Flow Rate Sensor
(Order Code FLO-BTA or FLO-DIN)

The Flow Rate Sensor measures the velocity of water in a river, stream, or canal. It can be used to study the discharge, flow patterns, and sediment transport of a stream or river.

Inventory of Items Included with the Flow Rate Sensor
Check to be sure that each of these items is included in your Flow Rate Sensor package:
• Flow Rate Sensor (impeller rod with 5 meter cable)
• Three riser rods (short, medium, and long)
• Flow Rate Sensor booklet

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

Equipment Setup
• To assemble the Flow Rate Sensor, simply unfold the four sections of the impeller rod and slide them together. Connect the rods to one another with a small push. To store the sensor, pull the rods apart and fold up the impeller rod. When the impeller rod is fully assembled, the distance between the impeller and the top of the rod is 1 m. The total length of the impeller rod, including all 3 risers, is 1.5 m.

Using the Flow Rate Sensor with a Computer
This sensor can be used with a computer and any of the following lab interfaces: LabPro, Go!Link, Universal Lab Interface, or Serial Box Interface.
1. Connect the Flow Rate Sensor, interface, and computer.
2. Start the Logger Pro® software or Logger Lite.
3. The program will automatically identify the Flow Rate Sensor, and you are ready to collect data.¹

Using the Flow Rate Sensor with TI Graphing Calculators
This sensor can be used with a TI graphing calculator and any of the following lab interfaces: LabPro, CBL 2™, or CBL™. Here is the general procedure to follow when using the Flow Rate Sensor with a graphing calculator:
1. Load a data-collection program onto your calculator:
   • LabPro or CBL 2-Use the 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 the Receive mode, and then press the Transfer button on the interface.
   • Original CBL-Use the CHEMBIO program. This program is available free on our web site at www.vernier.com. Load the program into a calculator using TI-GRAF LINK™ or TI Connect.
2. Use the calculator-to-calculator link cable to connect the interface to the TI graphing calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
3. Connect the Flow Rate Sensor to any of the analog ports on the interface. In most cases, Channel 1 is used.
4. Start the data-collection program. The Flow Rate Sensor will be identified automatically.²
5. You are now ready to collect data.

Using the Flow Rate Sensor with Palm OS Handhelds
1. Connect the Palm OS handheld, LabPro, and the Flow Rate Sensor.
2. Start Data Pro.
3. Tap New, or choose New from the Data Pro menu. Tap New again. The Flow Rate Sensor will be identified automatically.³
4. You are now ready to collect data.

Storage and Maintenance of the Flow Rate Sensor
When you have finished using the Flow Rate Sensor, simply rinse it with clean water and dry it using a paper towel or cloth. The probe can then be folded up and stored.

To prolong the life of your Flow Rate Sensor, we recommend that the moving parts of the impeller rod be lubricated with WD-40®, or a similar lubricant, after every few field uses.

When using the impeller rod, avoid hitting the impeller blade on rocks and other hard surfaces. If the impeller blade is bent, it will decrease the accuracy of the sensor.

¹ If your system does not support auto-ID, open an experiment file in Logger Pro, and you are ready to collect data.
² If your system does not support auto-ID, choose SETUP and set up an experiment.
³ If your sensor does not auto-ID, tap Setup and set up an experiment.
Specifications
Range: 0 to 4.0 m/s (0 to 13 ft/s)
Resolution: (with LabPro, ULI II or Serial Box Interface) 0.0012 m/s
(with CBL, CBL 2 or original ULI) 0.005 m/s
Accuracy: ±1% of full-scale reading
Response time: 98% of full-scale reading in 5 seconds, 100% of full-scale in 15 seconds
Temperature range (can be placed in): 0 to 70°C
Slope = 1 m/s/V Intercept = 0 m/s

This sensor is equipped with circuitry that supports auto-ID. When used with LabPro, Go! Link, or CBL 2, the data collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. This greatly simplifies the setup procedures for many experiments. Auto-ID is required for the Quick Setup feature of LabPro and CBL 2 when the unit operates remotely from the computer or calculator.

