F SERIES

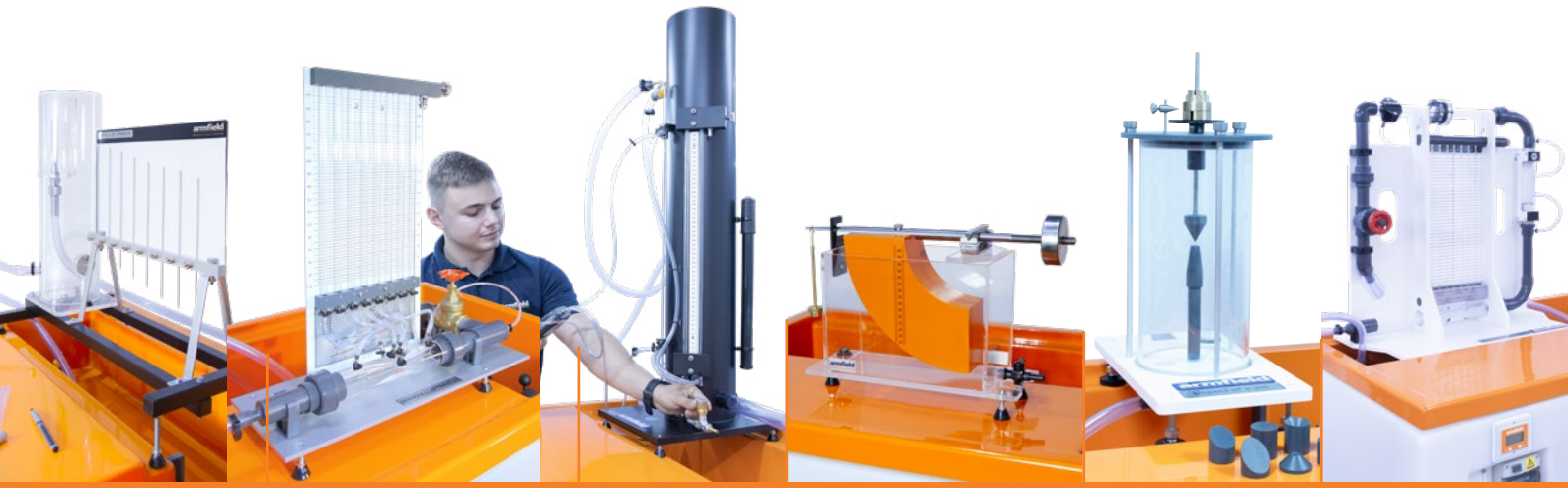
Fluid Mechanics Series

F1a-Basic SOFTWARE INCLUDED AS STANDARD

The Armfield F series is known worldwide for its durability, reliability and easy operation. This family of products covers all of the relevant aspects of Fluid Mechanics: Fluid Dynamics, Hydrostatics, Open and Closed Channel Flow as well as Rotodynamic Machines.

The latest upgrade of the range includes a Digital Hydraulic Bench, a redesigned Series and Parallel Pumps accessory and updated modules such as the Pascal's Apparatus and the Cavitation Demonstration.

The series is also now complemented with the exclusive Armfield F1-aBASIC software supplied along with both versions of the Basic Hydraulic Bench. This facilitates the laboratory sessions for students and instructors by enabling manual datalogging and permitting the users to focus on the understanding of the principles of the phenomena being simulated in the Fluid Mechanics Laboratory.



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F SERIES

F1a-Basic SOFTWARE INCLUDED AS STANDARD

F SERIES: BASIC FLUID MECHANICS

Complete Fluid Mechanics Laboratory – F1

Hydraulics Bench - F1-10

The F1-10 unit is a portable and self-contained service module providing a controlled flow of water to a range of optional accessories. It is supplied as standard with the Fluid Mechanics F1-aBASIC Software

This mobile bench is constructed from lightweight corrosion-resistant plastic and incorporates an open channel with side channels to support the accessories on test. The hydraulics bench includes a volumetric measuring tank stepped to accommodate low or high flow rates and a stilling baffle to reduce turbulence. A remote sight tube with scale gives an instantaneous indication of water level.

The bench additionally includes a quick-release pipe connector situated in the benchtop enabling rapid exchange of accessories without the need for hand tools, a measuring cylinder for measurement of very small flow rates, stopwatch and a copy of Armfield's F1-aBASIC educational software.

The F1-10 hydraulics bench can be supplied with either a factory fitted electronic flow meter with digital display or an optional inline digital flow meter that can be added in line to the experiment on test at any time.

Optional factory fitted electronic flow meter

Technical specifications	
Pump	Submersible
	Max head: 8.3m H_2O
(using volumetric tank)	Max flow: 80 litres/min
(using appropriate accessory)	Max flow: 100 litres/min
Motor rating	0.25kW
Sump tank capacity	250 litres
High flow volumetric tank	40 litres
Low flow volumetric tank	6 litres
Height of working surface	1m above floor level
Overall dimensions	
Length	1.13m
Width	0.73m
Height	1.0m
Packed and crated shipping specifications	
Volume	1.5m³
Gross weight	160kg

Requirements **Scale**

COLD

Electrical supply:

Basic Hydraulics Bench:

- **F1-10-A** 220-240V / 1ph / 50Hz @ 10 amp
- **F1-10-B** 110-120V / 1ph / 60Hz @ 20 amp
- **F1-10-G** 220V / 1ph / 60Hz @ 10 amp

Digital Hydraulics Bench (with digital flow meter):

- **F1-10-2-A** 220-240V / 1ph / 50Hz @ 10 amp
- **F1-10-2-B** 110-120V / 1ph / 60Hz @ 20 amp
- **F1-10-2-G** 220V / 1ph / 60Hz @ 10 amp

Water: Fill with clean water. No permanent connection required.

Ordering codes

- F1-10-A
- F1-10-B
- F1-10-G
- F1-10-2-A/-B/-G
- F1-10-2-A/-B/-G
- F1-10-2-A/-B/-G
- F1-10-1 Digital Flow Meter for F1-10 Hydraulics Bench

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URL: http://www.armfield.co.uk/f1

Applications: ChE ME CE IP

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

F SERIES: BASIC FLUID MECHANICS

Complete Fluid Mechanics Laboratory – F1

armSOFT Software F1-aBASIC

Armfield's F1-aBASIC software is now included as standard with either of the hydraulic benches. The Armfield software is a powerful manual data entry learning package which enhances the educational content and understanding of Armfield's F1 Fluid Mechanics accessories that utilise either of the F1-10 Hydraulics benches.

The software allows the user to manually input data from primary instrumentation and offers a powerful tool for displaying and processing the results.

Software additionally includes the electronic version of the manual for all the modules on test.

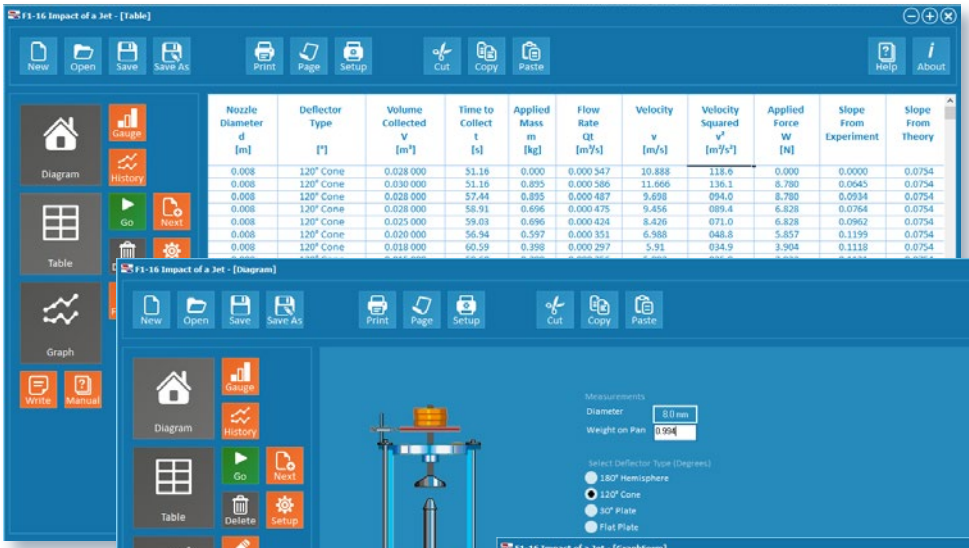
Some of the major features include:

Mimic Diagram - a pictorial representation of the equipment with fields to enter measurements from the equipment which displays any calculated variables directly in engineering units.

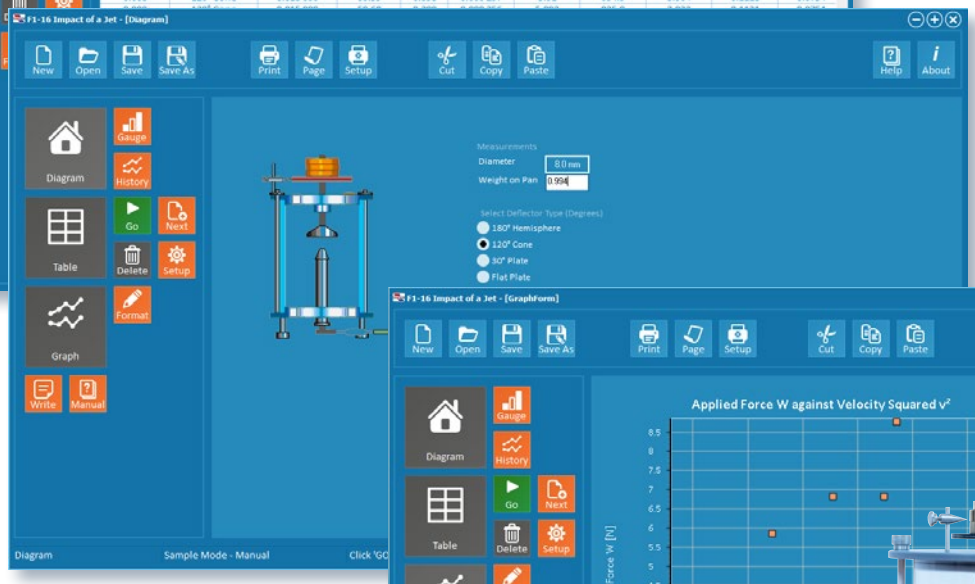
Tabular Display - As the data is entered, it is stored in a spreadsheet format. The table also contains columns for the calculated values.

Graphical Display - When several samples have been recorded, they can be viewed in graphical format. Powerful and flexible graph plotting tools are available in the software allowing the user full choice over what is displayed.

Tabular Display



Mimic Diagram



Graphical Display

Impact of a Jet F1-16-MKII

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Dead Weight Calibrator - F1-11

This calibrator functions under the same principle adopted in calibrating industrial pressure gauges.

Description

The Dead Weight Calibrator consists of a precision-machined piston and cylinder assembly mounted on levelling screws.

A Bourdon gauge is supplied for calibration. The weights supplied are added to the upper end of the piston rod which is rotated to minimise friction effects.

The gauge is thus subject to known pressures which may be compared with the gauge readings and an error curve drawn.

