Greeting the Sensors

## Waving at the (ultra-sound) motion sensor: PASCO Motion Sensor II CI-6742A

### Introduction:

The Motion Sensor II works with a ScienceWorkshop-compatible interface and PASCO data acquisition software (such as PASCO Capstone) to measure and record motion data. It produces a series of ultrasonic pulses and detects the sound reflecting back from an object in front of it. The interface **measures the times between outgoing pulses and returning echoes**. From these measurements, the data acquisition software **determines the position, velocity, and acceleration** of the object.[1]

### Quick Start

1. Connect the Motion Sensor II to your ScienceWork-shop interface and start Capstone on the computer.
2. Register the sensor with Capstone.
3. Place an object in front of the sensor at least 15 cm away.
4. Click “Record” or press “Start” to begin recording data.
5. Move the object in a straight line directly away from or toward the sensor.

### To Aim the Motion Sensor at an Object

1. Set the range switch to short range () or long range () setting.
   - •Select for measuring a cart on a track.
   - •Select for measuring most other objects.
2. Arrange the Motion Sensor and object so that the Motion Sensor's transducer faces the object.
   - •The object should be at least 15 cm from the transducer.
   - •If the object will move, it should move directly toward or away from the Motion Sensor.
   - •Aim the motion sensor slightly up to avoid detecting the tabletop.
3. Remove objects that may interfere with the measurement. These include objects between the sensor and target object, either directly in front of the sensor or to the sides.

To Record Data in Capstone, click Record and the Motion Sensor will begin clicking. If a target is in range, the target indicator flashes with each click. The data acquisition software should start collecting and displaying data.  Click Stop to stop data collection.

### To Display Data without Recording in Capstone:

Click the Recording Mode menu and select Fast Monitor Mode. The Record icon changes to a Monitor icon. Click Monitor to display live data without recording it.

### Sensor Configuration:

To Change the Sample Rate in Capstone, click the up or down button next to the Sample Rate setting.

The normal range of sampling rates is between 1 Hz and 50 Hz.  At the default rate, the Motion Sensor can measure distance up to 8 m. The maximum distance decreases with increasing sample rate. At very high sample rates (between 50 Hz and 250 Hz), the maximum distance is less than 2 m.

### Equipment Mounting:

- Mount the Motion Sensor as illustrated ona vertical rod (a) or a horizontal rod (b).
- Integrated clips allow it to be attached to the end of a dynamics track (c).
- A threaded hole in the bottom of the unit (d) is provided for attachment to the PS-2546 Magnetic Bracket (e), the ME-6743 Cart Adapter (f), and other 1/4-20 threaded mounting devices such as a camera tripod.

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1*Note: Essential PASCO Capstone tasks are described briefly in this instruction sheet. For more instructions on using Capstone, see the User’s Guide or the online help*

To protect the Motion Sensor from being hit by an object, use a device such as the SE-7256 Motion Sensor Guard (g) or ME-9806 bracket with a rubber band (h). The Motion Sensor can “see through” a wire screen or rubber band placed close to the transducer.

Troubleshooting:  If the Motion Sensor fails to perform satisfactorily, try these steps:

- Ensure that the target object is no closer than 15 cm.
- Switch the range switch to the other setting.
- Adjust the aim left, right, up, or down. In some cases the Motion Sensor works best when it is aimed slightly to the side or above the target in order to exclude interfering objects.
- Improve the target by adding a larger or harder surface to reflect ultrasound. A small object can be a better reflector than large object if it has a harder surface.
- Remove interfering objects near the target object or sensor.
- Increase or decrease the sample rate.

Theory of Operation:
The Motion Sensor uses an electrostatic transducer as both a speaker and a microphone. When triggered by the interface, the transducer **transmits a burst of 16 ultrasonic pluses** with a frequency of about 49 kHz. This burst of pulses can be **heard as a single click**. The ultrasonic pulses reflect off an object and return to the sensor. The **target indicator** on the sensor **flashes** when transducer **detects an echo**.