How the Flow Rate Sensor Works
The Vernier Flow Rate Sensor measures the velocity of flowing water. When placed in a stream, as shown here, water flows against the blades of the impeller, causing it to turn. The faster the water flows, the faster the impeller turns. A bar magnet rotating with the impeller triggers a reed switch with each half rotation. The switch sends a pulse to the signal conditioning box, where the pulses are converted into a voltage that is proportional to flow rate. Flow rate can be measured in m/s or ft/s.

Do I Need to Calibrate the Flow Rate Sensor? “No.”
We feel that you should not have to perform a new calibration when using the Flow Rate Sensor in the classroom. We have set the sensor to match our stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier in any of these ways:
1. If you ordered the FLO-BTA version of the sensor, and you are using it with a LabPro or CBL 2 interface, then a calibration (in m/s) is automatically loaded when the Flow Rate Sensor is connected.
2. If you are using Logger Pro software (version 2.0 or newer) on a Macintosh or Windows computer, open an experiment file for the Flow Rate Sensor, and its stored calibration will be loaded at the same time. 

Note: If you have an earlier version of Logger Pro, a free upgrade is available from our web site.
3. Any version of the DataMate program (with LabPro or CBL 2) has stored calibrations for this sensor.
4. Any version of the CHEMBIO program (for CBL), version 4/1/00 or newer, has stored calibrations for this sensor. Go to our web site, www.vernier.com, to download a current version.
5. Any version of the DataPro program (for Palm OS devices) has stored calibrations for this sensor.

Uses of the Flow Rate Sensor
Calculating Discharge
To determine the amount of water flowing in a stream, you need to measure the rate at which the water flows and the area the water occupies at a specific point in the stream. The discharge, or stream flow, is the flow rate multiplied by the area of water.

Flow Rate × Area of Cross Section = Discharge or Stream Flow

Detailed instructions on collecting flow rate data and calculating discharge can be found in the next section of this booklet.

Sediment Transport
The amount of sediment and maximum particle size that can be transported by moving water is related to the flow velocity. Therefore, flow velocity data obtained using the Flow Rate Sensor can be used to determine what size particles will stay in motion at a particular flow velocity. This chart, derived from accumulated observed data, shows that for a given flow velocity there is a range of behavioral possibilities for sediment particles lying on the bed, or entrained within the flow, of a stream. For example, at a measured flow velocity of 1 m/s, silt and sand (though not compacted clay) will be eroded from the stream bed and transported downstream. At the same velocity, all sediment particles between 10 mm and 100 mm that were already in motion will continue in motion. Particles greater than 100 mm will be deposited. Thus, a Flow Rate Sensor can be a valuable observational tool when used in sediment transportation studies.
Describing Flows

Using the Flow Rate Sensor, it is possible to map flow characteristics of a stream by taking measurements at different spots and depths. To understand the flow characteristics within streams of moving water, it is helpful to construct Stream Lines and Vector Lines. The illustration shown here shows how Stream Lines depict possible paths of a single fluid particle.

Vector Lines represent both the flow rate and direction. The longer and broader the line, the greater the flow velocity. Vector Lines convey useful information about the stream flow characteristics.

Stream Flow (Sample Activity)

Site Selection

1. Select two sites within a 50 m stretch of the stream that are as far apart as possible and are representative of the stream as a whole. Avoid sites with bends or breaks in the stream caused by rocks or sandbars. Try to choose a site where some flow can be observed. One site can have a swift flow similar to that found in a riffle. The second site can have a moderate or slow flow like that found after a pool. It is not necessary for both sites to be the same.

2. At each site, you are going to take a cross section of the stream and measure its width and depth. Try to select a cross section that is shallow enough to measure depth with a meter stick and easy to cross. To measure stream flow using the Flow Rate Sensor, avoid sites where the stream depth is less than 10 cm.