Technical specifications

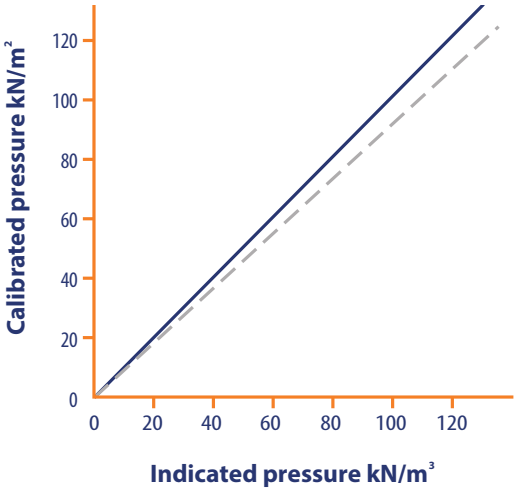
Pressure gauge	Bourdon tube
	range 0 to 200 kN/m^2 (kPa)
Area of piston	244.8 x 10^{-6} m^2
Mass of piston	0.5kg
Ancillary masses	2x 0.5kg, 1.0kg and 2.5kg

Overall dimensions

Length	0.25m
Width	0.125m
Height	0.50m

Experimental content

- To calibrate a Bourdon type pressure gauge and to determine the gauge errors
- To determine the measurement errors in the reference pressure source used for calibration



Ordering codes

- F1-11

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Hydrostatic Pressure – F1-12

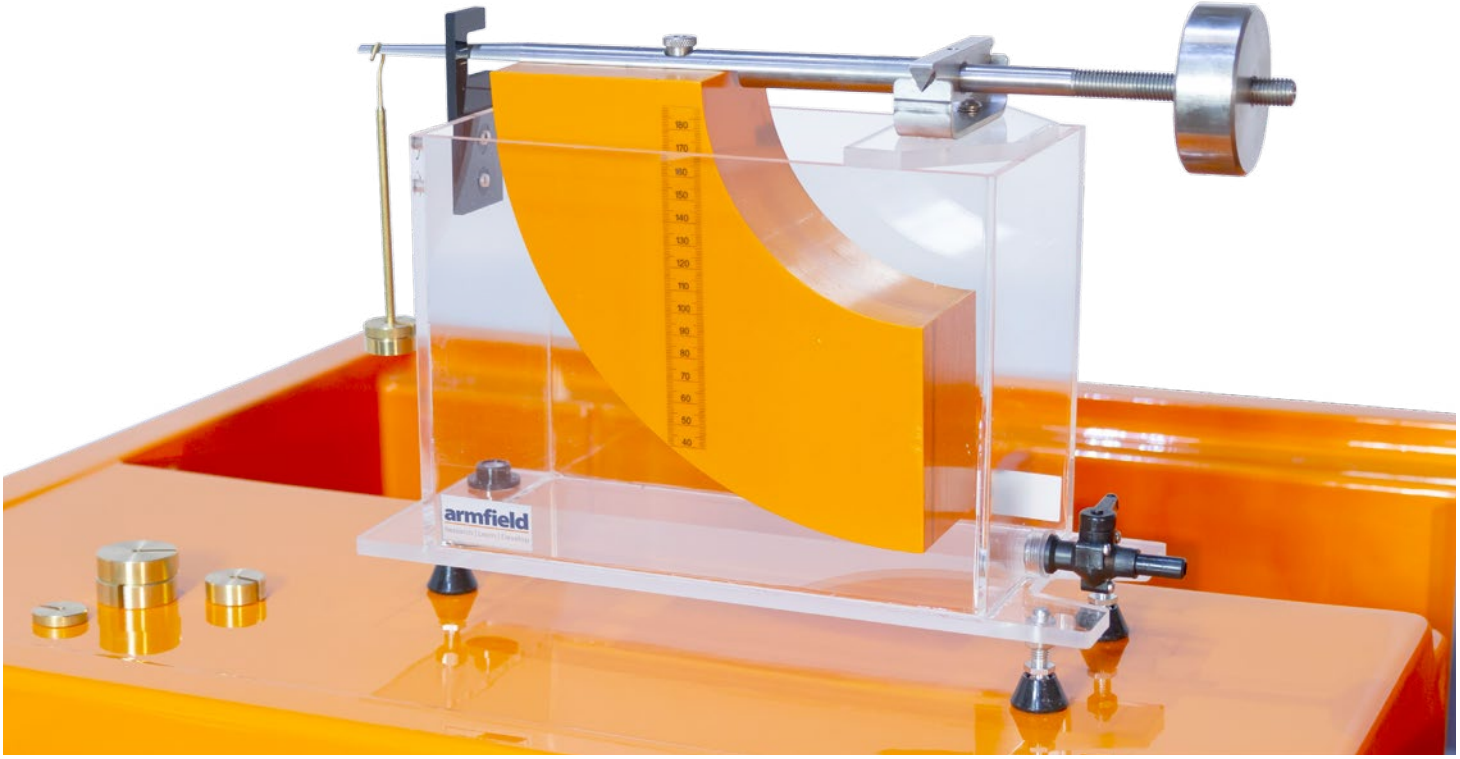
The Hydrostatic Pressure accessory has been designed to determine the static thrust exerted by a fluid on a submerged surface and enables comparison of the measured magnitude and position of this force with simple theory.

A fabricated quadrant is mounted on a balance arm which pivots on knife edges. The knife edges coincide with the centre of the arc of the quadrant. This means that when the quadrant is immersed, the only force that gives rise to a moment about the knife edges is the hydrostatic force acting on the end face of the quadrant.

The balance arm incorporates a hanger for the weights supplied and an adjustable counterbalance.

This assembly is mounted on top of an acrylic tank which may be levelled by adjusting screwed feet. Correct alignment is indicated on a circular spirit level mounted on the base of the tank.

An indicator attached to the side of the tank shows when the balance arm is horizontal. Water is added to the tank via a flexible tube and may be drained through a valve in the side of the tank. The water level is indicated on a scale on the side of the quadrant.



Experimental content

- To determine the hydrostatic thrust acting on a plane surface immersed in water when the surface is partially submerged or fully submerged
- To determine the position of the line of action of the thrust and to compare the position determined by experiment with the theoretical position

Technical specifications

Tank capacity	5.5l
Distance between suspended mass and fulcrum	275mm
Cross-sectional area of quadrant (toroid)	7.5 x $10^{-3}m^2$
Total depth of completely immersed quadrant	160mm
Height of fulcrum above quadrant	100mm
Overall dimensions	
Length	0.435m
Width	0.13m
Height	0.30m

Ordering codes

- F1-12

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F SERIES

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Flow over weirs - F1-13-MKII/F1-13a

Two different weir plates are provided enabling familiarisation and comparison with theory.

Experimental content

- To determine the characteristics of open channel flow over a rectangular notch
- To determine the characteristics of open channel flow over a triangular (vee) notch
- To determine values of the discharge coefficient for both notches

Description

The flow over weirs consists of five basic elements used in conjunction with the flow channel in the moulded benchtop of the Hydraulics Bench.

A quick-release connector in the base of the channel is unscrewed and a delivery nozzle screwed in its place.

A stilling baffle locates into slots in the walls of the channel. The combination of the inlet nozzle and stilling baffle promote smooth flow conditions in the channel.

A Vernier hook and point gauge is mounted on an instrument carrier which is located on the side channels of the moulded top. The carrier may be moved along the channels to the required measurement position.

The rectangular notch weir or V notch weir to be tested is clamped to the weir carrier in the channel by thumb nuts. The stainless steel weir plates incorporate captive studs to aid assembly.

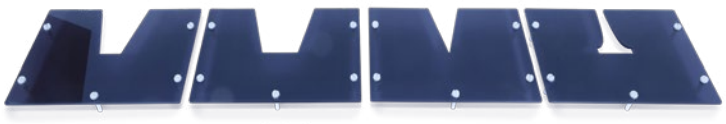
Overall dimensions of weir plate	
Thickness	0.002m
Width	0.23m
Height	0.16m
Dimensions of rectangular notch	
Thickness	0.002m
Width	0.03m
Height	0.082m
Angle of V notch weir	90° inclusive
Hook & point gauge range	0-150mm
Accuracy	0.1mm
Requires Hydraulics Bench Service unit F1-10	

F1-13-MKII Weirs

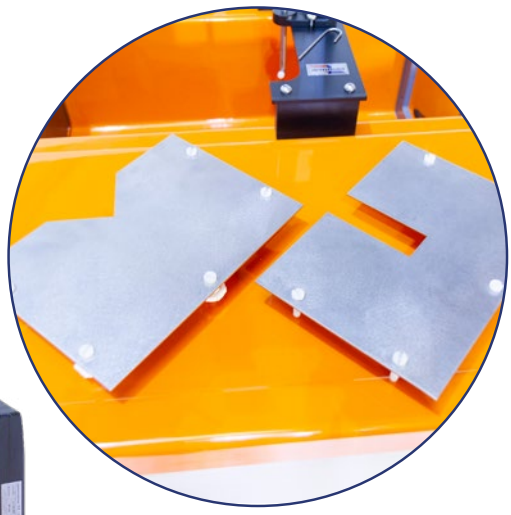
- Stiffling Baffle and Inlet Nozzle
- Vernier Hook & Point Gauge with Instrument Carrier
- Regular V Plate Weir 90°
- Large V Plate Weir 90°
- Large Notch Plate Weir 30mm
- Large Notch Plate Weir 50mm

F1-13a Advanced Weirs

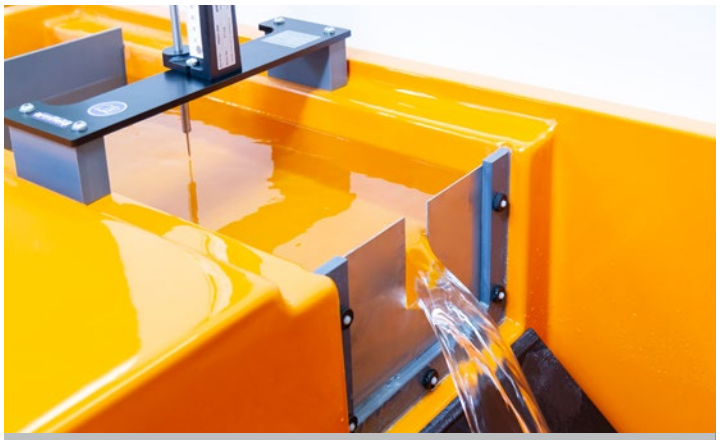
- Large Trapezoidal Weir 30mm
- Large Trapezoidal Weir 50mm
- Large V Plate Weir 30°
- Dog Bone Weir



F1-13-MKII V notch & rectangular notch weir plates



F1-13-MKII Vernier Hook & Point Gauge on Instrument Carrier



Ordering codes

- F1-13-MKII
- F1-13a

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

F SERIES: BASIC FLUID MECHANICS
Complete Fluid Mechanics Laboratory – F1

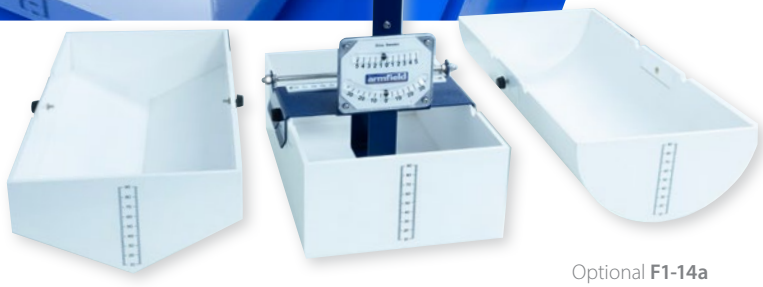
Metacentric Height - F1-14MKII

This equipment enables a thorough investigation of the factors affecting the stability of a floating body.

F1-14 MKII Calibrated scale

Experimental content

- Determining the centre of gravity of the pontoon
- Determining the metacentric height and from this the position of the metacentre for the pontoon
- Varying the metacentric height with angle of heel
- With Optional F1-14a comparison of two different hull shapes: hard chine and round bilge



Optional **F1-14a**

Description

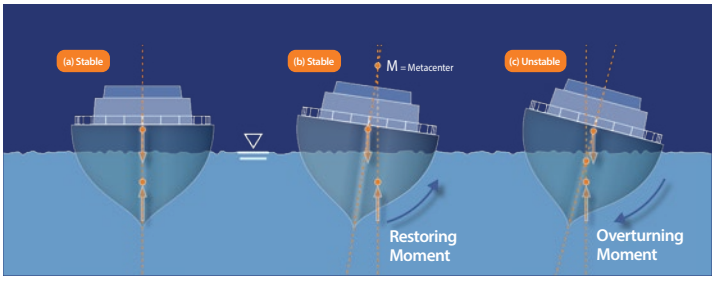
Metacentric Height is an extremely important measurement when considering the stability of a floating body such as a ship. The body can be stable, neutral, or unstable depending on the relative positions of the Centre of Gravity and a theoretical location called the Metacentre. This Metacentre is defined as the intersection of lines through the centre of buoyancy of the body when it is upright and when it is inclined at an angle.

