Data Logging Sensors – Operation and Applications

This document background information on all of the data logging sensors that are used in the Scitek Science program:

- Colorimeter
- Environmental light sensor
- Forcemeter sensor
- Heart rate sensor
- Light gate
- Light level sensor
- Magnetic field sensor
- Motion sensor
- Sound sensor
- Temperature sensor

For each sensor, the following information is provided:

- Technical Specification
- Practical Notes
- Usage
- Possible Investigations

The information in this document assumes that the teacher is already familiar with the operation of:

- The data logger. For further information please refer to the Data Logger User Manual.
- The dataLOG software. This software allows the computer to transfer data from the data logger for presentation and analysis of results. For further information please refer to the dataLOG Software Manual provided on the dataLOG software CD-ROM.

Colorimeter

Technical Specification

Transmittance Range: 0 to 110%T
Resolution: 0.1%

Absorbance range: 0.0500–1.0500 Abs

Practical Notes

The Colorimeter has a snap-shut lid to prevent stray light entering the unit from the environment. When a cuvette is in the Colorimeter and the lid is opened a small spring in the base of the cuvette holder will push the cuvette above the molding. This gives the user easy access to the cuvette and improves handling of the cuvette.

To open the lid, rest your forefinger on the lid and use your thumb to push back the catch. Allow the lid to open slowly. *Care needs to be taken to ensure that when the lid is opened the spring tension is not released too quickly, as this could cause the cuvette contents to spill.* To close the lid, firmly push it down until the catch snaps into place.

Four colored filters are provided to allow for the selection of wavelength of light during an investigation — red 630nm; green 560nm; blue 470nm; and orange 600nm.

The cuvettes should be handled carefully as small scratches could affect the results of any experiment.

Do not let liquids enter the body of the colorimeter.

Usage

If the sensor is plugged into the data logger it will be automatically recognized.

Since the unit has two possible ranges it is necessary to select the range required by using the dataLOG software (see dataLOG software manual).

Possible Investigations

Transmission

- Rate of reaction experiments e.g. sodium thiosulfate and acid
- Growth of yeast in a sugar solution
- Digestion of starch by amylase
- Use of oxygen in respiration
- Growth curve of chlorella

Absorption

- Rate reaction of crystal violet
- Colorimetric determination of manganese in a steel paper clip
- Estimation of chlorine in water
- Determination of glucose concentration

Beer's Law
Beer's law can be used to determine the concentration of an unknown solution. There are several solutions that can be easily made in the laboratory to demonstrate Beer's law. Examples include:

Crystal Violet
Dilute solutions of crystal violet produce good Beer's law results. Use the green filter and a stock solution of 8.0×10^{-5}M crystal violet. The stock solution is prepared by adding 65.3mg of crystal violet to 2 liters of water. Dilutions can then be made up to cover a range of absorbencies. Crystal violet is an intense stain and care needs to be taken when using it. To decolorize cuvettes and glassware rinse with dilute acid. For removal of more intense stains the acid can be left in contact for longer or increase the strength of the acid.

Food Coloring
Food colors diluted with water can demonstrate Beer's law easily. A liter of water can be colored by the addition of 5–6 drops of the coloring. This represents a 100% concentration; further dilutions can be made to create 80, 60, 40, and 20%.

For Blue food coloring use a Red filter.
For Red food coloring use a Green filter.
For Green food coloring use a Blue filter.

Copper Sulfate
Copper sulfate solutions made up to 0.1, 0.2, 0.3, and 0.4M concentrations will produce good results. The Red filter should be used.

Environmental Light Sensor

Technical Specification

Range: 0–100,000 lux

Resolution: 30 lux

Smoothed linear response

Practical Notes

The large range of this sensor makes it ideal for environmental monitoring applications requiring the measurement of sunlight. The response is smoothed to filter out unwanted signals of higher frequencies. The sensor responds to light in the range 350–700nm.

Usage

Connect the sensor to the data logger. The data logger will automatically recognize the sensor.

