Force Plate
(Order Code FP-BTA)

Designed for much higher forces than the Dual-Range Force Sensor, the Force Plate can measure the forces developed during stepping, jumping, and other human-scale actions. For example, you can perform the following kinds of experiments:

- Observe the change in normal force during an elevator ride.
- Measure the impulse delivered by the floor during a jump.
- Measure the reaction force as a student leans against a wall.

Parts included with the Force Plate

The Force Plate includes one pair of handles. They can be attached either to the top or the bottom of the Force Plate. Do not step on the Force Plate when the handles are attached.

Collecting Data with the Force Plate

This sensor can be used with the following interfaces to collect data.

- Vernier LabQuest® 2 or original LabQuest® as a standalone device or with a computer
- Vernier LabQuest® Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier Go!®Link
- Vernier EasyLink®
- Vernier SensorDAQ®
- CBL 2™
- TI-Nspire™ Lab Cradle

Here is the general procedure to follow when using the Force Plate:

1. Connect the Force Plate to the interface.
2. Start the data-collection software.
3. The software will identify the Force Plate and load a default data-collection setup. You are now ready to collect data.

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device.

- **DataQuest™ Software for TI-Nspire™** This calculator application for the TI-Nspire can be used with the EasyLink or TI-Nspire Lab Cradle.
- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2™, LabPro, and Vernier EasyLink. We recommend version 2.0 or newer, which can be downloaded from the Vernier web site, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2™ and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2™ Guidebooks for instructions on transferring DataMate to the calculator.
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

NOTE: Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Zeroing

In some situations you may want to zero the Force Plate, because changing the physical orientation of the sensor will change the reading when no force is applied. After you have set up your experiment, use your data-collection software to zero the sensor. Also, in the case of experiments involving large impact forces, you may need to zero the reading *after* one impact has taken place.

Specifications

Force range: –850 to +3500 N or –200 to +850 N, where positive value is a
   compression force

Maximum non-damaging force: 4500 N (1000 lb) compression or 900 N (200 lb)
   pull evenly distributed

12-bit resolution (LabQuest 2, LabQuest, LabQuest Mini, LabPro, Go! Link,
   TI-Nspire™ Lab Cradle, ULI): 1.2 N or 0.3 N

10-bit resolution (CBL 2™): 4.8 N or 1.2 N

Dimensions: 28 cm by 32 cm by 5 cm

Calibration function

slope (gain):	1000 N/V or 250 N/V
intercept (offset):	–1000 N or –250 N

$$\text{Force} = V_{out} * 1000 \text{ N/V} - 1000 \text{ N (3500 N range)}$$
$$\text{Force} = V_{out} * 250 \text{ N/V} - 250 \text{ N (850 N range)}$$

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, Go! Link, SensorDAQ, TI-Nspire™ Lab Cradle, 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.

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 850 N range if you can. If the forces exceed 850 N, you will need to use the 3500 N range. In normal use, the resolution with the different switch settings when used with a LabPro or LabQuest will be 1.2 N for the –1000/+3500 N range and 0.3 N for the –200/+850 N range.

The Handles – Pushes and Pulls

The Force Plate includes two handles with captive screws. You can attach the handles to either the top or bottom of the plate. Threaded holes for the handles are available on the bottom. For use on the top, you must remove four screws. We recommend attaching the handles by the bottom of the Force Plate.

With handles in place, you can support the unit by hand for pushing on a wall or other large object, or you can attach an optional second pair of handles for pulling experiments (order code FP-HAN). **Note:** the maximum force in extension is much less than the maximum force in compression.

Optional Calibration Procedure

You should not have to perform a new calibration when using the Force Plate. You can use the appropriate calibration file that is stored in your data-collection program from Vernier.

In many cases, you can simply load an experiment file that is designed for use with the Force Plate and you are ready to collect data. Select the correct file (3500 N or 850 N) to match your selected range setting on the sensor.

If you want to improve the calibration, it is easy to recalibrate following the same procedure used in calibrating most Vernier probes—a two-point calibration. One point is your zero, with no force applied to the sensor. Set the Force Plate on a level surface. Select the calibration option of the program you are using and remove all force from the Force Plate. Enter **0** (zero) as the first known intensity. Now apply a known force to the Plate. The easiest way to do this is to put an object of known weight on the Plate. The weight should be at least 25% of the range used for the plate (200 or 850 N); for example, exercise weights could be used. Enter the weight of the mass (**Note:** 1 kg weighs 9.8 N). Do not exceed the selected range setting during the calibration.

Calibrations are usually retained only for the current session. Restarting the software, opening a new file, or choosing New from the File menu will reset the calibration to the default calibration. To retain calibrations across sessions, consult the instructions or help files appropriate to your software. See also www.vernier.com/til/2342/

Suggested Experiments

- Analyze a crouched jump. Start with knees bent, hands on hips. Do NOT lower your body further; jump up only. Do not move arms. This very artificial jump is easier to analyze than a natural jump.
    a. Use the impulse of the force to find the change in momentum; find the jumper's velocity at take-off to estimate the jump height.
    b. Use the flight and kinematics to find the jump height.
    c. From the force *vs.* time graph, determine an acceleration *vs.* time graph. Integrate to find velocity and position *vs.* time graphs. Construct a plot of force *vs.* position, and use that to determine the work done on the jumper's center of mass by the floor. Since that work shows up as kinetic energy, use the energy to find the velocity at take-off.
- Repeat the above analysis for a natural jump, beginning with standing straight, crouching down, and then jumping. You will be able to jump higher this way, but the analysis will be more complex.
- Investigate the forces involved during the technique known as "unweighting" during ski or snowboard turns. Can you easily cut your apparent weight?
- Take the Force Plate on an elevator ride. Stand on the Force Plate, and record the force of the elevator floor on your feet as a function of time. Explain. Can you determine the speed of the elevator from the data?

References

1. R. Cross, "Standing, Walking, Running, and Jumping on a Force Plate," Am. J. Phys, 67(4), 304-309 (1999).
2. N.P. Linthorne, "Analysis of Standing Vertical Jumps Using a Force Platform," Am. J. Phys. 69(11), 1198-1204 (2001).
3. Haugland, "Physics Measurements for Sports," Phys. Teach. 39. 350–353 (Sept. 2001).

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.