The F1-14-MKII Metacentric Height Apparatus consists of a small rectangular floating pontoon that incorporates movable weights to allow manipulation of the Centre of Gravity and the transverse inclination (angle of heel). Practical results are taken for the stability of the floating body in different conditions, and these are compared to theoretical results derived from first principles.

The model can be used with the Armfield F1-10 Hydraulics Bench to provide a source of water for the stability experiments. Alternatively, the unit is supplied with a moulded plastic water tank that can be used if a Hydraulics Bench is not available.

Optionally available is the F1-14a a pair of additional hull shapes, Half-circle and Vee chine used in conjunction with the F1-14-MKII. Both Hulls are of the same volume as the F1-14-MKII allowing student to compare the stability of different hulls. For reduced set-up times, the mast is easily moved from one pontoon to another.

Optional **F1-14a**



Technical specifications

Overall dimensions:	
Maximum Angle of Heel:	+/- 30°
Hull Width:	200 mm
Hull Height:	100 mm
Hull & Pontoon Assembly Mass:	2kg

Ordering codes

- F1-14 MKII; F1-14a

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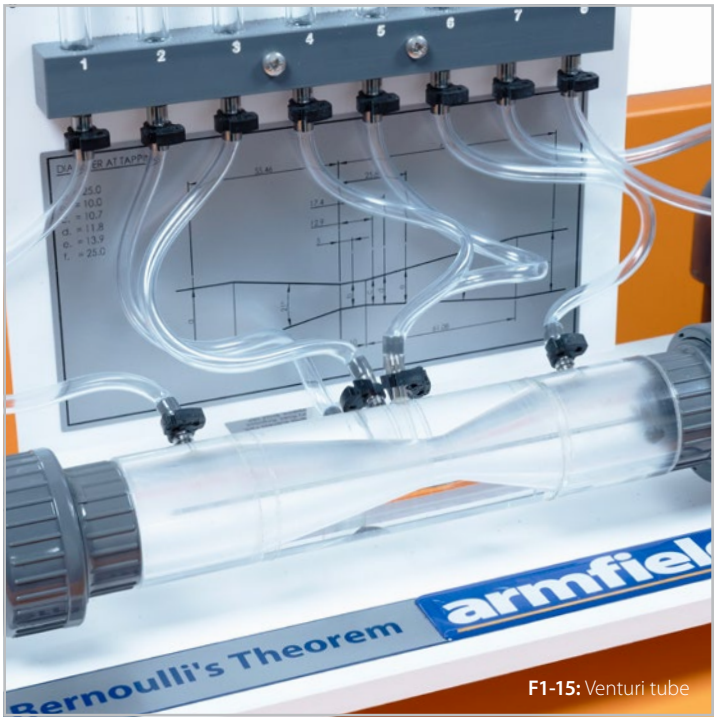
F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Bernoulli's Theorem Demonstration - F1-15

This accessory illustrates the circumstances to which Bernoulli's Theorem may be applied.

It also explains why in other circumstances the theorem gives an inadequate description of the fluid behaviour.



F1-15: Venturi tube

Experimental content

- To investigate the validity of the Bernoulli equation when applied to the steady flow of water in a converging, or, a diverging duct
- Conservation of energy divergent/convergent pipe flow
- Effect of friction loss on Bernoulli equation
- Recording the pressure curve in a Venturi nozzle
- Recording the velocity curve in a Venturi nozzle
- Determining the flow coefficient

Description

The test section consists of a classical Venturi machined in clear acrylic.

A series of wall tappings enable measurement of the static pressure distribution along the converging and diverging duct. A total head tube is provided to traverse along the centre line of the test section.

These tappings are connected to a manometer bank incorporating a manifold with an air bleed valve.

Pressurisation of the manometers is facilitated by a hand pump. The test section is arranged so that the characteristics of flow through both a converging and diverging section can be studied.

Water is fed through a hose connector and is controlled by a flow regulator valve at the outlet of the test section.

The Venturi can be demonstrated as a means of flow measurement and the discharge coefficient can be determined.

Technical specifications (Requires Hydraulics Bench Service unit F1-10/F1-10-2)

Manometer range	0-300mm
Number of manometer tubes	8
Throat diameter	10.0mm
Upstream diameter	25.0mm
Upstream taper	14°
Downstream taper	21°

Overall dimensions

Length	0.55m
Width	0.25m
Height	0.60m

Ordering codes

- F1-15

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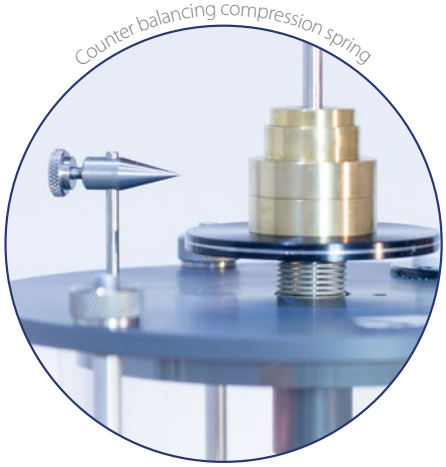
Impact of a Jet – F1-16-MKII

Water is discharged vertically through a nozzle to strike a target carried on a stem which extends through the cover.

The dead weight of the moving parts are counterbalanced by a compression spring.

The vertical force exerted on the target plate is measured by adding the weights supplied to the weight pan.



Experimental content

- Principle of linear momentum
- To investigate the reaction forces produced by the change in momentum of a fluid flow
- Measurement of the forces produced by a jet impinging on solid surfaces which produce different degrees of flow deflection

Description

The apparatus consists of a cylindrical clear acrylic fabrication with provision for levelling.

Water is fed through a nozzle and discharged vertically to strike a target carried on a stem which extends through the cover. A weight carrier is mounted on the upper end of the stem.

The dead weight of the moving parts is counterbalanced by a compression spring. The vertical force exerted on the target plate is measured by adding the weights supplied to the weight pan until the mark on the weight pan corresponds with the level gauge.

A total of eight targets are provided.

Technical specifications (Requires Hydraulics Bench Service unit F1-10/F1-10-2)

Nozzle diameter	8mm	
Distance between nozzle & target plate	40mm	
Diameter of target plate	36mm	
Target plate	120° target (cone)	30° target
	180° hemispherical target	60° target
	Flat target	Oblique 30/150°
	CUP 135°	Oblique 45/135°

Overall dimensions

Length	0.325m
Width	0.20m
Height	0.50m

Ordering codes

- F1-16-MKII

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F SERIES

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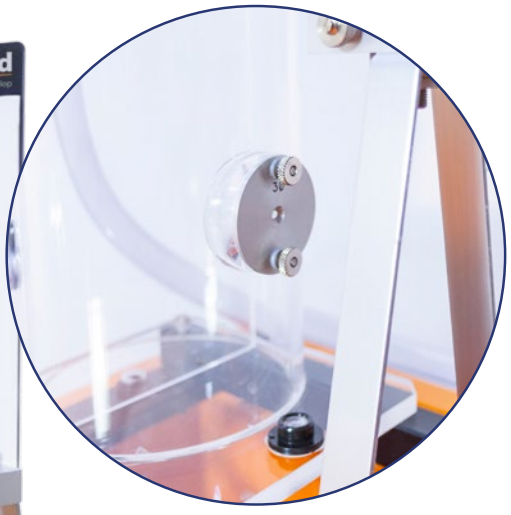
F SERIES: BASIC FLUID MECHANICS
Complete Fluid Mechanics Laboratory – F1

Orifice and Free Jet Flow - F1-17

A constant head tank is maintained with water supplied from the hydraulics bench.

The orifice (3mm or 6mm) is installed at the base of this tank ensuring a flush inside surface.

The jet trajectory is mapped using 8-point gauges to determine the discharge coefficient.



F1-17: Free Jet Flow Orifice

This equipment permits calibration of two orifices of differing diameter and enables the trajectory of the jet to be plotted.

Experimental content

- Establishing the coefficient of velocity for a small orifice
- Finding the coefficient of discharge for a small orifice with flow under constant head and flow under varying head
- Comparing the measured trajectory of a jet with that predicted by simple theory of mechanics
- Effect of tank level on jet outlet velocity

Description

The Orifice & Free Jet Flow accessory incorporates a constant head tank fed with water from the hydraulics bench. The orifice is installed at the base of this tank by means of a special wall fitting which provides a flush inside surface.

The head is maintained at a constant value by an adjustable overflow pipe and is indicated by a level scale. A series of adjustable probes enable the path followed by the jet to be ascertained.

Adjustable feet permit levelling.

Technical specifications

Orifice diameters	3.0mm and 6.0mm
Jet trajectory probes	8
Max constant head	410mm

Requires hydraulics bench service unit F1-10/F1-10-2

Overall dimensions

Length	0.67m
Width	0.33m
Height	0.60m

Ordering codes

- F1-17

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Orifice Discharge - F1-17a

The Orifice Discharge accessory enables full analysis of the flow through seven different orifices over a range of flow rates.

Description

The Orifice Discharge accessory consists of a cylindrical clear acrylic tank which has an orifice fitted in the base.

A traverse assembly is provided which enables a pitot tube to be positioned anywhere in the jet. Attached to this pitot tube is a fine wire which can be traversed across the jet to accurately measure the jet diameter and the vena contracta diameter and so determine the contraction coefficient.

The pitot head and the total head across the orifice are shown on manometer tubes adjacent to the tank.

In addition to the square aperture, triangular aperture and sharp edged orifice, four additional orifices with different profiles are supplied. All orifices have a common bore of 13mm for direct comparison of performance.

F1-17a: Manometer

Experimental content

- To determine the Coefficient of Discharge (CD), Coefficient of Velocity (CV) and Coefficient of Contraction (CC) for flow of water through a small orifice

Ordering specification

The Orifice Discharge accessory enables full analysis of the flow through different orifices over a range of flow rates. It consists of:

- Seven orifice plates: 1 x square aperture
  1 x triangular aperture
  1 x sharp edged orifice
  4 x orifices with different internal profiles
- A cylindrical clear acrylic tank with an orifice fitted in the base
- A carrier enables a pitot tube to be accurately positioned anywhere in the jet
- A wire micrometre is used to accurately measure the jet diameter and the vena contracta diameter and so determine the contraction coefficient

Technical specifications (Requires hydraulics bench service unit F1-10/F1-10-2)

Standard orifice	Sharp-edged 13mm diameter
Max head	365mm
Traverse mechanism	- Lead screw with adjusting nut - Calibrated 0.1mm per division
Overall dimensions	
Length	0.33m
Width	0.33m
Height	0.60m

Ordering codes

- F1-17a

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Applications: ChE ME CE IP

Energy Losses in Pipes - F1-18

The unit consists of a vertical test pipe on the side of the equipment which can be fed directly from the hydraulics bench supply or, alternatively, from the integral constant head tank above.

These in turn provide high or low flow rates which may be controlled by a valve at the discharge end of the test pipe. Manometers are used to measure the head loss.

For large pressure differentials a digital handheld manometer is used. In addition, a pressurised water manometer for small pressure differentials is also fitted to the unit.

Experimental content

- To investigate the head loss due to friction in the flow of water through a pipe and to determine the associated friction factor over a range of flow rates in laminar flow
- To investigate the head loss due to friction in the flow of water through a pipe and to determine the associated friction factor over a range of flow rates in turbulent flow
- Determining the critical Reynolds number

Description

The Energy Losses in Pipes accessory consists of a test pipe, orientated vertically on the side of the equipment, which may be fed directly from the hydraulics bench supply or, alternatively, from the integral constant head tank.

