SmartQ TECHNOLOGY

Low g 3-Axis Accelerometer

(Product No. 3200)

- ± 2.50 g X Axis
- ± 2.50 g Y Axis
- ± 2.50 g Z Axis
- 0.000 - 5.000 g Resultant force

- ± 10.0 g X Axis
- ± 10.0 g Y Axis
- ± 10.0 g Z Axis
- 0.00 - 20.00 g Resultant force

- ± 25.0 ms^{-2} X Axis
- ± 25.0 ms^{-2} Y Axis
- ± 25.0 ms^{-2} Z Axis
- 0.0 - 50.0 ms^{-2} Resultant force

- ± 100.0 ms^{-2} X Axis
- ± 100.0 ms^{-2} Y Axis
- ± 100.0 ms^{-2} Z Axis
- 0.0 - 200.0 ms^{-2} Resultant force

- ± 2.50 g Vibration
- ± 10.0 g Vibration

- ±90.0˚ Inclinometer

High g 2-Axis Accelerometer

(Product No. 3201)

- ± 40.0 g X Axis
- ± 40.0 g Y Axis
- 0.0 - 50.0 g Resultant force

- ± 400 ms^{-2} X Axis
- ± 400 ms^{-2} Y Axis
- 0 - 500 ms^{-2} Resultant force

DATA HARVEST

DS 103   No 1

Introduction

The Accelerometer consists of acceleration sensing circuits set at right angles to each other, each measuring acceleration along one axis.

The sensor element is a capacitive device. A central mass is held static while suspended interleaved plates are free to move relative to this mass. The result is that any movement will create a change in position of the suspended element relative to the static mass, this changes the capacitance. The change in capacitance is proportional to the force – acceleration.

The high g Accelerometer (*Product No. 3201*) measures along 2 axes (X and Y). The low g Accelerometer (*Product No. 3200*) will measure along 3 axes (X, Y and Z).

The direction of the axis is marked on the sensor's label and corresponds to:

X range - along the length of the sensor	**Y range** - across the width of the sensor	**Z range** – across the depth of the sensor (label to label side)

The high g 2-Axis Accelerometer is suitable for larger accelerations e.g. collision investigations between carts or a cart and a surface or impact investigations such as a rod landing on different surfaces.

It can record
- **Acceleration** along a single axis i.e. **X** or **Y.**
- **Resultant Force** – the sum of the forces in both component accelerations (X and Y).

The low g 3-Axis Accelerometer is suitable for small accelerations such as change of g investigations e.g. free fall, golf swings.

It can record

- **Acceleration** along a single axis i.e. **X**, **Y** or **Z.**
- **Resultant Force** – the sum of the forces in all component accelerations (X, Y and Z).
- **Vibration** by sensing the amount of dynamic acceleration
- **Angle (Inclinometer)** by measuring the amount of static acceleration due to gravity in all axis to find the angle the device is tilted at with respect to the earth.

Accelerations are normally measured in either **metres per second per second** (ms^{-2}) (the SI unit for acceleration) or **g** factor (one g is the acceleration due to gravity at the Earth's surface = $9.81\ ms^{-2}$).

The Accelerometer is supplied with a kit that allows the sensor to be attached to the top of a Data Harvest Dynamics cart.

The kit contains:
- 1 metal C clamp
- 1 white plastic screw
- 2 M4 black thumbscrews (TS1)
- 1 M4 hex nut (to fit the black thumbscrew)
- 1 black thin angle bracket (SB1)
- 1 Interrupt card (IC1)

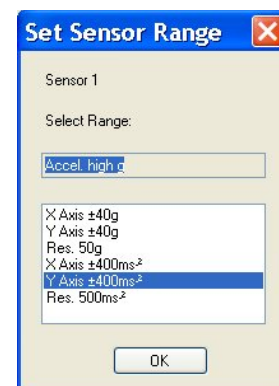Diagrams showing how to use this kit are on page 6.

Connecting

- Push one end of the sensor cable (supplied with the **EASY**SENSE unit) into the hooded socket on the adaptor with the locating arrow on the cable facing upwards.
- Connect the other end of the sensor cable to an input socket on the **EASY**SENSE unit.
- The **EASY**SENSE unit will detect that the Accelerometer is connected and display values using the currently selected range.

