Smart Q TECHNOLOGY

Motion Sensor

Product No 3705
(Self-powered type)

Product No 3270

Range 1: Distance 0.17 - 10 m
Resolution: 0.001 m (1 mm)

Range 2: Distance 17 - 1000 cm
Resolution: 0.1 cm

Range 3: Distance 7 - 400 inches
Resolution: 0.1 inch

Range 4: Time 1000 - 60,000 µs
Resolution: 1 µs

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Introduction

The *Smart Q* Motion Sensor is a sonar device that emits ultrasonic pulses, which reflect off an object. It measures the time it takes a high frequency sound pulse to travel from the Sensor to an object and back. This time data is used, together with the speed of sound, to determine the distance of an object from the Sensor.

There are two types of *Smart Q* Motion Sensor:

1. The original type (*Product No. 3270*), which takes the power it requires from the **EASY**SENSE unit. This makes it unsuitable for use with the **EASY**SENSE Flash Logger, Link, and V1.2 or less of the Q3 and Q5 loggers.

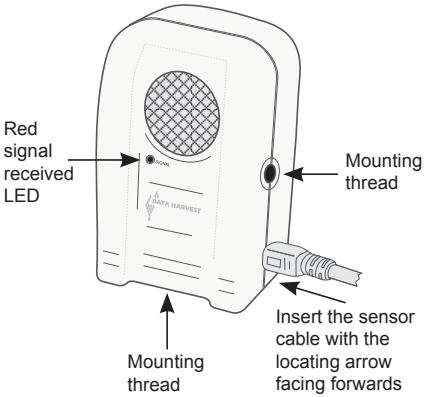
2. The self-powered type (*Product No. 3705*), which has an integral battery pack and is supplied with a 12 V mains power supply. This type can be used with any **EASY**SENSE unit (including the **EASY**SENSE Flash Logger, Link, and V1.2 or less of the Q3 and Q5 loggers).

Both types of Motion Sensor are supplied with a steel rod (size 80 mm long x 10 mm diameter with a M6 thread). The rod can be screwed into the mounting threads, which are found at the base and on the sides of the Motion Sensor. The rod can be used for clamping into a suitable holding device e.g. a retort stand.

The *Smart Q* Motion Sensor is equipped with a micro controller that greatly improves the accuracy, precision and consistency. It is supplied calibrated and the stored calibration is automatically loaded into **EASY**SENSE when the Motion Sensor is connected.

Connecting

- Push one end of the sensor cable (supplied with the **EASY**SENSE unit) into the shape socket on the side of the Motion Sensor with the locating arrow on the cable facing forwards.
- Connect the other end of the cable to the input socket on the **EASY**SENSE unit.
- The **EASY**SENSE unit will detect that the Motion Sensor is connected and display values using the currently selected range. If the range is not suitable for your investigation, set to the correct range (see page 4).



- The red signal LED on the Motion Sensor will only light when the **EASY**SENSE unit is powered and a signal has been reflected from the object. It will emit a clicking sound each time a pulse is sent.

Note: *The red signal LED on the Motion Sensor is **not** a power on indicator; it is used to indicate that a reflected signal has been received from an object.*

The Motion Sensor will start to pulse at approximately 50 pulses per second (every 20 ms). If the time for a pulse to reflect off an object is longer than 20 ms (when the object is over 2 metres away), the pulses will slow.

If your **EASY**SENSE unit goes into 'sleep mode' (nothing shown on LCD screen), the red LED on the Motion sensor will turn off and the unit will stop sending a pulse until the unit 'wakes up' to take a sample.

***EASY**SENSE **Flash Logger users:** Power is only supplied to the inputs when data is being logged (e.g. when the Start icon has been selected). The Motion Sensor will not emit a clicking sound and the red signal LED will not light until a sample is taken.*

Power requirements

Motion Sensor (*Product No. 3270*)

This type of Motion Sensor takes the power it requires from the **EASY**SENSE unit. If logging continuously for long periods connect the **EASY**SENSE unit to a mains power supply.