These sources provide high or low flow rates which can be controlled by a valve at the discharge end of the test pipe. Head loss between two tapping points in the test pipe is measured using two manometers, digital hand held manometer for large pressure differentials and a pressurised water manometer for small pressure differentials.

Excess water discharging from the constant head tank is returned to the sump tank of the hydraulics bench.

Adjustable feet permit levelling.

Technical specifications

Diameter of test pipe	3.0mm
Length of test pipe	760mm
Distance between pressure tapping points	500mm
Range of the digital manometer	103 kPa
Range of water manometer	500mm
Measuring cylinder capacity	1000ml

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.33m
Width	0.28mm
Height	0.75m

Ordering codes

- F1-18

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Issue: 2
URL: http://www.armfield.co.uk/f1
Applications: ChE ME CE IP

Flow Channel - F1-19

The Flow Channel introduces students to the characteristics of flow in an open channel at an elementary level.

- Demonstrating basic phenomena associated with open channel flow
- Visualisation of flow patterns over or around an immersed object

F1-19: Mounted on top of the hydraulics bench

F1-19: Dye injection system

Description

The channel consists of a clear acrylic working section of large depth-to-width ratio incorporating undershot and overshot weirs at the inlet and discharge ends respectively. Water is fed to the streamlined channel entry via a stilling tank to reduce turbulence. Water discharging from the channel is collected in the volumetric tank of the hydraulics bench and returned to the sump for recirculation.

A dye injection system incorporated at the inlet to the channel enables flow visualisation in conjunction with a graticule on the rear face of the channel.

Models supplied with the channel include broad and sharp-crested weirs, large and small-diameter cylinders and symmetrical and asymmetrical aerofoils. These in conjunction with the inlet and discharge weirs, permit a varied range of open channel and flow visualisation demonstrations.

Technical specifications

Diameter of test pipe	3.0mm
Length of test pipe	760mm
Distance between pressure tapping points	500mm
Range of mercury manometer	500mm
Range of water manometer	500mm
Measuring cylinder capacity	1000ml

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Experimental content

- To visualise flow patterns around immersed objects in an open channel
- Demonstration of flow phenomena in an open channel
- Undershot and Overshot weirs
- Broad Crested and Sharp Crested Weirs
- Discharge beneath a sluice gate
- Creation of a hydraulic jump downstream of a sluice gate and weir
- Drowning of a sluice gate and weir
- Flow over a broad crested and sharp edged weir
- Supercritical (fast) and sub-critical (slow) flows over the weir

Overall dimensions

Length	0.865m
Width	0.33m
Height	0.50m

Ordering codes

- F1-19

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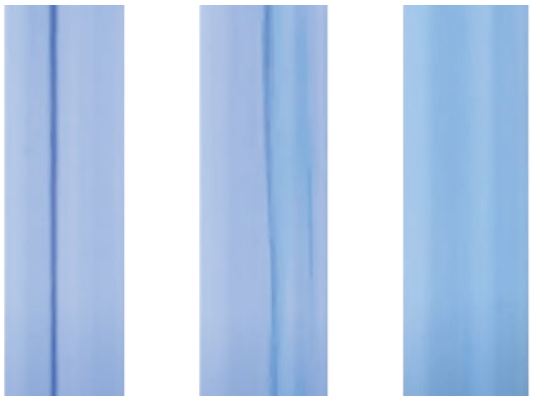
Issue: 2
URL: http://www.armfield.co.uk/f1
Applications: ChE ME CE IP

Osborne Reynolds' Demonstration - F1-20

This item is intended to reproduce the classic experiments conducted by Professor Osborne Reynolds concerning the nature of laminar and turbulent flow.

$$\mathrm{Re} = \frac{\rho u L}{\mu} = \frac{u L}{\nu}$$



Laminar flow | Transitional flow | Turbulent flow

Experimental content

- Reproducing the classic experiments conducted by Professor Osborne Reynolds concerning fluid flow condition
- Observing the laminar, transitional, turbulent flow and velocity profile

Description

The equipment operates in a vertical orientation. A header tank containing stilling media provides a constant head of water through a bellmouth entry to the flow visualisation pipe.

Flow through this pipe is regulated using a control valve at the discharge end. The flow rate of water through the pipe can be read on the digital flow meter or can be measured using the volumetric tank (or measuring cylinder) of the hydraulics bench. Velocity of the water can therefore be determined to enable calculation of Reynolds' number.

The equipment uses a similar dye injection technique to that of Reynolds' original apparatus to enable observation of flow conditions.

Technical specifications

Test pipe diameter	10.0mm (precision bore glass)
Length of test pipe	700mm
Dye reservoir capacity	0.45l
Requires Hydraulics Bench Service unit F1-10/F1-10-2	

Overall dimensions

Length	0.50m
Width	0.33m
Height	1.24m

Ordering codes

- F1-20

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Issue: 3
URL: http://www.armfield.co.uk/f1
Applications: ChE ME CE IP

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Flow Meter Demonstration - F1-21-MKII

This accessory is designed to introduce students to three basic types of flow meter: **Venturi meter**
Variable area flowmeter (Rotameter)
Orifice plate

- 8 pressure tappings are connected and displayed on the manometer bank to visualise pressure profiles
- Optional Pitot Static Tube; Optional Flow Nozzle

Experimental content

- To investigate the operation and characteristics of a Venturi meter, variable area flowmeter and orifice plate including accuracy and energy losses
- Comparison of pressure drops across each flow measurement device
- Calibrating each flow meter using the volumetric measuring tank of the hydraulics bench
- Application of the Bernoulli equation for incompressible fluids
- Optionally available Pitot Static tube and Flow Nozzle.

Description

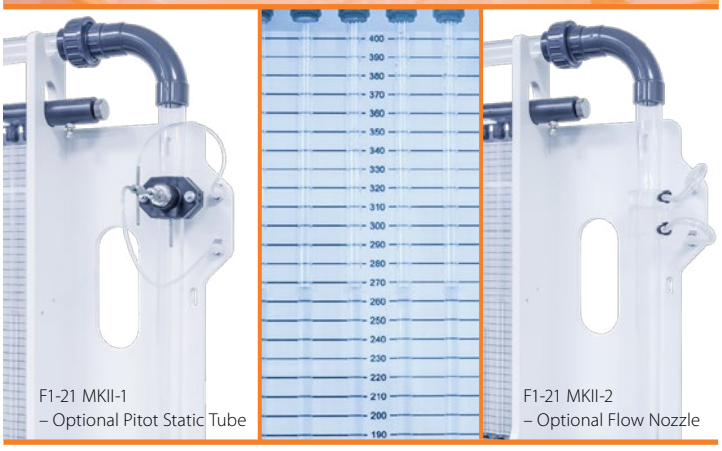
The equipment consists of a Venturi meter, variable area flowmeter and orifice plate installed in a series configuration to permit direct comparison.

A flow control valve permits variation of the flow rate through the circuit. Pressure tappings are incorporated so that the head loss characteristics of each flow meter may be measured. These tappings are connected to an eight-tube manometer bank incorporating a manifold with an air bleed valve.

Pressurisation of the manometers is facilitated by a hand pump.

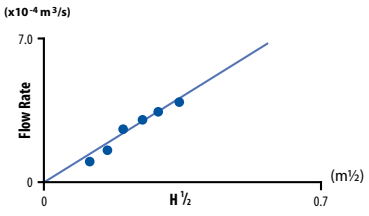
The circuit and manometer are attached to a support framework, which stands on the working top of the hydraulics bench.

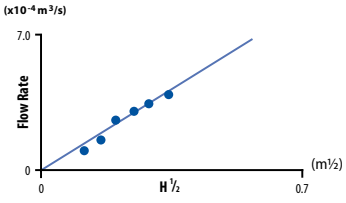
The hydraulics bench is used as the source of water supply and for volumetrically calibrating each flow meter.



F1-21 MKII-1
– Optional Pitot Static Tube

F1-21 MKII-2
– Optional Flow Nozzle





Technical specifications

Manometer range	0-400mm
Number of manometer tubes	8
Orifice plate diameter	17mm
Variable area meter	2-20 l/min
Venturi dimensions	
Throat diameter	14mm
Upstream pipe diameter	26mm
Upstream taper	21° inclusive
Downstream taper	9° inclusive

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.68m
Width	0.33m
Height	0.83m

Ordering codes

- F1-21-MKII, F1-21-MKII- 1, F1-21-MKII- 2

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Applications: ChE ME CE IP

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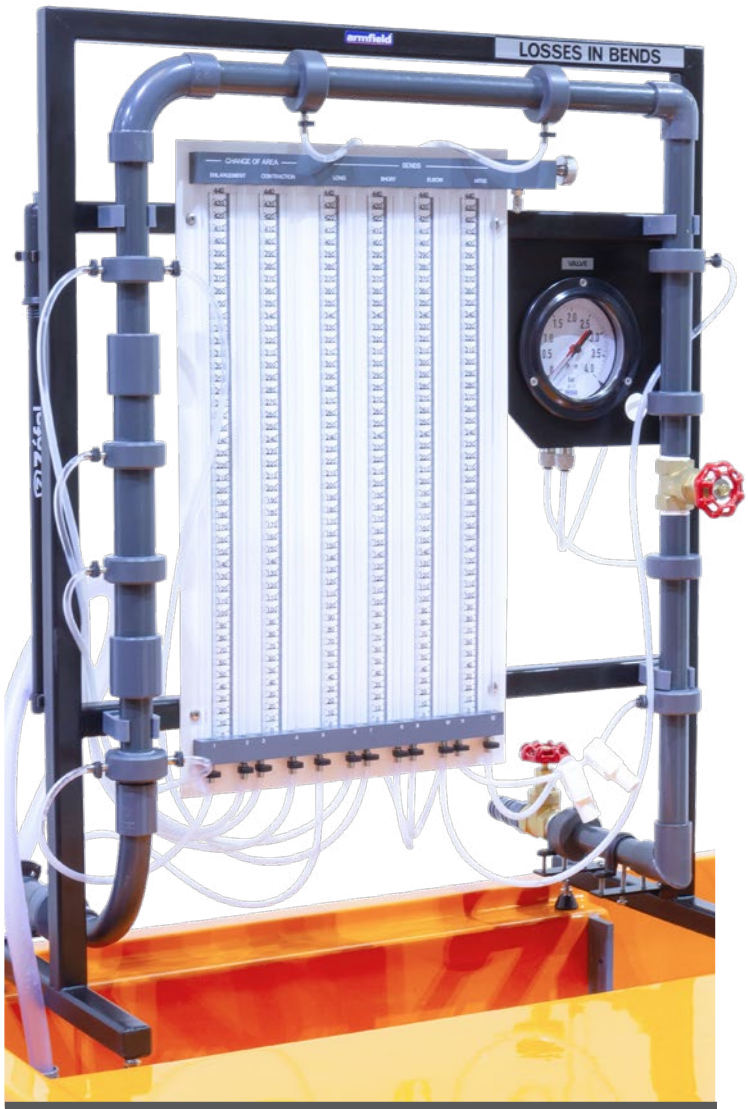
F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Energy Losses in Bends and Fittings - F1-22

This accessory permits losses in different bends and fittings, sudden contraction, sudden enlargement and a typical control valve to be demonstrated.

- Mitre bend - 90° elbow - Short and long bends
- Sudden contraction and sudden enlargement
- Fully instrumented with upstream and downstream pressure tappings
- A bank of 12 water manometer tubes mounted on the framework for visualisation of the pressure drop profiles
- Differential Pressure Gauge for direction reading of losses through the gate valve



Experimental content

Measuring the losses in the devices related to flow rate and calculating loss coefficients related to velocity head including:

- Short bend
- Long bend
- Elbow bend
- Mitre bend
- Area enlargement
- Area contraction
- Gate valve fitting
- Comparing the pressure drop across each device

Description

The equipment is mounted on a free-standing framework which supports the test pipework and instrumentation. The following typical pipe fittings are incorporated for study: mitre bend, 90° elbow, swept bends (large and small radius), sudden contraction and sudden enlargement.

