Infrared Thermometer

(Order Code IRT-BTA)

The Infrared Thermometer is a non-contact, fast-responding temperature measuring device. The sensor works by measuring the infrared radiation emitted by objects. For most objects, you simply point the sensor at the object and read its temperatures. Here are a few example uses of the sensor.

- Since the sensor responds so quickly, you can easily investigate skin temperature. For example, compare the temperature of your palm to the back of your hand, your forearm, or your foot.
- Demonstrate that most objects in the room are at equilibrium. For example, what is the temperature of the table top that feels cold? Compare its temperature to the temperature of the wall, the floor, or a book.
- Compare the surface temperatures of cars parked in the sun. Does color affect the surface temperature? Is the surface hot enough to cook an egg?
- On a sunny day compare the temperature of asphalt, concrete and lawn.

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.

Items Included with the Infrared Thermometer

Check to be sure that each of these items is included in your sensor package.

- Infrared Thermometer (order code IRT-BTA)
- Cable to connect the sensor to a data-collection interface (order code CB-IRT)
- 4 AAA batteries
- Omega Infrared Thermometer Manual

SAFETY INFORMATION: This sensor contains a laser that can be turned on and off. As with any laser, caution must be exercised when using the sensor. The sensor emits laser radiation, and therefore, should not be pointed at the eye. Pay special attention to the location of the aperture, which is located next to the sensing element. Direct eye contact with the laser beam may cause serious injury. Students should be reminded that this is not a toy, and it should be kept out of reach of children. It is recommended that you read the Omega sensor booklet that accompanies this sensor. It contains important safety information.

Infrared Thermometer Description

The Infrared Thermometer features automatic backlighting, simple on/off operation, and laser circle sighting. The sensor can be used as a standalone meter, or it can be connected to a data-collection interface.

The sensing element of the Infrared Thermometer is located at the end of the sensor. The sensor reading will appear in °C. When connected to a data-collection interface, data can be collected in other units, e.g., °F and K. To the side of the sensing element, you will find a clear plastic window. Behind this window is a laser that is used to aim the sensor. Do not look into this window when the laser is enabled.

The infrared temperature measurement of this sensor is based on a fixed value for the emissivity of the object. This value works well for lots of everyday objects, e.g., skin, wood, concrete, water, and glass; however there are objects that do not lend themselves to this measurement, such as shiny metals. (See the section entitled "How the Infrared Thermometer Works" for further information).

The sensor has a built-in light sensor located next to the MEAS button. This sensor controls the automatic backlighting feature.

The Infrared Thermometer is powered by 4 AAA batteries that are inserted into the back of the sensor. When the batteries are low, a low battery indicator will appear on the LCD.

Panel Buttons

MEAS This button turns the meter power on and off. When you press it once, the meter turns on. It will remain powered for 30 minutes, at which time it will automatically turn off. If you want to turn it off before then, press the MEAS button a second time.

Hold The Hold button is primarily used in the stand-alone mode. You can press the button to hold the current meter on the screen. The sensor output also remains at that value. If you are connecting the sensor to a data-collection interface, you probably will not use this button.

Laser button ( )–The laser button turns on a laser that shows a circular pattern. The pattern helps you identify the region from which the measurement is made. Note that if you are holding the object very close to the thermometer, parallax may prevent the laser sighting circle from representing the measurement area.

Operating the Infrared Thermometer

Here are the general operating procedures:

1. Turn the sensor over, remove the small screw on the back, and insert 4 AAA batteries. Replace the battery cover.
2. Press the MEAS button and point the sensor at an object to determine its temperature.
3. The temperature measurement is made from a circular region. This circular region gets larger as the sensor is moved away from the object. To better determine the region of the measurement, press the laser button ( ). The circular pattern shows the main region from which the measurement is made. To improve the accuracy, the measurement region should be 1.5 to 2 x the size of the circular laser pattern.
4. To turn the sensor off, press the MEAS button. **Note:** The sensor will automatically shut off in 30 minutes.

