Motion Sensor Worksheets

A Curriculum Resource for the Motion Sensor

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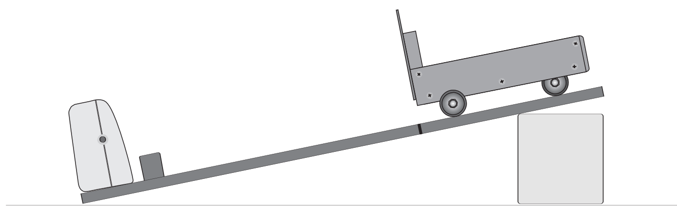

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Motion Sensor Worksheets

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The Motion Sensor - General Information

The Smart Q Motion Sensor is a sonar device that emits ultrasonic pulses that echo off an object. The time taken between emitting and receiving is used to calculate distance.

Read

The sensing is initiated by first creating an ultrasonic pulse at a specific frequency. The pulses are fed to the transducer and transmitted as a short burst of pulses. The frequency at which the pulses are broadcast is around 50kHz. For reference the human ear can hear sounds in the 20Hz to 20kHz range. A small click will be heard as the transducer goes into send mode, this is not the sound of the pulse being transmitted. The pulse moves radially away from the transducer at the speed of sound (approx 340 m/s).

Range limits

The range limit will be affected by two factors:

1. The inverse square law fall off.
2. Time for the pulse to return.

The signal strength will fall off according to the inverse square law. The intensity falls off very quickly to start with and more slowly at greater distances.

The pulse must return before the next transmission if distance is to be registered correctly. As distance increases the return time obviously increases and eventually a point is reached when the return is not received before the next transmission. At this point the measurements will become erratic, pulses being registered could be the return pulses from a previous transmission for example.

Close range limits

When the transducer switches to listening mode it needs to quench any residual "emitted pulses" to prevent false return echoes. This is accomplished by freezing or blanking the transducer for a short time. The time the transducer is blanked limits the minimum effective range.

The stated minimum range for the Sensor is 17cm.

Potential problems in measurement

The Sensor is sensitive to noise generated at its transmission frequency. With its use of a 50 Hz frequency means there is a possibility that mains hum could create erratic readings.

The cone of transmission is 12 degrees but the best response is within 5 degrees either side of the central line of the transducer. Smaller lobes of detection exist outside this cone.

The surface reflecting the signal needs to be "silk finished", if it is too glossy the readings will become less stable. Sound absorbing surfaces such as acoustic ceiling tiles will produce errors as the ultrasound will be absorbed. Surfaces such as thin foam will let the sound pulses through so the distance measured will be to the solid surface behind.

The object being measured can be quite small as long as no bigger object is within the cone or arc of the emitted pulse.

Hardware limitations

The fastest speed the sensor can be used to collect data is fixed by the frequency at which the unit transmits its ultrasound pulses, 50Hz. Trying to collect data at a faster frequency than this will result in the ultrasound unit not firing. If you notice on fast recording that the sensor unit is not clicking then the intersample time will need to be changed.

The fastest speed that data can be captured will depend on the Easy Sense units operating system.

- Version 1.0 - 1.3 operating system can log at 40Hz (25ms)*.
- Version 1.4 and upward can log at 50Hz

To find the version number of your *EasySense* unit.

EasySense Advanced or logger users:

Press the **METER, STOP**, and **ENTER** buttons. The version number will momentarily be displayed. or, all users; Select the Sensor Configuration application from the Sensing Science Laboratory folder. Click on the Easy Sense button. The Firmware version number of the unit will be displayed.

IMPORTANT.

Fast Setup information

Due to the number of hardware revisions in the Easy Sense range and the revisions of Sensing Science Laboratory it has been difficult to produce a fast set up file that is compatible with all combinations. The set up as loaded will need to be changed by the student to match the software and hardware combination they are using. Refer to the table below for the intersample times the student will need.

	Hardware ver.1.0	Hardware ver.1.2	Hardware ver.1.3	Hardware ver.1.4	Hardware ver.1.5
Graph v 2.33 and lower.	50ms	50ms	50ms	20ms	20ms
Graph v 2.33 and higher.	25ms	25ms	25ms	20ms	20ms

It is important to be aware of the size of the ultrasound cone, at one metre from the motion sensor the cone will have a diameter of 0.2m, at 2 metres it will be 0.4m.

**To be consistent with the logging time of 40Hz, the Graph application of the Sensing Science Laboratory software has had an intersample time of 25 milliseconds added to the fast menu. If the version of your Sensing Science Laboratory software does not offer this as an option, please contact Data Harvest for upgrade information.*

Viewing sample data files

The sample data files (.sid) included in the teachers' notes are for viewing in the Graph application. The sample files were produced during the testing of the experiments in the Motion Sensor notes. In most cases the only change that has been made is to the scale of the axis.

