

# Dual-Range Force Sensor

(Order Code DFS-BTA or DFS-DIN)

The Dual-Range Force Sensor is a general-purpose device for measuring pushing and pulling forces. It can be used as a replacement for a hand-held spring scale or mounted on a ring stand. It can also be mounted on a dynamics cart to study collisions. 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
- Measuring the force required to lift a known mass using simple machines

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

The Dual-Range Force Sensor is designed for use with the following interfaces:

- Vernier LabPro<sup>®</sup> (for use with computers, TI graphing calculators, or Palm Powered<sup>™</sup> handhelds)
- Go!<sup>®</sup> Link
- Vernier EasyLink<sup>®</sup>
- Texas Instruments CBL 2<sup>™</sup>
- Universal Lab Interface (ULI)
- Serial Box Interface

## What is included with the Dual-Range Force Sensor?

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



*Thumb Screw*



*Bumper*



*Utility Handle*



*Hook*



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

Hardware for attaching the Dual-Range Force Sensor to a Vernier dynamics cart is included with the 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 pulling force*



*With bumper for collision experiments or measuring pushing force*

## Using the Dual-Range Force Sensor with a Computer

This sensor can be used with a computer and any of the following lab interfaces:

Vernier LabPro, Go! Link, Universal Lab Interface, or Serial Box Interface.

1. Connect the Dual-Range Force Sensor, interface, and computer.
2. Start the Logger Pro<sup>®</sup> or Logger Lite<sup>®</sup> software.
3. The program will automatically identify the Dual-Range Force Sensor, and you are ready to collect data.<sup>1</sup>

## Using the Dual-Range Force Sensor with a TI Graphing Calculator

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

1. Connect the data-collection interface to the graphing calculator.
2. Connect the Dual-Range Force Sensor to any of the analog ports on the interface or to EasyLink.
3. Start the EasyData or DataMate App—the application you choose to use depends on your calculator and interface. See the chart for more information.

<sup>1</sup> If your system does not support auto-ID, open an experiment file in Logger Pro, and you are ready to collect data.

Calculator	Interface	Data Collection Program
TI-84 Plus Family	EasyLink	EasyData
	LabPro or CBL 2	EasyData (recommended) or DataMate
TI-83 Plus Family	LabPro or CBL 2	EasyData (recommended) or DataMate
All Others (TI-73, TI-83, TI-86, TI-89, TI-92 and Voyage 200)	LabPro or CBL 2	DataMate

- The Dual-Range Force Sensor will be identified automatically, and you are ready to collect data.

If the data-collection application is not on your calculator, use the following instructions to load it onto the calculator.

- EasyData App**—This program may already be installed on your calculator. Check to see that it is EasyData version 2.0 or newer. If it is not installed or is an older version, it can be downloaded to your computer from the Vernier web site, [www.vernier.com/easy/easydata.html](http://www.vernier.com/easy/easydata.html). It can then be transferred from the computer to the calculator using TI-Connect and a TI unit-to-computer cable or TI-GRAPH LINK cable. See the Vernier web site, [www.vernier.com/calc/software/index.html](http://www.vernier.com/calc/software/index.html) for more information on the App and Program Transfer Guidebook.
- 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 Receive mode, and then press the Transfer button on the interface.

### Using the Dual-Range Force Sensor with a Palm Powered Device

- Connect the Palm Powered handheld, LabPro, and the Dual-Range Force Sensor.
- Start Data Pro.
- Tap New, or choose New from the Data Pro menu. Tap New again. The Dual-Range Force Sensor will be identified automatically.
- You are now ready to collect data.

### 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:  $\pm 10$  N or  $\pm 50$  N.

### The Two Switch Settings—Resolution and Range

As with any instrument, there is a trade off between accuracy and the range of forces that can be measured. In general, you should use the  $\pm 10$  N range if you can. If the forces exceed ten newtons, you need to use the  $\pm 50$  N range. In normal use, the accuracy with the two different switch settings will be

$\pm 10$ N	0.01 N	Stored Calibration:	slope = $-4.9$ N/V intercept = $12.25$ N
$\pm 50$ N	0.05 N	Stored Calibration	slope = $-24.5$ N/V intercept = $61.25$ N

### Do I Need to Calibrate the Dual-Range Force Sensor?

You should not have to perform a new calibration when using the Dual-Range Force Sensor in the classroom. We set the sensor to match our stored calibration before shipping. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier. In many cases, you can 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 (10N or 50 N) to match your selected range setting on the sensor.

