



CIVIL  
CHEMICAL  
MECHANICAL  
ENVIRONMENTAL  
AGRICULTURAL  
MARINE  
FOOD  
PUBLIC HEALTH



## APPLICATIONS

The Armfield CAPTURE range is a unique range of small-scale teaching equipment, designed to give students an unparalleled insight into the principles of these machines.

With the introduction of CAPTURE, machines that were once costly, cumbersome and difficult to operate became affordable, space saving and easy to use. Now CAPTURE MkII takes the concept forward into new realms of student understanding, adding superb visibility of the working of the machines and taking full advantage of the latest software and instrumentation techniques.

CAPTURE MkII comprises:  
Pumps, Fans and Compressors, and Turbines.



# AIRFLOW MACHINES FM40 SERIES

## FANS & COMPRESSORS

The CAPTURE MkII Air Flow Machines (FM40 Series) are designed to demonstrate to engineering students the operating principles and characteristics of different types of fans and compressors.

Three different machines are available, a centrifugal fan, an axial fan and a centrifugal compressor.

### COMMON FEATURES OF ALL AIR FLOW MACHINES

- Transparent ducts for maximum visibility of the machines, and associated educational benefit
- Computer linking, with a common interface unit for all the CAPTURE MkII range (IFD7)
- Advanced educational software included with all units
- Simple interconnections and interfacing
- Stainless steel bases

### CENTRIFUGAL FAN DEMONSTRATION UNIT - FM40

The centrifugal fan is a radial flow machine, which produces the necessary pressure to move gas by the centrifugal force built up inside the fan casing. The design of the fan blade has a primary influence on performance.

These types of fans are usually employed for ventilating duties requiring a somewhat higher delivery pressure than that available from axial fans.



## AXIAL FAN DEMONSTRATION UNIT - FM41

The axial fan produces gas flow by virtue of the momentum changes imparted across the rotary blades, parallel to the axis of rotation. Such fans are more suitable for higher flows at lower delivery pressures than their centrifugal counterparts. Comparison of the performance characteristics of the FM41 Axial Fan with those of the FM40 Centrifugal Fan thus provides an instructional exercise of valuable practical application.



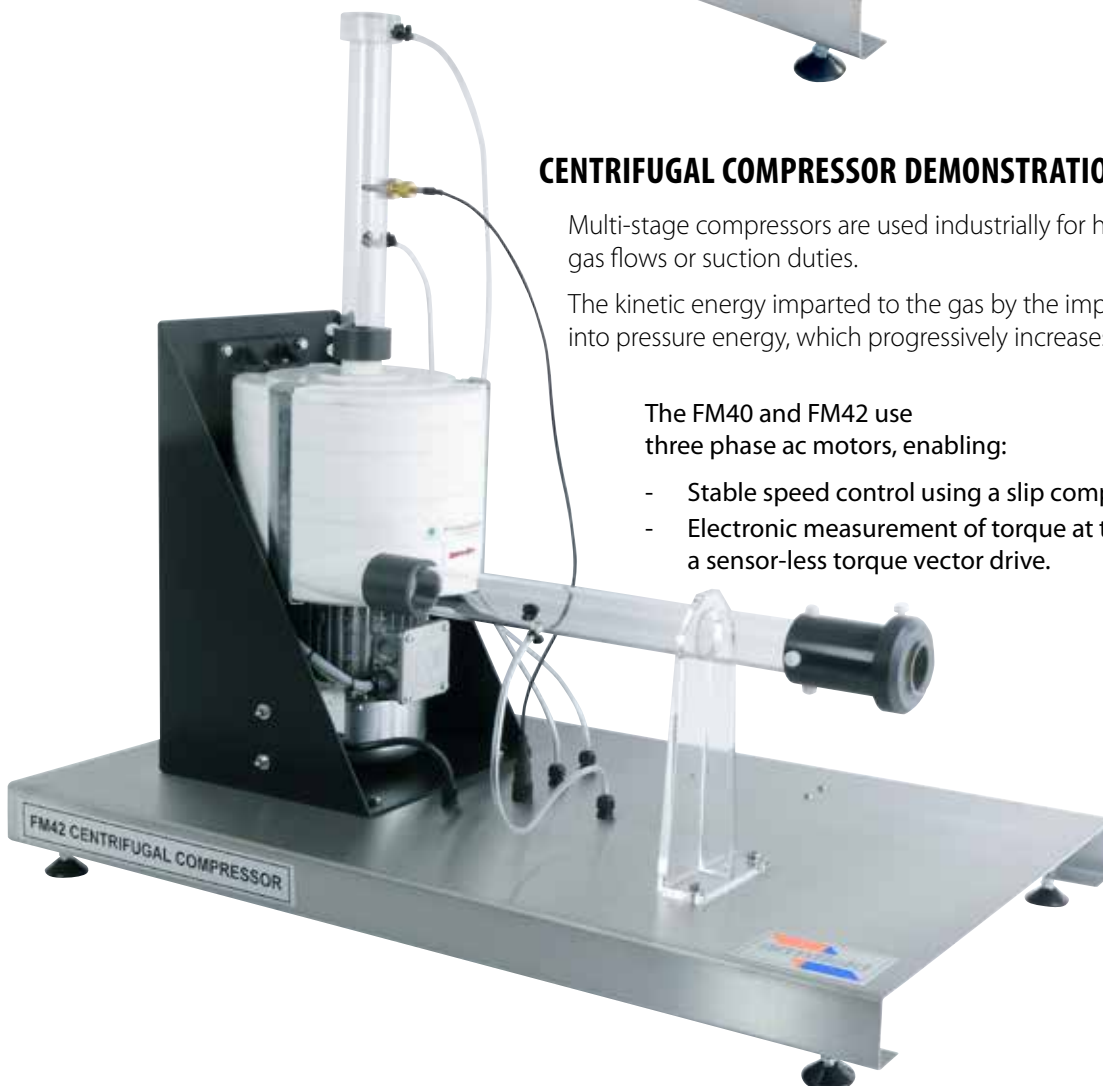
## CENTRIFUGAL COMPRESSOR DEMONSTRATION UNIT - FM42

Multi-stage compressors are used industrially for high pressure deliveries of gas flows or suction duties.

The kinetic energy imparted to the gas by the impeller rotation is converted into pressure energy, which progressively increases from stage to stage.

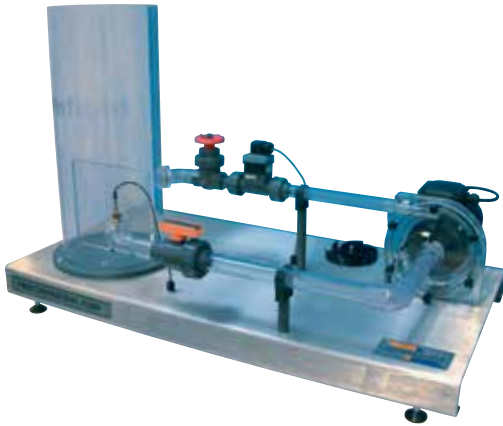
The FM40 and FM42 use three phase ac motors, enabling:

- Stable speed control using a slip compensated inverter drive.
- Electronic measurement of torque at the motor drive shaft using a sensor-less torque vector drive.



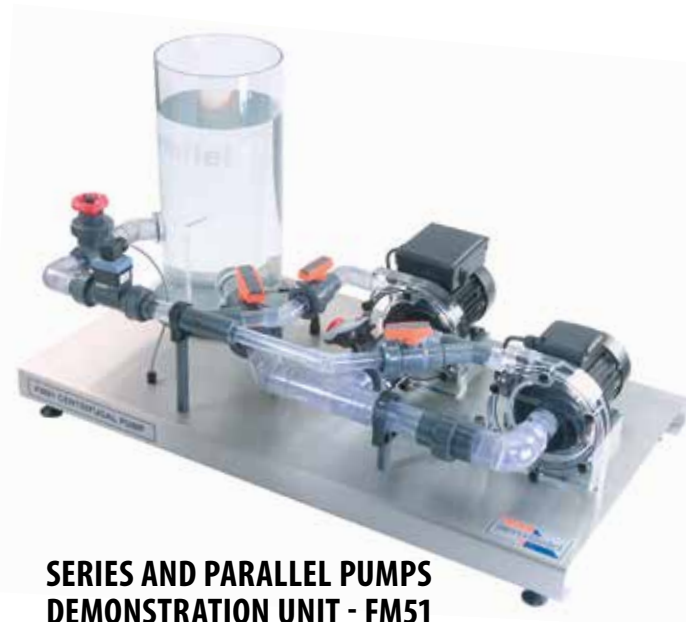
# PUMPS FM50 SERIES

## CENTRIFUGAL PUMP DEMONSTRATION UNIT - FM50



The centrifugal pump is the machine most commonly used to move liquids from one place to another. As such it's a particularly instructive unit, which introduces students to the whole subject of rotodynamic fluid machines.