Changing range

To alter the currently selected range:
- Connect the Accelerometer to the **EASY**SENSE unit.
- Start the **EASY**SENSE program and select one of the logging modes from the Home screen e.g. EasyLog. Select **Sensor Config** from the **Settings** menu.
- Select the Accelerometer from the list (it will use the currently selected range name) and click on the **Change Range** button.
- The current range will be highlighted. Select the required range and click on OK.
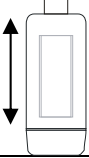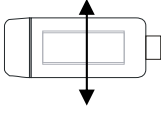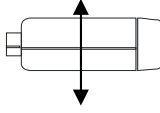- Close Sensor Config. Click on New ⬜ and then Finish for the change in range to be detected.

The range setting will be retained until changed by the user. With some **EASY**SENSE units it is possible to change the range from the unit. Please refer to the **EASY**SENSE unit's user manual.

Acceleration X, Y and Z

These ranges will record acceleration along a single axis using the selected axis range e.g. **X**, **Y** or **Z.**

The Accelerometer should be mounted in the appropriate orientation for an experiment (so that the particular axis is in the direction of interest). See the table below.

	X range	Y range	Z range
Vertical movement			

	X range	Y range	Z range
Horizontal movement			

For example:

Horizontal movement along a track. To keep the wires out the way its best to mount the sensor vertically and use the Y range.

See page 6 on how to mount the Accelerometer using the kit supplied

Vertical movement (rod is dropped onto sponge surface), use the X range.

Resultant

This range measures the sum of the force in the component accelerations. For the low g range Accelerometer (*Product No. 3200*) this is from three axes, X, Y and Z. For the high g range Accelerometer (*Product No. 3201*) from two axes, X and Y.

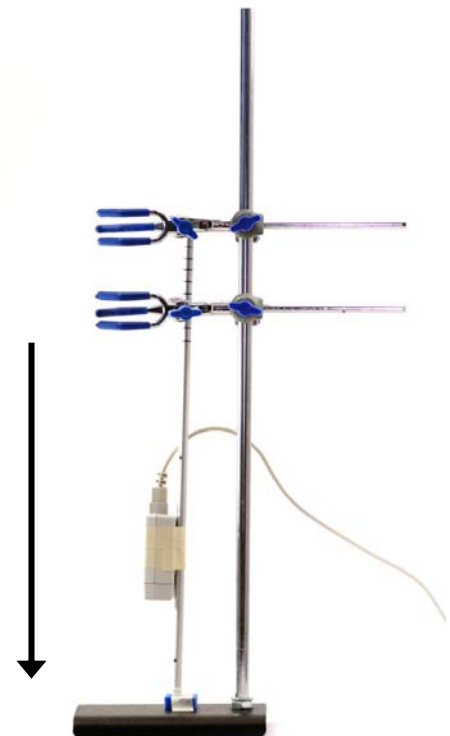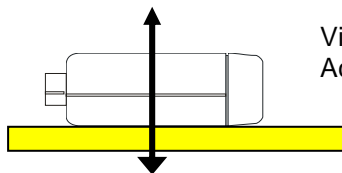Resultant (net) acceleration is the square root of the sum of the squares of all the component accelerations. This will be 1 g (9.8 ms^{-2}) when the Accelerometer has no acceleration and zero when it's in free fall.

With this range the orientation that the Accelerometer is mounted does not matter.

The maximum sample rate of the Resultant range is 50 Hz (intersample time of **20 ms**). If an interval between samples of less than 20 milliseconds is selected, then either the setup will be rejected or the values obtained will default to zero.
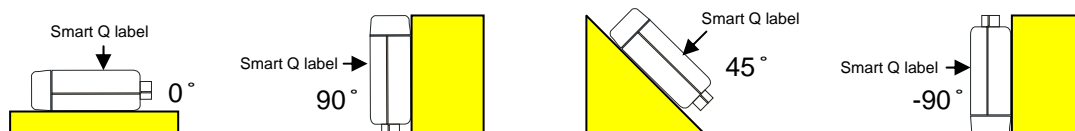
Vibration *(Low g Accelerometer only)*

By sensing the amount of dynamic acceleration, you can analyse the way a device is moving. This range could be used to show vibration in structures or to model the detection of earthquakes.

