# 25-g Accelerometer

## (Order Code ACC-BTA)

The 25-g Accelerometer can be used for a wide variety of experiments and demonstrations, both inside the lab and outside.

**Note:** Vernier products are designed for educational use. Our products are not designed nor are they 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.

## Compatible Software

See **www.vernier.com/manuals/acc-bta** for a list of software compatible with the 25-g Accelerometer.

## Getting Started

1. Connect the sensor to the interface (LabQuest Mini, LabQuest 3, etc.).
2. Start the appropriate data-collection software (Vernier Graphical Analysis®, LabQuest® App, or Logger *Pro*™) if not already running, and choose New from File menu. The software will identify the sensor and load a default data-collection setup. You are now ready to collect data.

If you are collecting data using a Chromebook™, mobile device such as iPad® or Android™ tablet, or a Vernier wireless interface, please see the following link for up-to-date connection information:

**www.vernier.com/start/acc-bta**

## Calibrating the Sensor

### Optional Calibration Procedure

You do not need to calibrate this sensor. Each sensor is calibrated prior to being shipped to you. The measurement being made by this sensor is complex and can be difficult to analyze, so be sure to read the Frequently Asked Questions section below. In most experiments you can simply use the default calibration, but then use the software's zeroing option and zero the sensor in the appropriate orientation.

Most accelerometers, including this one, sense gravity as well as acceleration. This can make results more difficult to understand, but it provides an easy calibration method. Calibration may be done using the acceleration due to gravity. To calibrate the sensor for measuring acceleration in the horizontal direction, position the accelerometer with the arrow pointing down for the first calibration point. Define this as –9.8 m/s$^2$ or –1*g*. Rotate the accelerometer so the arrow points up and use the reading for the second calibration point. Define this as +9.8 m/s$^2$ or +1*g*. The accelerometer will then read 0 with no acceleration when held horizontally. If you want to calibrate for measuring acceleration in the vertical direction, follow the procedure above, but define the first calibration point as 0*g* or 0 m/s$^2$ and the second point as 2*g* or 19.6 m/s$^2$.

## Specifications

| | |
|---|---|
| Power | 30 mA @ 5 VDC |
| Range | ±245 m/s$^2$ (±25*g*) |
| Accuracy | ±2.45 m/s$^2$ (±0.25*g*) |
| Frequency response | 0–100 Hz |
| 12-Bit resolution | 0.16 m/s$^2$ |
| Stored calibrations for the 25-g Accelerometer | slope: 127.9 m/s$^2$/V<br>intercept: –287.9 m/s$^2$ |

## Care and Maintenance

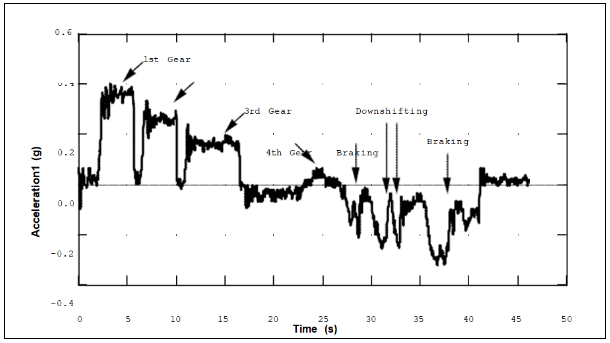
Do not wrap the cable tightly around the sensor for storage. Repeatedly doing so can irreparably damage the wires and is not covered under warranty.

## How the Sensor Works

The accelerometer senses acceleration using an integrated circuit (IC) originally designed to control the release of air bags in an automobile. This IC is micro-machined with very thin "fingers" carved in silicon. These fingers flex when accelerated. They are arranged and connected like the plates of a capacitor. As the fingers flex, the capacitance changes, and a circuit included in the IC monitors the capacitance, converting it into a voltage. The op-amp circuit on our circuit board amplifies and filters this signal.

The accelerometer measures acceleration along the line marked by the arrow on the sensor. Accelerations are normally measured in either meters per second per second (m/s$^2$) or *g*. One *g* is the acceleration due to gravity at the Earth's surface, or 9.8 m/s$^2$. This accelerometer will measure accelerations in the range of –25*g* (–250 m/s$^2$) to +25*g* (250 m/s$^2$). Even though this is a fairly large acceleration, it is easy to produce accelerations larger than this in collisions. In fact, dropping the accelerometer on a hard surface from even a few centimeters can produce accelerations of 100*g*. The accelerometer will not be damaged by accelerations up to 1000*g*.

There is inherent noise in the sensing device inside the accelerometer. This limits the use in low acceleration environments. The noise is typically on the order of 2.5 m/s$^2$ peak to peak. Therefore, best results are achieved if the experiments are designed around magnitudes or changes exceeding 9.8 m/s$^2$. The zero will drift with temperature.