Possible Investigations

- Inverse square law
- Studies of the light intensity in various parts of the school
- Studies of plant growth
- Efficiency of reflectors
- Investigating different sources of light and their brightness
- Measuring the intensity of a bulb in a simple electrical circuit
- Investigating the relationship between light intensity and distance

Forcemeter Sensor

Technical Specification

Range: ± 50N
Resolution: 0.1N

Practical Notes

This sensor features safety stops and solid aluminum housing, making it a useful device for measuring push and pull (bi-directional) forces in a broad ± 50N range.

The Force sensor is supplied with a 20N spring, cushioned and non-cushioned stops, and a hook, and can be clamped to a stand.

Usage

The force sensor is essentially two strain gauges. It should be clamped firmly when used, to reduce flexing so that it measures a force.

There a number of ways of setting up and using the Force Sensor for Physics experiments:

- The hook is used with the spring for simple harmonic motion investigations, and with stretchy rubber for bungee jumping, and with a stiff wire for investigating centripetal force in a pendulum.
- The cushioned and non-cushioned stops are used when investigating collisions and crumple zones, where a cart on a ramp collides with the sensor.

Possible Investigations

- Simple harmonic motion
- Collision impact
- Centripetal force
- Resultant forces
- Impulse and change in momentum
- Bungee jumping
- Effectiveness of crumple zones
- Tree girth (Force sensor used as a dendrometer)

Heart Rate Sensor

Technical Specification

Pulse rate:

Range: 0–200 bpm

Resolution: 1bpm

Waveform:

Range: -2000 to 2000 mV

Resolution: 1 mV

Practical Notes

The pleth (the sensing clip) can be connected to either the fingertip or earlobe and it may take a little while to settle down when it is first attached.

Heart rate changes with age and exercise. There is almost no such thing as a normal heart rate. It is suggested that a pulse rate of 170 should not be exceeded.

This instrument is not intended for medical diagnosis.

Usage

If the sensor is plugged into the data logger it will be automatically recognized. It can be used by connecting the datalogger to a computer running the dataLOG Software. Use the software to select the range required (see the dataLOG software manual).

Possible Investigations

- Monitoring fitness — after exercise pulse is timed until it gets back to the normal standing heart rate (this can be achieved by remaining in a sitting position and moving the legs)
- Monitoring resting
- Changes with mild stimulants (cups of coffee or cola — might show less effect on people who are accustomed to large amounts of caffeine)
- Variation in blood flow, i.e. people who suffer with cold fingers will show a very low blood flow in their veins — try warming their hands
- Investigating pulse rate with different body positions (sitting, crouching, standing, laying down)
- The effect of music on pulse rate
- The effect of the strictest teacher entering the room!

Light Gate

Technical Specification

Infrared source: Peak at 880 nm.

Response Time: less than 5 microseconds

Timing Resolution: 10μs

Practical Notes

The light gates are usually used for timing. Since the LED inside the light gate is a high power device, it is advised that the data logger should be freshly charged or connected to its power supply unit.

The light gates can be sensitive to high ambient light levels. It is suggested that they be shielded from bright light.

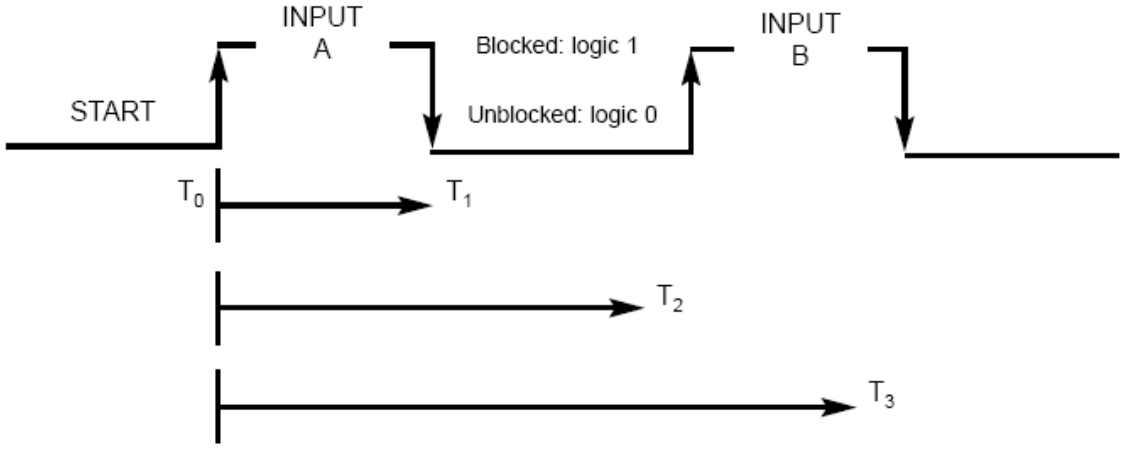
Each light gate is supplied with a mounting rod, allowing it to be easily connected to a retort stand with a boss.

