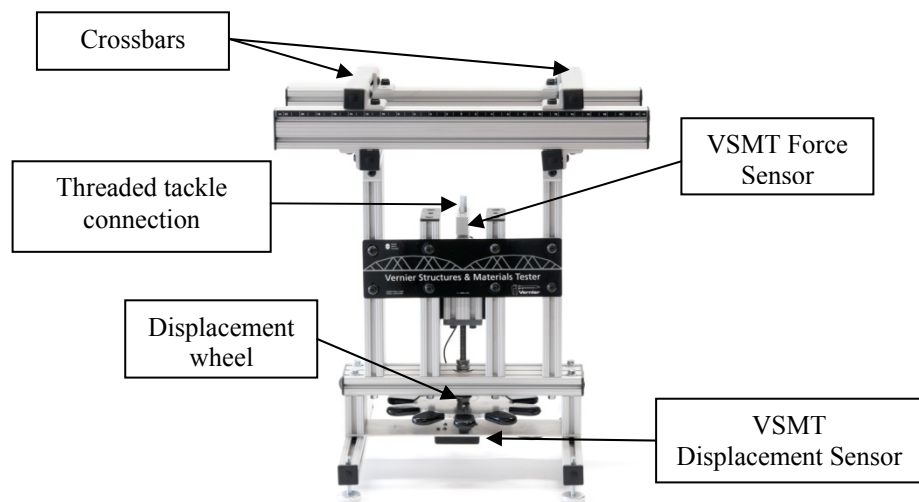


# Vernier Structures & Materials Tester

(Order Code: VSMT)

The Vernier Structures & Materials Tester (VSMT) is an excellent platform for testing bridges, structures, and beams as part of an engineering design activity. Use the Tester, along with the engineering design process, to design, build, and test structures, conduct bridge competitions, and investigate and analyze beam designs and properties of materials.



## VSMT Assembly Video

The VSMT requires minor assembly when first removed from the shipping box. Assembly instructions are included with the VSMT and a short video demonstrating assembly is available at [www.vernier.com/vsmt](http://www.vernier.com/vsmt)

## About the Tester

The Tester is equipped with a VSMT Force Sensor (rated to 1000 N) and a VSMT Displacement Sensor (0.1 mm resolution). Having both sensors allows you to record maximum breaking loads, as well as load/displacement characteristics to allow students to evaluate deflection, stress, and strain. Include *Logger Pro* video analysis with your sensor measurements to provide another method of structure analysis.

The crossbars of the Tester are designed to easily slide and secure into position. Rulers located on the Tester allow you to accurately position the support beams for center or off-center loading.

The Tester is equipped with a well-outfitted VSMT Tackle Kit. The Kit provides a variety of means to quickly and easily connect the load cell to materials, beams, and structures for testing. The VSMT Tackle Kit is also sold as an accessory kit (VSMT-TK). A second Kit may be useful in cases where large numbers of structures are being tested, such as bridge competitions.

## What is Included with the Vernier Structures & Materials Tester

- The testing device with force and displacement sensors
- Allen wrench for initial assembly
- A VSMT Tackle Kit with hardware to connect bridges, structures, and materials to the tester. This includes:
  - (1) 50 × 50 mm × 6 mm aluminum load plate
  - (1) 50 × 80 mm × 6 mm aluminum load plate
  - (1) 12 inch threaded rod
  - (1) 8 inch threaded rod
  - 6.5 inches of chain
  - (1) small U-bolt
  - (1) large U-bolt
  - (2) eyebolts
  - (1) coupling nut
  - (2) quick links

## General Use

Connecting your structure or material to the device securely is critical to the safe and proper use of the VSMT. The VSMT Tackle Kit comes with a variety of components that can be used in combination to secure the item to the VSMT frame and connect to the VSMT Force Sensor. All structures and materials are generally supported by the crossbars that can be adjusted from 0 cm to over 40 cm. The bars can be secured in place by finger tightening the thumb screws or gently tightening the screws with a screw driver.

The primary methods of attaching the tackle to the structure/material are to use a U-bolt in combination with quick links and chain or by using a threaded rod and loading plate.





*The beam on the left is secured using a U-bolt and quick links while the structure to the right is secured using a threaded rod attached to a metal loading plate.*

Once the structure or beam is secured in place with the appropriate tackle, connect the VSMT Force and VSMT Displacement Sensors to an interface. Open the appropriate experiment file if using *Logger Pro*. Zero the sensors and start data collection. Turn the displacement wheel in the direction of the arrows (counter clockwise) and the Force Sensor travels down, applying a force to the structure or beam via the tackle. The VSMT Force Sensor registers the force while the VSMT Displacement Sensor tracks how far the structure has been deflected, bent, or stretched.



