PASCO dynamics cart. 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.



Accessory Adapters *(sold separately)*

Dynamics Track Adapter (DTA-DFS, $46)

This adapter extends the versatility of your force sensor by increasing mounting possibilities. It is specifically designed to attach to a PASCO Dynamics Track. Multiple mounting options allow for sensor-to-sensor or sensor-to-cart collision measurements. Includes two magnetic bumper attachments.

Air Track Adapter (ATA-DFS, $43)

Allows the Dual-Range Force Sensor to be mounted on the end of an air track for collision studies. Compatible with most air tracks distributed or made by PASCO scientific, Central Scientific, or Daedalon Corporation. Includes two magnetic bumpers.

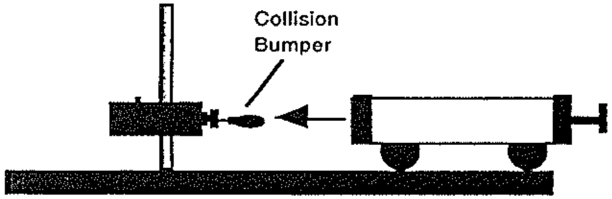
Force Table Adapter (FTA-DFS, $25)

Use your Dual-Range Force Sensor with your force table for resolution of vectors experiments. Includes mounting clamp for tables up to 3/4-winch thick.

Some Suggested Experiments

Collision Experiments

Place a vertical rod through the hole in the Dual-Range Force Sensor. Tighten the thumb screw. Collide the dynamics cart into the stationary collision bumper on the Dual-Range Force Sensor. This experiment requires a lab interface that can sample fast enough to get many readings during the collision of the cart/glider and the Dual-Range Force Sensor.



If you want to compare the integral of the force vs. time graph with the change in momentum of the cart/glider, there are two ways to do so:

1. Use a photogate and timing software to measure the speed of the cart before and after the collision.
2. Use a Motion Detector to make graphs of the motion and the force at the same time. One limitation of using a Motion Detector for these collision experiments is that the data sampling rate must be slowed down considerably. This means that the number of force measurements during the collision will also be reduced.

Studying Friction

Use the Dual-Range Force Sensor as a replacement for a spring scale. Run a string from the Force Sensor to a block of wood. Measure the force as you pull the block along a horizontal surface. You can investigate how frictional force is affected by surface area and type of surface. You can also compare static and dynamic friction.

Simple Harmonic Motion

Mount the Dual-Range Force Sensor and hang a weight from a spring connected to the beam as shown here. Start the weight oscillating and plot the force vs. time. A sinusoidal graph will be produced. Using most programs, you can plot graphs of the motion of the weight and monitor force at the same time. This allows you to compare the phase of the force and motion graphs.