Discovering the relationship between head, flow, rotational speed and power, provides a framework of general applicability. For example, matching the required duty point to the conditions of maximum energy efficiency may be explored as a creative student project.



## SERIES AND PARALLEL PUMPS DEMONSTRATION UNIT - FM51

Centrifugal pumps are often used together to enhance either the flow rate or the delivery pressure beyond that available from the single pump.

This unit is designed to demonstrate the operational advantages of parallel or series operation, depending on the required duty.



## GEAR PUMP DEMONSTRATION UNIT - FM52

The gear pump is the most widely used of the positive action rotary pumps. Two gear wheels operate inside a casing; one is driven while the other rotates in mesh with it. The liquid is carried around in the space between consecutive teeth and then ejected as the teeth mesh.

The pump has no valves. It is a positive displacement pump and will deliver against high pressures. The output is a more even flow than that of a reciprocating pump. It is particularly suitable for high viscosity fluids.

## PLUNGER PUMP DEMONSTRATION UNIT - FM53

The plunger pump is a positive displacement pump and is used for pumping small quantities of liquid at high pressures. It is similar to a piston pump except that the sealing gland is at one end of the cylinder.

The reciprocating motion of the plunger gives an uneven flow, although the inclusion of a damping vessel can reduce this effect. Priming is unnecessary.



# TURBINES FM60 SERIES

The Armfield FM60 range of hydropower units consists of four small-scale representations of industrial machines. The principles of design and operation of impulse and reaction turbines in both axial and radial flow situations are clearly demonstrated.

Three of the machines may be separately mounted on the common Turbine Service Unit (FM6X) for self-contained operation, while the fourth - the low head propeller turbine unit FM63 - has a specially designed service system of its own to accommodate the larger water flows.

## TURBINE SERVICE UNIT - FM6X



FM6X Turbine Service Unit shown with FM62 Pelton Turbine Demonstration Unit

A bench mounted unit consisting of a clear acrylic reservoir and a variable speed centrifugal pump, which provides water to power the accessory on test. The service unit also incorporates a water flow meter and electrically controlled dynamometer, which puts a load on to the turbine and measures the torque and speed.

## PROPELLER TURBINE DEMONSTRATION UNIT - FM63

A miniature-scale Propeller Turbine Unit, which is supplied as a floor-standing unit complete with a sump tank and recirculating pump. The turbine is housed in clear acrylic pipe work permitting excellent visibility. The turbine is loaded by an electronically controlled brake fitted with a load cell to measure the torque.



## AXIAL FLOW IMPULSE TURBINE - FM60



A miniature-scale Axial Flow, Impulse Turbine consisting of a brass runner, which is acted on by four jets of water. The flow to the turbine can be adjusted by changing the pump speed or closing off any of the nozzles. The turbine is housed in clear acrylic for excellent visibility. The unit is designed to mount on the FM6X Turbine Service Unit.

## RADIAL FLOW REACTION TURBINE - FM61



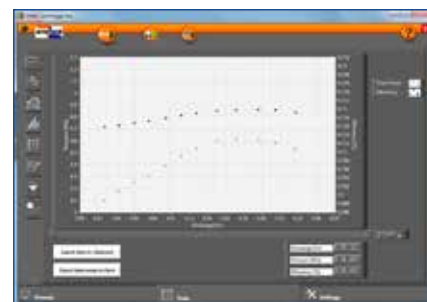
A miniature-scale Radial Flow Reaction Turbine, where water enters through a face seal and exits tangentially through two orifices. The reaction of these jets causes rotation of the runner. The turbine is housed in clear acrylic for excellent visibility. The unit is designed to mount on the FM6X Service Unit.

## PELTON TURBINE - FM62



A miniature-scale Pelton Wheel Turbine, complete with a spear valve to control the water flow. The turbine buckets are shaped to extract maximum momentum from the passing jet of water, while the spear valve is designed to enable adjustment of the cross sectional area of the jet.

## CAPTURE MKII SOFTWARE



Software screenshots

All Armfield CAPTURE units are now supplied with Armfield Armsoft LabVIEW™ based software to present and record the data in a way that is straightforward to use and understand for the student, yet offers a wide range of advanced features and capabilities.

### SOFTWARE CAPABILITIES

Each piece of FM equipment is supplied with its own run time software. This can be installed on any Windows based PC and requires no additional licences or software to be installed to use it to its full extent.

It include a range of facilities and capabilities designed to make the operation of the equipment and subsequent processing of the results very straightforward. This enables the student to focus on generating a true understanding of the subject material. Typical functions include:

- > Diagrammatic representation of the equipment, complete with real time display of the various sensor outputs
- > Detailed 'Help' facilities giving in depth guidance
- > Automatic data logging of sensor values into a spreadsheet format
- > Control over sampling intervals
- > Sophisticated graph plotting facilities of both measured and calculated values, including comparisons taken under different conditions
- > Export of data to Microsoft Excel or other spreadsheet software
- > General note pad facility
- > Facility to add notes to an individual sample
- > Calibration facility for sensors
- > Real time bar graph display of sensor outputs
- > Recent history graphical display

### UPGRADES

Existing CAPTURE MKII users can upgrade to the new LabVIEW™ software, (i.e. any system incorporating an IFD7 Interface Unit). No hardware changes are necessary unless also upgrading from a 32 to a 64 bit computer. If the computer operating system is being upgraded at the same time it may also be necessary to upgrade the IFD7. See the IFD7 section for more details.

### SOFTWARE SOURCE CODE

Advanced LabVIEW™ users may wish to access and modify the code supplied by Armfield. Armfield can supply the source code for the LabVIEW™ software, enabling the programs to be optimised for particular requirements.

To use this facility, an up to date version of the National Instruments LabVIEW™ development software must be installed on the PC, together with all applicable licences. (Note, Armfield do not supply National Instruments software.)

### SOFTWARE ORDER CODES

FM40-LV-RT, FM41-LV-RT etc. for standard software, or FM-LV-SC for the source code version.

## TECHNICAL DETAILS

### IFD7 INTERFACE UNIT

The interface between the CAPTURE MkII units and the user's computer is provided by the Armfield IFD7 Interface device. This conditions the raw data from the sensors, digitises the data and transfers it to the computer using the USB interface. It also includes a sophisticated three phase inverter for providing accurate motor speed control, and a second motor drive output, all under software control.



#### Note:

All IFD7 Interface Units supplied since October 2013 are compatible with both 32 and 64 bit computer operating systems.

Earlier units can be upgraded by changing a printed circuit board, (obviously for your safety, before opening the cover, follow the hardware and software installation and safety instructions as supplied with the upgrade).

### IFD7 INTERFACE UNIT UPGRADE ORDER CODE

#### IFD7-64BIT-UPG

Hardware and software upgrade for IFD7 for use with 64 bit operating systems, including software for FM40 through FM63 (one required for each IFD7).

## ORDERING SPECIFICATION

- A computer interface accessory for use with all CAPTURE MkII FM fluid machines
- Connects to FM equipment sensors via a single multi-way connector
- 3-phase mains output with variable frequency for accurate motor speed control
- Sensorless vector motor drive to measure motor torque
- Automatic slip compensation to maintain constant speed
- Secondary mains output, switched under software control
- Interface driver enables linking to other software packages
- Built-in watchdog circuitry for remote operation (with suitable equipment)

The screenshot shows the Armfield software interface with a 'Result Table' window open. The table displays various parameters for different test runs, including time, power, speed, and torque. The columns are: Time (s), Power (W), Speed (rpm), Torque (Nm), Power (W), Speed (rpm), Torque (Nm), Time (s), Power (W), Speed (rpm), Torque (Nm). The data rows show values for 100W, 200W, 300W, 400W, 500W, 600W, 700W, 800W, 900W, and 1000W. At the bottom of the table, there are 'Refresh' and 'Export selected data to Excel' buttons.