Motion Sensor (*Product No. 3705*)

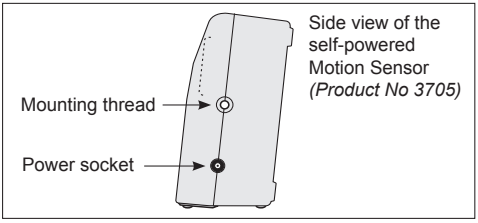
This Motion Sensor takes most of its power from its own batteries or from an attached mains power supply. It will not function correctly unless either the internal batteries are charged or it is connected to a power supply.

Note: *The red signal LED on the front of the Motion Sensor is not used to indicate that the Motion Sensor is receiving power or that it is fully charged. It is used to indicate that a reflected signal is being received from an object.*

The mains power supply included with this Motion Sensor can perform two tasks:

1. It can be used to re-charge the Motion Sensors internal batteries in preparation for use away from mains power.
2. It can be used to operate directly with the Motion Sensor connected to an **EASY**SENSE unit.

The specifications for the power supply are 12V DC (optional unregulated) and able to source at least 500 mA, with a positive centre and negative outer pin.



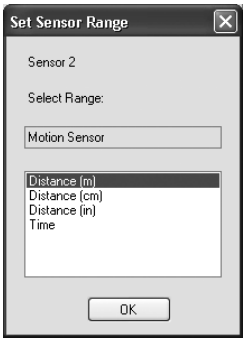
When the self-powered Motion Sensor is connected to the mains power supply the batteries will automatically be re-charged unless the Motion Sensor is taking samples. When taking samples, the current from the power supply is diverted to provide power for sampling rather than charging the batteries.

If the batteries are fully discharged attach the power supply and leave for a minimum of 10 minutes (without taking samples). Continue recording data with the power supply attached. If the batteries are fully discharged, it can take up to 7 hours to achieve full charge.

Although the main power consumption of the Motion Sensor is via its own batteries, it will also utilise some power from the **EASY**SENSE unit (or the Pocket PC if used with the Flash Logger).

To set the range

- Connect the Motion Sensor to the **EASY**SENSE unit.
- Start the **EASY**SENSE program and select one of the logging modes from the Home page e.g. EasyLog. Select **Sensor Config** from the **Settings** menu.
- Select the Motion Sensor from the list (it will be listed using its current range) 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 by the logging mode.



The range setting will be retained until changed by the user.

With some **EASY**SENSE units it is possible to set the range from the unit. Please refer to the **EASY**SENSE unit's user manual.

Practical information

Fastest Speed - The maximum sample rate of the Motion Sensor is 50 Hz **(20 ms)**.

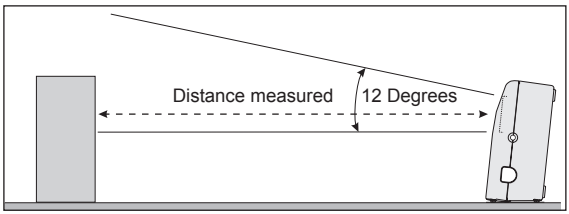
If an interval between samples of less than 20 milliseconds is selected, then either the set up will be rejected or the **values** obtained will **default to zero**.

Note: *The fastest speed that Version 1.0 - 1.3 Advanced users can log at is 40 Hz (25 ms).*

The data from the Motion Sensor is **not** suitable for use with the Timing function or the Time & Motion mode in the **EASY**SENSE software or data loggers. These functions will only use data from switch-type digital sensors.

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 12º. The Motion Sensor then 'listens' for the echo of the ultrasonic waves returning.

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



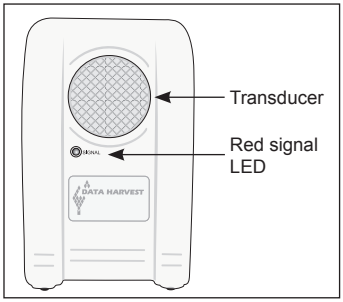
Motion Sensor

The **EASY**SENSE unit measures how long it takes for the ultrasonic waves to make the trip from the Motion Sensor to the object and back. Using this time and speed in air, the distance to the nearest object is determined. Any object that reflects sound can be used as a target.