Vibration is measured using data from the Z axis so lay the Accelerometer label down on the surface.

Inclinometer *(Low g Accelerometer only)*

The inclination angle data represents the tilt away from the ideal plane, which in this case, is normal to the earth's gravitational force. This calculation assumes that no force outside of the earth's gravitational force is acting on the device and takes into account the gravitational force in all axes present in the sensor element.

The angle ($\pm 90.0\,^\circ$) is measured when the sensor is placed on a surface with the Smart Q label face up and the hooded socket pointing down. If the hooded socket is pointing up the angle is shown negative to indicate the direction vector.

The maximum sample rate of the Inclinometer range is 50 Hz (intersample time of **20 ms**). If an interval between samples of less than 20 milliseconds is selected, then either the setup will be rejected or the values obtained will default to zero.

Practical information

- Attach the sensor firmly to the object under test.
- If possible secure the sensor lead firmly to the mounting body.
- The accelerating object should weigh more than the Accelerometer (which weighs approximately 28 g).

- Do not drop the sensor directly onto a solid surface as extreme jarring could damage the sensor.
- If the low g Accelerometer's Resultant range is selected to record a vehicle's journey it uses data from all 3 axes, this will include any bumps or vibrations which may confuse results.
- If you hold the accelerometer in different directions e.g. horizontal instead of vertical, it may give a different reading. This is because an accelerometer doesn't know the difference between acceleration and gravitational force. For example when the arrow representing an axis (e.g. X) points up its value is +1 g (9.8 ms^{-2}). When the arrow points down its value is -1g (-9.8 ms^{-2}). When the axis arrow is held horizontally its value is zero.

How the orientation of the Low g range Accelerometer affects readings (no force present other than gravity):

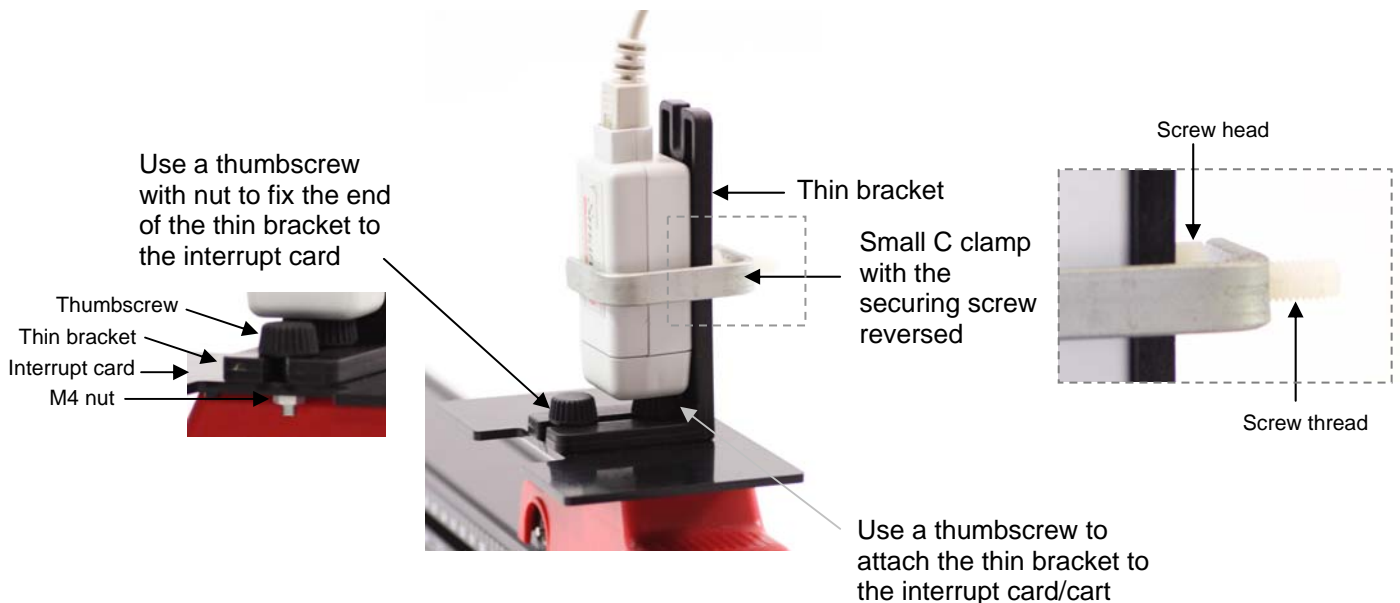| Sensor orientation						
Smart Q label	Facing	Facing	Facing	Facing	On top	On base
X axis reading	**+1** g	**-1** g	0 g	0 g	0 g	0 g
Y axis reading	0 g	0 g	**+1** g	**-1** g	0 g	0 g
Z axis reading	0 g	0 g	0 g	0 g	**+1** g	**-1** g

