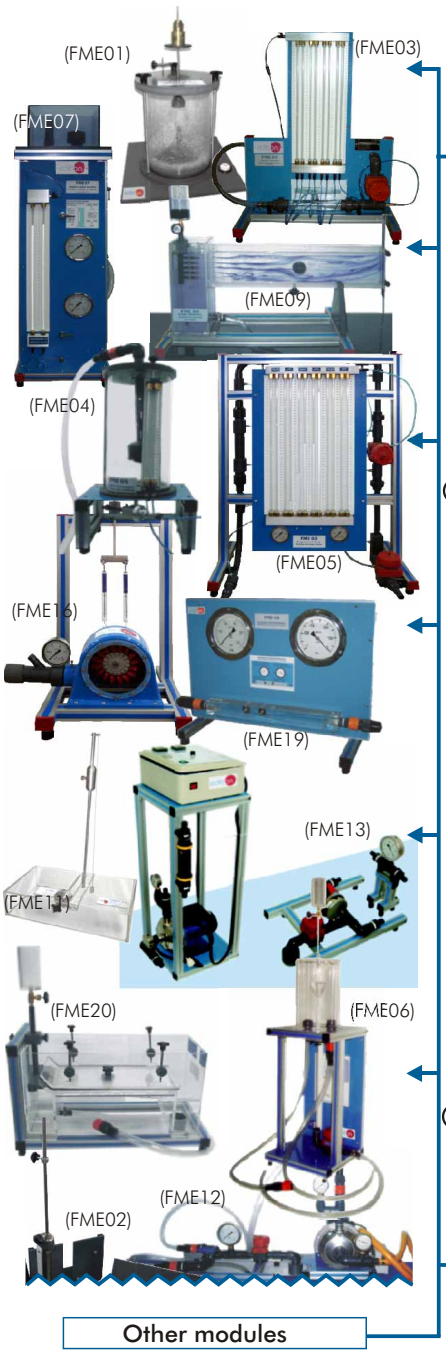
Basic Fluid Mechanics Integrated Laboratory

edibon
Technical Teaching Equipment

LIFLUBA

Laboratory structure

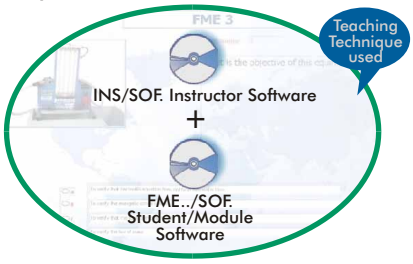
② Modules



Other modules

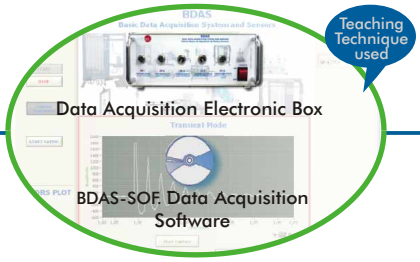
① Base Service Units

③**CAI.** Computer Aided Instruction Software System



④ **FME/CAL.** Computer Aided Learning Software (Results Calculation and Analysis)

⑤**BDAS.** Basic Data Acquisition System and Sensors



② Modules

Other modules

The complete laboratory includes parts 1 to 5 and any part can be supplied individually or additionally.
(Base Service Unit + Module/s is the minimum supply)