Note: *The Motion Sensor will report the distance to the* ***closest*** *object that produces a sufficiently strong echo; this can be any object (such as chairs or tables) that are found in the cone of the ultrasound.*

The Motion Sensor has been calibrated for measurements of distance to be made from the centre of the perforated cover of the transducer.

The minimum distance between the object and the Motion Sensor should be 0.17 m (17 cm, 7 inches). The circuit inside the Sensor needs to switch off after a pulse has been sent to allow the transducer to stop oscillating before it tries to detect the reflected signal.



The further the object is from the Motion Sensor, the wider the detection cone becomes. The best response is within 5˚ either side of the central line of the transducer. At long distances, stray objects become more of a problem. The sensitivity of the echo detection circuitry automatically increases in steps as time elapses before the echo returns. This is to allow for echoes being weaker from distant objects. This increase in step can produce a slight change in distance measurement that maybe become noticeable if the distance graph is differentiated.

Before starting an investigation, use Meter or Test mode to determine if an object is providing a good reflection. Flat objects can be masked if they are not perpendicular to the waves.

When the Motion Sensor is held in a clamp, experiment to find the best angle of tilt and therefore the best echo.

The Motion Sensor will continue to send pulses until the **EASY**SENSE unit stops asking for a reading. This may result in the clicking noise continuing after logging has stopped.

If you intend to collect remote data with the original unpowered Motion Sensor (*Product No. 3270*), check the batteries in the **EASY**SENSE unit are fully charged before you start.

The self-powered type (*Product No. 3705*) will take most of its power from its batteries or power supply. If the batteries in the Motion Sensor are fully discharged it will not function. Attach the power supply and leave for a minimum of 10 minutes

(without taking samples). Continue recording data with the power supply attached. If the batteries are fully discharged, it can take up to 7 hours to achieve full charge.

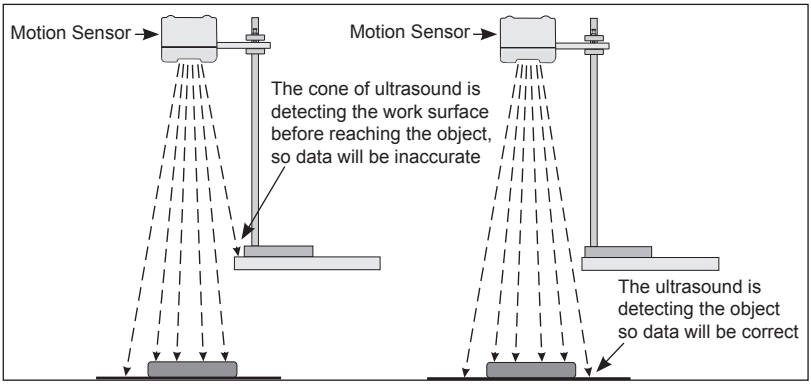
Automatic correction for variation in air temperature has been incorporated into the Distance ranges. The Motion Sensor will use its internal temperature sensor to apply a correction factor to the value for speed of sound used in calculating the distance (344 ms-1 at 21ºC). Without compensation, values for large distances between hot and cold days could have an error of up to 0.5 m. The Time range is not temperature compensated.

There is no compensation made for relative humidity or air pressure.

Although the moulding of the Motion Sensor has been designed to help protect the transducer, extra protection will be required if an object is being dropped from above. A protective wire mesh such as an office in-tray could be used. Test to ensure the wire does not interfere with the echo; the cone of the echo is at its narrowest close to the transducer.

If data appears inaccurate

- Check the object is at least 0.17 m (17 cm, 7 inches) from the Motion Sensor.
- Check for stationary objects e.g. tables, chairs, walls and floors that could be positioned in the cone of the ultrasound. They maybe detected instead of the object, especially if it is at a long distance.



- Other sound sources could cause a problem if they produce ultrasonic waves in the same frequency range (around 50 kHz) e.g. air track blowers, air exiting holes on an air track.
- Check that the reflecting surface reflects squarely. Try to increase the strength of the reflection from the target by increasing the target area.