### ORDERING CODES

IFD7-A: 220-240V/1Ph/50Hz

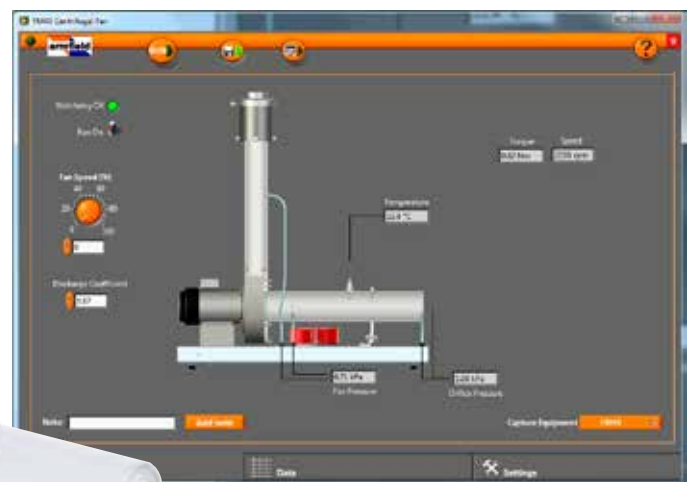
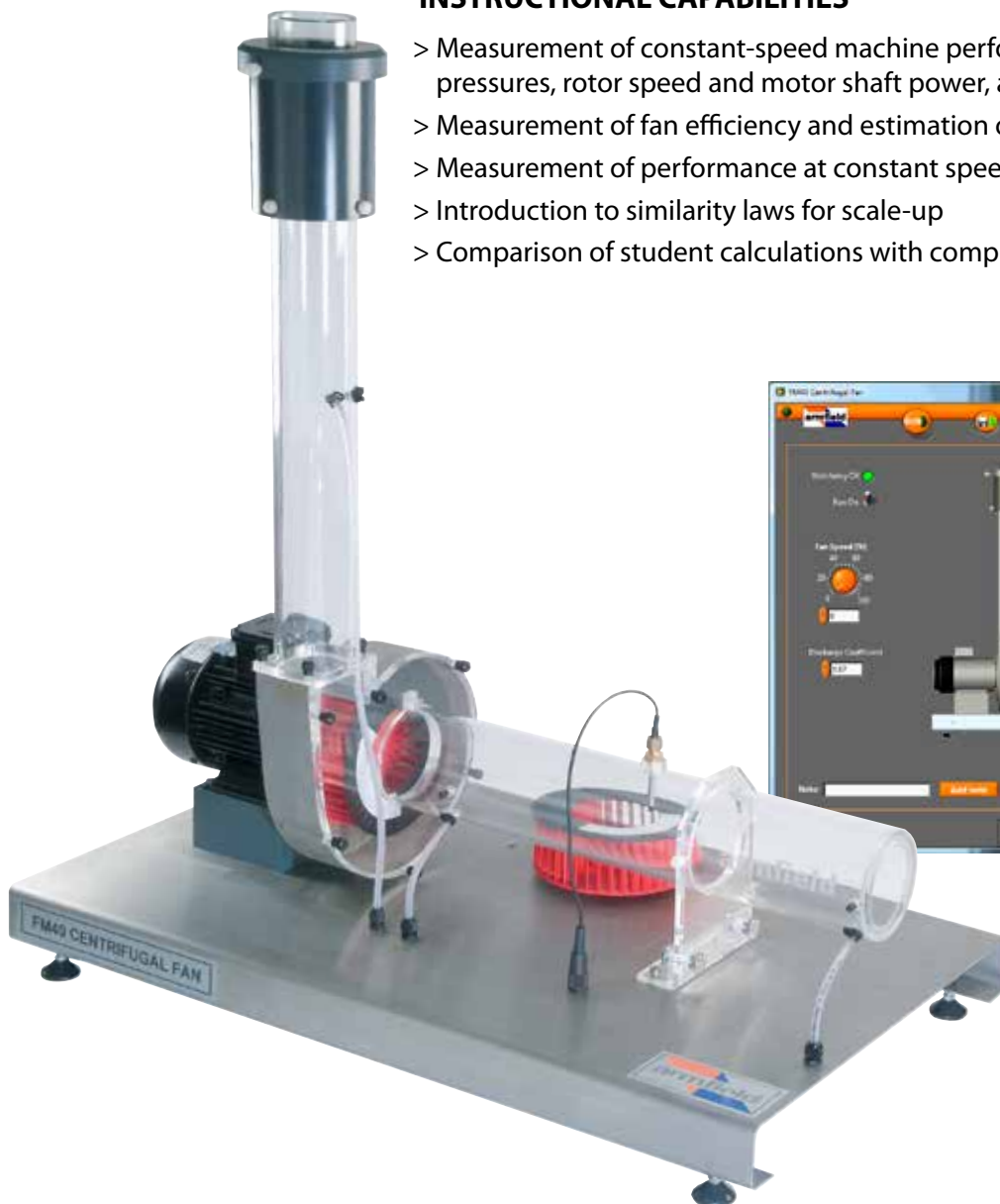
IFD7-G: 220-240V/1Ph/60Hz

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

## CENTRIFUGAL FAN DEMONSTRATION UNIT - FM40

### INSTRUCTIONAL CAPABILITIES

- > Measurement of constant-speed machine performance in terms of static and total pressures, rotor speed and motor shaft power, as a function of inlet flow
- > Measurement of fan efficiency and estimation of impeller power efficiency
- > Measurement of performance at constant speeds
- > Introduction to similarity laws for scale-up
- > Comparison of student calculations with computer results



Software screenshot

The centrifugal fan is a radial flow machine, which produces the necessary pressure to move gas by the centrifugal force built up inside the fan casing. The design of the fan blade has a primary influence on performance.

These types of fans are usually employed for ventilating duties requiring a somewhat higher delivery pressure than that available from axial fans.



Detail of the Centrifugal Fan



## DESCRIPTION

A motor driven centrifugal fan, mounted on a stainless steel plinth.

Transparent air inlet and air outlet ducts enable the fan volute and the impeller to be clearly observed. A manually operated adjustable aperture enables the air flow rate to be varied at constant fan speed. A calibrated orifice plate is used on the discharge to measure the air flow rate.

Interchangeable backward and forward curved blade impellers are provided, to facilitate direct comparison between their respective operating characteristics and to demonstrate which duties each is best suited.

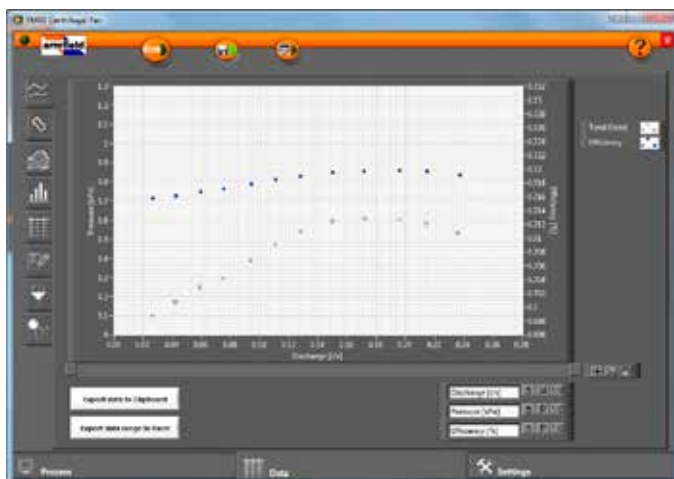
Electronic sensors measure the pressure head developed across the fan, the pressure across the orifice plate (and hence the flow rate) and the air temperature.

The fan speed is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory). This inverter also calculates the torque produced at the motor drive shaft, enabling the power used by the fan to be derived. The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a connector for the fan motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max Flow Rate:	70 l/s typical
Max Head:	0.7kPa
Max fan speed:	3000rpm
Motor Power rating:	550W



## ORDERING SPECIFICATION

- A small-scale centrifugal fan demonstration unit, comprising of an inlet duct, the fan, an outlet duct and an adjustable aperture, all mounted on a stainless steel base
- Equipped with electronic measurement sensors for fan head pressure, flow rate (via orifice plate) and air temperature
- Transparent cover plate on fan volute for visibility
- Supplied with two different, easily interchangeable impellers
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

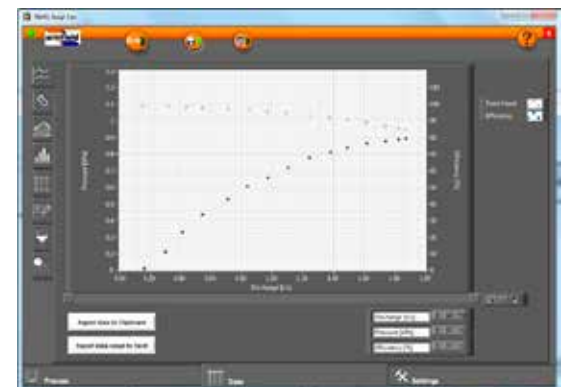
Height:	0.97m
Length:	0.88m
Width:	0.51m