The LED on the outside of the light gate shows its signal status.

Usage

Measurements can be taken from either a single Light Gate connected to **Input A**, or from two Light Gates connected to both **Input A** and **Input B**.

Timing commences when the infrared beam at Input A is blocked (T_0), which changes the logic level from 0 to 1. When the infrared beam is unblocked its logic state changes back to 0 and the time interval is stored as T_1. If another Light Gate is connected to Input B, then the time its infrared beam is blocked is stored as T_2 and the time when it is unblocked is stored as T_3.



Possible Investigations

- Dynamics experiments involving calculating time, speed, velocity, acceleration using inclined planes and air track
- Acceleration due to gravity investigations
- Pendulum investigations
- Measure the time period of an oscillating body.

Light Level Sensor

Technical Specification

Range 1: 0–1000 lux

Resolution: 1 lux

Range 2: 0 to 110% transmission

Slow linear response

Practical Notes

The sensor responds to light in the range 350–700nm. One of the main problems relating to the use of light sensors concerns background or ambient lighting. Changes in ambient lighting can ruin many experiments. If the ambient lighting remains constant, its effect can often be eliminated from the experiment. If it changes it is impossible to do this.

Usage

Connect the sensor to the data logger. The data logger will automatically recognize the sensor.

As there are two possible ranges for this sensor it is necessary to set the range you require. This can be done using the dataLOG Software (see the dataLOG software manual for more details).

Possible Investigations

- Inverse square law
- Makeshift colorimeter
- Studies of the light intensity in various parts of the school
- Studies of plant growth
- Rates of reaction
- Transparency of materials
- Efficiency of reflectors
- Investigating different sources of light and their brightness
- Measuring the intensity of a bulb in a simple electrical circuit.

Magnetic Field Sensor

Technical Specification

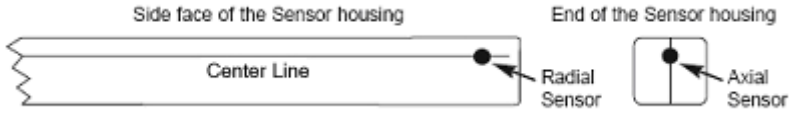
Range 1: ± 10mT **radial**

Range 2: ± 10mT **axial**

Resolution: 0.01mT

Practical Notes

The magnetic field sensor contains two sensing devices arranged at right angles to each other. This enables fields along the axis of the sensor (the axial field) or at right angles to it (the radial field) to be measured. The position of the sensors is indicated by the molded circles on the sensor housing. The sensor will only measure the component of the magnetic field that is acting at right angles to the circle on the sensor housing. Use the center line markings on the sensor housing to line up the correct position.



This sensor is not suitable for investigation of very small fields, such as the Earth's magnetic field.

Care should be taken when plotting electromagnetic fields since low voltage power supplies often have considerable ripple on their outputs, resulting in fields that are not constant.

Usage

When the sensor is plugged into the data logger it will be automatically recognized. The range can be selected using the dataLOG Software (see the dataLOG Software Manual for details).

Possible Investigations

- Comparison of the field strength of different types of magnet
- Investigating materials that a magnetic field will pass through
- Change of magnetic field strength with distance
- Change in magnetic field strength between magnets
- Directly measuring the field due to a magnet or coil
- Investigating magnetic field patterns around magnets and coils
- Relationship between the field due to a coil and the current in the coil
- Relationship between the field due to a coil and the number of turns in the coil
- The variation of the field due to Helmholtz coils
- Variation of the field of a solenoid along its axis
- Variation of the field due to an AC current.