The sensor is sensitive enough to measure the weight of the sensor hook. To minimize this effect, simply place the sensor in the orientation in which it will be used (horizontal or vertical) and choose zero in the software. This will define the current situation as 0 N of force.

If you want to improve the calibration, it is easy to recalibrate. Simply follow the same procedure used in calibrating most Vernier sensors—a two point calibration. One of the points is usually with no force applied. Select the calibration option in the program you are using and remove all force from the sensor. Enter **0** as the first known force. Now apply a known force to the 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 applies a force of 9.8 newtons). For calibration using the  $\pm 10$  N range, we recommend using 300 g of mass (2.94 N) for the second calibration point. For calibration using the  $\pm 50$  N range, we recommend using a 1 kg mass (9.8 N) for this second calibration point. Be careful not to exceed the selected range setting during calibration. If you plan to use the Dual-Range Force Sensor in a different orientation (horizontal vs. vertical) than calibrated, zero the Force Sensor to account for this. This additional step makes the sensor ready exactly zero when no force is applied.

## Mounting on a Ring Stand

The Dual-Range Force Sensor is designed to be mounted on a ring stand in several different ways. Use a 13 mm rod extended through the hole in the Dual-Range Force Sensor. Tighten the thumb screw.



*Mounted for vertical  
data collection*



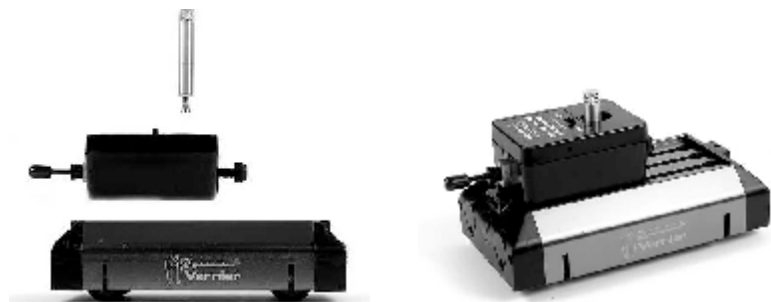
*Mounted for horizontal  
data collection*

## Mounting on a Dynamics Cart

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

### Vernier Dynamics Cart

First mount the T-nut to the cart and tighten. Then mount the Dual-Range Force Sensor to the T-nut using the thumb screw.



## Accessory Adapters (sold separately)

### Dynamics Track Adapter (DTA-DFS)

This adapter extends the versatility of your force sensor by increasing mounting possibilities. It is designed to attach to either a Vernier Dynamics Track or 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)

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.



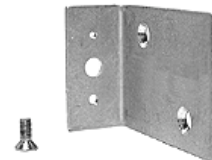
### Force Table Adapter (FTA-DFS)

Use your Dual-Range Force Sensor with your force table for resolution of vector experiments. Includes mounting clamp for tables up to  $\frac{3}{4}$  inch thick.



### PASCO Cart Adapter (PCA-DFS)

This adapter is designed to attach the Dual-Range Force Sensor to a PASCO dynamics cart.



This sensor is equipped with circuitry that supports auto-ID. When used with LabPro, Go! Link, EasyLink, or CBL 2, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. If you purchased a DFS-DIN to connect the sensor to a ULI or Serial Box Interface, the auto-ID feature is not supported in these interfaces.

## Some Suggested Experiments

### Collision Experiments



Screw a vertical rod through the hole in the Dual-Range Force Sensor. 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 Motion Detector to make graphs of the motion and the force at the same time.
2. Use a photogate and timing software to measure the speed of the cart before and after the collision.

### Studying Friction

Use the Dual-Range Force Sensor as a replacement for a spring scale. Run a string from the Dual-Range 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 mass from a spring connected to the beam as shown here. Start the mass 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 mass and monitor force at the same time. This allows you to compare the phase of the force and motion graphs.



## Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.



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