## SHIPPING SPECIFICATION

Gross Weight:	90kg
Volume:	0.75m <sup>3</sup>

### INSTRUCTIONAL CAPABILITIES

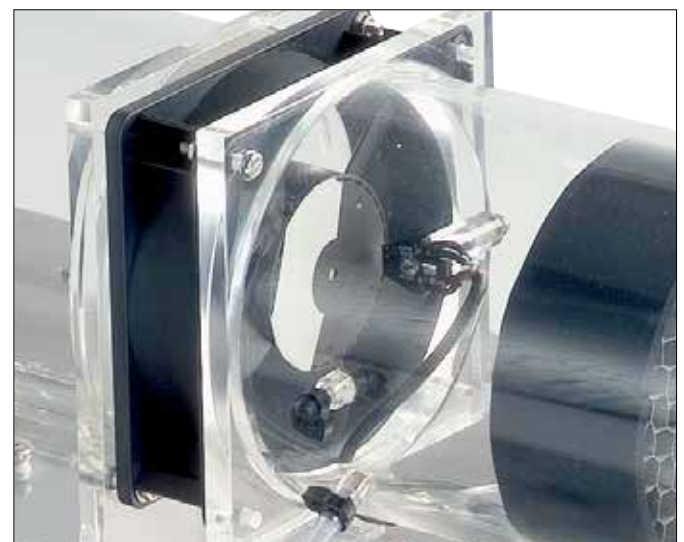
- > Measurement of inherent speed machine performance in terms of static and total pressures, rotor speed and motor input power, as a function of inlet flow
- > Measurement of overall efficiency and estimation of impeller power efficiency
- > Measurement of performance at constant speeds
- > Introduction to similarity laws for scale-up
- > Comparison of student calculations with computer results



Software screenshots

The axial fan produces gas flow by virtue of the momentum changes imparted across the rotary blades, parallel to the axis of rotation. Such fans are more suitable for higher flows at lower delivery pressures than their centrifugal counterparts.

Comparison of the performance characteristics of the FM41 Axial Fan with those of the FM40 Centrifugal Fan thus provides an instructional exercise of valuable practical application.



Detail of the Axial Fan

## DESCRIPTION

An axial fan, mounted on a stainless steel plinth. Transparent air inlet and air outlet ducts enable the fan construction to be clearly observed.

A manually operated adjustable aperture enables the air flow rate to be varied.

A calibrated orifice plate is used on the discharge to measure the air flow rate.

Electronic sensors measure the pressure head developed across the fan, the pressure across the orifice plate (and hence the flow rate), the rotational speed of the fan and the air temperature.

The fan speed is controlled by modulated dc supply, complete with current sensing to enable the power drawn by the fan to be measured.

An IFD7 is required to provide the conditioning electronics for the sensors and to enable their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a power connector for the fan drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max Flow Rate:	38 l/s typical
Max Head:	0.06 kPa
Max fan speed:	2700rpm
Motor Power rating:	5W

Fan Speed (rpm)	Inlet Pressure (kPa)	Discharge Pressure (kPa)	Power (W)	Air Flow (l/s)	Discharge Coefficient	Fan Speed (RPM)	Head (kPa)	Volume Flow Rate (m <sup>3</sup> /s)
2700	0.0612	0.0200	20.8	3.7	1.000	8.206	0.02	0.08
2400	0.0595	0.0189	20.8	3.8	1.000	8.196	0.02	0.08
2100	0.0582	0.0182	20.5	3.5	1.000	8.206	0.02	0.08
1800	0.0569	0.0175	20.8	3.4	1.000	8.196	0.02	0.08
1500	0.0556	0.0168	20.8	3.3	1.000	8.196	0.02	0.08
1200	0.0543	0.0161	20.8	3.2	1.000	8.196	0.02	0.08
900	0.0530	0.0154	20.8	3.1	1.000	8.196	0.02	0.08
600	0.0517	0.0147	20.8	3.0	1.000	8.196	0.02	0.08
300	0.0504	0.0140	20.8	2.9	1.000	8.196	0.02	0.08
0	0.0491	0.0133	20.8	2.8	1.000	8.196	0.02	0.08
2700	0.0478	0.0126	20.8	2.7	1.000	8.196	0.02	0.08
2400	0.0465	0.0119	20.8	2.6	1.000	8.196	0.02	0.08
2100	0.0452	0.0112	20.8	2.5	1.000	8.196	0.02	0.08
1800	0.0439	0.0105	20.8	2.4	1.000	8.196	0.02	0.08
1500	0.0426	0.0098	20.8	2.3	1.000	8.196	0.02	0.08

Software screenshots

## ORDERING SPECIFICATION

- A small-scale axial fan demonstration unit, comprising of an inlet duct, the fan, an outlet duct and an adjustable aperture, all mounted on a stainless steel base
- Equipped with electronic measurement sensors for fan head pressure, flow rate (via orifice plate), fan speed and air temperature
- Transparent ducts give visibility of the fan in operation
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.95m
Length:	0.85m
Width:	0.45m