- When studying a person's movement, the target may not supply a strong enough reflection e.g. by wearing non-acoustically reflective clothing. Get the target to hold a large flat object in front of them as a reflector.
- The surface reflecting the signal needs to be 'silk finished'. If a surface is shiny or reflective it can reflect signals. If the room has many sound reflecting surfaces, ultrasound can bounce around the room. If this happens try covering them with a cloth to reduce the reflections.
- Sound absorbing surfaces such as acoustic ceiling tiles will produce errors, as ultrasound will be absorbed.
- Balls made from foams or balls smaller than 5 cm diameter may not be detected. The best size is 15 cm diameter or more. Using a light ball e.g. an inflatable beach ball, to measure gravity is not advised since the air resistance (compared to gravitational force) will be too large.

If values default to zero
If an intersample time of less than **20 milliseconds** is selected the values will default to zero.

If values default to maximum
- When the red LED on the self-powered Motion Sensor is flashing erratically or is off, then it is possible that the batteries in the Motion Sensor are discharged. Attach the power supply and leave for a minimum of 10 minutes (without taking samples). Continue recording data with the power supply attached (a full recharge will take up to 7 hours).

  Note: *If you are using the Motion Sensor with **EASY**SENSE Flash Logger, the red light will not be lit until a recording has started e.g. by clicking on the Start icon in Graph.*

- Check the power level in the **EASY**SENSE unit (or the Pocket PC if used with Flash Logger).

Time range
The **Time** range will measure the time taken for the pulse to travel to the object and then back again.

When used with the Time range selected, the Motion Sensor can be used to measure the speed of sound. Place the Motion Sensor at least one metre away from the object. Select either Meter or Test mode and record a value.

Example: the Motion Sensor was placed 1 metre away from a wall (one metre to the wall and one metre back = a distance of 2 metres). The value for time measurement was 5800 µs.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{2}{5800 \times 10^{-6}} = 344.8 \text{ ms}$$

The value of the velocity of sound in air increases with temperature.
At 0˚C, v = 331.3 ms^{-1}. If the velocity of sound increases at 0.607 $ms^{-10}C^{-1}$ then at 24˚C, v = 331.3 + 24 x 0.607 = 331.3 + 14.6 = 345.9 ms^{-1}.

Temperature	18 C	19 C	20 C	21 C	22 C	23 C	24 C
Speed of sound in air	342.23	342.83	343.44	344.05	344.65	345.26	345.87
Temperature	25 C	26 C	27 C	28 C	29 C	30 C	31 C
Speed of sound in air	346.47	347.08	347.69	348.30	348.90	349.51	350.12

Investigations

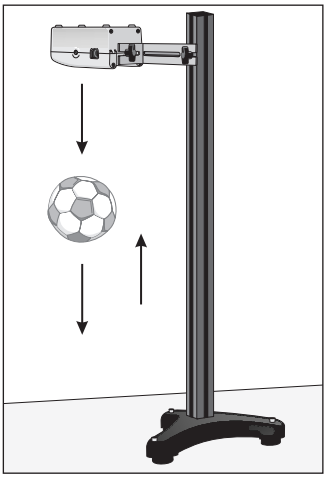
- *Walking toward and away from the Sensor*
- *Movement of an object up or down a slope*
- *Simple harmonic motion*
- *Newton's laws of motion*
- *Pendulum motions*
- *Air track gliders - collisions*
- *Acceleration due to gravity - free fall, pendulum swing, objects dropped or tossed upward*
- *Balanced forces*
- *Conservation of energy - a bouncing object*
- *Speed of sound*
- *Energy changes in simple harmonic motion*
- *Oscillation of a spring*

Can be used with a Force Sensor to:

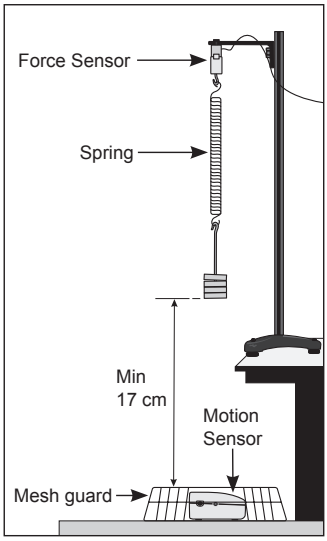
- *Study the relationship between force & motion*
- *To study collision and impulse*
- *Simple harmonic motion*
- *Spring characteristics, extension, oscillation, SHM*

