

➤ **World leading  
supplier of  
engineering  
teaching  
equipment**

## Material Science

Strength of Materials



UTM Magnus



The material science range from P.A.Hilton Limited enables clear and comprehensive learning of materials and their respective properties.

An understanding of the way in which materials act and react is fundamental when studying the application on a variety of fixed or moving structures.



**Carlo Alberto Castigliano (1847-1884) who was an Italian railroad engineer. In 1879, Castigliano published two theorems.**

### Castigliano's first theorem

The first partial derivative of the total internal energy (strain energy) in a structure with respect to any particular deflection component at a point is equal to the force applied at that point and in the direction corresponding to that deflection component. This first theorem is applicable to linearly or nonlinearly elastic structures in which the temperature is constant and the supports are unyielding.

### Castigliano's second theorem

The first partial derivative of the total internal energy in a structure with respect to the force applied at any point is equal to the deflection at the point of application of that force in the direction of its line of action. The second theorem of Castigliano is applicable to linearly elastic (Hookean material) structures with constant temperature and unyielding supports.



#### HSM1 Deflection of Beams Apparatus

- Experiments to show, Deflection of a simply supported beam with varying span. Deflection for an offset load on a simply supported beam. Distributed Loads on a simply supported beam



#### HSM1C Advanced Beam Testing Apparatus (Analogue Version)

- Bench top apparatus for large number of beam tests. With three reaction piers with digital displays and a fixed pillar for cantilever work. A quick and easy adjustment of test span permits a large number of test setups and variations.



#### HSM1CD Advanced Beam Testing Apparatus, Digital Version (6 Beams supplied with different thickness) Optional Extras: HSM1f, HSM1g

- An unlimited range of beam experiments can be performed to measure support reactions, deflections and rotations of simply supported, fixed and two span continuous beams, simple and propped cantilevers, and sinking supports.



#### HSM2 Torsion of Bars Apparatus

- Apparatus to understand and investigate directly the relationship between the torsional load applied to a round bar and the angular twist produced and how this relationship varies with the beam material and it's cross sectional polar moment of area.



#### HSM6 Compound wires Apparatus

- To determine Modulus of Elasticity (E) for the specimen wire to verify Hooke's Law.



#### HSM7 Extension of Springs Apparatus

- To determine spring stiffness using measured spring data and load versus extension graphs. The dependence of spring stiffness on the wire diameter, spring diameter, length, number of turns and material can be calculated



#### HSM8 Compression of Springs

- To test the relationship between the load applied and the change in compressive length of a spring (Hooke's Law) Determines spring stiffness using measured experimental results and the formulae provided. Demonstrates the dependence of spring stiffness on the wire diameter, spring diameter, length, number of turns and material.



#### HSM10 Curved Bar Apparatus

- To experimentally determine the vertical and horizontal deflections of various curved bars whose cross sectional dimensions are small compared with the bar radius



#### HSM11 Combined Bending and Torsion Apparatus

- A self contained, bench mounted apparatus to determine elastic failure of a specimen subjected to several ratios of simultaneous bending and torsion : allowing comparison of results with the established theories of failure.



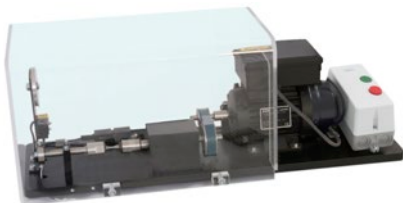
### HSM15 Critical condition of Struts

- To observe the behaviour of four struts of the same length, but with different end constraints, when subjected to buckling loads. Compare the results with theoretical predictions, such as Euler's formula.