www.edibon.com
Products
Products range
Units
8.-Fluid Mechanics & Aerodynamics

Available Modules

-FME01. Impact of a Jet.
-FME02. Flow over Weirs.
-FME03. Bernoulli's Theorem Demonstration.
-FME04. Orifice Discharge.
-FME05. Energy Losses in Bends.
-FME06. Osborne-Reynolds' Demonstration.
-FME07. Energy Losses in Pipes.
-FME08. Hydrostatic Pressure.
-FME09. Flow Visualization in Channels.
-FME10. Dead Weight Calibrator.
-FME11. Metacentric Height.
-FME12. Series/Parallel Pumps.
-FME13. Centrifugal Pumps Characteristics.
-FME14. Free and Forced Vortex.
-FME15. Water Hammer.
-FME16. Pelton Turbine.
-FME17. Orifice and Free Jet Flow.
-FME18. Flow Meter Demonstration.
-FME19. Cavitation Phenomenon Demonstration.
-FME20. Laminar Flow Demonstration.
-FME21. Radial Flow Turbine.
-FME22. Venturi, Bernoulli and Cavitation Unit.
-FME23. Basic Pipe Network Unit.
-FME24. Unit for the study of Porous Beds in Venturi Tubes (Darcy's Equation).
-FME25. Flow Channel, 1m. length.
-FME26. Depression Measurement System (Vacuum gauge).
-FME27. Axial Flow Turbine.
-FME28. Francis Turbine.
-FME29. Kaplan Turbine.
-FME30. Vortex Flow Meter.
-FME31. Horizontal Osborne-Reynolds Demonstration.
-FME32. Pitot Static Tube Module.
-FME33. Pascal's Module.

INTRODUCTION

Hydraulics is the branch of science that deals with the mechanical properties of fluids, and Fluid Mechanics provides the foundation for hydraulics.

With LIFLUBA (Basic Fluids Mechanics Integrated Laboratory), EDIBON tries to give answer to the academic demand for teaching and learning the basics of Fluids Mechanics, in an easy and practical way. With the LIFLUBA modules series, students accomplish experiments that clearly show them the laws of Hydraulics, and they acquire a valuable experience in the use of hydraulics instrumentation and tools, in a natural, pleasant and uncomplicated way.

GENERAL DESCRIPTION

EDIBON presents a flexible and modular-based system for learning Basic Fluid Mechanics.
Any desired configuration can be chosen (see next page), according to the working mode, areas of study and numbers of working posts.
Being a modular and open system, it is very economical and may be enlarged depending on required needs; all previously acquired systems are fully compatible and valid.

What are the parts included in the laboratory?

① **Base Service Units:**

Each module needs to be provided with water in order to run the experiment. There are two options:

-FME00. Hydraulics Bench. This is a mobile hydraulic bench, mounted on resistant wheels, where the modules can be placed on top to ease their manipulation.

-FME00/B. Basic Hydraulic Feed System. This is a simpler and more basic base and service unit.

② **Modules:**

Each module is a set of components that allows the realization of several experiments on Hydraulics.
EDIBON offers 32 different Modules covering the most important topics in the learning of Fluid Mechanics.
Each Module has its own manuals (8 manuals are normally supplied), that gives the theoretical background and explains everything the student needs to carry out the exercises/experiments.
Connectors, pipes and cables for completing the exercises and practices are supplied.

③ **CAI. Computer Aided Instruction Software System:**

The best help in classroom for both teacher and students.
It includes:

3.1) INSTRUCTOR SOFTWARE: INS/SOF. Classroom Management Software Package (Instructor Software).
Only one package is needed per classroom.
It helps creating databases, reports and statistical comparisons among many more features.

3.2) STUDENT SOFTWARE : FME/SOF. Computer Aided Instruction Software Packages (Student/Module Software).
Each "FME" type module has its own package.
It gives to the students the proper assistance for theoretical knowledge as well as in practice, presenting exercises and questions.

④ **FME/CAL. Computer Aided Learning Software (Results Calculation and Analysis).**

Windows based software, simple and easy to use, specifically developed for using with "FME" type modules.
Thought for results calculation and analysis, this software compute and plot the obtained data.

⑤ **BDAS.Basic Data Acquisition System and Sensors.**

For being used with modules type "FME".
Content: Data Acquisition Electronic Box, Sensors (will be included in the modules) and Data Acquisition Software.

Complete LIFLUBA/ LABORATORY includes: ①+②+③+④+⑤

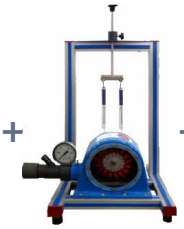
Minimum supply: ① Base Service Unit + ② Module/s.