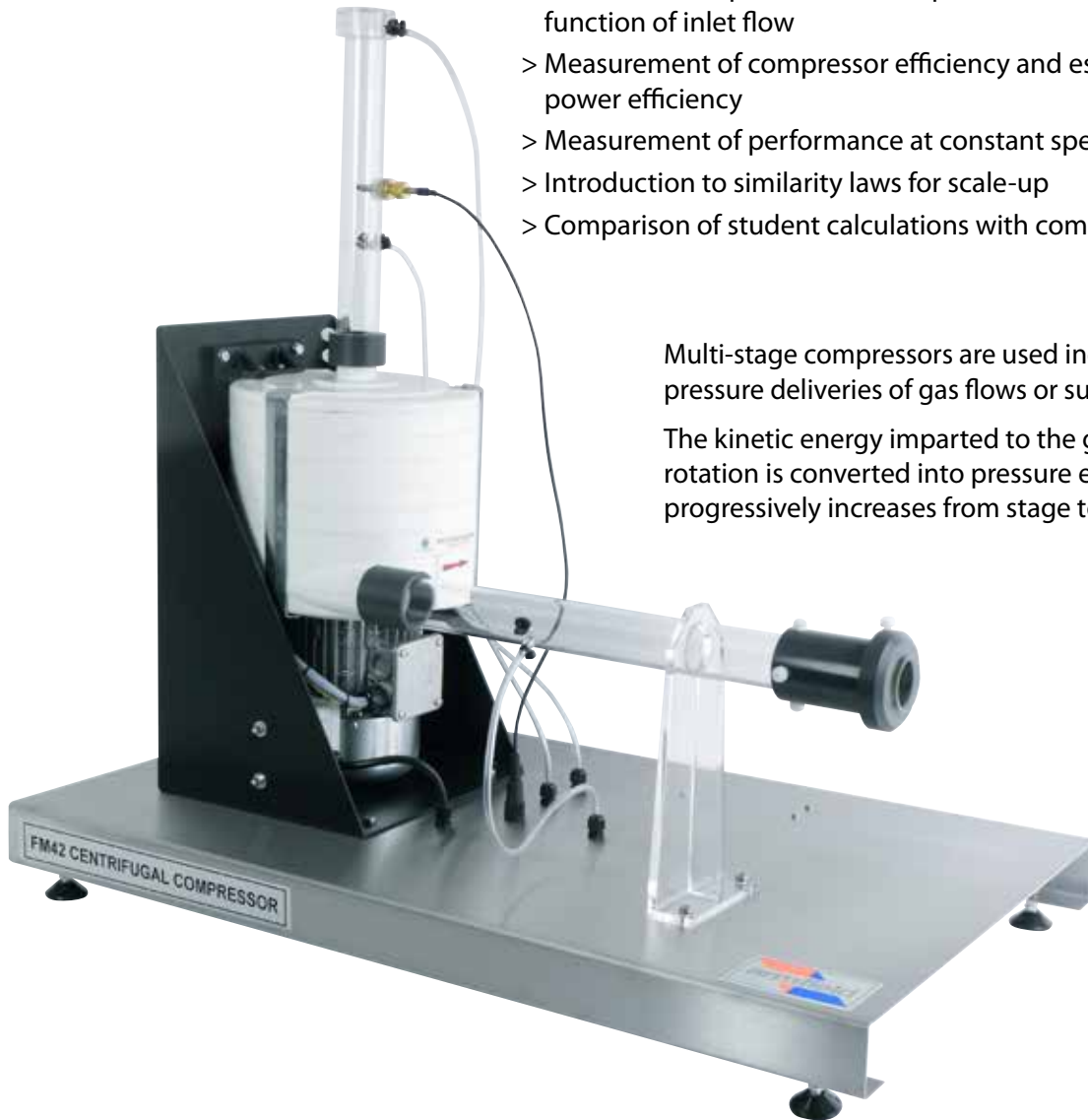
## SHIPPING SPECIFICATION

Gross Weight:	90kg
Volume:	0.75m <sup>3</sup>

## CENTRIFUGAL COMPRESSOR DEMONSTRATION UNIT - FM42

### INSTRUCTIONAL CAPABILITIES

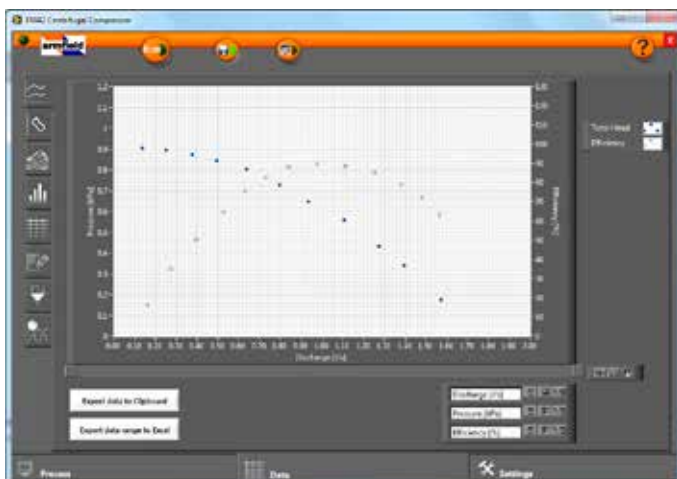
- > Measurement of constant speed machine performance in terms of static and total pressures, rotor speed and motor shaft power, as a function of inlet flow
- > Measurement of compressor efficiency and estimation of impeller power efficiency
- > Measurement of performance at constant speeds
- > Introduction to similarity laws for scale-up
- > Comparison of student calculations with computer results



Multi-stage compressors are used industrially for high pressure deliveries of gas flows or suction duties.

The kinetic energy imparted to the gas by the impeller rotation is converted into pressure energy which progressively increases from stage to stage.

Software screenshots



## DESCRIPTION

A motor driven multi-stage centrifugal compressor, mounted on a stainless steel plinth with transparent air inlet and air outlet ducts. A manually operated adjustable aperture enables the air flow rate to be varied at constant fan speed. A calibrated orifice plate is used on the discharge to measure the air flow rate.

Electronic sensors measure the pressure head developed across the blower, the pressure across the orifice plate (and hence the flow rate) and the air temperature.

The compressor speed is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory). This inverter also calculates the torque produced at the motor drive shaft, enabling the power used by the fan to be derived. The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a connector for the pump motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max Flow Rate:	20 l/s typical
Max Head:	6.0kPa
Max fan speed:	3000rpm
Motor Power rating:	250W
Number of stages:	7

## ORDERING SPECIFICATION

- A small-scale multi-stage centrifugal compressor demonstration unit, comprising of an inlet duct, the compressor, an outlet duct and an adjustable aperture, all mounted on a stainless steel base
- Seven stages in the compressor
- Equipped with electronic measurement sensors for head pressure, flow rate (via orifice plate) and air temperature
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation, complete with a student questions and answers session

## ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.95m
Length:	0.88m
Width:	0.51m

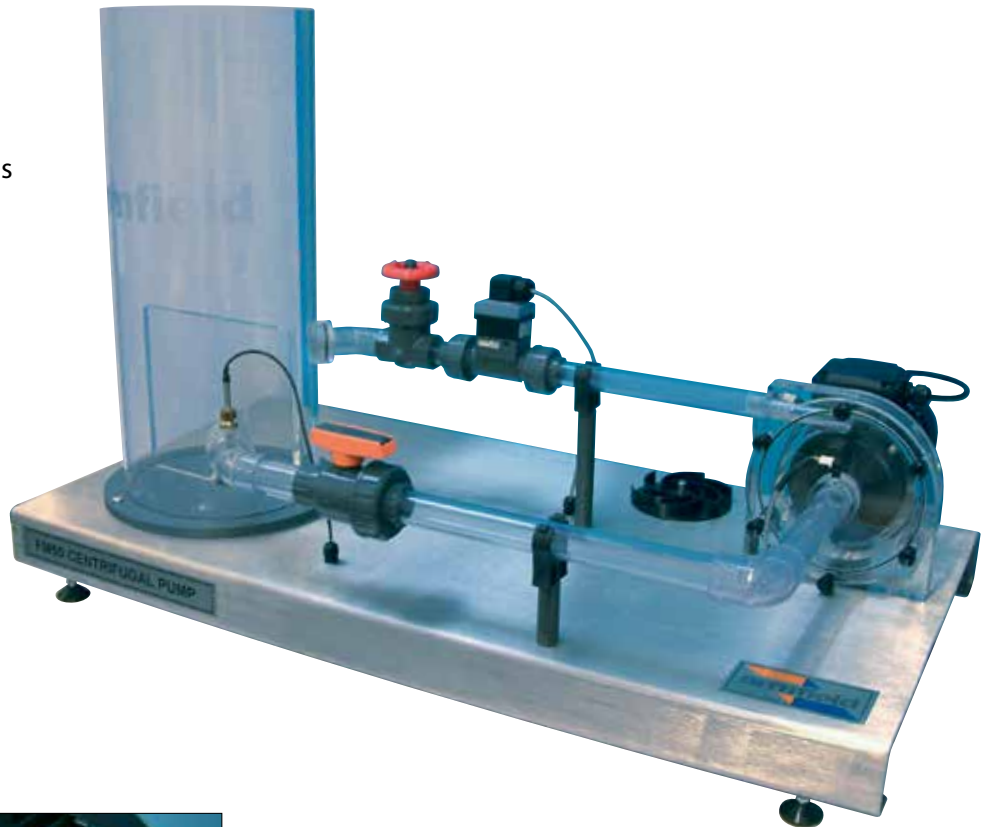
## SHIPPING SPECIFICATION

Gross Weight:	100kg
Volume:	0.75m <sup>3</sup>

## CENTRIFUGAL PUMP DEMONSTRATION UNIT - FM50

### INSTRUCTIONAL CAPABILITIES

- > Demonstration of a single stage centrifugal water pump in operation
- > Measurement of constant speed pump performance, including production of characteristic curves:
  - pump total head
  - motor shaft power
  - impeller speed
  - pump efficiency
- > Introduction to pump speed laws
- > Investigation of impeller styles
- > Comparison of student calculations with computer results



Detail of the Centrifugal Pump (shown with cover removed prior to exchanging the impellor)

The centrifugal pump is the machine most commonly used to move liquids from one place to another. As such it is a particularly instructive unit with which to introduce students to the whole subject of rotodynamic fluid machines.

Discovering the relationship between head, flow, rotational speed and power provides a framework of general applicability. For example, matching the required duty point to the conditions of maximum energy efficiency may be explored as a creative student project.

## DESCRIPTION

A motor driven centrifugal pump, mounted on a stainless steel plinth with a water reservoir and pipework for continuous circulation. The pump volute and the water reservoir are manufactured from clear acrylic for maximum visibility. Similarly the pipe runs are made from transparent pvc. Manually operated valves at the pump inlet and outlet enable control of the flow and also facilitate the study of suction effects.

The pump volute has been designed so that the impeller can be easily accessed and replaced without tools. The FM50 is delivered with two impellers, one with forward curved blades and one with backward curved blades, enabling the students to investigate the effects of impeller characteristics.

Electronic sensors measure the pump inlet pressure, the pump outlet pressure, the flow rate and the water temperature.

The pump speed is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory). This inverter also calculates the torque produced at the motor drive shaft, enabling the power used by the pump to be derived. The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a connector for the pump motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max flow rate:	1.6 l/s typical
Max head:	9.0m
Max pump speed:	1800rpm
Motor power rating:	250W

## ORDERING SPECIFICATION

- A small-scale centrifugal pump demonstration unit, comprising of a water reservoir, the pump, control valves and interconnecting pipework all mounted on a stainless steel base
- Equipped with electronic measurement sensors for pump head pressure, suction, flow rate and water temperature
- Transparent pump volute for visibility
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

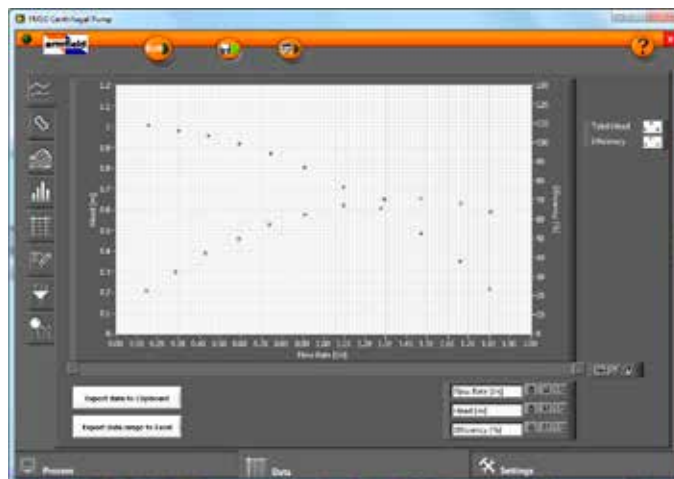
Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.6m
Length:	0.88m
Width:	0.51m

## SHIPPING SPECIFICATION

Gross Weight:	110kg
Volume:	1.10m <sup>3</sup>

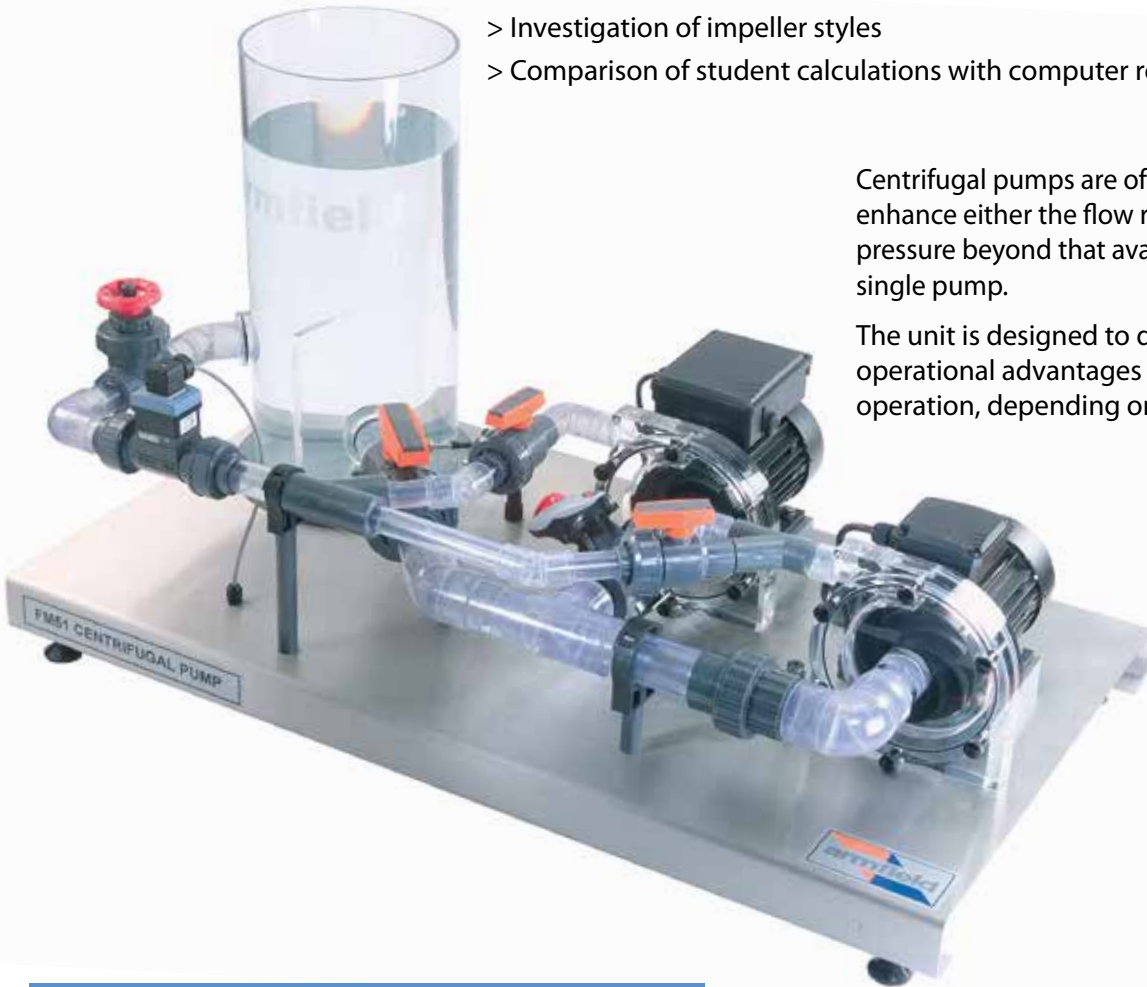


### INSTRUCTIONAL CAPABILITIES

- > Demonstration of either series, parallel or single pump operation
- > Measurement of constant speed pump performance, including production of characteristic curves (one pump)
- > Comparison of head flow characteristics with single pump operation, at inherent speed
- > Investigation of impeller styles
- > Comparison of student calculations with computer results

Centrifugal pumps are often used together to enhance either the flow rate or the delivery pressure beyond that available from the single pump.

The unit is designed to demonstrate the operational advantages of parallel or series operation, depending on the required duty.



### DESCRIPTION

Two motor driven centrifugal pumps, mounted on a stainless steel plinth with a water reservoir and pipework for continuous circulation. The pumps can be configured for single pump operation, two pumps in parallel or two pumps in series by using manually operated ball valves. Similarly, manual valves are used to control the flow and facilitate the study of suction effects, including demonstration of air release.

In parallel operation the two pumps draw from a shared inlet pipe of a wider diameter than the pump inlet, reflecting a typical industrial configuration of parallel pumping. Each pump has impellers that can be easily accessed and replaced without tools. The FM51 is delivered with three impellers in total, one with forward curved blades and two with backward curved blades, enabling the students to investigate the effects of impeller characteristics.

Electronic sensors measure the pump outlet pressure of each pump, the shared pump inlet pressure, the flow rate and the water temperature.

The pump speed of the first pump is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory) and can be varied over the full range. The inverter also calculates the torque produced at the motor drive shaft, enabling the power used by the pump to be derived.

The second pump runs at inherent motor speed. This combination of control facilities enables a wide range of different configurations to be investigated.



## DESCRIPTION - CONTINUED

The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a connector for the pump motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max Flow Rate:	2.2 l/s (parallel pumping, both pumps 50 Hz)
Max Head:	6.0 m (single pump) 12.0m (series)
Max pump speed	1800 rpm (pump1) 1500 rpm (pump 2 nominal)
Motor Power rating	250W

## ORDERING SPECIFICATION

- A small-scale series/parallel pump demonstration unit, comprising of a water reservoir, two pumps, control valves and interconnecting pipework, all mounted on a stainless steel base
- Equipped with electronic measurement sensors for pump head pressure (2 off), suction, flow rate and water temperature
- Transparent pump volutes for visibility
- Inlet valve throttling demonstrates air release
- Supplied with different easily interchangeable impellers
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

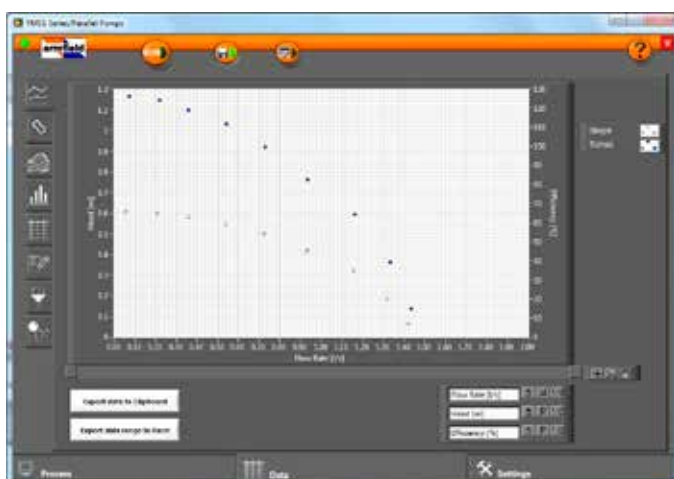
Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.59m
Length:	1.01m
Width:	0.58m

## SHIPPING SPECIFICATION

Gross Weight:	120kg
Volume:	1.40m <sup>3</sup>



### INSTRUCTIONAL CAPABILITIES

- > Demonstration of a gear pump in operation
- > Measurement of constant speed pump performance, including the production of characteristic curves of outlet pressure against:
  - flow rate
  - motor shaft power
  - pump speed
  - pump efficiency
  - volumetric efficiency
- > Comparison of student calculation with computer results



Flow Rate (l/min)	Motor Speed (rpm)	Motor Power (W)	Pump Efficiency (%)	Volumetric Efficiency (%)	Motor Shaft Power (W)	Pump Output Power (W)	Pump Efficiency (%)	Volumetric Efficiency (%)
0.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
0.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
1.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
1.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
2.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
2.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
3.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
3.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
4.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
4.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
5.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
5.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
6.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
6.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
7.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
7.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
8.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
8.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
9.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
9.5	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0
10.0	1500	1.5	0.0	0.0	1.5	0.0	0.0	0.0

Software screenshots

The gear pump is the most widely used of the positive action rotary pumps.

Two gear wheels operate inside a casing. One is driven whilst the other rotates in mesh with it. The liquid is carried around in the space between consecutive teeth and then ejected as the teeth mesh. The pump has no valves. It is a positive displacement pump and will deliver against high pressures. The output is a more even flow than that of a reciprocating pump. It is particularly suitable for high viscosity fluids.



Detail of the Gear Pump

## DESCRIPTION

A motor driven gear pump, mounted on a stainless steel plinth with a water reservoir and pipework for continuous circulation. The pump head and the water reservoir are manufactured from clear acrylic for maximum visibility.

A manually operated valve at the pump outlet enables control of the flow and a pressure relief valve protects the operator and the equipment.

Electronic sensors measure the pump outlet pressure, the flow rate and the water temperature.

The pump speed is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory). This inverter also calculates the torque produced at the motor drive shaft, enabling the power used by the pump to be derived. The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi way connector for the sensors and a connector for the pump motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max flow rate:	6.5 l/m typical
Max head:	25m
Max pump speed:	1800rpm
Motor power rating:	250W

## ORDERING SPECIFICATION

- A small-scale gear pump demonstration unit, comprising of a water reservoir, pump, control valve, relief valve and interconnecting pipework, all mounted on a stainless steel base
- Equipped with electronic measurement sensors for pump head pressure, flow rate and water temperature
- Transparent pump head for visibility
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.41m
Length:	0.88m
Width:	0.51m

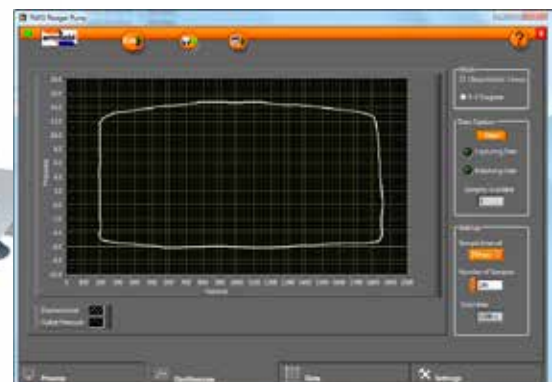
## SHIPPING SPECIFICATION

Gross Weight:	100kg
Volume:	0.75m <sup>3</sup>

## PLUNGER PUMP DEMONSTRATION UNIT - FM53

### INSTRUCTIONAL CAPABILITIES

- > Measurement during each pump cycle of:
  - plunger displacement
  - cylinder pressure
  - pump outlet pressure
- > p-V diagram displays on PC
- > Measurement of volumetric efficiency
- > Measuring the effect on pump performance of:
  - sprung loading valve or needle valve
  - adjusting the outlet loading valve
  - the inclusion of a pulsation damper vessel



Software screenshots

The plunger or ram pump is a positive displacement pump and is used for pumping small quantities of liquid at high pressures. It is similar to a piston pump except that the sealing gland is at one end of the cylinder. The reciprocating motion of the plunger gives an uneven flow, although the inclusion of a damping vessel can reduce this effect. Priming is unnecessary.



Detail of the Plunger Pump

## DESCRIPTION

A motor driven plunger pump, mounted on a stainless steel plinth with a water reservoir, pulsation damper and pipework for continuous circulation. The pump head, measuring tank, pulsation damper and the water reservoir are manufactured from clear acrylic for maximum visibility. The pump outlet is connected to both a sprung loading valve and a needle valve to investigate different loading characteristics. A pressure relief valve protects the operator and the equipment. An additional valve can be used to isolate or include the pulsation damper, enabling the effect of damping to be investigated.

Electronic sensors measure the instantaneous cylinder pressure within the pump, the pump displacement and the cumulative flow over a period of time.

The pump speed is accurately controlled by an advanced electronic inverter within the IFD7 (an essential accessory). The IFD7 also provides the conditioning electronics for the sensors and enables their readings to be displayed on the computer software. Connections to the IFD7 are a single multi-way connector for the sensors and a connector for the pump motor drive.

The equipment is provided with advanced education and data logging software. See the software section of this data sheet for further details.

## PERFORMANCE SPECIFICATION

Max flow rate:	0.725 l/m typical
Max head:	4 bar
Swept volume:	15mm stroke x 32mm diameter
Pumping speed:	variable up to 60 strokes/minute
Motor power rating:	250W

## ORDERING SPECIFICATION

- A small-scale plunger pump demonstration unit, comprising of a water reservoir, pump, control valve, relief valve and interconnecting pipework, all mounted on a stainless steel base
- Includes both a sprung loading valve and a needle valve for loading the pump
- Equipped with electronic measurement sensors for cylinder pressure, plunger position, pump outlet pressure and cumulative flow
- Pulsation damping facility
- Transparent pump head for visibility
- Capable of being linked to a PC (not supplied) via a USB interface console (an essential accessory), which does not require internal access to the computer  
Also enables interfacing to other software packages
- Supplied with software providing full instructions for setting up, operating, calibrating and performing the teaching exercises. Facilities for logging, processing and displaying data graphically
- Offers a complete teaching package of coursework and laboratory investigation

## ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

## OVERALL DIMENSIONS

Height:	0.41m
Length:	0.88m
Width:	0.51m

## SHIPPING SPECIFICATION

Gross Weight:	120kg
Volume:	1.00m <sup>3</sup>

## TURBINE SERVICE UNIT - FM6X

## INSTRUCTIONAL CAPABILITIES



FM6X Turbine Service Unit shown with FM62 Pelton Turbine Demonstration Unit

### DESCRIPTION

The FM6X Turbine Service unit provides a water supply, which is required to operate the FM60, FM61 and FM62 turbine demonstrations. The service unit consists of a stainless steel base on which is mounted a water reservoir, a compact three-phase pump and an electronic flow meter. The pump is controlled direct from the computer using the speed controller inside the IFD7 USB interface console.

### DYNAMOMETER

The turbine under test is connected to the dynamometer by a toothed drive belt. Load is applied to the turbine using a magnetic brake controlled directly from the computer.

The outer casing of the brake is restrained from rotating by a lever arm, which is connected to a load cell. This enables the braking force and the torque produced to be directly measured. The dynamometer unit also incorporates an optical sensor, which measures the rotational speed of the turbine.

### PERFORMANCE SPECIFICATION

Reservoir Capacity:	28 l
Maximum Flow Rate:	20 l/m
Maximum Head:	30m

- > Determining the characteristics of the selected turbine, including the relationships of volume flow rate, head, torque produced, power output and efficiency to rotational speed (FM60/FM61/FM62)
- > Comparison of nozzle and throttling control of an Impulse Turbine (FM60)
- > Comparison of throttle control and spear valve control of the speed of a Pelton Turbine (FM62)
- > Determination of characteristic performance curves for a peripheral pump, including constant speed head/flow and efficiency curves (FM64)

### ORDERING SPECIFICATION

- A bench top service unit which provides a suitable water supply for testing a range of different turbines
- Clear acrylic reservoir which holds up to 28 litres
- Peripheral type pump providing up to 20 litres per minute or up to 30m head (not simultaneously)
- Paddle wheel type flow meter
- Magnetic type dynamometer controlled from software
- Software control of both pump and brake enables remote operation of the equipment over an intranet by writing suitable software
- Links to a suitable computer via a USB interface device which does not require internal access to the computer Also enables interfacing to other software packages
- Supplied with full education software package including comprehensive results processing and help facilities

### ESSENTIAL EQUIPMENT

Armfield IFD7 Interface Unit  
PC with spare USB port

### REQUIREMENTS

See Essential Equipment

### OVERALL DIMENSIONS

Height:	0.73m
Width:	0.80m
Depth:	0.51m

### SHIPPING SPECIFICATION

Gross Weight:	100kg
Volume:	1.10m <sup>3</sup>

## IMPULSE TURBINE - FM60



### DESCRIPTION

The FM60 is a small-scale Impulse Turbine unit, which is designed to be used in conjunction with the FM6X service unit. An impulse turbine uses the momentum transferred from the impact of a jet of water onto the turbine blades to generate power.

The FM60 consists of an inlet manifold, which supplies water to four jets which are equally spaced around the turbine runner. Each of the jets can be individually controlled using ball valves. The runner itself is mounted on a horizontal shaft with a clear acrylic splash guard to enable maximum visibility of the workings.

The unit incorporates a pressure sensor to measure the inlet condition of the water. This pressure can be accurately controlled using the software supplied with the service unit.

### PERFORMANCE SPECIFICATION

Maximum Power:	35W
Maximum Speed:	7000rpm
Maximum Torque:	0.15Nm

## INSTRUCTIONAL CAPABILITIES

- > Determining the characteristics of the turbine, including the relationships of volume flow rate, head, torque produced, power output and efficiency to rotational speed.
- > Comparison of nozzle and throttling control of an Impulse Turbine.