All are instrumented with upstream and downstream pressure tappings. These tappings are connected to a bank of 12 water manometer tubes mounted on the framework. Pressurisation of the manometers is facilitated by a hand pump. A gate valve is used to control the flow rate.

A separate gate valve is instrumented with upstream and downstream pressure tappings which are connected to a differential gauge on the edge of the framework. The unit stands on the working top of the hydraulics bench which is also used as the source of water supply.

Overall dimensions

Length	0.63m
Width	0.33m
Height	0.83m

Technical specifications

Pipe diameter	19.48mm
Differential pressure gauge	0-3 bar
Enlargement diameter	26.2mm
Contraction diameter	19.48mm
Fittings	short bend
	long bend
	elbow bend
	45° mitre bend
	enlargement
	contraction
	gate valve
Manometer range	0-440mm
Number of manometer tubes	12
Differential manometers	6

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Ordering codes

- F1-22

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Applications: ChE ME CE IP

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Free and Forced Vortices - F1-23-MKII

This equipment is designed to produce and measure the characteristics of free and forced vortices.

F1-23-MKII Vortices

Experimental content

- Understanding the difference between free and forced vortices
- Determining the surface profile of a forced vortex
- Determining the surface profile and total head distribution of a free vortex
- Visualisation of secondary flow in a free vortex

Description

The apparatus comprises a clear acrylic cylinder on a plinth designed to produce and measure free and forced vortices.

The free vortex is generated by water discharging through an interchangeable orifice in the base of the cylinder, and the resulting profile is measured using a combined calliper and depth scale.

The forced vortex is induced by a paddle in the base of the cylinder, which is rotated by jets of water. The profile of the forced vortex is determined using a series of depth gauges.

Velocity at any point in the free or forced vortices may be measured using the appropriate pitot tube supplied.

Dye crystals (not supplied) may be used to demonstrate secondary flow at the base of the free vortex.

Technical specifications

Tank diameter	245mm
Height to overflow point	180mm
Orifice diameters	8, 12, 16 and 24mm
Forced vortex measuring probes	
Distance from centre	0, 30, 50, 70, 90 and 110mm
Pitot tubes having measuring point (nose) at	15, 25 and 30mm radius
Inlet tubes	9 and 12.5mm diameter

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.60m
Width	0.50m
Height	0.46m

Ordering codes

- F1-23-MKII

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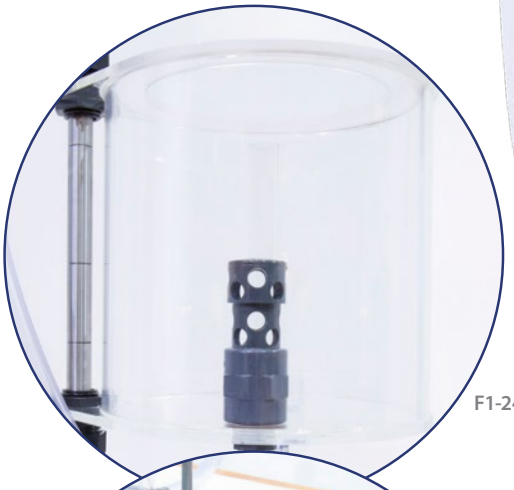
F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

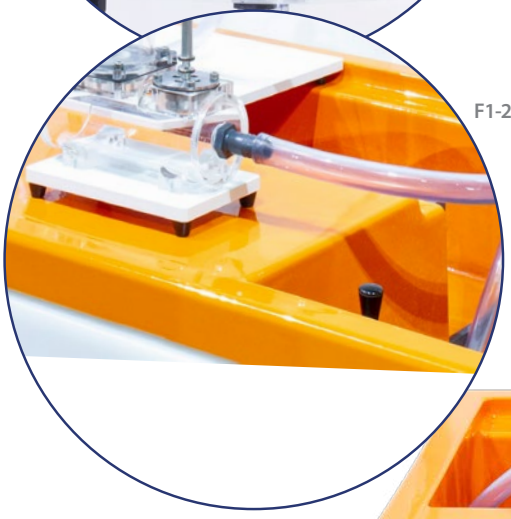
Hydraulic Ram - F1-24

If flowing water is suddenly brought to rest in a long pipe, a phenomenon known as water hammer occurs. This produces a pressure wave that travels along the pipe.

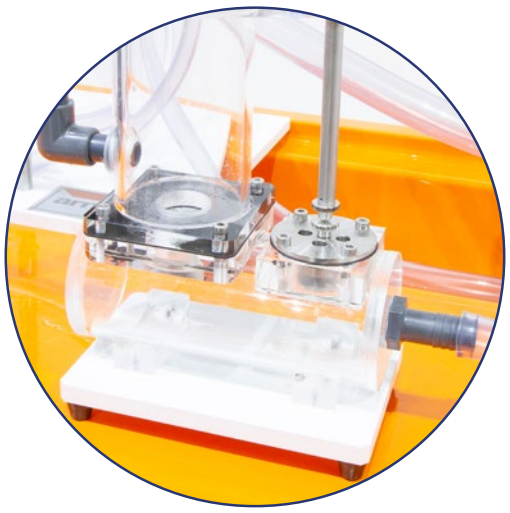
This principle is used in the hydraulic ram to pump water.



F1-24 Header tank



F1-24 Weight platform



F1-24 Hydraulic ram pump

Experimental content

- To demonstrate the operating principles of the hydraulic ram
- Establishing flow/pressure characteristics and determining efficiency of the hydraulic ram

Description

The hydraulic ram comprises an acrylic base incorporating pulse and non-return valves and a supply reservoir on a stand which is fed by the hydraulics bench. An air vessel above the valve chamber smooths cyclic fluctuations from the ram delivery.

The weights supplied may be applied to the pulse valve to change the closing pressure and thus the operating characteristics.

Technical specifications

Supply head	300-700mm variable
Delivery head	750-1500mm variable

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.75m
Width	0.33m
Height	1.62m

Ordering codes

- F1-24

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Demonstration Pelton Turbine - F1-25-MKII

The Demonstration Pelton Turbine provides a simple low-cost introduction to turbine performance.

F1-25-MKII Brake assembly

F1-25-MKII Pelton Turbine buckets

Pelton Turbine brake being operated

Experimental content

- To determine the operating characteristics of a Pelton Turbine
- Performance charts of power, speed, torque and efficiency
- Turbine output torque v rotor speed
- Turbine output power v rotor speed
- Turbine overall efficiency v rotor speed

Description

This accessory comprises a miniature Pelton wheel with a spear-valve arrangement mounted on a support frame which fits onto the hydraulics bench top channel. Mechanical output from the turbine is absorbed using a simple friction dynamometer.

Pressure at the spear-valve is indicated on a remote gauge.

A non-contacting tachometer is supplied which will be used to determine the speed of the Pelton wheel. Basic principles of the Pelton turbine may be demonstrated and with appropriate measurements, power produced and efficiency may be determined.

Technical specifications

Speed range	0-1800 rpm
Brake power	10W
Pressure gauge range	0-1 Bar / 0-15 PSI
Force balance range	2x0-20 N spring balance
Number of Pelton buckets	24
Diameter of Pelton wheel	130mm

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.34m
Width	0.295m
Height	0.81m

Ordering codes

- F1-25-MKII

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Applications: ChE ME CE IP

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

F1-27 Centrifugal Pump Characteristics

This accessory offers enhanced capabilities provided by the inclusion of a variable-speed pump with inverter drive rather than a fixed-speed pump.

F1-27 Centrifugal pump attached to F1-10 bench

Experimental content

- Determining the relationship between head, discharge, speed, power and efficiency for a centrifugal pump at various speeds
- Determining the head/flow rate characteristics of two similar pumps operating in either parallel or series configuration at the same speed

Description

This accessory comprises a variable speed pump assembly and independent discharge manifold interconnected by flexible tubing with quick release connectors. This auxiliary pump is intended to be used in conjunction with the basic Hydraulics Bench F1-10/F1-10-2.

The pump speed is varied by an inverter drive. The motor speed, output voltage and motor current can be monitored on the inverter display. A compound pressure gauge is mounted on the pump inlet and a pressure gauge is mounted on the pump outlet.

An independent discharge manifold incorporates a pressure gauge and flow control valve prior to a discharge pipe with diffuser.

The auxiliary pump is mounted on a support plinth designed to be positioned on the floor besides the hydraulics bench , adjustable feet allowing levelling.

Overall dimensions

Length	0.36m
Width	0.16m
Height	0.325m

Technical specifications

Pump	Centrifugal type
Max head	21m H_2O
Max flow	1.35 l/s
Motor rating	0.36kW
Speed controller	Frequency inverter
Speed range	0-1500 rpm
Pressure gauge range	0-60m H_2O
Compound gauge range	–10 to +32m H_2O

See Hydraulics Bench F1-10 technical details for primary pump characteristics.

Requirements

Scale

Electrical supply:

F1-27-A:	220-240V / 1ph / 50Hz @ 10 amp
F1-27-G:	220V / 1ph / 60Hz @ 10 amp

G version has optional 1.5kVA transformer available to accommodate 120V / 1ph / 60Hz.

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Ordering codes

- F1-27-A
- F1-27-G

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Applications: ChE ME CE IP

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F SERIES

SOFTWARE INCLUDED WITH ALL F1-10 BENCH'S AS STANDARD

Cavitation Demonstration - F1-28

This equipment demonstrates to students visually, audibly and numerically the phenomenon of cavitation and its association with the vapour pressure of a liquid.

F1-28 Vacuum gauge

Experimental content

- To demonstrate the appearance and sound of cavitation in a hydraulic system
- To demonstrate the conditions for cavitation to occur (liquid at its vapour pressure)
- To observe the difference between air release from the water and true cavitation
- To show how cavitation can be prevented by raising the static pressure of a liquid above its vapour pressure
- Verification of Bernoulli's equation
- Comparison of theoretical and actual pressure at cavitation conditions

Description

This accessory consists of a circular Venturi-shaped test section manufactured from clear acrylic to enable visualisation inside the section.

As the flow of water increases, the pressure at the throat falls in accordance with the Bernoulli equation until a limit is reached corresponding to the vapour pressure of the liquid. At this low pressure small bubbles of vapour form then collapse violently as the pressure rises again downstream.

This process is called cavitation.

Bourdon gauges indicate the pressure upstream of the contraction, inside the throat and downstream of the expansion in the test section. Flow control valves upstream and downstream of the test section enable the flow and pressure to be adjusted, enabling cavitation to be clearly demonstrated.

Technical specifications

Upstream pressure gauge	
Diameter	63mm
Range	0 to 2 bar
Throat vacuum gauge	
Diameter	100mm
Range	-1 to 0 bar
Downstream pressure gauge	
Diameter	63mm
Range	0 to 1 bar

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.55m
Width	0.23m
Height	0.19m

Ordering codes

- F1-28

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Issue: 2
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F SERIES

Fluid Statics and Manometry - F1-29

The right-hand manometer tube is separate from the other tubes and incorporates a pivot and indexing mechanism at the base that enables this tube to be inclined at fixed angles of 5°, 30°, 60° and 90° (vertical).

The reservoir incorporates a hook and point gauge with Vernier scale mounted through the lid that enables large changes in level to be measured with precision.

A vertical transparent piezometer tube through the lid of the reservoir enables the static head above the water in the reservoir to be observed when the air space above the water is not open to the atmosphere.