Working possibilities

A) CAI + FME/CAL + BDAS working possibility (complete EDIBON system)

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

+



Module/s

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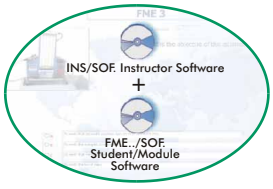

CAI.
Computer Aided
Instruction Software System

+

FME/CAL.
Computer Aided Learning Software
(Results Calculation and Analysis)

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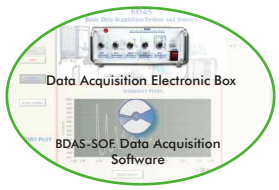


BDAS.
Basic Data Acquisition
System and Sensors

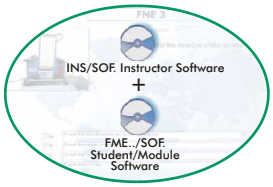
B) CAI + FME/CAL working possibility

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

+

Module/s

+



CAI.
Computer Aided
Instruction Software System

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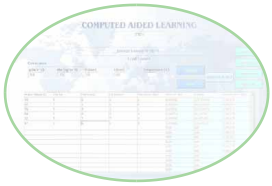

FME/CAL.
Computer Aided Learning Software
(Results Calculation and Analysis)

C) BDAS working possibility

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

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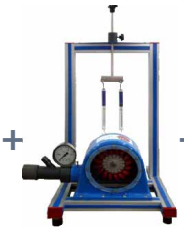

Module/s

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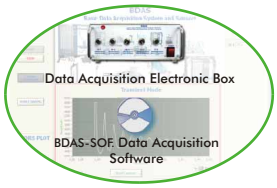

BDAS.
Basic Data Acquisition
System and Sensors

D) FME/CAL working possibility

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

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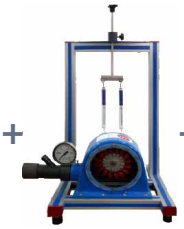


Module/s

+

FME/CAL.
Computer Aided Learning Software
(Results Calculation and Analysis)

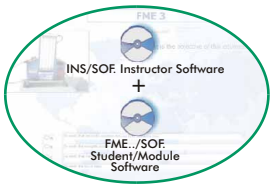
E) CAI working possibility

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

+

Module/s

+



CAI.
Computer Aided
Instruction Software System

F) Simplest working possibility

Base Service Unit:
FME00. Hydraulics Bench
or
FME00/B. Basic Hydraulic Feed System

+

Module/s

FME00. Hydraulics Bench

DESCRIPTION

An unit for the study of fluid behaviour, hydraulic theory and the properties of fluid mechanics.

It is formed by a movable hydraulics bench which is used to hold a wide variety of modules, which allow the student to experiment with the problems presented by fluid mechanics.

Autonomous unit (tank and pump included).

Innovating water saving system consisting of a high capacity sump tank and spillway that sends the excess of water back to the tank.

Easy access draining valve.

The volumetric measuring tank is stepped to accommodate for low or high flow rates. A measuring cylinder (1 litre-capacity) is included in the supply for measurement of very small flow rates.

Level tube with a scale that shows the water level in the upper tank.

Flow adjusted by means of a membrane valve.

Flow stilling baffle for reducing the turbulence rate.

Specially designed channel, in the upper part, to support the modules on test.

The modules are easily mounted on its top without the use of tools, what ensures its simplicity.

Manufactured with corrosion resistant materials ensuring a long life of the unit.

Centrifugal pump.

Pump breaker starting, safety and contact light.

Each module is supplied as a complete piece of equipment with easy and quick coupling to the bench, maximizing the available student's time to perform the demonstrations or experimental measurements.

To be used with the different units of Fluid Mechanics Area: "FME" type modules, Fluid Friction in Pipes Equipment "AFT", etc., to increase the profitability.

PRACTICAL POSSIBILITIES

1.-Flow measurement.