Specifications

The sensor has been calibrated to read 1.0 g or 9.81 ms^{-2} when the force of g is acting along the axis of the selected range.

The Inclinometer has resolution of 0.1 degree and an accuracy of 2 degrees. The difference in angle between paired measurements in the Inclinometer range will be to 0.1 degree i.e. when finding the angle of surface and then changing the angle of the surface, the difference between the angle changes will be correct.

The sensor transducer has a design to shock resistance of 1,500 g. The transducer sensing elements have been drop tested from a height of 1.5 m. We would expect the case to be damaged before damage to the transducer takes place.

Using the kit to attach the Accelerometer to a Dynamics cart

Use a thumbscrew with nut to fix the end of the thin bracket to the interrupt card

Thumbscrew
Thin bracket
Interrupt card
M4 nut

Thin bracket

Small C clamp with the securing screw reversed

Screw head

Screw thread

Use a thumbscrew to attach the thin bracket to the interrupt card/cart

Background information

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or dynamic - caused by moving or vibrating the accelerometer. It is able to detect the magnitude and direction of the acceleration. Accelerometers are common devices but are usually unseen and unnoticed.

o   A modern car's airbag system uses acceleration sensors to determine the trigger point for release.
o   Seat belt tensioners in a car are often triggered by accelerometers
o   Portable computing devices e.g. laptop computers use accelerometers to lock hard drives if the computer is dropped.
o   Mobile phones use an accelerometer to determine the orientation of the screen and to adjust the screen resolution and mode
o   Gaming consoles e.g. the Nintendo Wii use accelerometers in the hand controllers.
o   As an accelerometer can be used to measure vibration it can be used to detect the change in vibration signature of a machine as it starts to fail e.g. a motor bearing has a characteristic vibration pattern, smooth and quiet when in good order, gradually getting rougher and noisier as it wears out.

An accelerometer does not measure gravity - it measures the component of "total acceleration minus gravity" along its input axis as "non-gravitational" acceleration (the acceleration it experiences relative to freefall).

The term 'g - force' is normally used as short hand to describe the force acting on a moving object relative to the force felt by an accelerating object at the earth's surface. It is not an SI unit; it is used to express the relative force experienced. To convert to a correct SI unit all g values should be multiplied by 9.81 to give the ms^{-2} value.

Astronauts, fighter pilots and racing drivers are often said to experience a force of so many 'g' when performing a particular manoeuvre. This force is rarely gravitational as it's a rocket, jet, or combustion engine that provides the force needed to accelerate e.g. when a pilot changes speed or direction, or a racing driver goes around a corner. The effect of high acceleration on humans can be significant as most will lose consciousness if subjected to a sustained acceleration of between 5 to 7 g. This effect is only felt if the acceleration is sustained, i.e. jumping onto a hard floor can produce a deceleration of many g but only for a fraction of a second.

Investigations

In all investigations you should use the range that follows the line of acceleration forces in the motion of the object being studied.

Using the high g 2-Axis Accelerometer (Product No 3201)
▪   *Acceleration of a Dynamics cart on a track*
▪   *Impulse (force change at collision)*
▪   *Collisions between carts or a cart and a surface*
▪   *Impact force on landing e.g. athlete landing on a crash mat after a jump*
▪   *Forces when ball is kicked or thrown or struck with a racquet*
▪   *Explanation of opposing forces e.g. resistive forces countering force of mass on a surface*