Connecting the Infrared Thermometer to Vernier products

The Infrared Thermometer package includes a removable cable (order code CB-IRT). Connect the mini-plug end of the cable into the bottom of the sensor. Connect the other end to the data-collection interface, e.g., Vernier LabPro, LabQuest 2, LabQuest, Go! Link, CBL 2™, EasyLink, or SensorDAQ.

Collecting Data with the Infrared Thermometer

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™

Here is the general procedure to follow when collecting data with the Infrared Thermometer.

1. Connect the Infrared Thermometer to the interface.
2. Start the data-collection software.
3. The software will identify the Infrared Thermometer 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 is used as a standalone device.
- **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.

Specifications

Temperature range: –20°C to 400°C

Operating temperature range: 0°C to 50°C at < 70% relative humidity

Display resolution: 1°C

Accuracy: ±2% of reading or ±3°C, whichever is greater @ 18 to 28°C ambient operating temperature

Response time: 1 second

Display resolution on the meter: 1°C

Spectral response: 6 to 14 µm nominal

Emissivity: preset 0.95

Detection element: Thermopile

Field of view: 65 mm diameter circle at 1000 mm range

Average battery life: 100 hours (laser and backlight not illuminated)

This sensor ships with a cable that is equipped with circuitry that supports auto-ID. When used with LabPro, LabQuest 2, LabQuest, LabQuest Mini, Go! Link, CBL 2™, or EasyLink, 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.

How the Infrared Thermometer Works

All objects emit infrared radiation. The amount emitted is proportional to the object's temperature and its ability to emit infrared radiation. This ability, called emissivity, is based on the material of the object and its surface finish. Emissivity values range from 0.10 to 1.00 for a perfect black body (see chart below). This sensor makes its measurement based on a fixed emissivity of 0.95 which covers most everyday objects. This sensor and all other infrared thermometers do not accurately measure the temperature of shiny substances, e.g., polished metals. To measure the temperature of shiny objects, paint them with a flat paint or cover them with tape. Also, if the object is covered by frost or another material, clean it to expose the surface. If the sensor appears to measure incorrectly, check the front cone of the sensor. It may be covered with condensation or debris. If necessary, wipe it with a clean cloth.

To measure temperature, this sensor gathers infrared radiation in the 6 to 14 µm wavelength range. A Fresnel lens on the front of the sensor focuses the radiation onto the sensing element. The observed spectral distribution is used to determine the object's temperature assuming standard blackbody radiation with an emissivity of 0.95.

Another consideration in this measurement is the field of view. The field of view is the angle of vision at which the measurement is made. One of the valuable features of this sensor is the laser sighting pattern which helps you identify the field of view. The field of view and the spot almost coincide. The object that you are measuring should fill the field of view, or better yet be 1.5 to 2 times size of the circular spot.

The laser sighting circle is great help in identifying the measurement region; however be aware that if you are measuring small objects, e.g., approaching the size of the sensor window, you will need to hold them close to the sensor. In that arrangement parallax may prevent the laser circle from matching the measurement reading.

Table of Emissivities

Substance	Thermal emissivity
Asphalt	0.90 to 0.98
Concrete	0.94
Cement	0.96
Sand	0.90
Earth	0.92 to 0.96
Water	0.92 to 0.96
Ice	0.96 to 0.98
Snow	0.83
Glass	0.90 to 0.95
Ceramic	0.90 to 0.94
Marble	0.94

Substance	Thermal emissivity
Plaster	0.80 to 0.90
Mortar	0.89 to 0.91
Red brick	0.93 to 0.96
Black cloth	0.98
Human skin	0.98
Lather	0.75 to 0.80
Charcoal powder	0.96
Rubber (black)	0.94
Plastic	0.85 to 0.95
Timber	0.90
Paper	0.70 to 0.94

Calibration

This sensor is factory calibrated and not designed to be recalibrated.