SPECIFICATIONS

Mobile hydraulic bench, made in fibreglass reinforced polyester, and mounted on wheels for mobility.
Centrifugal pump, 0.37 KW, 30 - 80 l/min at 20.1-12.8 m., single phase 220V. / 50Hz or 110V. / 60Hz.
Runner made in stainless steel.
Sump tank capacity: 165 litres.
Small channel: 8 litres.
Flow measurement: volumetric tank, gauged from 0 to 7 litres for low flow values and from 0 to 40 litres for high flow values.
Control valve for regulating the flow.
Open channel to place the test module.
Measuring cylinder is provided for the measurement of small flow rates.
Remote hand-operating dump valve in the base of the volumetric tank.
Rapidity and ease interchanging of the different modules.

DIMENSIONS AND WEIGHT

Dimensions: 1130 x 730 x 1000 mm. approx.
Weight: 70 Kg. approx

REQUIRED SERVICES

Water supply.
Drainage.
Chronometer.

Electrical supply:
single-phase 220V/50 Hz or 110V./60 Hz.

FME00/B. Basic Hydraulic Feed System

DESCRIPTION AND SPECIFICATIONS

The FME00/B is a service unit for different Fluid Mechanics Area units as: "FME" type modules, Fluid Friction in Pipes Unit "AFT", etc., increasing the equipment profitability.

Centrifugal pump: 0.37 KW, 30 - 80 l/min at 20.1-12.8m., single-phase 220V. / 50Hz. or 110V. / 60Hz.

Stainless steel impeller.

Tank capacity:140 litres approx.

Flowmeter.

Membrane type flow adjusting valve.

Safety switch ON/OFF.

Supports for accomodating the module to test.

This unit incorporates wheels for mobility.

PRACTICAL POSSIBILITIES

1.- Flow measurement.

DIMENSIONS AND WEIGHT

Dimensions: 1000 x 600 x 700 mm. approx.
Weight: 40 Kg. approx

REQUIRED SERVICES

Water supply.
Drainage.

Electrical supply:
single-phase 220V/50 Hz or 110V./60 Hz.

FME01. Impact of a Jet

DESCRIPTION

The module consists of a cylindrical tank with lateral transparent surfaces where a nozzle, connected to the Hydraulics Bench (FME00), is aligned with a device in which the problem surface is fitted. The vertical force made by the water against the surface is measured using calibrated weights that balance this force. Taking as a reference a gauge, which has been previously adjusted to a zero reference, we measure the force thanks to a mark that appears on the surface where the masses were placed.

Adjustable supports that let the device balance.

Holes made on the tank base in order to drain the water . In this way, splashes are avoided.

PRACTICAL POSSIBILITIES

1.- Impact against a flat surface.
2.- Impact against a curve surface of 120°.
3.- Impact against a hemispherical surface.
4.- Use of the fast connectors.

SPECIFICATIONS

Jet diameter: 8 mm.
Impact surfaces diameter: 40 mm.
Impact surfaces:
180° hemispherical surface.
120° curve surface.
90° flat surface.
A set of masses of 5, 10, 50 and 100 g. is supplied.
Easy and quick coupling system built-in.

DIMENSIONS AND WEIGHT

Dimensions: 250 x 250 x 500 mm. approx.

Weight: 5 Kg. approx.

SERVICES REQUIRED

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).

Chronometer.

FME02. Flow over Weirs

DESCRIPTION

This module has many elements that are used in combination with the Hydraulics Bench (FME00):

A special mouthpiece is coupled to the outlet mouthpiece for water in the Hydraulic Bench (FME00).

Two soothing screens that, together with the previous element, provide a slow current in the channel.

A level meter consisting on a "nonius" adjusted to a mast, where the heights are pointed out on a caliber coupled to it.

A small hook or point is attached to the bottom of the mast to carry out the measures.

Two drains (a rectangular neckline and a V-shape) are assembled to the final part of the channel of the Hydraulics Bench (FME00).

PRACTICAL POSSIBILITIES

1.- Study of the flow characteristics through a weir with a rectangular neckline, made on a thin wall.
2.- Study of the flow characteristics through a weir with a V-shape neckline, made on a thin wall.

SPECIFICATIONS

Dimensions of the weirs: 160x230x40mm.
Neckline angle in the V-shape weir: 90°.
Dimension of rectangular notch: 30x82mm.
Scale of the level meter: 0 to 160 mm.

