Motion Detector 2
(Order Code MD-BTD)

The Motion Detector is used to collect position, velocity, and acceleration data of moving objects. Students can study a variety of motions with the Motion Detector, including

- Walking toward and away from the Motion Detector
- Dynamics carts moving on track
- Objects in simple harmonic motion, such as a mass hanging on a spring
- Pendulum motions
- Objects dropped or tossed upward
- A bouncing object

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.

What's Included
- Motion Detector
- Digital Sensor Cable

Compatible Software and Interfaces
See **www.vernier.com/manuals/md-btd** for a list of interfaces and software compatible with the Motion Detector.

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 sensor or interface, please see the following link for up-to-date connection information:

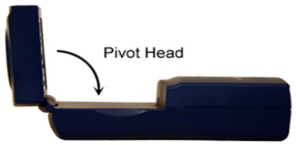
www.vernier.com/start/md-btd

Using the Product
Connect the sensor following the steps in the Getting Started section of this user manual.

Note: Connect the Motion Detector to the interface using the included Digital Sensor Cable. Connect the cable to the DIG/SONIC port on the side of the Motion Detector. Connect the other end of the cable to a DIG port on the interface.

Here are some suggestions for getting good results with the Motion Detector:

- The Motion Detector is capable of measuring objects as close as 0.15 m and as far away as 6 m. The short minimum target distance allows objects to get close to the detector, which reduces stray reflections.
- The Motion Detector has a pivoting head, which helps you aim the sensor accurately. For example, if you wanted to measure the motion of a small toy car on an inclined plane, you can lay the Motion Detector on its back and pivot the Motion Detector head so that it is perpendicular to the plane.



- The Motion Detector has a Sensitivity Switch, which is located under the pivoting Motion Detector head. To access it, simply rotate the detector head away from the detector body.
  - Slide the Sensitivity Switch to the right to set the switch to the Ball/Walk setting. This setting is best used for experiments such as studying the motion of a person walking back and forth in front of the Motion Detector, a ball being tossed in the air, pendulum motion, and any other motion involving relatively large distances or with objects that are poor reflectors (e.g., coffee filters).
  - The Track sensitivity setting works well when studying motion of carts on tracks like the Dynamics Cart and Track System, or motions in which you want to eliminate stray reflections from objects near to the sensor beam.

Videos
View videos related to this product at **www.vernier.com/md-btd**

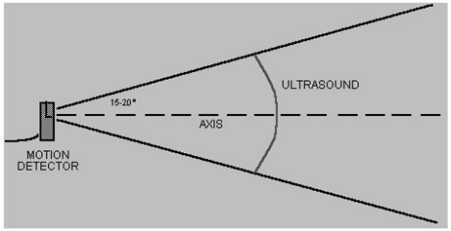
Calibration
You cannot perform a traditional two-point calibration of the Motion Detector. But in most cases, calibration is unnecessary. You can make several adjustments to the readings by zeroing and changing the direction of the coordinate system. You can find details on how to adjust Motion Detector readings at **www.vernier.com/til/2972**/

Specifications

Range	0.15 to 6 m
Accuracy	≤ ±1.0% FS
Resolution	1 mm

How the Sensor Works

This Motion Detector emits short bursts of ultrasonic sound waves from the gold foil of the transducer. These waves fill a cone-shaped area about 15 to 20° off the axis of the centerline of the beam. The Motion Detector then "listens" for the echo of these ultrasonic waves returning to it. The equipment measures how long it takes for the ultrasonic waves to make the trip from the Motion Detector to an object and back. Using this time and the speed of sound in air, the distance to the nearest object is determined.



Note that the Motion Detector will report the distance to the closest object that produces a sufficiently strong echo. The Motion Detector can pick up objects such as chairs and tables in the cone of ultrasound.

The sensitivity of the echo detection circuitry automatically increases, in steps, every few milliseconds as the ultrasound travels out and back. This is to allow for echoes being weaker from distant objects.

Troubleshooting

The most frequently reported problems with a Motion Detector are that it does not work beyond a certain distance or that the graph is very noisy. Try these troubleshooting tips in such situations.

1. See if the Sensitivity Switch makes a difference. Set the Sensitivity Switch to the other position and retry the experiment. This change may solve the problem.
2. The Motion Detector does not work beyond a certain distance (e.g., it does not detect anything beyond 1.2 m). Here are some things to check if you have this problem:
   - Check for movable objects (textbooks, ring stands, etc.) in the cone of the ultrasound. If possible, move these objects out of the measurement cone. It may not take a very large object to cause problems.
   - Check for a stationary object (chair, table, etc.) in the cone of the ultrasound. This object may be detected when you are trying to study an object farther away. It may not take a very large object to cause problems. If you have trouble with a stationary object causing unwanted echoes, try setting the equipment up so that the objects are not in the cone or placing a cloth over the object. This minimizes the ultrasound reflection.
   - Also note that the cone of ultrasound extends downward from the center line. This can cause problems if you are using the Motion Detector on a hard, horizontal surface. In these cases, try pivoting the head of the Motion Detector to aim it slightly upward.

3. Noisy or erratic data may have a number of causes. Here are some tips.
   - Sometimes other sound sources can cause problems. If there is another source of ultrasonic waves in the same frequency range, this will cause erroneous readings. Examples include motors and fans, air track blowers, the sound made by the air exiting the holes on an air track, etc. Try to eliminate these sources of noise. If you are using an air track, try changing the air flow volume.
   - Make sure that the Motion Detector is not placed close to a computer or computer monitor.
   - If the room in which the Motion Detector is being used has a lot of hard, sound-reflecting surfaces, you can get strange effects caused by the ultrasound bouncing around the room. Standing waves can be set up between the Motion Detector and a sound reflector. Try placing a cloth horizontally just in front of and below the Motion Detector. This sometimes helps eliminate ultrasound that is "skipping" into the Motion Detector.
   - Try changing the data-collection rate. Sometimes Motion Detectors work better at one data rate than another. Rates above 30 Hz do not work well in acoustically live rooms.
   - If you are studying people moving, have them hold a large, flat object (e.g., a large book or a pizza box) as a reflector. If you have an irregular reflecting surface, sometimes the waves will be reflected back to the transducer, and sometimes not. The results will seem erratic.

An excellent discussion of motion detector theory and operation can be found in "Physics and Technical Characteristics of Ultrasonic Sonar Systems", Dan MacIsaac and Ari Hamalainen, *The Physics Teacher 40*, 39–46 (January 2002).

For additional troubleshooting tips and FAQs, see **www.vernier.com/til/1374**

Repair Information

If you have watched the related product video(s), followed the troubleshooting steps, and are still having trouble with your Motion Detector, 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.

Accessories/Replacements

Item	Order Code
Digital Sensor Cable	MDC-BTD
Digital Extension Cable	EXT-BTD
Motion Detector Clamp	MD-CLAMP

Warranty

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

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

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