F1-29: Different inclination angles in the inclined manometer

F1-29 Manometer

Experimental content

- Demonstrating the behaviour of liquids at rest (hydrostatics)
- Showing that the free surface of a liquid is horizontal and independent of cross section or inclination of the container
- Effect of changes in air pressure above a liquid surface
- Measuring the level of a liquid using basic measuring techniques such as a scale, vernier depth gauge and inclined scale and the effect of parallax
- Measuring small changes in liquid level using a micro-manometer
- Measuring changes in liquid level using a Vernier hook and point gauge
- Using a single limb manometer / piezometer tube to measure head
- Using manometer tubes to measure differential pressure
- Using an inclined manometer to measure small pressure differences
- Using a 'U' tube manometer to measure pressure differences in a gas (air over liquid)
- Using an inverted pressurised 'U' tube manometer to measure pressure differences in a liquid
- Enlarged limb manometer
- Using liquids with different densities to change the sensitivity of a 'U' tube manometer
- Demonstrating the effect of trapped air on the accuracy of a manometer
- Demonstrating the effects caused by friction when a fluid is in motion

Overall dimensions

Length	0.425m
Width	0.15m
Height	1.09m

Technical specifications

Max depth inside reservoir	574mm
Inside diameter of reservoir	100mm
Scale length of manometer tubes	460mm

Ordering codes

- F1-29

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F SERIES

F1-30 Fluid Properties Apparatus

This apparatus provides an introduction to the fundamental properties of liquids that affect their behaviour in practical applications.

F1-30 Fluid properties components

Experimental content

- Measuring density and relative density (specific gravity) of a liquid using a universal hydrometer
- Measuring density and relative density (specific gravity) of a liquid using a Pycnometer (density bottle)
- Measuring density and relative density of solid objects or granular material using a Pycnometer
- Measuring viscosity of various liquids at atmospheric temperature and pressure using a Falling Sphere Viscometer
- Measuring the effect of capillary elevation inside capillary tubes
- Demonstrate the effect of capillary elevation between two flat glass plates due to surface tension in a liquid
- Verifying Archimedes principle using a brass bucket & cylinder with a lever balance
- Measuring atmospheric pressure using an aneroid barometer

Description

A clear understanding about the physical properties of fluids is essential before studying the behaviour of fluids in static or dynamic applications.

This apparatus introduces students to the following properties of fluids:

- Density and relative density (specific gravity)
- Viscosity
- Capillarity – capillary elevation between flat plates and in circular tubes
- Buoyancy (Archimedes principle)
- Atmospheric pressure

The apparatus consists of a collection of components that demonstrate individual fluid properties. The components are stored on a common support frame manufactured from PVC with circular spirit level and adjustable feet for levelling.

The apparatus is designed to stand on a suitable benchtop where some of the components can be operated independently from the support frame.

A free-standing dual-scale lever balance is also supplied to support several of the demonstrations.

Technical specifications

The following components are included
2 hydrometer jars (clipped to stand)
1 universal hydrometer (in protective housing)
2 falling-sphere viscometer tubes (clipped to stand)
1 plastic storage box containing steel spheres
1 spirit-filled glass thermometer (in protective housing)
1 direct-reading aneroid barometer (fixed to stand)
1 parallel-plate capillary apparatus
1 capillary tube apparatus with six tubes of varying size
1 Archimedes apparatus comprising displacement vessel, machined bucket & matching cylinder
1 50ml density bottle (Pycnometer)
1 250ml plastic measuring cylinder
1 600ml glass beaker
1 dual-scale lever balance, adapted for use with the Archimedes apparatus

Overall dimensions	
Length	0.60m
Width	0.16m
Height	0.50m

Ordering codes

- F1-30

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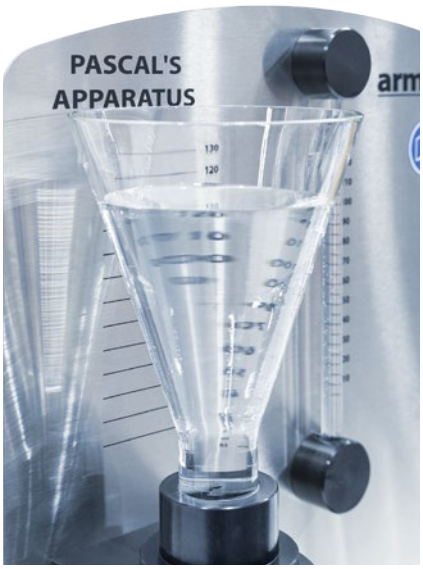
F SERIES

F1-31 PASCAL'S APPARATUS

The Pascal's Apparatus demonstrates in a simple way that the pressure in an incompressible fluid varies with depth and does not depend on the shape of the container.



Experimental content

- Demonstrating that the pressure in a liquid contained in a vessel, varies with depth and is not affected by the shape of the vessel

Description

This apparatus, designed to demonstrate Pascal's principle, consists of a machined body into which one of four alternative glass vessels can be fitted. The fitting at the base of each vessel is common but the shape of each vessel varies; one parallel sided, one conical, one tapering inwards, and one parallel sided, but with an offset.

The pressure at the base of the vessel is measured by the manometer on the right, via a tube at the rear of the equipment. The reading on the manometer depends on the pressure generated within the main body. An adjacent scale is marked in millimetres (mm).

A scale on the back of the apparatus allows each of the vessels to be filled to the same depth so that the pressure / force can be shown to be common for all four vessels, independent of shape.

The seal at the base of the vessels is in the form of a flat washer, allowing for ease of cleaning and replacement when necessary.

A lever operated drain valve on the underside of the machined body allows liquid to be drained from the apparatus before removing the vessel.

A "Vessel Store" is provided on the base of the equipment to provide safe storage for the vessels not in use in each experiment.

A beaker is provided to allow easy filling and draining between experiments.

Technical specifications

Parallel vessel	26mm inside diameter
Conical vessel	26-101mm inside diameter at top
Tapered vessel	26mm to 9mm inside diameter at top
Diameter at diaphragm	56mm
Maximum depth of water	228mm (to top of vessels)

Overall dimensions

Length	0.35m
Width	0.135m
Height	0.45m

Ordering codes

- F1-31

UK office - email: sales@armfield.co.uk tel: +44 (0) 1425 478781 (for ROW)
USA office - email: info@armfield.inc tel: +1 (609) 208-2800 (USA only)

Issue: 2
URL: http://www.armfield.co.uk/f1
Applications: ChE ME CE IP

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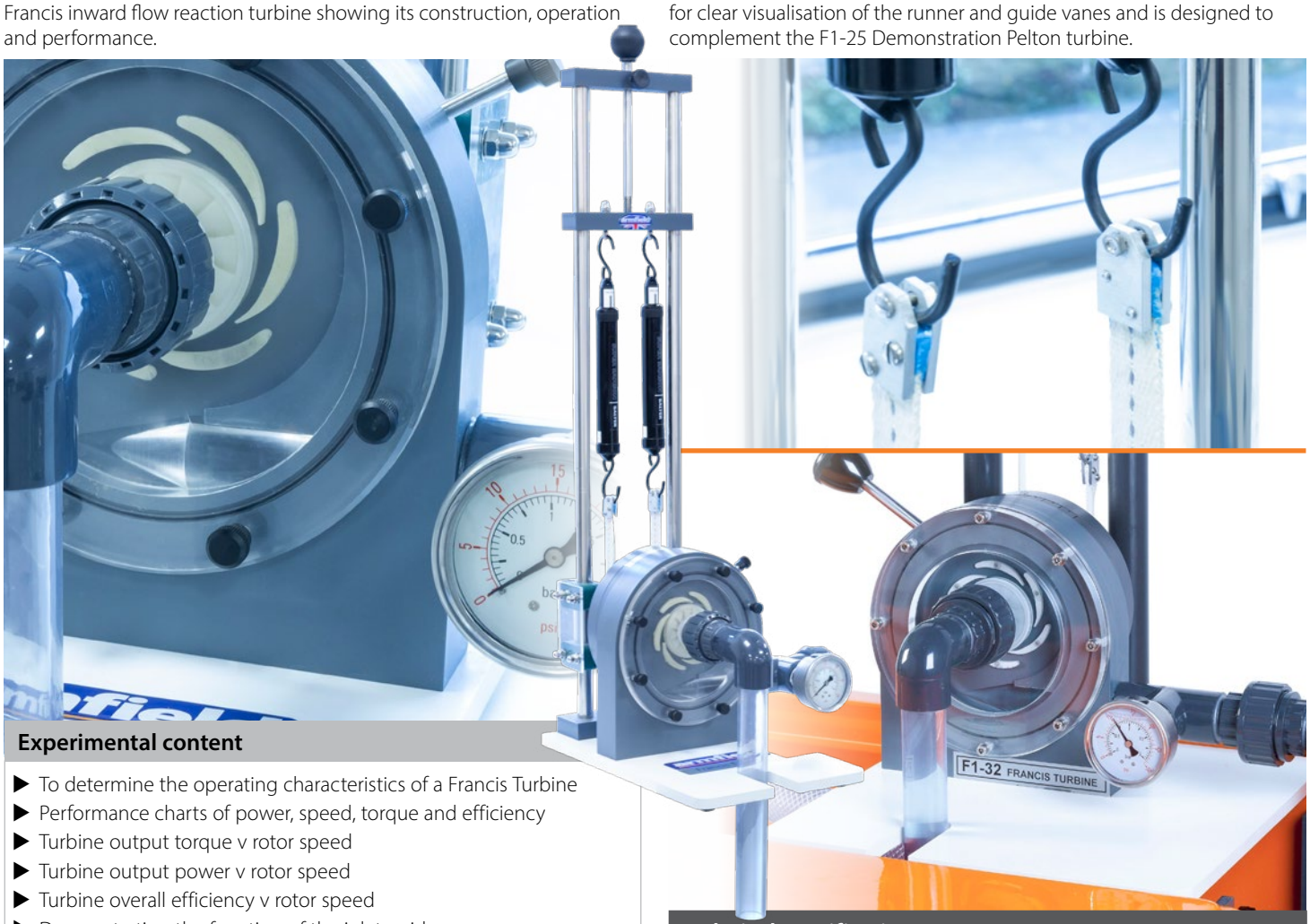
F SERIES

F1-32 FRANCIS TURBINE

This demonstration turbine provides a simple low-cost introduction to the Francis inward flow reaction turbine showing its construction, operation and performance.

The volute of the Francis Turbine incorporates a transparent front cover for clear visualisation of the runner and guide vanes and is designed to complement the F1-25 Demonstration Pelton turbine.



Experimental content

- To determine the operating characteristics of a Francis Turbine
- Performance charts of power, speed, torque and efficiency
- Turbine output torque v rotor speed
- Turbine output power v rotor speed
- Turbine overall efficiency v rotor speed
- Demonstrating the function of the inlet guide vanes on a Francis Turbine to vary the flow through the turbine and consequently the power produced

Description

A tapering, spiral-shaped volute conveys water to the runner via a ring of guide vanes that are adjustable in angle to vary the flow through the turbine. Water enters the runner tangentially at the periphery, flows radially inward through the blades toward the hub then exits axially via a draft tube.

Power generated by the turbine is absorbed by a Prony friction brake consisting of a pair of spring balances attached to a brake belt that is wrapped around a pulley wheel driven by the runner. The load on the turbine is varied by tensioning both spring balances which increases the friction on the pulley wheel. Brake force is determined from the difference in the readings on the two spring balances and the torque calculated from the product of this force and the pulley radius.

The head of water entering the turbine is indicated on a Bourdon gauge and the speed of rotation is measured using a non-contacting tachometer (option) 100-2/1 Tachometer including carrying pouch.