DIMENSIONS AND WEIGHT

Dimensions: 16 x 400 x 750 mm. approx.

Weight: 10 Kg. approx.

SERVICES REQUIRED

Hydraulics Bench (FME00).
Chronometer.

FME03. **Bernoulli's Theorem Demonstration**

DESCRIPTION

Bernoulli's Theorem Demonstration module is mainly composed of a circular section conduit with the shape of a truncated cone, transparent and with seven pressure taps to measure, simultaneously, the static pressure on each section.
All the pressure taps are connected to a manometer with a water collector (water might be pressurized).
The ends of the conduits are removable, enabling to place it in either convergent or divergent form with respect to the stream direction.
Also, there is a probe (Pitot's tube) moving along the conduct for measuring the height in every section (dynamic pressure).
The flow rate and the pressure in the module can be modified by adjusting the control valve located at the end of the module.
A flexible hose attached to the outlet pipe is directed to the volumetric measuring tank.
During operation, the module is placed on the Hydraulics Bench (FME00).
It has adjusted legs for levelling.
The inlet pipe ends in a female coupling which may be connected directly to the bench supply.

PRACTICAL POSSIBILITIES

1.- Determination of the exact section in Venturi's tube.
2.- Demonstration of Bernoulli's Theorem. Divergent-convergent position.
3.- Determination of Bernoulli's Theorem equation. Convergent-divergent position.
4.- Observation of differences between convergent and divergent position.

SPECIFICATIONS

Manometer range: 0 to 470 mm of water.
Number of manometer tubes: 8
Upstream diameter of the throat: 25 mm.
Narrowing:
Downstream: 21°.
Upstream: 10°.
Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 800 x 450 x 700 mm. approx.
Weight: 15 Kg. approx.

SERVICES REQUIRED

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME04. **Orifice Discharge**

Detail of the 5 type of mouthpieces

DESCRIPTION

The module consists of a transparent cylindrical tank that is fed from above by the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B). The water flows through an interchangeable mouthpiece (a set of 5 mouthpieces is supplied, representing orifices of different characteristics) located in the base center. The liquid flowing vein goes directly to the volumetric tank of the Hydraulics Bench or from the Basic Hydraulic Feed System.

A Pitot's tube can be placed in any point of the flowing vein to determine its total height of load.

A transverse device, joined to the Pitot's tube, allows to determine the diameter of the liquid flowing vein.

It´s possible to measure the height of the Pitot's tube and the total height through the orifice, in a panel of 2 manometric tubes located beside the tank.

PRACTICAL POSSIBILITIES

1.- Determination of the discharge coefficient for the mouthpiece of thin wall, Venturi type.
2.- Determination of the velocity coefficient for the mouthpiece of thin wall, Venturi type.
3.- Determination of the contraction coefficient for the mouthpiece of thin wall, Venturi type.
4.- Determination of the discharge coefficient for the mouthpiece of thin wall, diaphragm type.
5.- Determination of the velocity coefficient for the mouthpiece of thin wall, diaphragm type.
6.- Determination of the contraction coefficient for the mouthpiece of thin wall, diaphragm type.
7.- Determination of the discharge coefficient for the mouthpiece of thin wall, colloidal type.
8.- Determination of the velocity coefficient for the mouthpiece of thin wall, colloidal type.
9.- Determination of the contraction coefficient for the mouthpiece of thin wall, colloidal type.
10.- Determination of the discharge coefficient for the mouthpiece of thick wall, cylindrical type.
11.- Determination of the velocity coefficient for the mouthpiece of thick wall, cylindrical type.
12.- Determination of the contraction coefficient for the mouthpiece of thick wall, cylindrical type.
13.- Determination of the discharge coefficient for the mouthpiece of thick wall, Venturi type.
14.- Determination of the velocity coefficient for the mouthpiece of thick wall, Ventury type.
15.- Determination of the contraction coefficient for the mouthpiece of thick wall, Ventury type.

SPECIFICATIONS

Transparent cylindrical tank.
Five type of mouthpieces: diaphragm, colloidal, 2 of Venturi and cylindrical.
Height of maximum load: 400 mm.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 450 x 450 x 900 mm. approx. Weight: 15 Kg. approx.