*Using the accelerometer in a manual-shift car*

## Suggested Experiments

Some suggested activities in the laboratory include the following:

- Measure acceleration during a collision.
- Measure acceleration for motion in a horizontal circle. Study the relationship between acceleration and period, acceleration and radius, and acceleration and mass.
- Measure acceleration for motion in a vertical circle.
- Put the accelerometer under your belt buckle, and jump up and down. Measure the acceleration as you land, both with a regular knee bend and a deep knee bend (do not land with locked knees).
- Have a packing contest. Challenge people to pack the accelerometer in a box and to minimize the deceleration when it is dropped from a specified height. Note that you need to orient the accelerometer (and the box) so that the accelerometer measures properly. It can only measure acceleration along the line marked by the arrow.

If you have a data-collection interface that allows you to collect data away from the lab, you might try to measure acceleration

- in a car
- on amusement park rides
- on playground equipment, such as merry-go-rounds and swings
- of bicyclists, skiers, or bungee jumpers, etc.

## Frequently Asked Questions on Accelerometer Measurements

Since the accelerometer is sensitive to both acceleration and the Earth's gravitational field, interpreting accelerometer measurements is complex. A useful model for understanding accelerometer measurements is a spring-based scale with a reference mass (or object) attached to the scale. If the scale is pointing upward (the usual orientation for such a device) the weight of the mass causes the spring to compress, and you get a non-zero reading. If you were to turn the scale upside down, the spring will be extended, instead of compressed, and we get a reading of the opposite sign. If you turn the scale so it points sideways, and keep it motionless, then the spring will just be at its relaxed length, and the reading will be zero. If you accelerated the scale *toward* the mass, the spring would compress. If you accelerated the scale *away* from the mass, the spring would stretch. In each case the scale is reading a value corresponding to the normal force on the mass. This reading can be made relative by dividing out the mass, giving units of N/kg, which is the same as m/s$^2$.

The accelerometer measurements can be interpreted in exactly this way.

**Q: What does an accelerometer measure?**

A: Normal force per unit mass.

Note that it's not the net force per unit mass (which would be acceleration), but it is the normal force per unit mass. This somewhat unusual quantity corresponds with what a rider on a roller coaster feels during the turns. This interpretation is useful even for the scalar total acceleration value, which is 9.8 N/kg for a three-axis accelerometer at rest, 0 N/kg for one in free fall, and greater than 9.8 N/kg for one making a corner.

This normal force interpretation works even for a one-axis accelerometer being accelerated in a horizontal direction. The reading is non-zero as the test mass inside the device has to have a force applied to accelerate it. That's just a normal force that happens to be horizontal.

When discussing the accelerometer reading, we can call it the Normal Force per Unit Mass, with units of N/kg.

**Q: I thought the accelerometer measured acceleration!**

A: Here we are being very careful to not call something an acceleration when it is not a kinematic acceleration. For example, an "acceleration" of 9.8 m/s$^2$ for an object that remains at rest is clearly a problematic interpretation, yet that's what the accelerometer reads.

You can correct the accelerometer reading to get a true acceleration by adding the component of the gravitational acceleration field along the direction of the sensor arrow. For example, if the axis of the accelerometer is pointing upward, then the gravitational component is –9.8 m/s$^2$. The accelerometer reads 9.8 m/s$^2$ when the arrow is upward and the device is at rest. By adding –9.8 m/s$^2$, we get zero, which is the correct acceleration. If the arrow is horizontal, then the reading is zero, but the gravitational component is zero, and we still have zero for the true acceleration. If an accelerometer is zeroed to remove the influence of gravity while vertical, the zeroing is later wrong if the accelerometer is rotated to be horizontal.

**Q: What about *g*-force measurements?**

A: We avoid the term *g*-force because the quantity doesn't have units of force. Instead, *g*-factor can be used as a simplified label for Normal Force per Unit Mass in axis labels and discussions.

You can see that the *g*-factor is then 1 for an object sitting at rest on a table, zero in free fall, etc. The *g*-factor is dimensionless. If the Normal Force is a vector, then so is the *g*-factor. *g*-factor is completely optional–it is just a shortcut to avoid a long name.

## Troubleshooting

For troubleshooting and FAQs, see **www.vernier.com/til/1411**

## Repair Information

If you have watched the related product video(s), followed the troubleshooting steps, and are still having trouble with your 25-g Accelerometer, contact Vernier Technical Support at support@vernier.com or call 888-837-6437. Support specialists will work with you to determine if the unit needs to be sent in for repair. At that time, a Return Merchandise Authorization (RMA) number will be issued and instructions will be communicated on how to return the unit for repair.

## Warranty

Warranty information for this product can be found on the Support tab at **www.vernier.com/acc-bta**

General warranty information can be found at **www.vernier.com/warranty**

## Disposal

When disposing of this electronic product, do not treat it as household waste. Its disposal is subject to regulations that vary by country and region. This item should be given to an applicable collection point for the recycling of electrical and electronic equipment. By ensuring that this product is disposed of correctly, you help prevent potential negative consequences on human health or on the environment. The recycling of materials will help to conserve natural resources. For more detailed information about recycling this product, contact your local city office or your disposal service.

The symbol, shown here, indicates that this product must not be disposed of in a standard waste container.

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