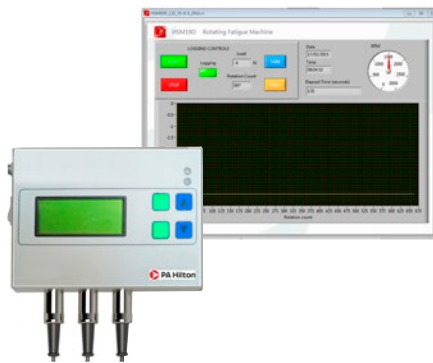
### HSM18 Electrical Resistance Strain Gauge

- The apparatus has been designed to illustrate the basic features of electrical resistance strain gauges and their application in measuring bending and torsion.



### HSM19 Rotating Fatigue Machine (Analogue Version)

- This unit has been designed to introduce students to the effects of material fatigue using a sinusoidal variation of bending stress.



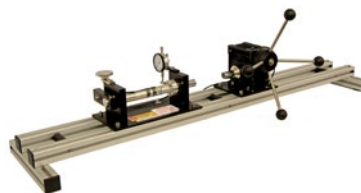
### HSM19D Rotating Fatigue Machine (Electronic Loading Mechanism)

- This unit has been designed to introduce students to the effects of material fatigue using a sinusoidal variation of bending stress. Comes complete with data logging functionality.



### HSM30 Unsymmetrical Cantilever Apparatus

- This apparatus allows the vertical and horizontal deflections of the free end of a test specimen to be measured when loading occurs along a principle axis or at a known angle.



### HSM31 Torsion Testing Machine (30Nm)

- Torsion testing machine for destructional testing of steel, brass and aluminium samples.



### HSM34 Creep Testing Machine

- A sturdy bench top mounted unit for studying the affect of creep on different material test specimens and at different temperatures.



### HSM35 Torsion and Deflection Testing Apparatus

Includes 4 torsion specimens and 8 bending specimens as standard

- This bench top unit allows a variety of experiments to be undertaken to investigate test specimens under torsional loading and bending loading within their elastic limits.



### HSM41 Pendulum Impact Tester (25J Impact Energy)

- A sturdy bench top mounted unit for the study of notched bar (Charpy) impact strength tests.



### HSM51 Rockwell / Brinell Hardness Tester

- A combined hardness tester designed for measuring hardness of metals and alloys of all types (hard & soft)



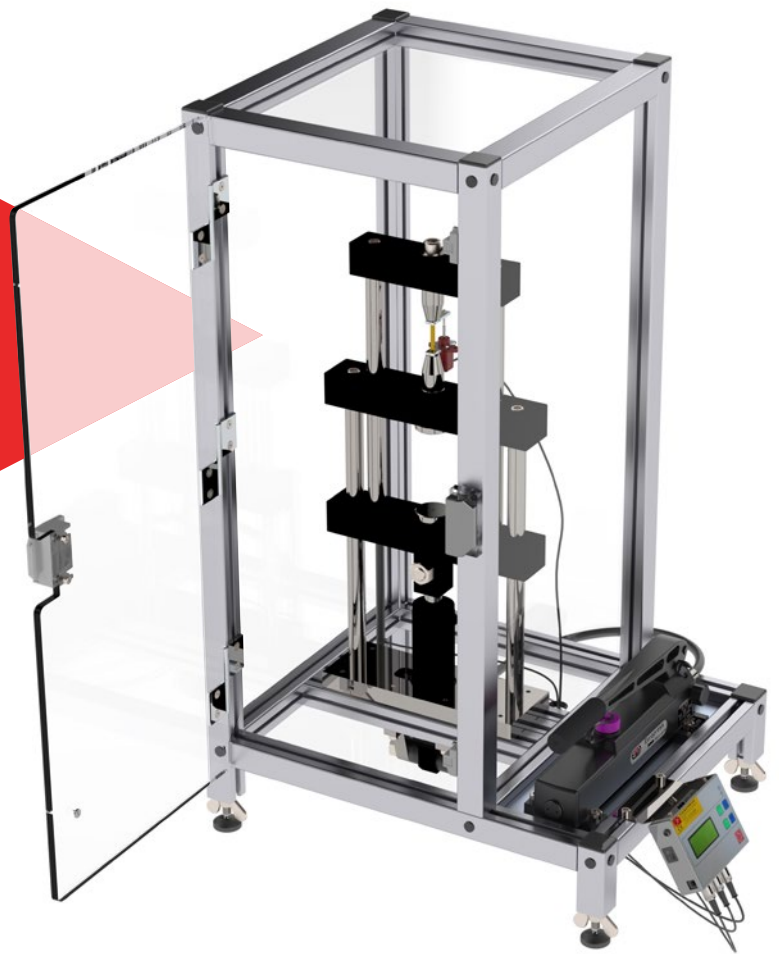
### HSM56 Extension and Compression of Springs

- Wall mounted apparatus to demonstrate Hooke's law and the relationship between deflection and load for tension and compression springs

The HSM58 is a modular, flexible, compact, safe, materials tester allowing students to conduct up to eight (8) experiments on seven (7) different material types.

The results of these experiments allow students to gain a thorough understanding of materials properties and how the performance of these effects design.

The fully enclosed unit allows safe 360° viewing maximising visibility for large class sizes.



#### HSM58 Universal Materials Tester, 35kN

- Fully enclosed safety guard for operator safety
- Sturdy ground steel pillars – for durability and repeatability
- Utilises linear slide bearings – for ease of use
- Digital Extensometer accurate to 3 decimal places



#### Newton's second law

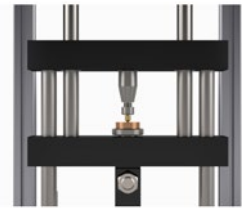
The second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force.

$$\mathbf{F} = \frac{d\mathbf{p}}{dt} = \frac{d(m\mathbf{v})}{dt}$$

[https://en.wikipedia.org/wiki/Newton%27s\\_laws\\_of\\_motion#Newton's\\_second\\_law](https://en.wikipedia.org/wiki/Newton%27s_laws_of_motion#Newton's_second_law)

#### Related Laws/Study Areas

- Young's Modulus
- Hooke's Law
- Poisson's Ratio
- Modulus of Elasticity
- Shear Modulus
- Material Hardness (Brinell Method)
- Beam Bending Theory
- Planar Moment of Inertia
- Deep Drawing



**HSM58B Brinell Hardness Test Set, comprising Indentor and 16 specimens (4 Steel, 4 Aluminium, 4 Brass, 4 Copper)**

- Brinell type indenter attachment to the base unit to allow the testing of various samples for material hardness.



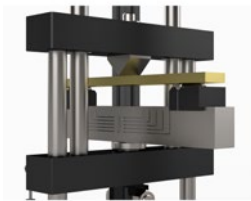
**HSM58F Measuring Magnifier for Brinell**

- The Brinell Microscope is a small microscope with a detachable light source for measuring small indentations within the test specimens
- The light source creates illumination of the surface of the test specimen thus ensuring visibility of any indentations



**HSM58I Spring Testing Set**

- Characteristic curves of springs with various spring stiffness's
- Mounted within compression area of apparatus
- 3 x helical springs
- 2 x disc springs



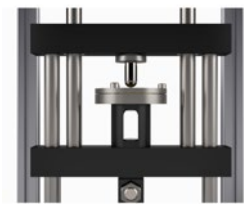
**HSM58C Bending Device Test Set including 5 specimens (2 Steel, 2 Aluminium, 1 Brass)**

- Elastic deformation of bending bars subject to a point force
- Test bars to be placed on two sliding bearings for span adjustment
- Test bars to be loaded with a point force generated by the tester



**HSM58G Asymmetrical Shear Test Set (Inc. 5 x Copper Shear specimens)**

- Asymmetrical Shear Testing with lower support block and upper shear anvil
- Shearing anvil and inserts in support block made of hardened steel



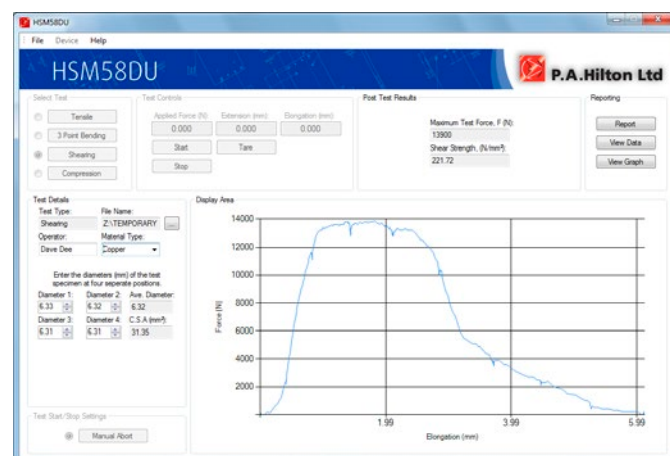
**HSM58P Device for Deep Drawing**

- Also known as cupping
- Includes Punch, die and Die holder
- Punch and specimens comply with BS EN ISO 20482:2003



**HSM58E Symmetrical Shearing Test Set including 5 Copper Shear Specimens**

- Symmetrical Shear Testing with lower support block and upper shear anvil
- Shearing anvil and inserts in support block made of hardened steel



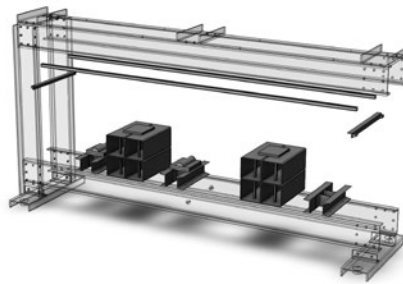
The Magnus universal testing frame enables clear and comprehensive learning of stress, strain, deflections and forces within a full size structure such as roof truss, concrete beams and wooden structures.



I am opposed to the laying down of rules or conditions to be observed in the construction of bridges lest the progress of improvement tomorrow might be embarrassed or shackled by recording or registering as law the prejudices or errors of today.



Isambard Kingdom Brunel, 1806-1859



#### HPM2 Set of essential accessories for HPM1

- A full range of rocker and roller bearings, plates, support blocks, clamps and dial gauge mounting systems for setting up test specimens

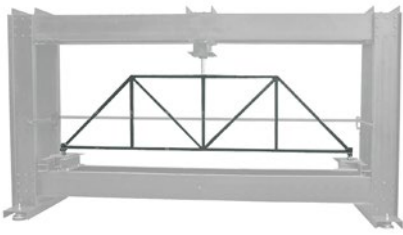
#### HPM1 Universal Testing Machine 300kN - MAGNUS

- A large scale, sturdy steel channel section frame, that enables students to conduct a wide variety of materials testing experiments on full size samples such as concrete and timber beams



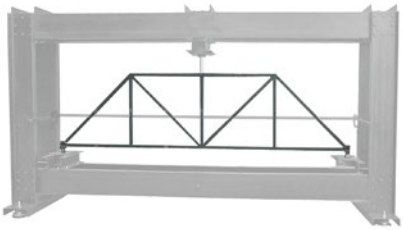
#### HPM3A Twin Hydraulic Ram System

- Optional experimental accessory to enhance the learning experience in conjunction with the HPM1 Magnus 300kN Test Frame. Manually operated, double acting 700bar hydraulic rams mounted on travelling carriages, enable the loading span to be varied as required. Also available as HPM3, single ram system. Essential Extras
  - HPM3 Single Hydraulic Ram System
  - HPM12 Protective Guard
  - HPM15 Data Acquisition System
  - HPM20 Dial Gauges and Holders
  - HAC20K Strain Gauge Kit



### HPM6/1 Plane Frame

- Optional experimental module to further enhance the experimental capabilities by a comparison of deflections and influence lines with theoretical values. Allows the comparison between normal and underslung (inverted) trusses and investigation of reciprocal theorem.
- Also available as HPM6/1a Optional Plane Frames Fitted with Strain Gauges.
- Essential Accessories: HPM1, HPM3 or HPM3a



### HPM6/1A Plane Frame fitted with Strain Gauges

- Optional strain gauged experimental module to further enhance the experimental capabilities by a comparison of deflections and influence lines with theoretical values. Allows the comparison between normal and underslung (inverted) trusses and investigation of reciprocal theorem.



### HPM12 Protective Guard

- To provide maximum protection to the face from splinters, etc., each guard is supplied with a 450 mm square transparent shield. This shield is 5 mm thick and hooks onto the wire mesh in any position. It is possible to have four of these on each side of the Test Frame at any one time.



### HPM15 Data Acquisition Upgrade

- This unique and compact unit is essential for all HPM experiments requiring the key parameters of Force, Strain, Deflection and Pressure to be monitored and captured. It can also be used for customer designed experiments where HPM compatible sensors are used.



### HAC20K Strain Gauge Kit

- A complete strain gauge kit, which contains all necessary components to enable strain gauging to be successfully completed.





Maximise students per session, so **more efficient use of lab and student time.**

## Innovative teaching software



### HPM15 Interface

The HPM15 Interface has been designed to function with UTM Magnus (HPM) experiments fitted with appropriate transducers. It has the facility to display, record, store and review parameters of strain, pressure, force and deflection and can be operated in two modes; with PC (USB) or without PC (Standalone).

The unit is a fully integrated data acquisition / signal conditioning interface. Each of the 23 channels has its own signal conditioning. The variables, either displayed on the internal LCD, or PC software, are returned as 'real world' values of either microstrain, Force (N), Pressure (bar) or deflection (mm) making it very user friendly. The local display, along with the USB PC connection, make this a highly flexible and versatile unit for any application.

The unit also has the ability to operate with bespoke customer experiments which use appropriate transducers.

The HPM15 includes 16 channels for either strain or Force or any combination of the two up to 16 maximum, 6 dial gauge inputs, and one pressure input.

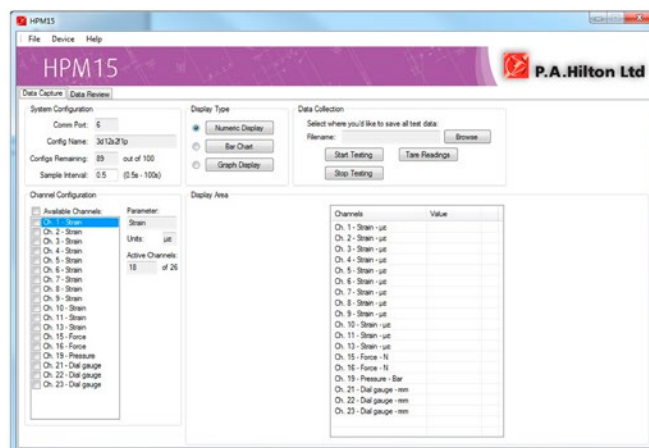
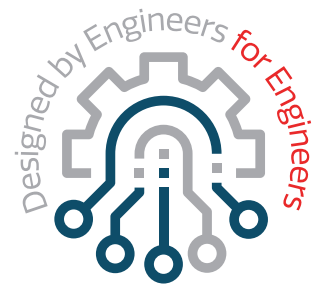
It has a front fascia 4 line display, which displays the parameters in standard engineering units. Front fascia buttons also allow the end user to tare the displayed values.

Connections to the hardware transducers are made via external sockets surrounding three sides of the interface unit. Mating connectors are either factory fitted to the hardware transducer cables, or can be fitted by the end user.

The interface is powered via a universal voltage power supply with removable plug adaptors for different countries.

The HPM15 software supplied has been designed to capture the data from the HPM15 interface. This captured data is displayed live in a variety of different formats including graph, numerical, or bar, and is stored on-board. Retrieval of the data for reviewing is available, along with exporting to other applications.

The software also allows for bespoke channel configuration, when customers wish to use the interface and software with their own experiments.



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