SERVICES REQUIRED

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME05. **Energy Losses in Bends**

DESCRIPTION

This module can work with the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B).
This module consists of a hydraulic circuit with a set of elements that disrupt the normal flow of the fluid that circulates by the pipe, due to sudden section and direction variations, as well as friction.
These elements are:
- Two 90° elbows, a short one and a middle one.
- A 90° curve or long elbow.
- A broadening.
- A sudden narrowing section.
- A sudden direction change, miter type.

The module has two manometers, Bourdon type: 0 - 2.5 bar and twelve manometric pipes of pressurized water. The system pressurization is carried out with a manual air pump.
The hydraulic circuit has pressure tappings along the whole system, which enable to measure the local load losses in the system.
This module has two membrane valves, a valve which enables the regulation of the outlet flow, and a valve placed in series with the rest of accessories of the hydraulic circuit.

PRACTICAL POSSIBILITIES

1.- Filling of the manometric tubes.
2.- Measurement of the flow.
3.- Measurement of load losses for a short elbow of 90°.
4.- Measurement of load losses for a middle elbow of 90°.
5.- Measurement of load losses for a curve of 90°.
6.- Measurement of load losses for a broadening of 25/40.
7.- Measurement of load losses for a narrowing 40/25.
8.- Measurement of load losses for an angle of 45°.
9.- Measurement of load losses for a membrane valve.

SPECIFICATIONS

Range of the two type Bourdon manometers: 0 to 2.5 bar.
Differential manometers range: 0 to 500 mm.
Number of manometric tubes: 12.
PVC Rigid pipes:
- **Internal diameter: 25 mm.**
- **External diameter: 32 mm.**

Flexible pipes:
- **Pressure taking-differential Manometer. External diameter: 10 mm.**
- **Pressurizing equipment. External diameter: 6 mm.**
- **Drain. External diameter: 25 mm.**

Fittings:
- **45° angle.**
- **90° curve.**
- **90° medium elbow.**
- **90° short elbow.**
- **90° long elbow.**
- **Broadening of 25/40.**
- **Narrowing of 40/25.**

Valves:
- **Membrane valves. Diameter 25 mm.**
- **Antireturn: 6 mm.**

Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 550 x 950 mm. approx.
Weight: 10 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME06. **Osborne-Reynolds Demonstration**

DESCRIPTION

The module consists of a cylindrical tank endowed with a nozzle, that is fitted to a methacrylate pipe, which allows fluid visualization.
A spillway guarantees the homogeneity of the flow and a needle fitted to the deposit provides the dye. Water is supplied by the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B).
The visualization of the laminar or turbulent regime can be carried out through the flow control valve.

PRACTICAL POSSIBILITIES

1.- Observation of the laminar, transition and turbulent regime.
2.- Study of the velocity profile, reproducing the Osborne-Reynolds's experiment.
3.- Reynolds's number calculation.

SPECIFICATIONS

Tube inner diameter: 10 mm.
Tube outer diameter: 13 mm.
Visualization pipe length: 700 mm.
Capacity of the dye tank: 0.3 litres.
Tank capacity: 10 litres.
Flow control valve: diaphragm type.
The coloured fluid is regulated with a needle valve.
Easy and quick coupling system built-in.
Anodized aluminium structure and panels in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 1250 x 450 x 450 mm. approx.
Weight: 20 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Thermometer.
Vegetable Colouring (Fluorescein $C_{20}H_{12}O_5$).
Chronometer.

FME07. **Energy Losses in Pipes**

DESCRIPTION

The module consists of the following elements, used in combination with the Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B):

A pipe with quick connector to be coupled to the water outlet's mouthpiece at the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B).

6 mm external/4 mm inner diameter metallic test pipe.

One water column differential manometer.

Tank of constant height.

Two Bourdon type manometers.