Examples:

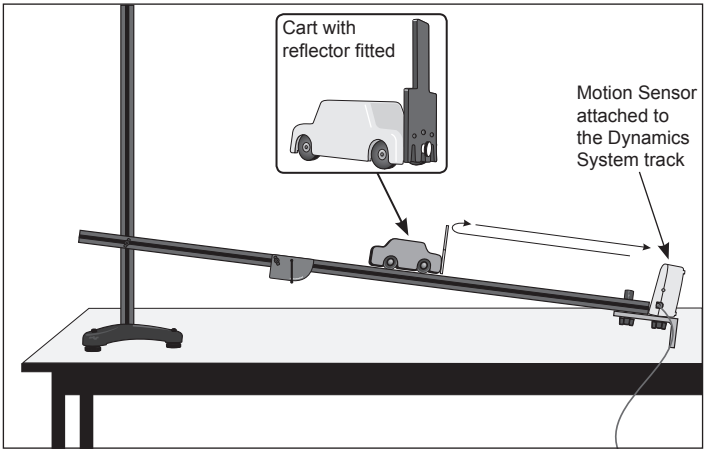
1. Measuring gravity by free fall - select an intersample time of 20 ms, pre-trigger greater than 30 cm. Hold ball about 10 cm below the Motion sensor , click on Start release the ball and move hands away quickly.



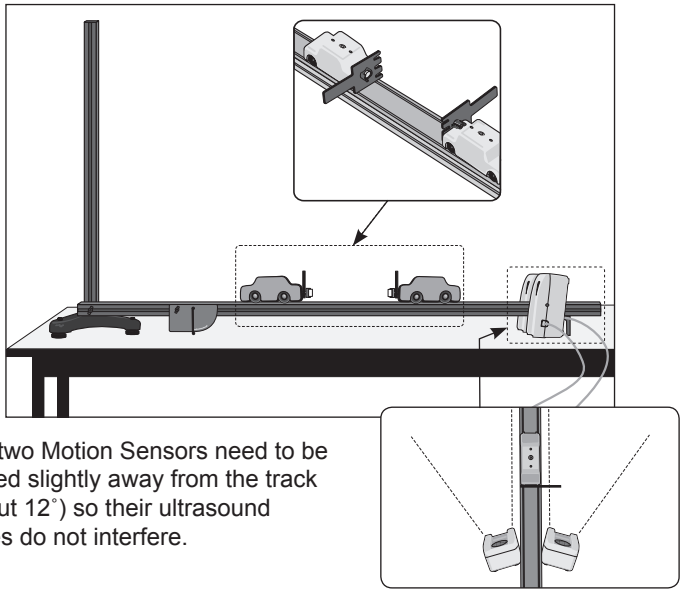
2. Simple harmonic motion, energy changes, extension characteristics, oscillation of a spring. The Force Sensor is used to measure the force in the spring as it oscillates. The position of the mass is monitored using the Motion sensor.



3. Used to plot the position of the trolley on the slope to find how the distance and speed change as a cart rolls up and down a slope; investigating whether acceleration depends on the angle of the slope; measuring g by rolling a cart down a slope; etc.



4. Elastic and inelastic collisions using two Motion Sensors and carts on the Dynamics System track.



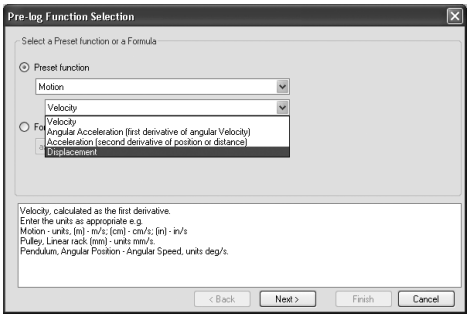
The two Motion Sensors need to be angled slightly away from the track (about 12˚) so their ultrasound cones do not interfere.