Technical specifications

Speed range	0-4000 rpm
Diameter of Francis runner	60mm
Number of blades on runner	12
Number of guide vanes	6, adjustable from fully open to fully closed
Range of spring balances	0-50N x 0.5N
Range of Bourdon gauge	0-2 bar

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	0.60m
Width	0.34m
Height	0.85m

Ordering codes

- F1-32
- 100-2/1 Tachometer including carrying pouch

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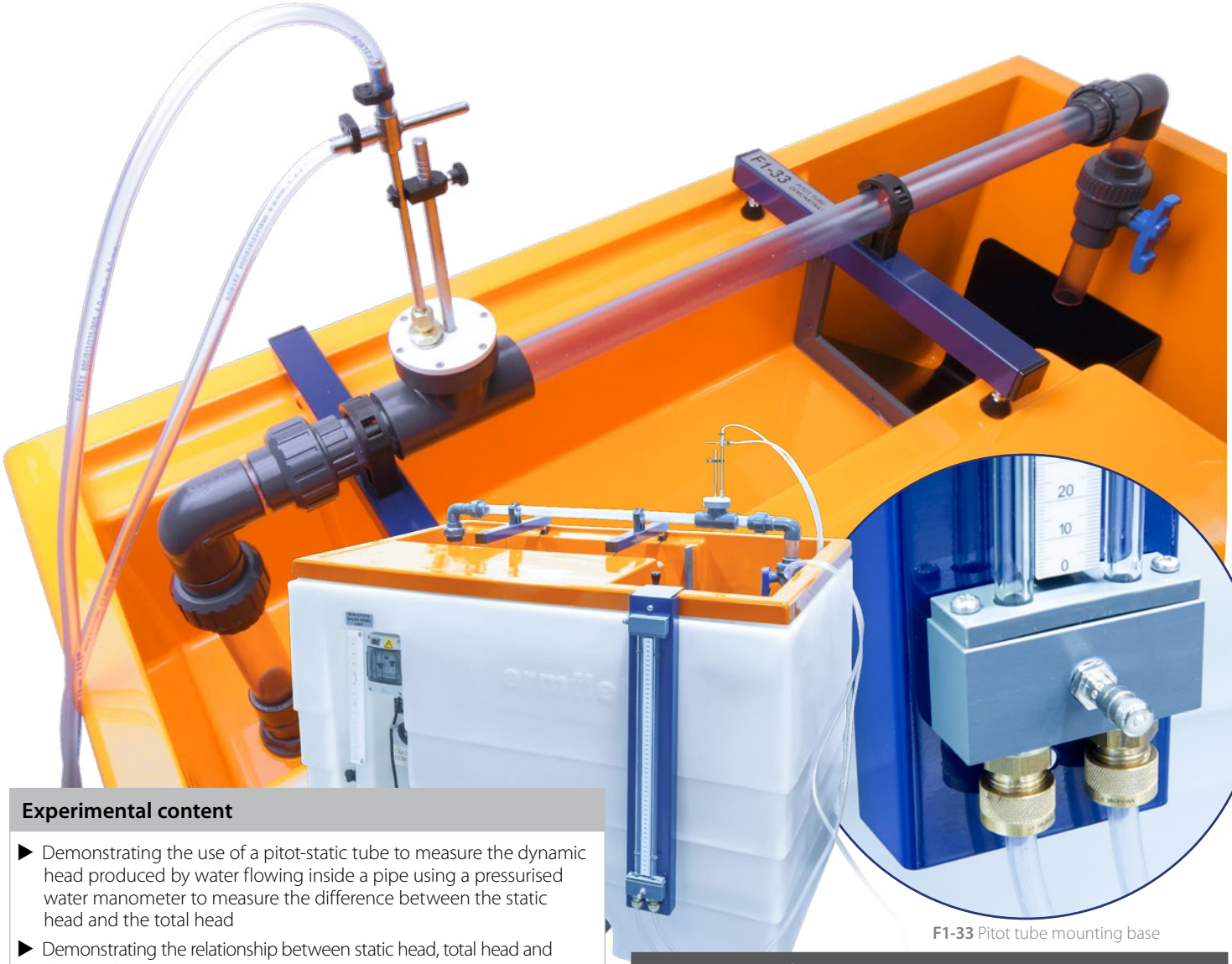
F SERIES

Pitot Tube Demonstrator – F1-33

The pitot tube can be moved across the cross-section of the pipe in order to measure the dynamic head profile.



F1-33 Pitot tube mounting base

Experimental content

- Demonstrating the use of a pitot-static tube to measure the dynamic head produced by water flowing inside a pipe using a pressurised water manometer to measure the difference between the static head and the total head
- Demonstrating the relationship between static head, total head and dynamic head
- Demonstrating how a pitot-static tube can be used to determine the velocity of a fluid
- Demonstrating how the dynamic head of a fluid flowing inside a pipe varies with radius due to the development of a boundary layer at the wall of the pipe
- Demonstrating how the dynamic head profile varies at the entrance to a pipe downstream of a 90 degree bend with undeveloped flow

Description

The pitot tube can be moved across the cross-section of the pipe in order to measure the dynamic head profile.

The position of the measuring tip relative to the wall of the pipe can be read on a scale.

The pitot tube is connected to a pressurised water manometer to measure the differential head across the pitot static tube.

Technical specifications

Inside diameter of test pipe	27mm
Pitot-static tube outside diameter	6mm
Pitot-static tube inside diameter	3.2mm
Scale length of manometer tubes	500mm
Cross section of manometer tubes	5.6mm diameter
Range of pitot-static tube traverse	21mm with 3mm scale increments

Requires Hydraulics Bench Service unit F1-10/F1-10-2

Overall dimensions

Length	1.00m
Width	0.35m
Height	0.52m

Ordering codes

- **F1-33**

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Issue: 2
URL: http://www.armfield.co.uk/f1
Applications: ChE ME CE IP

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F SERIES

Series & Parallel Pumps - F1-35

The F1-35 accessory is for use with the F1-10-2 Hydraulics Bench and is used to demonstrate the head / flow characteristics of Rotodynamic or Velocity pumps.

F1-35 Flow valve

Experimental content

Determining the head/flow rate characteristics of:

- A single centrifugal pump at a single speed
- Two similar pumps operating in parallel configuration at the same speed
- Two similar pumps operating in series configuration at the same speed
- Two similar pumps operating in parallel configuration at a variable speed
- Two similar pumps operating in series configuration at a variable speed

Description

The series and parallel accessory is designed to be positioned securely on the F1-10-2 Hydraulics Bench and has two pumps to demonstrate the characteristics of pumps connected in series or parallel. The pumps are driven by integral DC motors **with variable speed control**. Pressure gauges are mounted to measure the pressure at the inlet and outlet.

The pumps are fed from a constant head tank that forms part of the accessory, fed by the F1-10-2 pump. Flow discharges into the volumetric tank of the F1-10-2 via a flow control valve which permits an output pressure to be applied to load the pumps.

They can be operated either independently or in conjunction, connected in series or parallel. Both pumps speeds are individually controlled and varied by using the controllers allocated on the frame.

Flexible tubing and quick release connectors are supplied to allow the pumps to be connected for single pump, series or parallel pump operation.

Overall dimensions

Length	0.85m
Width	0.35m
Height	0.55m
Packed and crated shipping specifications	
Volume	1.2m^3
Gross weight	20Kg
Technical details	
Power Consumption	48W (max. per pump, for this application)
Max. Flow Rate	22L/min (max per pump (series), for this application (44L/min in parallel)
Max. Head	0.96m (datum to manifold gauge) (max pump head = 11m)
Constant head tank	2L (approx)
Speed range	0-22 L/min
Measuring ranges	
Pressure (inlet)	1 x 2.0 bar
Pressure (outlet)	2 x 2.2 bar
See Hydraulics Bench F1-10 technical details for primary pump characteristics.	
Specifically requires Hydraulics Bench Service unit F1-10-2 for operation	

Ordering codes

- F1-35

UK office - email: sales@armfield.co.uk tel: +44 (0) 1425 478781 (for ROW)
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Issue: 1
URL: http://www.armfield.co.uk/f1

Applications: ChE ME CE IP

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FE SERIES

Hele Shaw Apparatus – F1-38

The Armfield F1-38 Hele Shaw Apparatus enables investigation into the principles of potential flow and enables modelling of appropriate physical systems.

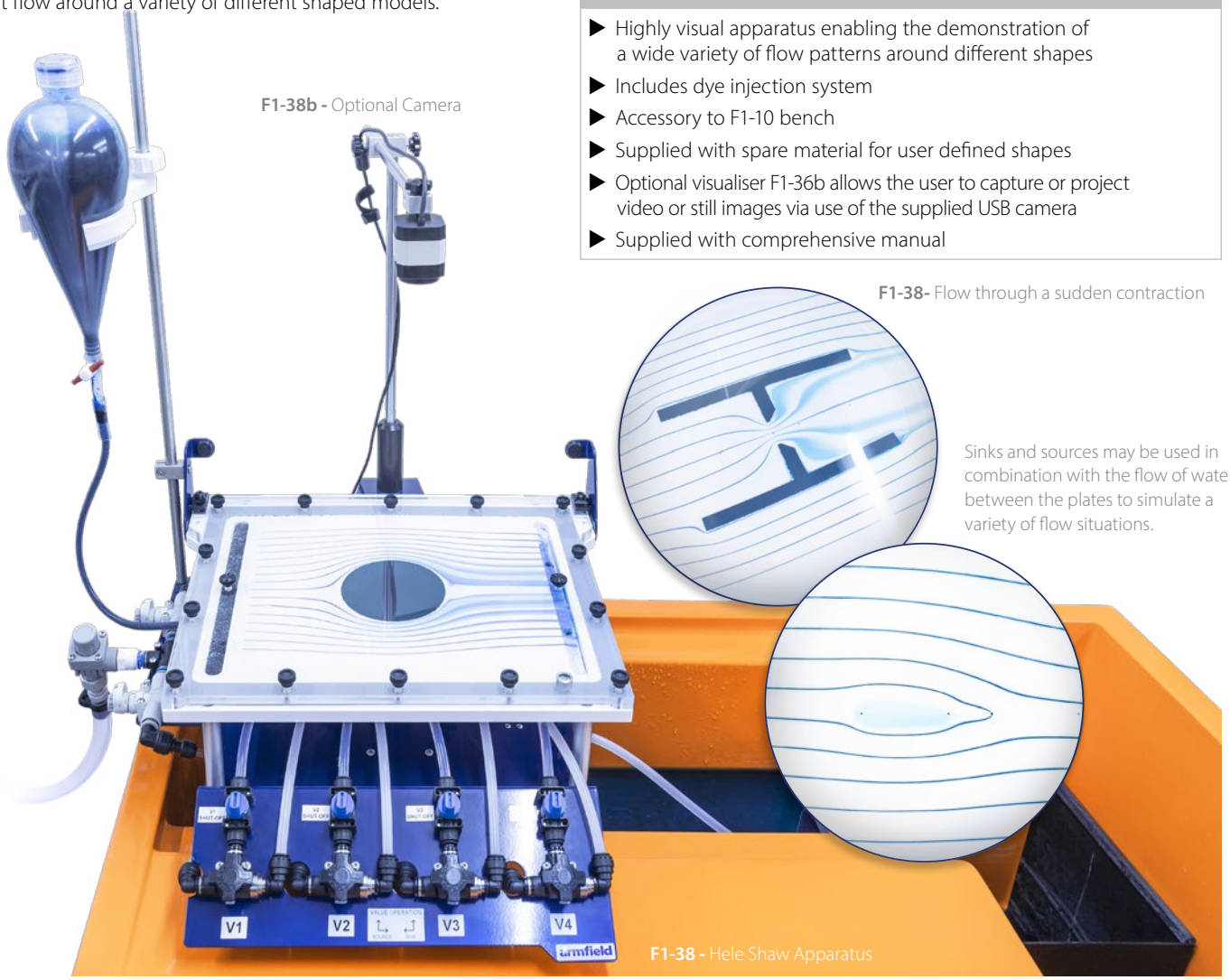
It allows students to study various source and sink arrangements and look at flow around a variety of different shaped models.

EXPERIMENT TO DEMONSTRATE POTENTIAL FLOW IN FLUID DYNAMICS
SUPPLIED WITH SPARE MATERIAL FOR USER DEFINED SHAPES
SUPPLIED WITH COMPREHENSIVE MANUAL

Features

- Highly visual apparatus enabling the demonstration of a wide variety of flow patterns around different shapes
- Includes dye injection system
- Accessory to F1-10 bench
- Supplied with spare material for user defined shapes
- Optional visualiser F1-36b allows the user to capture or project video or still images via use of the supplied USB camera
- Supplied with comprehensive manual

F1-38b - Optional Camera



F1-38- Flow through a sudden contraction

Sinks and sources may be used in combination with the flow of water between the plates to simulate a variety of flow situations.