PRACTICAL POSSIBILITIES

1.- Energy loss in pipes for a turbulent regime.
2.- Determination of the energy loss in a turbulent regime.
3.- Determination of the number of Reynolds for a turbulent regime.
4.- Energy loss in pipes for a laminar regimen.
5.- Determination of the energy loss factor *f* for a pipe in laminar regime.
6.- Determination of Reynolds number for the laminar regime.
7.- Determination of the kinematic viscosity of water.

SPECIFICATIONS

Test pipe of 4 mm. of inner diameter, 6 mm. of external diameter and 500 mm. of length.
1 differential manometer of water column.
Manometer scale: 0 to 500 mm (water).
2 Bourdon type manometers, range: 0 to 2 bar.
Tank of constant height.
Easy and quick coupling system built-in.
Anodized aluminium structure and panels in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 330 x 330 x 900 mm. approx.
Weight: 30 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Thermometer.
Chronometer.

FME08. **Hydrostatic Pressure**

DESCRIPTION

The module consists of a quadrant assembled to the arm of a scale that swings around an axis.
When the quadrant is immersed in the water tank, the force that acts on the flat rectangular front surface, exerts a momentum with respect to the supporting axis.
The swinging arm is fitted with a tray and an adjustable counter balance.
The tank has adjustable supporting legs for a right levelling.
It has a drainage valve.
The level reached by the water inside the tank is indicated by a graduated scale.

PRACTICAL POSSIBILITIES

1.- Determination of the center of pressures with an angle of 90°, partially submerged.
2.- Determination of the resultant force with an angle of 90°, partially submerged.
3.- Determination of the center of pressures, angle <> 90° partially submerged.
4.- Determination of the equivalent force with an angle <>90° partially submerged.
5.- Determination of the center of pressures with an angle of 90° totally submerged.
6.- Determination of the resultant force with an angle of 90° totally submerged.
7.- Determination of the center of pressures, angle <>90° totally submerged.
8.- Determination of the resultant force, angle <>90° totally submerged.
9.- Balance of momentum.

SPECIFICATIONS

Tank capacity: 5.5 l.
Distance between the suspended masses and the support point: 285 mm.
Area of the section: 0.007 m².
Total depth of the submerged quadrant: 160 mm.
Height of support point on the quadrant: 100 mm.
A set of masses of different weights is supplied (4 of 100 gr, 1 of 50 gr, 5 of 10 gr, and 1 of 5 gr).

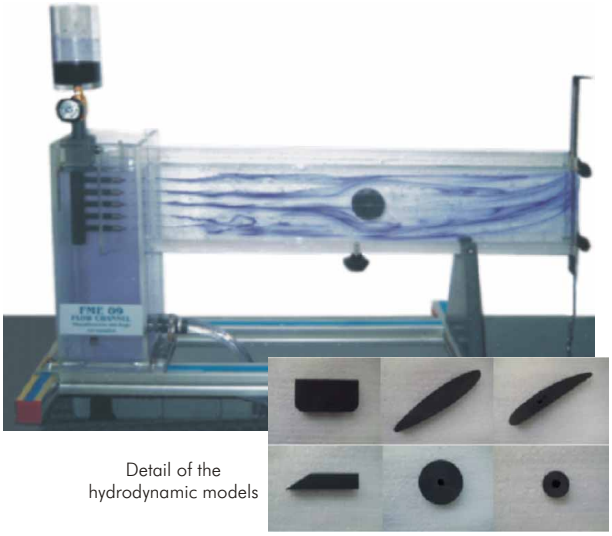
DIMENSIONS AND WEIGHT

Dimensions: 550 x 250 x 350 mm. approx.
Weight: 5 Kg. approx.

REQUIRED SERVICES

It can work in autonomous way.

FME09. Flow Visualization in Channels



Detail of the hydrodynamic models

DESCRIPTION

The module consists of a transparent methacrylate channel with an overflow pipe on top and an adjustable plate in the discharge end. This plate allows regulating the flow level.
The water is supplied to the channel by the pulse mouth of the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B), by means of a flexible pipe, passes through a damping tank that eliminates the turbulences.
It has a colouring injection system consisting on a tank, a flow control valve and some needles that allow a better visualization of the flow around the different hydrodynamic models, which have to be placed in the middle of the channel.
Module levelling through adjustable feet .
Several hydrodynamic models are given to study the flow around them.