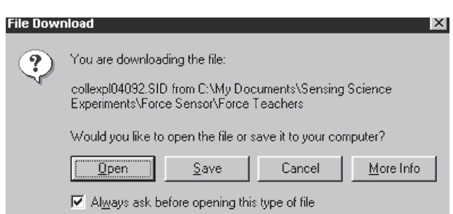
The files have all been made read only through the properties tab of the file in explorer. If the files need to changed and the changes saved then they should be copied to another folder and the read only attribute removed. Renaming the file is advisable to prevent confusion with the original file.

The files are located in the folder that contains the teachers notes and are all in .sid format.

Accessing the files

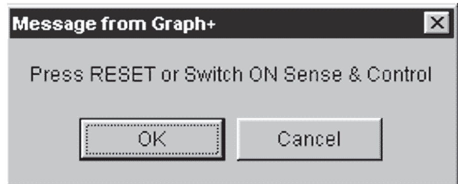
The files can be viewed by clicking on the screen shot of the graph. The file will open Graph and the data will be displayed. All the functions of graph can then be used. Depending on how your system is set up you may see several information panels before the data is loaded into Graph.

Screen message 1.



File download message, click on the OPEN button for the file to be loaded into graph. If the “always ask before opening this type of file” tick box is unselected then in future this panel will not reappear.

Screen message 2.



Message from graph. This type of communication message will appear if a datalogging interface is not attached to the computer. If an interface is attached follow the instructions and continue loading the file. If there is no datalogging interface attached click on “cancel”

Motion Sensor

Teachers' notes Introducing the Motion Sensor; MS-01 (A) Distance, objects and materials, (B) Detecting movement.

This pair of investigations is a series of short experiments designed to familiarise the student with the motion sensor.

Learning Objectives

- To understand that the motion sensor measures distance.
- Information about velocity can be obtained from the distance-time graph.
- The limitations of the sensor in terms of size and distance of the reflecting object.

Apparatus

EasySense datalogger.

Motion Sensor with the range set to record distance.

Meter rule (a metal expanding rule is ideal).

Card.

Scissors.

Wires of different diameters e.g. 2 mm, 1 mm, 0.5 mm.

Logger setup

Ms01(a)

The meters application will load and show distance as a full screen numeric display.

Ms01(b)

The graph application will launch preset for a 20 second timespan with overlay.

Sample data and hints

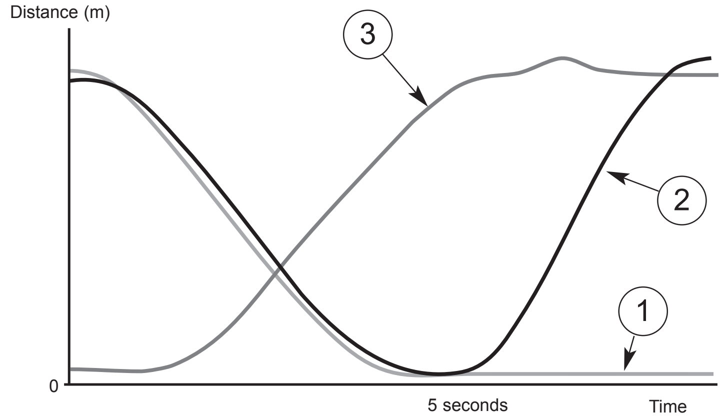
1. Ms01(a) Measuring Distances

a) The length of the lab may exceed 10m if so students will have to measure the length in two sections and add them together.

b) Sound absorbent ceiling tiles or walls may cause problems. It may help to put a large piece of card on the ceiling / wall with Blu Tack.

2. Ms01(b) Detecting Movement

The graph below shows a typical recording from this practical. The line 1 shows a student moving towards the sensor and then standing still. The line 2 shows a student moving towards the sensor then moving away from it. The line 3 shows a student moving away from the sensor and stopping.



3. More about the Motion Sensor

a) Minimum detecting distance will be about 17cm. If the student moves closer than this the value stays the same.

b) Students will find that thin straight wires are detected at quite a large distance. e.g a 1.7 mm diameter wire was detected at 1.5 m.

c) The Sensor is very good at selecting the nearest object, even when there is a wider object close behind it.

d) The Sensor will sometimes detect the further object even when thin layers of cloth, and foam objects, partially obscure a more distant object.

Distance, objects and materials

Read

The Motion Sensor enables you to measure distances up to10m or show how an object is moving.

The Motion Sensor sends out ultrasonic pulses 50 times a second. It times how long each pulse takes to return to the Sensor and then calculates how far away the object is to within 3 mm.

What you need

A clear working space with direct line of sight to walls, notice boards etc. at a variety of distances.