F1-38 - Hele Shaw Apparatus

Valve operation and shut-off taps

Flow straightener and dye injection system

Bubble level

Capture video or still images

F1-38b- Optional Camera

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Issue: 2
URL: http://www.armfield.co.uk/f1-38
Applications ChE IP

Description

The F1-38 Hele-Shaw Apparatus provides a very visual means of showing potential flow in the field of fluid dynamics. The water flows through a very narrow channel which is formed between two plates causing the water to flow in a special way.

The mean velocity of the water along the channel obeys equations as those for local velocity in potential flow. The water flow within the channel is designed to be in a steady, laminar state.

The apparatus injects dye (by gravity) into the water flow to produce streamlines that clearly show the effect of different flow conditions around shapes and/or with the use of sinks and sources.

F1-38 Hele-Shaw Apparatus is a demonstration of classic experiments with visualisation of flow behaviour by injection of dye as a steady flow in a working cell.

The apparatus is designed to fit onto the top of the standard F1-10 series Hydraulic Bench forming part of the F1 series fluid mechanics' range. The F1-10 Hydraulics Bench can be used as a work surface and water collection sump.

The apparatus requires a supply of clean cold water with an optional overhead tank, (F1-38a supplied separately) available if required. In addition the optional F1-38b Visualisation accessory allows the user to capture or project video or still images via use of the supplied USB camera.

Technical specifications

Working section	
Viewing Area	892mm
Sinks/source/closed	4 points
Dye injectors	16
Dye	Food based dye
Flow control valve	Operates fully closed (0) to fully open(11)
Camera requirements	USB - PC: Windows 10, 8, 7, Vista, XP
Operational water pressure minimum/maximum	0.2 – 0.3bar

Models supplied

A set of basic model shapes are provided to analyse flow patterns around these. Further models can be cut from the same material used in the standard models to ensure compatibility with the unit

Ordering specification

- Desktop or F1-10 bench mounted apparatus, demonstrates ideal flow, and Hele-Shaw principles and is able to accept student-made models
- Working section dimensions 345mm x 265mm
- Actual viewing area 295mm x 245mm
- Comprehensive instruction manual with illustrations

Overall dimensions

Length	0.50m
Width	0.44m
Height	0.78m
Packed and crated shipping specifications	
Volume	0.3m³
Gross weight	40Kg

Experimental content

- **Ideal flow around immersed bodies**
  - Cylinder
  - Aerofoil
  - Bluff body
- **Ideal flow associated with sinks and sources**
  - Formation of a Rankine half body
  - Formation of a Rankine oval
  - Circular streamlines from a doublet
  - Superposition of sinks and sources user defined shape
- **Ideal flow in channels and at boundaries**
  - Convergent channel
  - Divergent channel
  - 90-degree bend
  - Sudden contraction
  - Sudden enlargement

Requirements

Scale

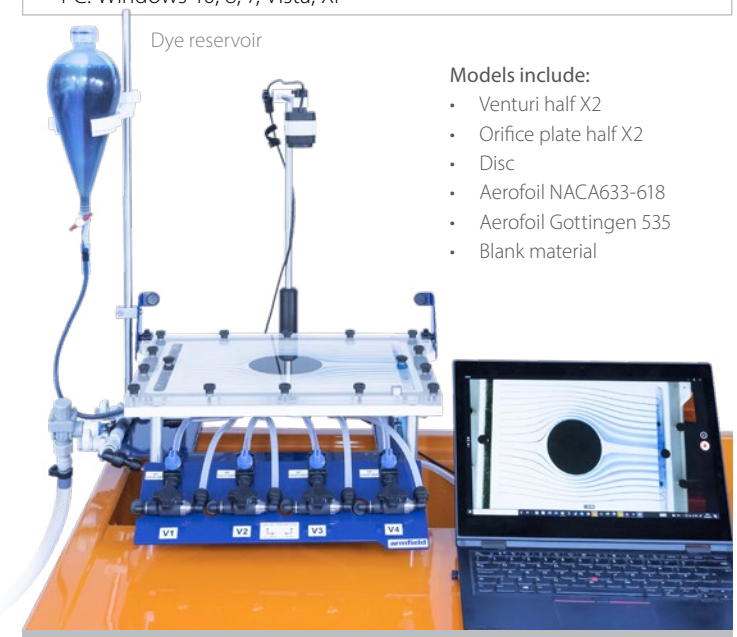
Water supply

Drain: Suitable for water containing dye

Optional accessories

- **F1-38a Header Tank:** If mains water cannot be connected
- **F1-38b Visualiser:** Auto-focusing. Still and video capture

  Mac: OS 10.12 and later (Mac OSX 10.5 and later compatible)
  PC: Windows 10, 8, 7, Vista, XP



Ordering codes

- F1-38
- F1-38a
- F1-38b

Armfield standard warranty applies with this product

Knowledge base

> 28 years expertise in research & development technology
> 50 years providing engaging engineering teaching equipment

Benefit from our experience, just call or email to discuss your laboratory needs, latest project or application.

An ISO 9001:2015 Company

CE Products CE certified

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Aftercare

Installation
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Training
Service and maintenance
Support: armfieldassist.com

Fluid Properties & Hydrostatics Bench – F9092

F SERIES

HANDS ON LEARNING

The Armfield F9092 Fluid Properties and Hydrostatics Bench is designed to demonstrate the properties of fluids and their behaviour under hydrostatic conditions (fluid at rest).

This enables students to develop an understanding and knowledge of a wide range of fundamental principles and techniques, before studying fluids in motion.

Dead Weight Pressure Guage Calibrator - F1-11

Demonstration Capabilities

▶ Understanding the properties of fluids:

- Principles and use of a hydrometer
- Measurement of densities and specific gravities
- Measurement of Viscosity

▶ Understanding the effects of static pressure:

- Observation of effect of capillarity
- Measurement of Capillary elevation
- Demonstrating that the free surface of a static liquid is horizontal
- Studying the effect of flow on a free surface
- Measurement of Liquid Levels using the Hook and point Gauge
- To show that pressure in a liquid varies with the depth and does depend on the shape or area of the vessel
- To determine the hydrostatic thrust acting on a plane surface immersed in water when the surface is partially submerged or fully submerged
- To determine the position of the line of action of the thrust and to compare the position determined by experiment with the theoretical position

▶ Studying the operation and application of pressure gauges and manometers:

- Using a direct reading mercury barometer to read the barometric or atmospheric pressure (mercury not supplied)

>

- To calibrate a Bourdon-type pressure gauge using the dead-weight pressure gauge calibrator
- To determine the measurement errors in the reference pressure source used for calibration
- To use a water over mercury 'U' tube manometer to determine the pressure at a point
- To compare the reading of a manometer with a Bourdon gauge
- To use an air over mercury 'U' tube manometer to determine the pressure at a point
- To use a water over manometer to determine and compare differences in pressures in a water and air system

▶ Investigating the buoyancy force and stability of floating bodies:

- Show that pressure in a liquid varies with the depth and does depend on the shape or area of the vessel - Verifying Archimedes' principle
- Stability of a floating body and determination of metacentric height
- Determining the centre of gravity of the pontoon
- Determining the metacentric height and from this the position of the metacentre for the pontoon
- Varying the metacentric height with angle of heel

Description

The equipment is mounted on a steel-framed bench fitted with castors. A variety of measuring devices is incorporated either fastened to the back of the bench or free-standing.

Water is stored in a polythene tank situated on the lower shelf of the bench.

The water can be transferred by two positive displacement hand pumps, either to an elevated open storage tank connected to a number of glass tubes for free surface studies, or to a plastic sink recessed into the working surface so that benchtop experiments may be conducted without spillage. All excess water is returned to the storage tank via the sink drain.

The following experimental apparatus is included:

- Universal hydrometer and hydrometer jars
- Falling sphere viscometers
- Free surface tubes
- Hook and point gauge
- Mercury barometer (mercury not supplied)
- Bourdon gauge
- U-tube manometers
- Deadweight pressure gauge calibrator and weights
- Hydrostatic pressure apparatus
- Pascal's apparatus
- Parallel plate capillary apparatus
- Capillary tube apparatus
- Lever balance with displacement vessel, bucket and cylinder
- Metacentric height apparatus
- Measuring cylinder
- Thermometer
- Air pump
- 600ml beaker
- Stop clock

Technical Details

Universal hydrometer	Range 0.70-2.00 subdivided in 0.01 intervals
Falling sphere viscometer	40mm tube diameter
Hydrostatic pressure apparatus	Comprises counterbalanced precision quadrant pivoted on knife edges at its centre of arc
Direct reading barometer	With compensated silvered metal scale Range 585-790mm subdivided in 1mm intervals Includes thermometer
100mm dial pressure gauge	Range 0-200 kN/m^2 (kPa) and equivalent head of water in metres
Deadweight pressure gauge calibrator	With 2 x 0.5kg, 1kg and 2.5kg weights
Lever balance	178mm diameter pan, hook for use in buoyancy experiments, antiparallax cursor, double scale 0-0.25kg and 0-1.00kg
Thermometer	Range -10˚C to +50˚C

Requirements

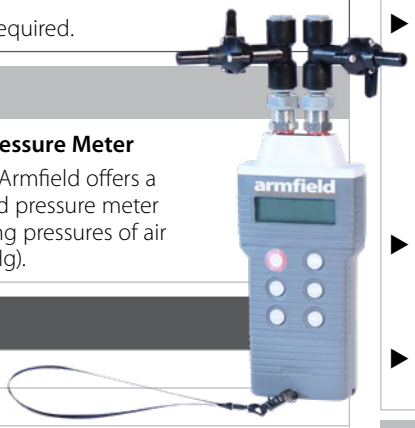
Water: Fill with clean water.
No permanent connection required.

Scale

Optional products

H12-8: Basic Portable Pressure Meter

Consequent to its hazardous nature Armfield offers a handheld, portable, battery-operated pressure meter (H12-8), which is capable of measuring pressures of air or water from 0-2.8 Bar (0-2100mm Hg).



Overall dimensions

Length	1.45m
Width	1.83m
Height	0.61m

Packed and crated shipping specifications

Volume	2.7m^3
Gross weight	270kg

Ordering specifications

- A self-contained and mobile unit for demonstration of the properties of fluids and hydrostatics
- The equipment is mounted on a steel-framed bench fitted with castors
- The benchtop incorporates a recessed plastic sink
- A variety of measuring devices is incorporated in the unit including a universal hydrometer, range 0.70-2.00; falling sphere viscometer; hook and point gauge; hydrostatic pressure apparatus; Pascal's apparatus; double-scale lever balance with displacement vessel, bucket and cylinder; metacentric height apparatus; direct reading barometer range 585-790mm; dial pressure gauge range 0-200 kN/m2 (kPa); deadweight pressure gauge calibrator with weights; thermometer range -10°C to +50°C
- These devices enable a full range of 16 experiments to be carried out, demonstrating the properties of fluids, the effects of static pressure, the operation and application of pressure gauges and manometers and the investigation of the stability of floating bodies
- A comprehensive manual is included describing how the experiments are performed as well as how to commission the equipment

Ordering codes

- F9092

Armfield standard warranty applies with this product

Our Commitment to you

Armfield recognises that it is not enough to just supply quality engineering equipment, but that it must also ensure a complete range of services both pre and post-sale:

- Supplied equipment meets global curriculum requirements
- Expert consultation in laboratory design and layout
- Professional installation and commissioning service
- Comprehensive training for all products in house or on site
- Detailed learning outcomes and experiments supplied with all equipment
- In house trials (industrial and research)
- Two year warranty on all products
- Dedicated aftersales service

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