Sound intensity decreases with distance; to compensate, the sensor increases the gain of the receiver amplifier as it waits for the echo. The increased gain allows the sensor to detect an object up to 8 m away. The lower gain at the beginning of the cycle reduces the circuit's sensitivity to echoes from false targets.

The interface **measures the time** between trigger rising edge and the echo rising edge. The data acquisition software uses this time and the speed of sound to **calculate the distance** to the object. To determine velocity, the software uses consecutive position measurements to **calculate the rate of change of position**. Similarly, it **determines acceleration using consecutive velocity measurements**.

Minimum Range: 15 cm
Maximum Range: 8 m
Transducer Rotation: 360°
Range Settings:

- Short Range: for distance measurement up to 2 m with improved rejection of false target signals and air-track noise
- Long Range: for distance measurement up to 8 m

Mounting Options:

- On rod up to 12.7 mm diameter
- Directly to PASCO dynamics tracks
- On table top

Connector: Dual stereo phone plug for ScienceWorkshop-compatible interfaces

Verify the Sensor's Performance and connection to DAQ (data acquisition) software:

1. Connect the Acceleration Sensor to the computer interface with the interface cable (see Figure 1a) and set up Capstone. Open a Digital Display and select position from the pop-up menu. Set the range switch on the sensor to long (stick figure icon).
2. Create a digital display of the position reading and begin recording data in continuous mode
3. wave a hand around and watch the echo indicator and the digital display to get a feel for the cone of reliable detection
4. take picture of group members miming the extent of the cone
5. change range to short (cart)
6. Wave around again to get a feel for the cone of detection
7. take picture of group members miming the extent of the cone

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# Flipping out over accellerometers: PASCO Model CI-6558 Rev A

Introduction:

The Acceleration Sensor is designed to measure accelerations ranging up to 5 times the earth's gravitational field with an accuracy of 0.01 g (g = acceleration of gravity, 9.8 m/s

It produces a bipolar output that may vary from +5 g to -5 g, depending on the direction of acceleration. It is capable of resolving changes in acceleration on the order of 1 milli-g when a gain of 10 is applied in Capstone

It has two built-in features for configuring it to a particular application:
(1) a tare button, used to set the output of the sensor to 0 regardless of the acceleration being applied (allows the effect of the earth's gravitational field to be nulled);
(2) a filter with two settings —"slow" or "fast", setting the frequency response of the Acceleration Sensor to a range suitable for the application.

For experiments such as measuring the acceleration of elevators, roller coasters, and automobiles, select the "slow" setting. The slow filter reduces errors due to high frequency vibrations and noise. For applicationsinvolving mechanical systems, such as cart collision experiments, select the fast setting.

The Data Studio software will display the output of the Acceleration Sensor in units of $m/s^2$, or in terms of g.

Very small values of acceleration can be measured by taring the sensor and adding gain in Data Studio.

Verify the Acceleration Sensor's Performance in the Earth's Gravitational Field:

8. Connect the Acceleration Sensor to the computer interface with the interface cable (see Figure 1a) and set up Capstone. Open a Digital Display and select Acceleration (g) from the pop-up menu. Set the filter switch on the sensor to SLOW.

9. Place the sensor flat on a level surface with the arrow indicating direction of sensitivity parallel to the ground (Figure 3a) and press the tare button.

10. Orient the sensor so the arrow on the label is perpendicular to the ground (see Figure 3b). Monitor Data in Capstone.

11. Observe that Capstone is displaying a value for acceleration of either plus or minus 1g.

12. Rotate the sensor 180° around its major axis so the arrows point in the opposite direction.

13. Observe that Data Studio now displays 1 g with the opposite sign as observed before.

14. Can you imagine a way to measure the tilt angle of the sensor? (Hint: tilt angle = arcsin(acceleration in g) ).

Figure 5. Response of the Acceleration Sensor to the earth's gravitational field