Stored Calibrations for the Infrared Thermometer

For °C	slope: –84.388 °C/V	intercept: 398.19 °C
For °F	slope: –151.9 °F/V	intercept: 748.74 °F
For Kelvin	slope: –84.388 K/V	intercept: 671.34 K

Use in the Classroom

This sensor lets you collect measurements that would be difficult if not impossible to make. Here are some classroom uses for the sensor.

Understanding Temperature

Temperature can be difficult concept to understand. Our personal experiences complicate the situation. Imagine being a grade school student in a classroom on a hot day in September. Your arm touches the metal leg of the desk, and you discover that the metal is cold. When you touch the top of your desk, it's not cold. As a matter of a fact most of the objects in the room are not cold. The infrared thermometer would be a perfect sensor for this teachable moment. A student could use it to discover that the temperature of the metal leg of the desk is the same as the desk top, which is the same as the temperature of the wall, door, textbook, etc. This knowledge helps students better understand temperature, equilibrium and thermal conductivity. This experiment could lead to a field trip to the school's parking lot. With the sun shining brightly on the cars, the students could compare the temperatures of the surfaces of cars. Are these temperatures the same, or does the color of the car make a difference? Is the surface of the car hot enough to fry an egg? They could expand their exploration to compare temperatures of the lawn, concrete and asphalt.

The Drinking Bird Demo

More than likely you are familiar with the "Drinking Bird" toy. The bird sits on a stand that allows it to rotate about a pivot point. After the "head" of the bird, which is covered with felt, is wetted, the bird oscillates about the pivot point while a liquid moves up and down a tube connecting the head and bottom of the bird. A number of concepts can be discussed when explaining the motion of the bird. They include center of gravity, vapor pressure, temperature, equilibrium, etc. An important part of the explanation centers around understanding what happens to the temperature of the bird's head. Since the head is covered with moist felt, we can hypothesize that evaporation is occurring at the bird's head. Since evaporation is a cooling process, the head must be cooling, and the drop of vapor pressure in the bird's head contributes to the rise of the liquid in the tube. Without this sensor, you don't have direct evidence that the bird's head is cooling. With this sensor you can verify the hypothesis. We tried it and found that the temperature of the felt before adding water was 25°C. We measured the temperature again after wetting the head and letting the bird oscillate for 10 minutes. The temperature had dropped to 19°C.

Investigating Skin Temperature

Since the sensor responds very quickly, you can easily investigate skin temperature. For example, simply point the sensor at your palm to determine its temperature. Compare that reading to the back of your hand, your forearm or your foot. After measuring the temperature of your forearm, cover it with a shirt and take another reading. Is the temperature the same? Open your mouth and take the temperature. How does its temperature compare to skin temperature? Next take the temperature of hair on the top of you head. How does it compare to the previous temperatures?

Evaporation and Intermolecular Attraction Lab

A popular experiment from our chemistry lab manual is the Evaporation and Intermolecular Attraction lab. In this experiment students wrap filter paper around two temperature probes. They then wet the filter paper with room temperature hydrocarbons, e.g., methanol, ethanol, pentane, etc. Next they expose the probe to air and collect temperature data as the hydrocarbons evaporate. They repeat the experiment two more times with other pairs of hydrocarbons. Each data-collection run takes four minutes in addition to the preparation time. In the end the students relate the temperature change to the strength of intermolecular forces of attraction. The Infrared Thermometer could be used to simplify this experiment. The students would start by measuring the temperature of dry room-temperature filter paper. They then place separate pieces of paper in different hydrocarbons. The filter papers could be laid out on a rack for evaporation to occur. The sensor could then be used to quickly record the final temperature of each paper. The disadvantage to this approach is that students do not have a record of change of temperature as a function of time.

Warranty

This product is manufactured by OMEGA Engineering. OMEGA warrants it to be free from defects in materials and workmanship for a period of 13 months 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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