Motion Sensor

Technical Specification

Range 1: Distance 0.17–0m

Values displayed: 3 decimal places

Resolution: 0.001m (1mm)

Automatic correction for variation in air temperature

Range 2: Distance 17–1000cm

Values displayed: 1 decimal place

Resolution: 0.1cm

Automatic correction for variation in air temperature

Range 3: Distance 7–400 inches

Values displayed: 1 decimal place

Resolution: 0.1inch

Automatic correction for variation in air temperature

Range 4: Time 1000–60000µs

Resolution: 1µs

No temperature compensation

Practical Notes

The motion sensor emits pulses of ultrasonic sound waves from the gold foil of the transducer. These waves will fill a cone that diverges at about 12°. The Motion Sensor then 'listens' for the echo of these ultrasonic waves returning to it.

When stood upright on a flat surface the Motion Sensor will lean back at a 6° angle. This tilt allows the waves to run parallel with the horizontal surface.

Because the maximum sample rate of the Motion Sensor is 50 Hz, it can track the position of a fast moving object.

Users can utilize Fast mode. The fastest speed that data can be captured will be 50Hz.

If an inter-sample time of less than 20 milliseconds is selected, then the values obtained will default to zero.

A mounting rod is supplied with the sensor so that it can be mounted in a retort stand with a boss.

Usage

Connect the sensor to the data logger. The data logger will automatically recognize the sensor. The range can be selected using the dataLOG Software (see the dataLOG software manual for more details).

Possible Investigations

- Walking toward and away from the sensor
- Movement on a ramp
- Simple harmonic motion
- Newton's laws of motion
- Pendulum motions
- Air track gliders
- Objects dropped or tossed upward
- A bouncing object
- Speed of sound.

Sound Sensor

Technical Specification

Sound pressure level:

Range: 40 to 110dB.

Resolution: 0.1dB.

Response Time: 125ms.

Frequency content:

Range: ±2000mV.

Resolution: 1mV

Frequency response: 100Hz to 7kHz

Practical Notes

Sound in a laboratory can be very distracting. Take care that your experiment does not distract others working in the same area.

Do not immerse the sound sensor directly in water.

Usage

When the sensor is plugged into the data logger it will be automatically recognized. It can be used with the dataLOG Software. Refer to the Data Logger User Manual for help if needed.

The sensor can be configured to measure either Sound Pressure or Frequency content. This can be done using the software. Refer to the dataLOG Software Manual for help if needed.

Possible Investigations

- Animal activity studies
- Field studies
- Road safety
- Ear design
- Noise meter
- Noise pollution
- Sound insulation
- Sound decay
- Sound frequency
- Speed-of-sound
- Air resonance
- Sound waves: monitoring the effect of altering frequency and amplitude, waveforms of musical instruments, beat patterns.

Temperature Sensor

Technical Specification

Range: -30 to 110 °C

Accuracy: ±0.3 °C between 0 to 70 °C rising to ±0.6 °C at extremes of the range

Resolution: 0.1°C

Practical Notes

This is a general-purpose temperature sensor with a sensing element housed at the end of a stainless steel tube. It is the very tip of the sensor that is sensitive to temperature. Do not put the sensor into a flame as temperatures in excess of 150 °C may damage the sensor.

It has a high degree of corrosion and chemical resistance making it suitable for experiments in all main science areas. Note that some strong chemicals may cause some discoloration to the stainless steel tube but this will have no effect on the sensor's performance.

The sensor should not be immersed in most acids for longer than 48 hours. The exception is Hydrochloric acid. If 1M Hydrochloric acid is used then the time should not exceed 20 minutes.

Wash the probe thoroughly after use.

Usage

When the sensor is plugged into the data logger it will be automatically recognized. It can be used by connecting the data logger to a computer running the dataLOG Software.

This is one of the most versatile of laboratory sensors and can be used in place of a thermometer in almost all applications.

Possible Investigations

- Monitoring indoor and outdoor temperature
- Weather studies
- Insulation studies
- Solar homes
- Monitoring endothermic and exothermic reactions
- Solubility of salts
- Studying freezing and boiling points
- Cooling rates
- Evaporation, radiation, conduction and convection investigations
- Energy content of fuels and foods
- Heat of fusion investigations