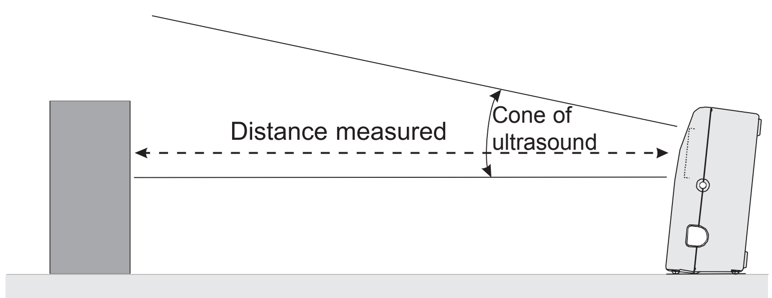
A range of different sized and different shaped objects, pens, card, scissors and wires of different diameters.

A range of materials with different textures, solid card, foam sheet, felted cloth, glass etc.

What you need to do

Measuring distances.

Use the Motion Sensor to measure a variety of distances, including the dimensions of the laboratory.



Setup.

1. Use the diagram above to set up the Motion Sensor, notice the slight tilt on the Motion Sensor, this is to keep the lower edge of the ultrasound cone parallel to the bench / desk surface.
2. Objects must be within the cone of ultrasound if you are to get good distance readings.
3. Click the launch button to load the meters program .

Measuring the room.

1. Place the Motion Sensor on the floor, pointing at the ceiling. Note down the value.
2. Place the sensor against a wall pointing to the opposite wall, note down the value.
3. Repeat for the other pair of walls.
4. How high is the laboratory bench?
5. Find the length and width of the bench.

What is the smallest distance that the sensor will measure?

1. Place an object, a book for example, about 1m from the sensor.
2. Slowly move the book towards the sensor.
3. Note the minimum distance it will measure.

What is the smallest object the Motion Sensor can detect?

1. Use a variety of objects e.g. pen. Rulers, pieces of card, wires, all placed about 30cm away from the sensor to find the diameter of the smallest object it can detect.
2. Repeat at different distances.

What is the thickness of a book?

1. Place the Motion Sensor on a bench pointing to the ceiling. Write down the distance.
2. Place the book to be measured between the bench and the sensor and write down the new reading.
3. Take the second reading away from the first reading, to find the thickness of the book.
4. You could modify this method to measure your height by placing the Sensor above your head, recording the distance when you stand under the Sensor and the distance when the space under the Sensor is empty.

Do some materials reflect ultrasound better than others?

1. Hold samples of different materials 1m away from the sensor, try to make sure your hand is not in the ultrasound cone.
2. Does moving the samples have an effect on the accuracy of the reading?
3. Try holding the material at different distances from the Sensor if you have time.

Results and analysis

Measuring the room

Laboratory

Length (l) = …….m

Breadth (b) = …….m

Height (h) = …….m

Use these results to work out the volume in m^3.

Volume = l x b x h = …….m^3

Bench

Height = …….m

Length = …….m

Breadth = …….m

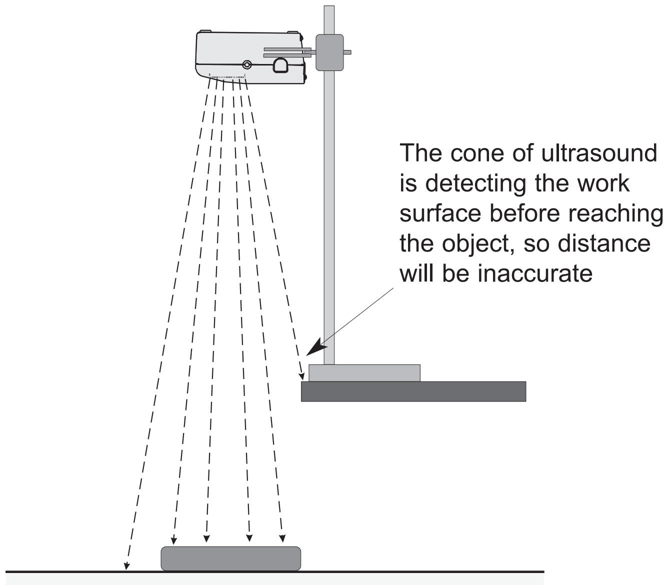
Trouble shooting the Motion Sensor.

Inaccurate data.

The Motion Sensor is accurate to within 17cm. Objects closer to the sensor than 17cm will cause erratic measurements. Check that there is no object in the cone of ultrasound closer than 17cm.

A common error comes from not allowing the sensor to sit back in its tilted position, the sensor then starts to record the distance to the work surface.

Check for stationary objects e.g. tables, chairs, pens, walls, floors etc. that could be positioned in the cone of the ultrasound. Objects at long distance within the cone maybe detected.



The texture of the reflecting surface can have a severe effect on the accuracy of the distance measurements. Acoustic tiles (the slightly textured tiles used in ceilings) will absorb the ultrasound and the “pulse echo” being returned will give a false reading. Foam over a hard surface will also give unusual readings. If there is suspicion that this may be a problem fix a piece of paper on the target and re-check the measurement.

In a busy class you can get reflected echoes from other devices or people moving into the cone of ultrasound. Try to position your work so that you have as much clear space for the cone as possible and try not to let the cone cut across areas where other people may have to be moving around.