### ORDERING SPECIFICATION

- Small-scale hydropower unit designed to demonstrate the operating principles of an impulse turbine
- Horizontal shaft and transparent guarding enable excellent visibility
- Mounts on a dedicated service unit
- Connects to a PC via the service unit and a USB interface device

### ESSENTIAL EQUIPMENT

FM6X Service Unit  
IFD7 Interface Unit

### REQUIREMENTS

See Essential Equipment

### OVERALL DIMENSIONS

Height:	0.29m
Width:	0.56m
Depth:	0.13m

### SHIPPING SPECIFICATION

Gross Weight:	20kg
Volume:	0.20m <sup>3</sup>



Software screenshot

## REACTION TURBINE - FM61



### DESCRIPTION

The FM61 is a small-scale Reaction Turbine unit, which is designed to be used in conjunction with the FM6X service unit. A reaction turbine uses the momentum transferred from the reaction of a jet of water leaving a nozzle to generate power.

The FM61 consists of an inlet manifold, which supplies water to a central hub. Water exits the hub radially through two square orifices. The hub is connected to the manifold using a graphite face seal. The turbine is mounted on a horizontal shaft with a clear acrylic splash guard to enable maximum visibility of the workings.

The unit incorporates a pressure sensor to measure the inlet condition of the water. This pressure can be accurately controlled using the software supplied with the service unit.

### DYNAMOMETER

The turbine under test is connected to the dynamometer by a toothed drive belt. Load is applied to the turbine using a magnetic brake controlled directly from the computer.

The outer casing of the brake is restrained from rotating by a lever arm, which is connected to a load cell. This enables the braking force and the torque produced to be directly measured. The dynamometer unit also incorporates an optical sensor, which measures the rotational speed of the turbine.

### PERFORMANCE SPECIFICATION

Maximum Power:	25W
Maximum Speed:	8000rpm
Maximum Torque:	0.12Nm

## INSTRUCTIONAL CAPABILITIES

- > Determining the characteristics of the turbine, including the relationships of volume flow rate, head, torque produced, power output and efficiency to rotational speed.

### ORDERING SPECIFICATION

- Small scale hydropower unit designed to demonstrate the operating principles of a reaction turbine
- Horizontal shaft and transparent guarding enable excellent visibility
- Mounts on a dedicated service unit
- Connects to a PC via the service unit and a USB interface device.

### ESSENTIAL EQUIPMENT

FM6X Service Unit  
IFD7 Interface Unit

### REQUIREMENTS

See Essential Equipment

### OVERALL DIMENSIONS

Height:	0.29m
Width:	0.56m
Depth:	0.18m

### SHIPPING SPECIFICATION

Gross Weight:	20kg
Volume:	0.20m <sup>3</sup>



Software screenshot



## PELTON TURBINE - FM62



### DESCRIPTION

The FM62 is a small-scale Pelton Turbine unit, which is designed to be used in conjunction with the FM6X service unit. A Pelton turbine uses the momentum transferred from the impact of a jet of water onto its buckets to generate power. The FM62 consists of an inlet manifold, which supplies water to a spear valve. This enables users to vary the jet cross section while maintaining the water velocity. The runner itself is mounted in a clear acrylic enclosure to enable maximum visibility of the workings.

The unit incorporates a pressure sensor to measure the inlet condition of the water. This pressure can be accurately controlled using the software supplied with the service unit.

### PERFORMANCE SPECIFICATION

Maximum Power: 35W  
Maximum Speed: 7000rpm  
Maximum Torque: 0.15Nm

## INSTRUCTIONAL CAPABILITIES

- > Determining the characteristics of the turbine, including the relationships of volume flow rate, head, torque produced, power output and efficiency to rotational speed.
- > Comparison of throttle control and spear valve control of the speed of a Pelton Turbine.

### ORDERING SPECIFICATION

- Small-scale hydropower unit designed to demonstrate the operating principles of a Pelton turbine
- Transparent guarding enables excellent visibility of the Pelton wheel operation
- Mounts on a dedicated service unit
- Connects to a PC via the service unit and a USB interface device

### ESSENTIAL EQUIPMENT

FM6X Service Unit  
IFD7 Interface Unit

### REQUIREMENTS

See Essential Equipment

### OVERALL DIMENSIONS

Height: 0.33m  
Width: 0.52m  
Depth: 0.14m

### SHIPPING SPECIFICATION

Gross Weight: 20kg  
Volume: 0.20m<sup>3</sup>



Software screenshot

## PROPELLER TURBINE - FM63



### DESCRIPTION

The FM63 is a self contained, small-scale Propeller Turbine unit. This fixed blade, axial flow turbine may be considered as the prototype form of a propeller turbine, itself a forerunner of the Kaplan turbine.

The inclusion of angled inlet guide vanes and the design of the runner blades utilise both impulse and reaction effects. It can be demonstrated that this type of machine works most efficiently where high flows at relatively low heads are available.

The FM63 consists of a framework base, which houses a large water reservoir and a circulating pump. A stainless steel top supports the turbine and a dynamometer assembly. The propeller itself, is housed in a clear acrylic pipe to enable maximum visibility of the workings.

The unit incorporates a paddle wheel type flow meter and a pressure sensor to measure the inlet condition of the water. The dynamometer module incorporates a magnetic type brake, which applies load to the turbine. The level of braking is controlled directly from the software.

A load cell measures the braking force, and the power, while an optical sensor measures the rotational speed of the turbine.

### PERFORMANCE SPECIFICATION

Maximum Power:	55W
Maximum Speed:	8500rpm
Maximum Torque:	0.60Nm

## INSTRUCTIONAL CAPABILITIES

> Determining the turbine characteristics of a propeller turbine, including the relationships of volume flow rate, head, torque produced, power output and efficiency to rotational speed.

### ORDERING SPECIFICATION

- Self-contained, small-scale hydropower unit designed to demonstrate the operating principles of a Propeller Turbine
- 75 litre water reservoir
- Circulating pump, which produces 14m head at 4.4 l/s
- Loaded by a magnetic brake unit, which is controlled direct from the PC
- Links to a PC via a USB interface
- Electronic sensors monitor process variables
- Supplied with full education software package including comprehensive results processing and help facilities

### ESSENTIAL EQUIPMENT

IFD7 Interface Unit

### REQUIREMENTS

Single phase electrical supply:

FM63-A	220V-240V/50Hz/13A
FM63-B	120V/60Hz/25A

### OVERALL DIMENSIONS

Height:	1.12m
Width:	0.91m
Depth:	0.66m

### SHIPPING SPECIFICATION

Gross Weight:	160kg
Volume:	1.40m <sup>3</sup>



Software screenshot

## PUMP TEST ACCESSORY - FM64



### DESCRIPTION

The FM64 is a compact accessory, which enables the FM6X service unit to be used as a pump test accessory.

The FM64 consists simply of a return tube incorporating a gate valve, which can be attached to the pump outlet on the FM6X service unit.

The unit incorporates a pressure sensor to measure the inlet condition of the water.

### PERFORMANCE SPECIFICATION

Maximum Flow: 50 l/m  
Maximum Head: 55m

## ORDERING SPECIFICATION

- Compact accessory to enable investigation of pump performance
- Mounts on a dedicated service unit
- Links to a PC via the service unit and a USB interface console

### ESSENTIAL EQUIPMENT

FM6X Service Unit  
IFD7 Interface Unit

### REQUIREMENTS

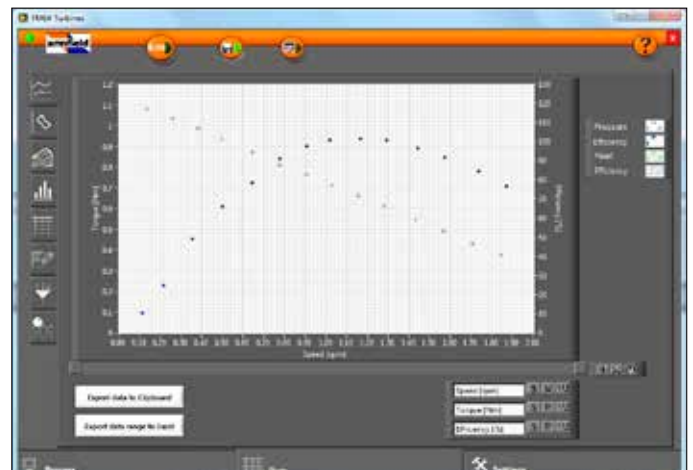
See Essential Equipment

### OVERALL DIMENSIONS

Height: 0.23m  
Width: 0.50m  
Depth: 0.14m

### SHIPPING SPECIFICATION

Gross Weight: 10kg  
Volume: 0.10m<sup>3</sup>



Software screenshot

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