*The VSMT Displacement Sensor is mounted below the wheel. Turning the wheel pulls the Force Sensor down, applying a force to the structure above.*

### Safety

The VSMT is capable of storing energy as it applies force to structures being tested. When structures fail under stress they can release that energy very quickly. Vernier recommends the use of safety glasses when using the VSMT to protect eyes from flying debris.

It is also important to connect the tackle securely. Threaded parts should be attached so that a sufficient amount of the threaded component is engaged. For example, the threaded rod should extend through the load plate so that its end is at least flush with the upper surface. Quick links should be secured and not left open.

### Sensor Auto-ID

The VSMT Force Sensor is equipped with circuitry that supports auto-ID. When used with LabQuest<sup>®</sup> 2, LabQuest, LabQuest Mini, LabPro<sup>®</sup>, SensorDAQ<sup>®</sup>, or TI-Nspire™ the data-collection software identifies the VSMT Force Sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

The VSMT Displacement Sensor does not auto-ID. If you open an experiment file for the VSMT, it will prompt you to confirm the VSMT Displacement Sensor is connected to the DIG1 port. If you do not open an experiment file, you will have to manually set up the VSMT Displacement Sensor. To set up the VSMT Displacement Sensor in *Logger Pro* manually choose Setup Sensors from the Experiment menu, click on the interface being used, click on the port the sensor is connected to (e.g., DIG 1) and select the VSMT Displacement Sensor from the list. To set up the VSMT Displacement Sensor in LabQuest or LabQuest 2, choose Sensor Setup from the Sensors menu. Tap on the port the sensor is connected to (e.g., DIG 1) and choose VSMT Displacement from the list.

The Go! Link interface will recognize the VSMT Force Sensor, but the VSMT Displacement Sensor cannot be connected via a Go! Link.

### Zeroing the Sensors

Zero both of the sensors before any data collection. The VSMT Displacement and VSMT Force Sensors should be zeroed with the tackle slack but attached to the structure or beam as it will be *just prior* to applying a force.

If a structure is attached to the VSMT Force Sensor by means of a rigid connection (e.g., a threaded rod), the tackle is supported by the Force Sensor. If this is zeroed prior to testing then the sensor will measure only the force actually applied to the structure.

If a structure is attached to the VSMT Force Sensor by means of a non-rigid connection (e.g., U-bolt, quick link and chain) then the weight of the tackle is an additional force that is applied to the structure. Account for the weight of the tackle by entering the mass of the tackle in the provided User Parameter ("MassTackle") in the experiment files. Note that this is only an option for *Logger Pro*. Address this in LabQuest and LabQuest 2 by adding a new calculated column.

### Data Collection

Essential steps for using the VSMT using *Logger Pro*:

1. Connect the VSMT Force Sensor and VSMT Displacement Sensor to an interface, such as a LabQuest Mini. Connect the interface to your computer.
2. Open *Logger Pro* and it will identify the VSMT Force Sensor and load a default data-collection setup. The default file does not include the VSMT Displacement Sensor.
3. Open the appropriate experiment file by choosing Open from the File menu and choosing Probes & Sensors. Choose Structures and Materials Tester to open the folder and choose the appropriate file.
4. Confirm that the VSMT Displacement Sensor is connected to DIG1 when prompted.
5. You are now ready to collect data.

Essential steps for using the VSMT using the LabQuest App (Original LabQuest or LabQuest 2):

1. Connect the VSMT Force Sensor and VSMT Displacement Sensor to LabQuest.
2. Choose Sensors Setup from the Sensors Menu. Tap on the appropriate digital port and choose VSMT Displacement.
3. You are now ready to collect data.

## Suggested Activities

### Individual Structure Analysis

#### Experiment File:

#### Probes and Sensors/Structures & Materials Tester/Structure Prototype

This experiment file is designed to allow the student to test a single unit and evaluate its performance and failure mechanism. Combine this experiment file with Video Capture to analyze the point of failure, develop explanations, and re-design the structure to improve performance. This file is at the heart of the engineering design process.

Enter the mass of the bridge (aka “structure”) and the mass of any non-rigid tackle (see comments under Zeroing the Sensors). Play back the video and synced data to see what element of the structure broke and how much force it withstood. The second page of this file provides a template to include video capture or import a movie of the test.

### Class Bridge Design

#### Experiment File:

#### Probes and Sensors/Structures & Materials Tester/Structures Comparison

The VSMT is an ideal tool to use for class bridge and structure engineering and design competitions. Students can test their bridges or other structures to determine the maximum force or efficiency (force/weight of bridge). The experiment file *Structures Comparison* allows for side-by-side comparison of students' results.



Enter the mass of the bridge (aka “structure”) and the mass of any non-rigid tackle (see comments under Zeroing the Sensors), if any is being supported by the structure. Rename the run with the student's name and watch as the efficiency of the bridge is tracked real time during the test on the bar chart. The force vs. time data are displayed on the top graph.