Distance, Velocity and Acceleration

To **create a set of Velocity or Acceleration data**

1. Select either **Pre-log function** (not available in Scope) or **Post-log function** from the **Tools** menu.

   Use Pre-log before the distance data has been recorded (the set of Velocity or Acceleration data will be created as logging progresses).
   Use Post-log when the distance data has already been recorded.

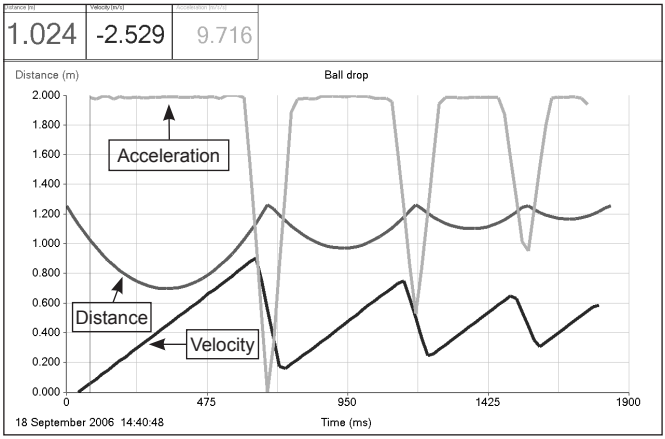


2. Select Preset function and then Motion.

3. From the drop down menu select Velocity or Acceleration (second derivative of distance).

   Velocity - click on Next. Select the Distance channel, Next. Enter the units as appropriate e.g. m (m/s), cm (cm/s), in (in/s), Finish.

   Acceleration (second derivative of distance) - click on Next. Select the Distance channel, Next. Enter the units as appropriate e.g. m (m/s/s), cm (cm/s/s), in (in/s/s), Finish.



Presets

Creating a Distance Preset

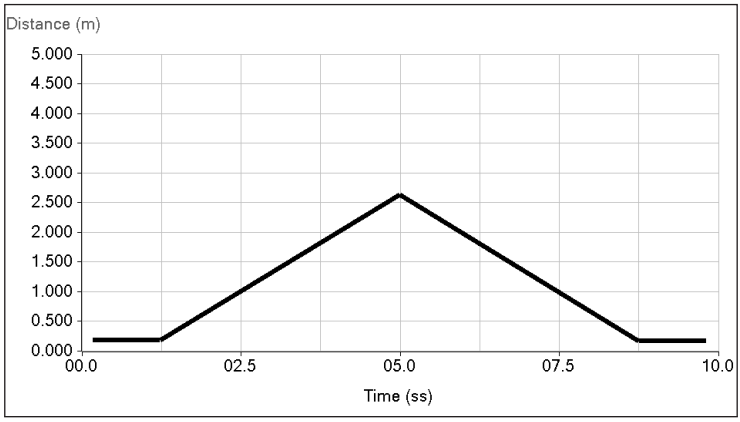
- Open **Graph** and select a suitable time span e.g. 10 seconds.
- Select **Sensor settings** from the Display menu and alter the maximum to a more suitable number e.g. 5.00 m.
- Right click in the graph area and select **Predict**. Use the predict tool to draw a line on the graph for the pupils to follow. Click with the right mouse button to finish the line.
- Select **Save Setup** from the File menu. Enter a name for the experiment and then a file name.

Creating Distance and Velocity Presets

- Select 2 from **Number of Graphs** in the Display menu.
- Use **Pre-log** from the Tools menu to create a Motion / Velocity preset function - alter the Y-axis limits to **Manual** and change to a more suitable minimum & maximum value e.g. -5 to 5.
- To display a different data set in each graph, right click in the first graph area, select **Show or Hide Channels** and deselect Velocity. Repeat in the second graph but deselect Distance.
- Right click in the graph area and select **Predict**. Use the predict tool to draw a line in each graph for the pupils to follow. Click with the right mouse button to finish the line.
- Select **Save Setup** from the File menu. Enter a name for the experiment and then a file name.

To open a preset

From the Home page select **Open Setup**. Select the setup you created from the list. Click on **Start** to begin recording.



A distance preset to copy

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 are fully compliant with WEEE legislation and are 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.

Notes: