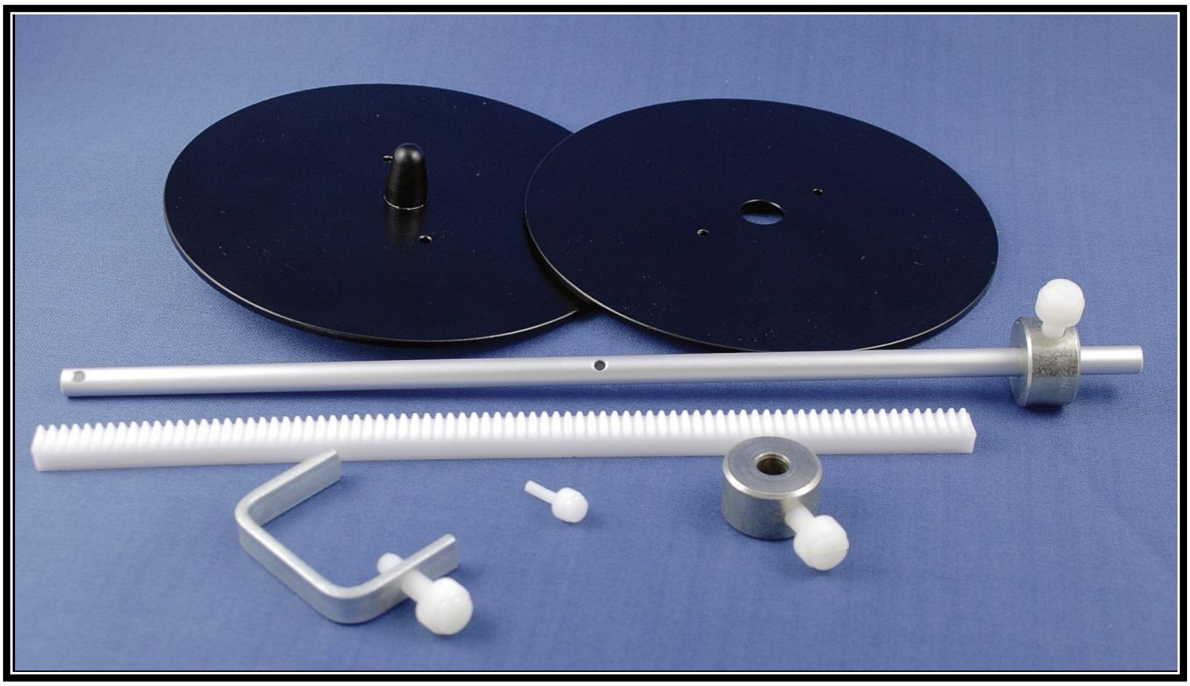
Sensor Accessories

Rotary Motion Accessory Pack

(Product No. 3288)

Pendulum Rod with two masses, an Angular Momentum disc set and Linear Rack with mini c-clamp



Data Harvest Group Ltd.
1 Eden Court, Leighton Buzzard,
Beds, LU7 4FY
Tel: 01525 373666
Fax: 01525 851638
e-mail: sales@data-harvest.co.uk
www.data-harvest.co.uk

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Introduction

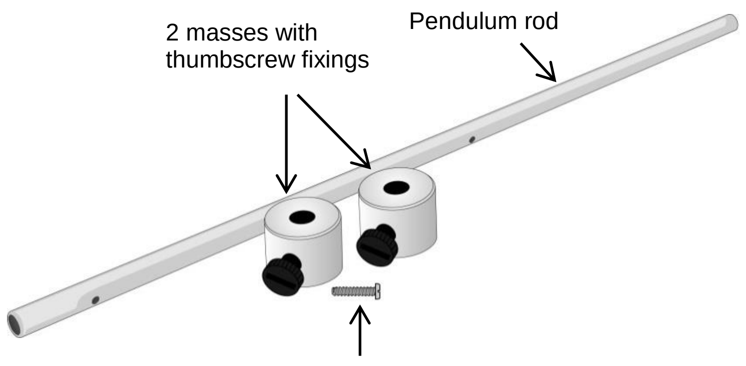
The Rotary Motion accessory pack consists of three main accessories that extend the functionality of the *Smart Q* Rotary Motion Sensor (Product No. 3280).

They are:

1. The **Pendulum Rod** – an aluminium rod with two adjustable ring masses and a fixing screw. Can be used with or without the masses to perform pendulum and rotational inertia investigations.
2. The **Angular Momentum disc set** – two aluminium discs. Can be used to study rotational inertia and conservation of angular momentum.
3. The **Linear Rack** - a 250 mm plastic rack with mini c-clamp. Can be used to measure linear motion over the length of the rack. The c-clamp is for attaching a *Smart Q* sensor to the rack.

The Pendulum Rod

The pendulum is a predrilled aluminium rod, two adjustable masses and a fixing screw. The masses can be adjusted to any point on the pendulum rod using the thumbscrew fixings.

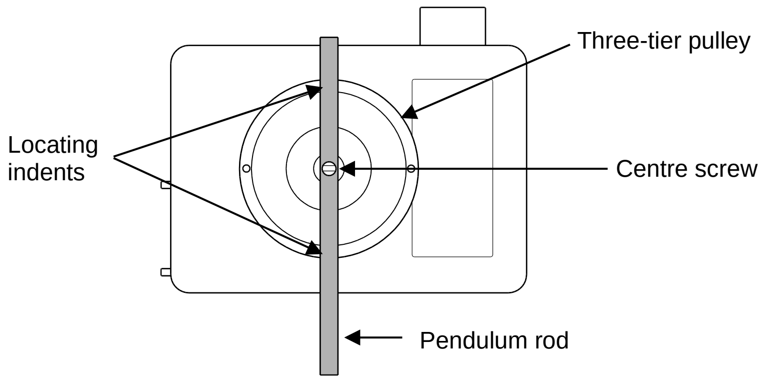


For accurate results weigh and record the exact measurement of each component before use, i.e.

Mass of rod = ___________ gm,
Length of rod = ______________ mm,
Mass with thumbscrew = ___________ gm.

- Set the Rotary Motion Sensor to a suitable range e.g. Pendulum.

- Use a screwdriver to remove the screw and washer from the centre of the pulley wheel.



- Push the screw supplied in this pack through the appropriate hole in the pendulum rod. Position the rod in the locating indents on the outer pulley with the screw in the centre hole of the pulley. Tighten the screw.
- If a mass or masses are being used in the investigation slide onto the rod and tighten the thumbscrew to secure in position.

Studying Pendulums

Select either the Pendulum or Angular position range (Angular position range: 0 - 360 degrees, Pendulum: ±20 degrees).

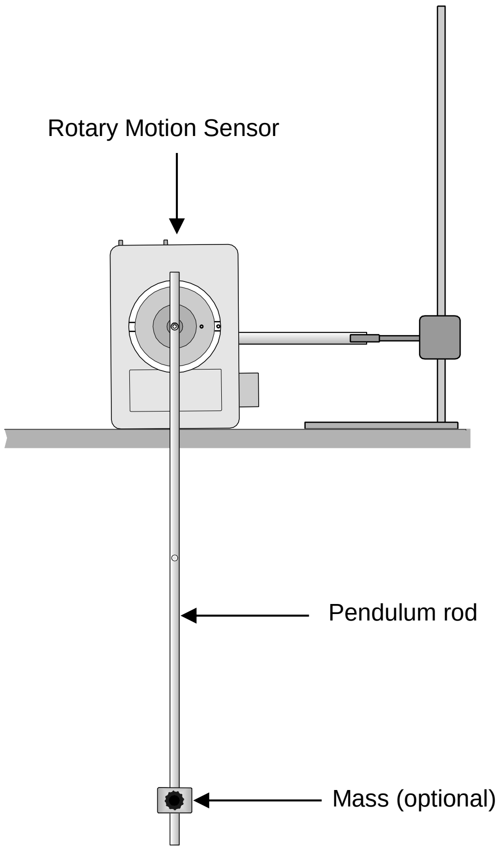
Use the hole at the end of the rod to attach the pendulum to the Rotary Motion Sensor.

Clamp the Rotary Motion Sensor to a retort stand using its rod attachment to prevent it from moving. Position so that the pendulum rod will hang freely over the surface edge.

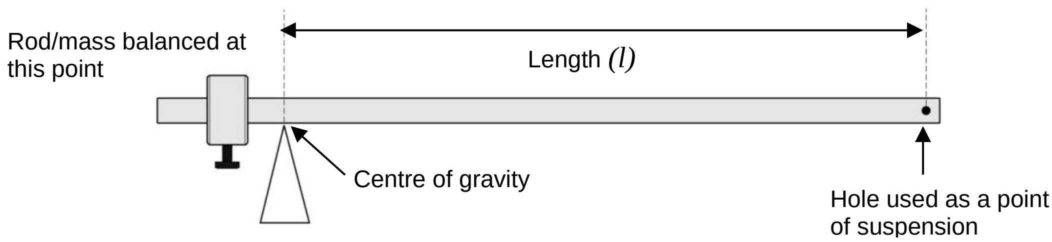
Note: *Only the rod should be clamped not the body of the Sensor.*

With the pendulum hanging freely and stationary, press the reset button on the Rotary Motion Sensor to set zero.

The pendulum can be used with or without a mass attached. The mass can be moved up or down the rod to change the effective length of the pendulum.



The length of the pendulum is defined as the distance from the point of suspension to the centre of gravity of the bob. To find the centre of gravity, place the pendulum rod/mass rod on a ‘knife’ edge and find the point at which it is balanced. Measure the distance from the point of suspension to the centre of gravity and use this value to give more accurate results.

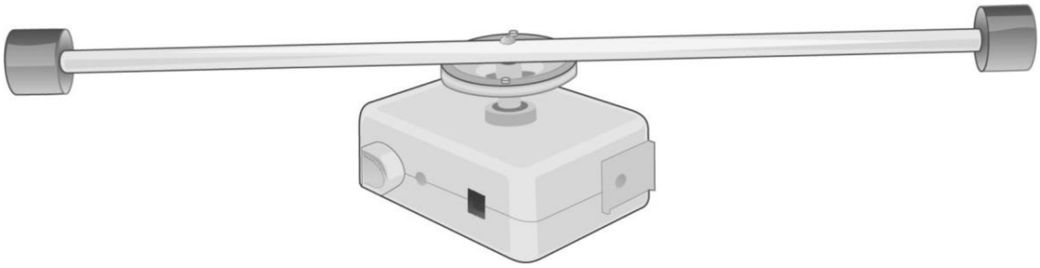


Measuring rotational inertia

When the pendulum rod is used in rotational inertia investigations either the Angular velocity (rads.) or Angular velocity (revs.) range is suitable.

Use the hole in the centre of the rod to attach the pendulum to the Rotary Motion Sensor.

Position the Sensor so the rod can rotate freely in a circular motion. Use with or without any masses attached to study rotational inertia.



The Angular Momentum Disc set

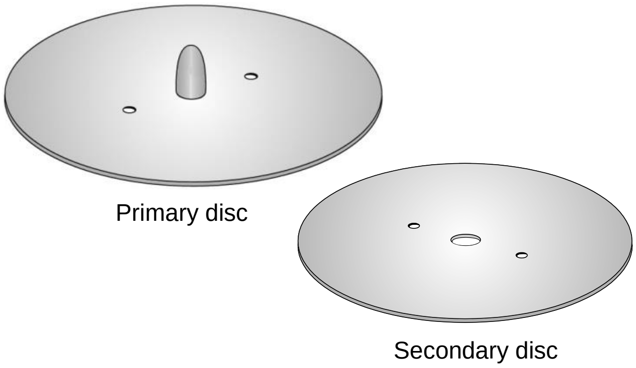
The angular momentum disc set is comprised of two 2 mm thick aluminium discs. Both discs have locating holes that will fit onto the locating pins of the largest pulley of the Rotary Motion Sensor. The primary disc has a central thimble-shaped spindle. The secondary disc has a hole in the centre (that will fit over the spindle of the primary disc) and three friction pads on its lower surface.

For accurate results weigh each disc and record the exact measurement on the disc for future reference, i.e.

Mass of primary disc:____________ gm

Mass of secondary disc: _________ gm

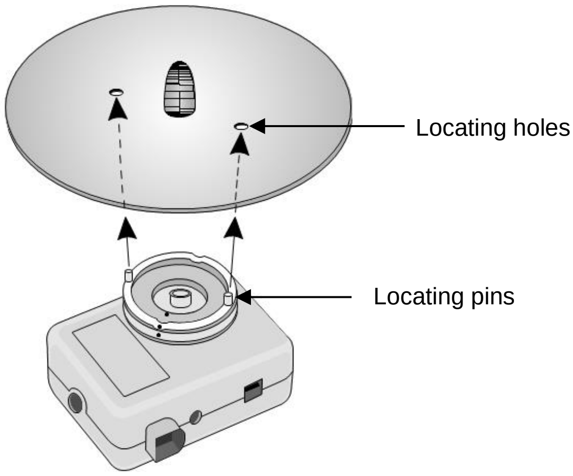
Diameter of the discs: ___________ mm



Studying rotational inertia

- Set the Rotary Motion Sensor to a suitable range e.g. Angular Velocity in radians or revolutions per second.
- Mount the Rotary Motion Sensor horizontally with the largest of the three-step pulleys orientated outwards.
- Place the primary disc so its locating holes fit over the pins on the outer pulley. Check that the Rotary Motion Sensor and disc are level.
- Use the central spindle to manually spin the disc in a clockwise direction.

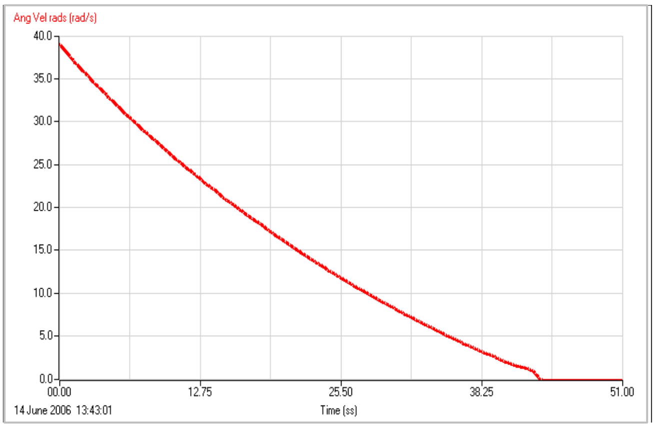
Note: *If the disc slows down quicker than expected, place a drop of light machine oil at each set of bearings (see maintenance on page 8).*



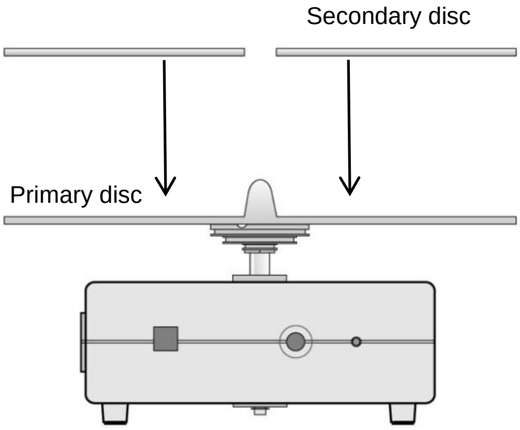
- Open the **EASY**SENSE program and select **Graph** from Home page. From the New recording wizard select a suitable timespan and start condition.

  In this example the start condition was set so that data was not collected until the value from the Rotary Motion Sensor (Ang Vel rads) fell below 39 rads. Click on the **Start**/Stop icon and a 'Waiting for Trigger' message will appear in the status bar. Spin the disc fast so the value exceeds 40 rads, then leave to continue spinning. When the value falls below 40 rads, the recording will start.

  Note: *The minimum displayed has been altered to 0 in Sensor Settings (Options icon)*.



Conservation of angular momentum



- To investigate that momentum is conserved in a rotational collision follow the steps above, set the start condition and give the primary disc a spin. When recording has started, wait a few seconds, and then drop the secondary disk onto the primary disc whilst it is still spinning.
- Select Overlay, and repeat the procedure several times. The data can be used to determine the angular speed just before and just after the disc was dropped.

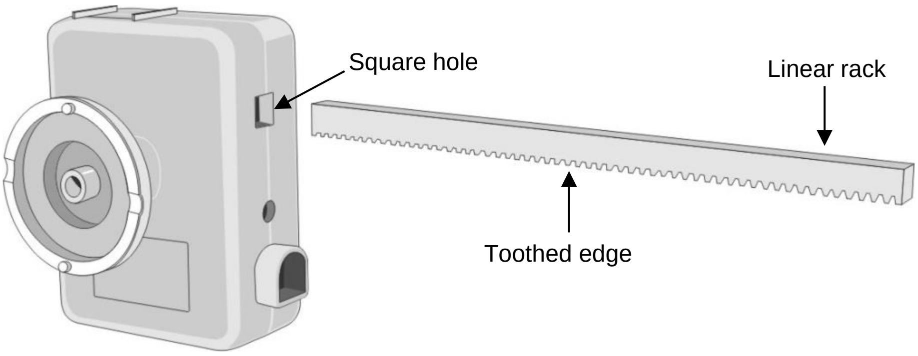
Round table

There are locating holes in the secondary disc that fit onto the locating pins on the large pulley to produce a flat circular surface. The angular position of an object e.g. a prism, placed on this surface can be monitored as the disc is rotated.

The Linear Rack

The linear rack can be used to measure linear motion over the length of the rack e.g. by a force which cannot be tensioned. The rack is 250 mm long. It has 80 teeth, which are pitched at 3.2 teeth per 10 mm.

The shaft of the Rotary Motion Sensor is fitted with a gear wheel. The teeth on the linear rack will engage the gear wheel so that any movement of the rack will rotate the shaft to convert linear to rotary motion. The calibration for the stored linear rack range is calculated from one revolution of the gear wheel being equal to approximately 78.5 mm length of the linear rack.



The linear rack fits into the small square hole that can be found on both sides of the Rotary Motion Sensor. Insert the linear rack gently into the hole (from either side) with its teeth pointing downwards (towards the shaft of the pulley wheel). Feed in the rack until it just emerges from the square hole on the other side.

Note: *A small amount of vertical movement allows the teeth on the rack to mesh correctly with the gear wheel. Use this movement to adjust the rack and line up with the exit hole. Do not use force as this may damage the Sensor.*

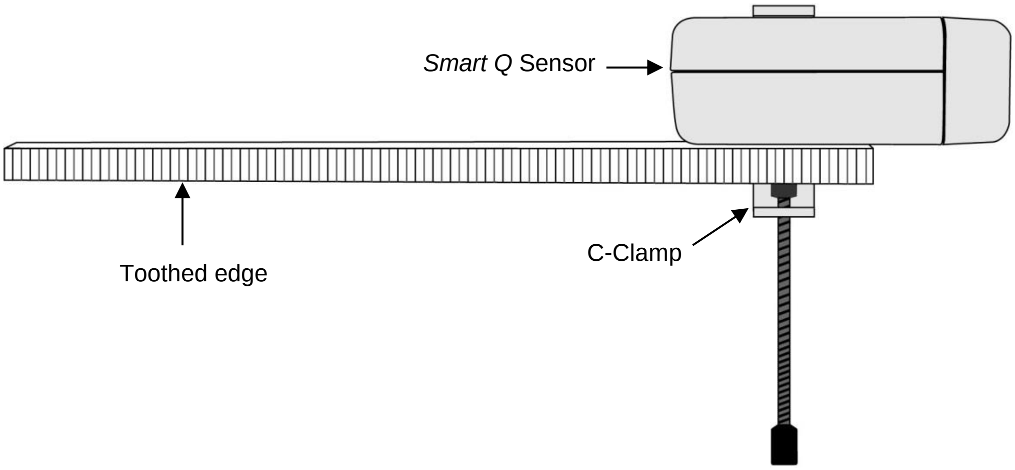
Movement of the linear rack that rotates the pulley in a clockwise direction will give negative values; in an anticlockwise direction will give positive values.

Studying linear movement

- Set up the Rotary Motion Sensor in a suitable position.
- Set the Rotary Motion Sensor to the 'Linear Rack' range.
- If applicable, use the c-clamp to attach a *Smart Q* Sensor to the linear rack (see below).
- Insert the linear rack into the square hole on the Sensor and feed through until it just emerges from the other side.
- Press the reset button on the Rotary Motion Sensor to set near zero. If an exact 0 mm start point is required manually adjust the rack to a zero reading.

A **mini c-clamp** has been provided to enable a *Smart Q* Sensor to be secured to the linear rack. Used this way the position of the Sensor can be recorded as it is moved in an investigation e.g. in an inverse square law investigation with a Light level Sensor or Sound Sensor.

To use the c-clamp:
Place the *Smart Q* Sensor to be used e.g. a Light level Sensor, in position on the side edge of the linear rack. Open the jaws of the c-clamp and locate over both the Sensor and rack so the adjustable screw will tighten onto the smooth side of the rack.

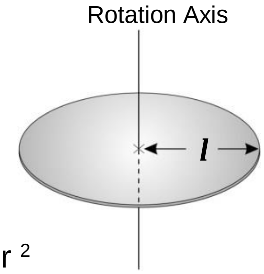


Note: *Make sure that the clamp does not tighten onto the teeth of the rack.*

Tighten the clamp gently until the Sensor is secure. Do not over tighten or the Sensor case/linear rack could be damaged.

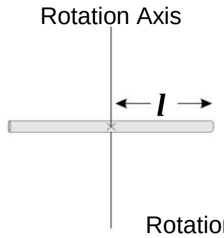
Common moments of inertia

The rotational inertia of a rotating body depends not only on its mass but also on how that mass is distributed with respect to the rotation axis.

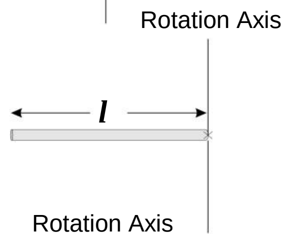


i = the rotational inertia
m = the mass of the object
r = the radius of the object (if spherical/circular)
l = the length of the object

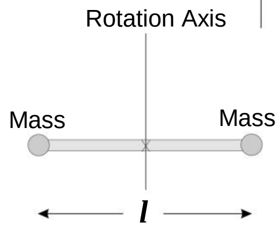
The rotational inertia of a solid disc about a central axis: $i = \frac{1}{2} mr^2$
e.g. the angular momentum disc.



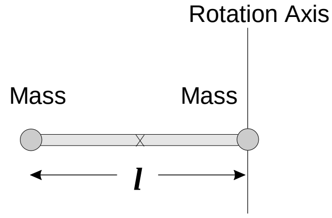
Thin rod about axis through centre perpendicular to length: $i = \frac{1}{12} ml^2$
e.g. the pendulum rod fixed at its centre point.



Thin rod about axis through one end perpendicular to length: $i = \frac{1}{3} m l^2$
e.g. pendulum rod fixed at its end point.



Rigid body consisting of two masses connected by a rod of length l and negligible mass whose rotation axis is through the centre of the mass: $i = \frac{1}{2} m l^2$
e.g. pendulum rod fixed at its centre point with a mass attached to each end of the rod.



Rigid body consisting of two masses connected by a rod of length l and negligible mass whose rotation axis is through the end of rod: $i = m l^2$
e.g. pendulum rod attached using the end hole, with a mass attached to each end of the rod.

Example:
The 'moment of inertia' of the angular momentum discs is calculated from the formula: $\frac{1}{2} m \times r^2$

Secondary disc

Mass (m) = 136.8 gm = 0.1368 kg
Radius = 75 mm = 0.075 m
r^2 = 0.005625 metres
The moment of inertia is = $\frac{1}{2} m \times r^2$ = (0.5 x 0.1368) x 0.005625 = 0.0003847 = 0.38×10^{-3} kgm^2

Primary disc

Mass (m) = 150.4 gm = 0.1504 kg
Radius = 75 mm = 0.075 m
r^2 = 0.005625 metres
The moment of inertia is = $\frac{1}{2} m \times r^2$ = (0.5 x 0.1504) x 0.005625 = 0.000423 = 0.42×10^{-3} kgm^2

Maintenance

If the Rotary Motion Sensor is not moving as freely as expected place a drop of light machine oil (e.g. 3 in 1) at the two bearings points:

1. On the spindle at the back of the Sensor and
2. Between the three-tier pulley and the body of the Sensor.

Spin the pulley several times so the oil fully penetrates the bearings.

Investigations

Using the Pendulum rod and masses:

Pendulum investigations e.g. effect of amplitude or mass on period

Rotational inertia

Using the Angular Momentum discs:

Conservation of Angular Momentum

Rotational inertia

Circular Movement

Using the Linear Rack:

Linear motion e.g. gas syringe plunger

Linear movement of a Smart Q Sensor e.g. inverse square law investigation, Young's slit

Limited warranty

For information about the terms of the product warranty, see the Data Harvest website at: https://data-harvest.co.uk/warranty.

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