3. The Flow Rate Sensor is equipped with a 5 m cable. This enables you to take measurements up to 4 meters away from the shore without carrying the interface out into the stream.

4. Always follow safety precautions when entering the stream. If the water is too deep or swift, select another site. Never venture out into the stream alone without another person available to assist you in case of emergency.

Testing Procedure

Measuring a Stream Cross Section

1. Using the measuring tape, determine the width of the stream cross section in meters and record the measurement on a data sheet. Divide the cross section into six equally spaced sections.

2. Using the meter stick, measure the depth of the stream in meters at each of the equally spaced points along the cross section. Record the depth and the distance out from one shore edge, in meters, on a data sheet. Always measure from the same shore. Be sure to include both the initial distance and depth and the final distance and depth.

Measuring Flow Velocity

3. Plug the Flow Rate Sensor into the interface and start the data-collection program.

4. Collect stream flow data.
   a. Use the Stream Flow experiment file in Logger Pro or set up Data Pro or DataMate for single point data collection.
   b. Submerge the impeller of the Flow Rate Sensor to about 40% of the depth measured at each section. If the section is shallow enough, use the plastic risers that are included with the flow rate sensor to support the sensor on the stream bed. The risers make it easier to keep the impeller of the sensor in the same spot and oriented in the same direction.
c. Point the impeller of the sensor upstream (as shown below) and directly into the flow. Select START or b Collect to begin sampling. Hold the sensor in place for 10 seconds while data are being collected. Once data collection is finished, the flow rate will be displayed. Record the reading on the Data & Calculations sheet. Repeat for each of the remaining sections.

Calculating Stream Flow
5. Create a graph of stream depth vs. distance from the shore.
6. Integrate the data. The integral value will give you the cross-sectional area of the stream.

Determining Discharge
7. Calculate the average velocity for each site.
8. To calculate the discharge or stream flow, multiply the average stream velocity by the cross-sectional area. Repeat for Site 2. To convert from m³/s to cubic feet per second, multiply by 35.315

Detailed instructions for data collection with computers using Logger Pro, TI graphing calculators using DataMate, and Palm OS handhelds using Data Pro may be found in our Water Quality with Computers, Water Quality with Calculators, and Water Quality with Handhelds lab books. The Stream Flow test is test number 16 in each of the books.

Additional Information for Instructors
Safety Tips
1. Follow safety guidelines when students are working in or near water. Avoid sites where the water is deep or swift. Water with a flow velocity of 0.5 m/s or greater is considered to be swift. Water with a depth greater than the top of your knee should be considered deep.
2. Never work alone around a stream. Students should always work with others in groups of 2-3. Do not allow students to wander away from their group. It is important to know where student groups are at all times. Students should not change locations without notifying their instructor first.
3. Before using a particular site, it is best to survey the area for unseen dangers, such as unstable banks, dangerous obstacles in the stream, or fallen trees. Avoid these possible dangers.
4. Always be careful when crossing a stream. If it looks dangerous, select another spot in the stream to cross.
5. Students should wear warm, waterproof clothes when working in a stream. If possible, they should bring spare items such as dry socks that can be worn after working in the water. Prolonged exposure to cold waters can result in hypothermia, which can be a life-threatening condition.

Additional Tips
1. The plastic risers that come with the Flow Rate Sensor can be very helpful in keeping the sensor at the same orientation while taking measurements. When using the risers, simply place the bottom of the sensor rod against the stream bottom. If you are unsure which riser to use, start with the medium riser first and gauge the depth from there.
2. When students are selecting sites to take flow measurements, they should choose a site where the stream is not split by rocks, partially submerged obstructions, or sand bars.
3. The impeller of the flow rate sensor should always be pointing into the flow when measurements are being made. Students need to stand on the shore when taking measurements close to the shore, or stand as far downstream as possible from the sensor when placing the sensor in deeper water.
4. Because stream flow is easily affected by weather conditions, it is important that good notes concerning date, time, and weather be taken whenever flow measurements are made.

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.