Using the low g 3-Axis Accelerometer (Product No 3200)
▪   *Bungee jump*
▪   *Pendulum*
▪   *Changes in acceleration in a golf swing*
▪   *Explanation of free fall*
▪   *Explanation of opposing forces e.g. resistive forces countering force of mass on a surface*
▪   *Tilt of an object*
▪   *Earthquake simulation e.g. test how long your model of a tower stays upright*
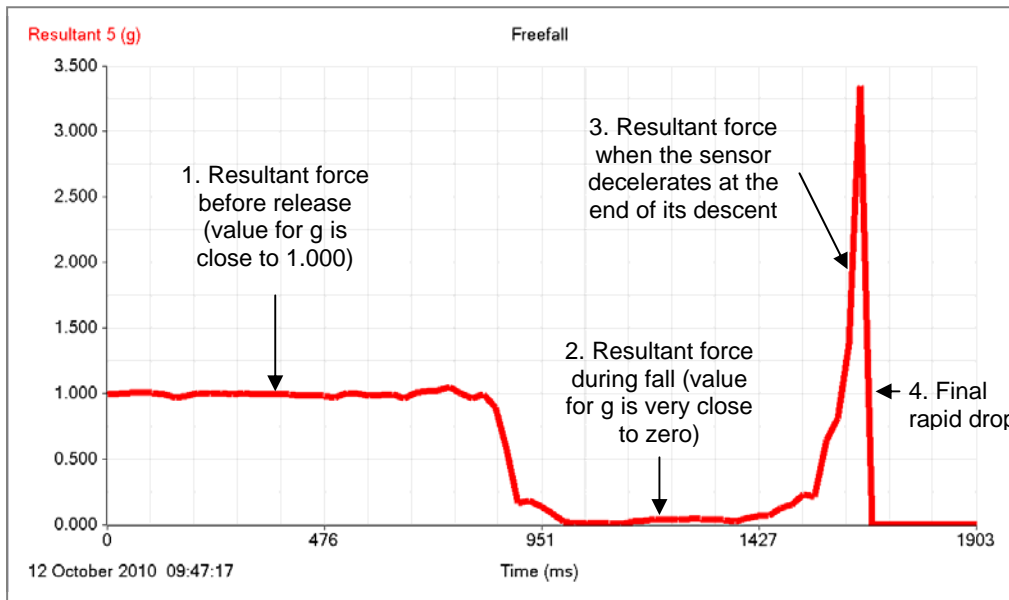
Recording free fall

You will need:
1. An **EASY**SENSE logger that can be used disconnected from a PC e.g. VISION, Q Advanced.
2. The Low g Accelerometer set to the **±5 g** or **50 ms^{-2} Resultant** force range
3. Long sensor lead and sensor extension leads to the height of the drop being used.

    Note: The length of cable should be shorter than the height of the drop to stop the Sensor striking the floor.

4. A decent height for the drop – a stairwell of 2 stair flights is sufficient
5. Attach a small mass (about 30 g max) to the end cap of the sensor to make it fall vertically along its long axis

What you need to do:
1. Hold the Sensor over the clear drop; make sure the cables will unravel behind it without opposing its fall.
2. Set the logger to record in EasyLog mode, and start logging.
3. Drop the sensor (mass end first).
4. When the sensor has finished falling stop logging.
5. Transfer the data to **EASY**SENSE and view the result.
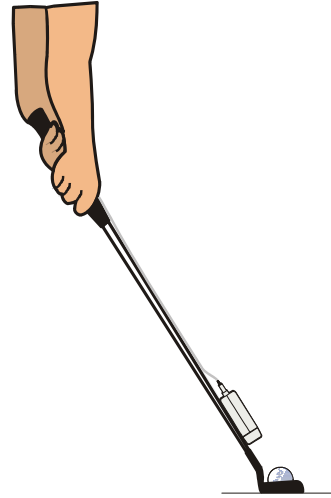

There are 4 stages in the data:
1. A period of readings of g = 1.0 just before release.
2. A period of readings of g = 0 as the sensor falls (free fall).
3. A period of increasing g as the sensor slows down (decelerates) at the end of its descent.
4. The final rapid drop where the force of deceleration separated the sensor from its lead and cut the signal back to the logger

A change in acceleration as a putter is swung and strikes a ball.

You will need:
1. The Low g Accelerometer set to the **±2.5 g** or **25 ms⁻² Y axis** range.
2. A Golf putter, with the Accelerometer securely attached.
3. Masking tape and or cable ties to secure the sensor to the putter and keep cables tidy.
4. Long sensor lead and sensor extension leads.
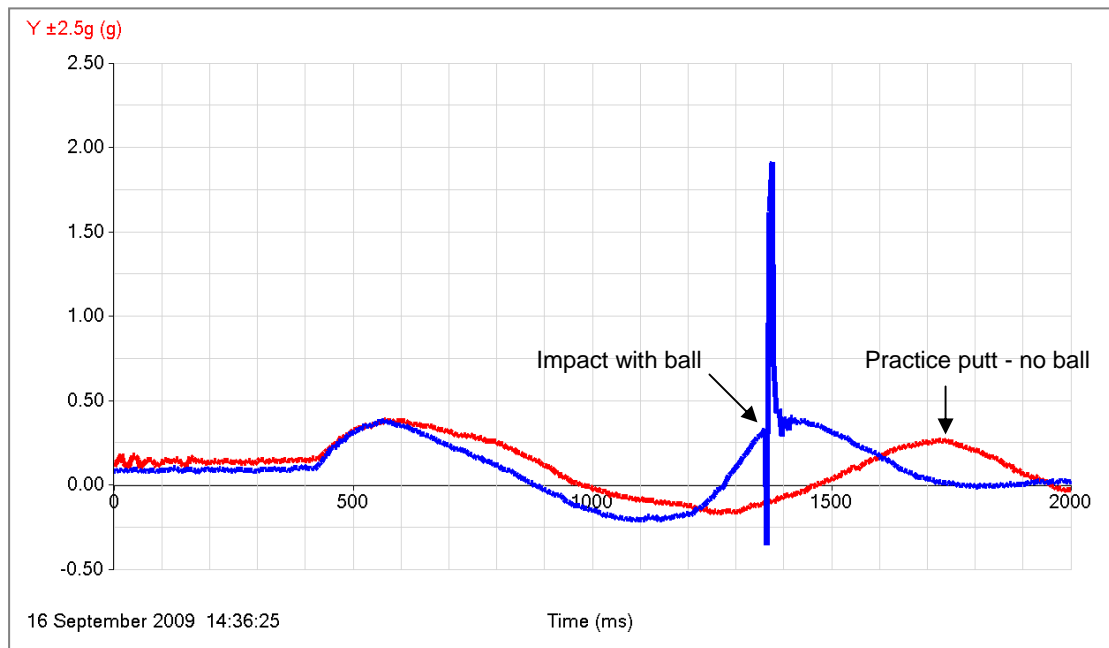5. Golf ball(s).
6. Practice hole (optional).

Setup of the logger or software

Record method	Time	Intersample	Trigger	Overlay
Graph	2 seconds	2 ms	Rises above 0.35 g or 3.5 ms⁻² with 25% pre-trigger	On

What you need to do:
1. Make a mark on the floor to represent the balls start position. Create a simple target e.g. masking tape in cross shape or a piece of paper on the floor with a mark upon it (without a target most people will find it difficult to produce a regular stroke).
2. Check that you can address the ball (target mark on floor) with your grip on the putter handle. Take a practice swing to make sure you have enough space and check the cables do not tangle or interfere with the stroke.
3. Position yourself at the start position and get ready to make the stroke.
4. Ask your helper to click on **Start**, and then make the stroke. If the recording does not start then the stroke you played may not have exceeded the trigger value.

Warranty

All Data Harvest Sensors are warranted to be free from defects in materials and workmanship for a period of 12 months from the date of purchase provided they have been used in accordance with any instructions, under normal laboratory conditions. This warranty does not apply if the Sensor has been damaged by accident or misuse.

In the event of a fault developing within the 12 month period, the Sensor must be returned to Data Harvest for repair or replacement at no expense to the user other than postal charges.

Note: Data Harvest products are designed for **educational** use and are not intended for use in industrial, medical or commercial applications.

WEEE (**W**aste **E**lectrical and **E**lectronic **E**quipment) Legislation

Data Harvest Group Ltd is fully compliant with WEEE legislation and is pleased to provide a disposal service for any of our products when their life expires. Simply return them to us clearly identified as 'life expired' and we will dispose of them for you.