### Evaluating Deflection of a Beam Supported on Both Ends

#### Experiment File:

#### Probes and Sensors/Structures & Materials Tester/Elastic Modulus Moment of Inertia

Students can explore properties of materials and beam construction. This experiment file is designed around the deflection of a beam supported on both ends and loaded by a downward force at its center.

The three pages of this file explore different aspects of this equation:

$$\Delta = \frac{Fl^3}{48EI}$$

where  $\Delta$  is the deflection of the beam,  $F$  is the force applied,  $l$  the length between the supports,  $E$  the modulus of elasticity and  $I$  the moment of inertia (by area) of the beam.

The first page of this experiment file will allow students to determine the modulus of elasticity for the material being tested using a rectangular beam with known dimensions. Compare your results to published values. The second page allows students to conduct subsequent tests of other rectangular beams to evaluate how the predicted deflection compares with actual results. The final page allows students to test different beam configurations (e.g., I-beam, box, etc.) to determine the effective moment of inertia and evaluate the effectiveness of the construction.

## Specifications

### VSMT Force Sensor

Operational range	0 to 1000 N
Safety range (maximum force without damage done to sensor)	0 to 1300 N
Resolution	
12-bit (LabPro, LabQuest, LabQuest 2, LabQuest Mini, Go!Link)	1 N
Stored calibration values	
slope	241.9 N/V
intercept	-107.6 N

### VSMT Displacement Sensor

Range	0 to 7 cm
Resolution	0.1 mm displacement (22.5° of wheel rotation)

## How the VSMT Displacement Sensor Works

The VSMT Displacement Sensor uses a quadrature optical (incremental type) encoder to measure the amount and direction of rotation. The encoder, which is attached to the threaded rod that causes the force sensor to move up or down, consists of a coded pattern of opaque and transparent sectors. The quadrature encoder produces two pulse output patterns 90° apart in phase. The movement of the threaded rod is determined by counting the pulses. The phase relationship between the output signals determines the direction of rotation. The encoder counts a pulse every 22.5° or 16 pulses per revolution of the wheel.

The VSMT uses this count to determine the revolutions of the wheel (or fractions, thereof). The VSMT Displacement Sensor and the VSMT Force Sensor are linked by a threaded rod with a pitch of 16 (16 threads per inch). For each counter clockwise revolution the Force Sensor moves down 1/16 of an inch.

## Collecting Data with the Vernier Structures & Materials Tester

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

- Vernier LabQuest Mini with a computer
- Vernier LabQuest 2 or original LabQuest as a standalone device or with a computer
- Vernier LabPro with a computer or TI graphing calculator
- SensorDAQ with a computer
- TI-Nspire™ Lab Cradle

## Data-Collection Software

This sensor can be used with one of the above interfaces and the following data-collection software.

- **Logger Pro 3** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, or LabPro. Version 3.9 or newer is required.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, or LabPro. Version 1.8 or newer is required. Note that Logger Lite does not support Experiment Files or Calculated Columns. As a result the software will only provide direct readings from the sensors.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device. Versions 1.7.3 for the original LabQuest or 2.5 for the LabQuest 2, or newer, are required.
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. LabVIEW is commonly used with SensorDAQ and can be used with a number of other Vernier interfaces. See [www.vernier.com/labview](http://www.vernier.com/labview) for more information.

**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.

## Optional Calibration Procedure

You should not have to perform a calibration when using the VSMT. The VSMT Force Sensor comes pre-calibrated, and you can simply use the appropriate calibration value that is stored in the data-collection program. In many cases, you can load an experiment file that is designed for use with the VSMT, and you are ready to collect data.

If you want to improve the calibration, recalibration is allowed. Follow the same procedure used in calibrating most Vernier sensors—a two point calibration.

- **First Calibration Point** 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.
- **Second Calibration Point** The second point can be set by lifting the VSMT by the eyebolt. This allows you to maintain the sensor in the orientation that it will be used. Enter the weight of the VSMT for the second calibration point. **Note:** This weight should be approximately 60–70 N. This must be determined with properly calibrated scale.

The VSMT Displacement Sensor cannot be calibrated. The device counts fractions of rotations and converts that value into a linear displacement based on the pitch of the threaded rod.

## Accessories

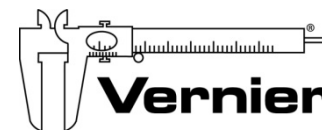
Name	Order code
VSMT Tackle Kit	VSMT-TK

### VSMT Tackle Kit (order code: VSMT-TK)

Teachers may wish to have a second VSMT Tackle Kit in order to efficiently run a class activity with several structures to be tested.

## 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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