PRACTICAL POSSIBILITIES

1.- Leakage of liquids by thin-wall weirs.
2.- Liquid leakage by thick-wall weirs.
3.- Models with wing profile submerged in a fluid current. Aerodynamics.
4.- Circular models submerged in a fluid current. Aerodynamics.
5.- Demonstration of the phenomenon associated to the flow in open channels.
6.- Visualization of the flow lines around different submerged hydrodynamic models.

SPECIFICATIONS

Capacity of the dye tank: 0.3 litres.
Width/length of channel approx.: 15/630 mm.
Depth of channel approx.: 150 mm.
Damping tank.
Hydrodynamic models:
Two lengthened.
Two circular of 25 and 50 mm. diameter.
Rectangle with rounded edges.
Wedge.
Easy and quick coupling system built-in.
Anodized aluminium structure.

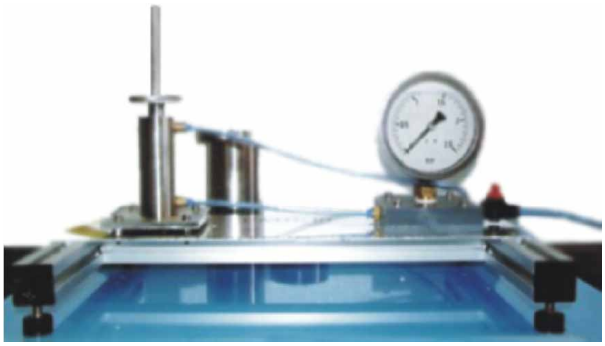
DIMENSIONS AND WEIGHT

Dimensions: 900 x 450 x 500 mm. approx.
Weight: 7 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Vegetable Colouring (Fluorescein $C_{20}H_{12}O_5$).
Chronometer.

FME10. Dead Weight Calibrator



DESCRIPTION

The module consists of a hollow cylinder in whose interior a precision piston fits and slips. Using a system of calibrated weights, we produce predetermined pressures inside the cylinder.

The Bourdon manometer that must be contrasted is connected to the cylinder by means of a flexible pipe.

Module levelling through adjustable feet.

PRACTICAL POSSIBILITIES

1.- Bourdon type manometer calibration.

2.- Hysteresis curve determination.

SPECIFICATIONS

Pressure manometer:
Bourdon type.
0 - 2.5 bar.
Masses (approximated weights):
0.5 kg.
1.0 kg.
2.5 kg.
5 kg.
Piston diameter: 18 mm.
Piston weight: 0.5 kg.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 400 x 750 mm. approx.
Weight: 4 Kg. approx.

REQUIRED SERVICES

It can work in autonomous way.

FME11. **Metacentric Height**

DESCRIPTION

The module consists of a floating methacrylate prismatic base, with a vertical mast placed on it. An adjustable mobile mass has been added to alter the position of the center of gravity.

An adjustable traverse mass lets modifying the inclination of the floating base.

A plumb line, attached to the upper part of the mast is used to measure the inclination angle of the floating base with the help of a graduated scale.

PRACTICAL POSSIBILITIES

1.- Study of the stability of a floating body. Angular displacements.

2.- Study of the stability of a floating body. Different positions of the center of gravity.

SPECIFICATIONS

Maximum angle: +/- 13°.

Corresponding lineal dimension: +/- 90 mm.

Dimension of the float:

Length: 353 mm.

Width: 204 mm.

Total height: 475 mm.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 400 x 750 mm. approx.

Weight: 5 Kg. approx.

REQUIRED SERVICES

It can work in autonomous way.

Scale.

FME12. **Series/Parallel Pumps**

DESCRIPTION

The module consists of a pump of similar characteristics to the one in the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B).
This module has three Bourdon-type manometers: two of manometric pressure and one of absolute pressure. The absolute pressure manometer has been placed at the pump admission; the other two at the discharge and at the discharge accessory supplied with the module.
The accessory has a flow-regulating valve. Moreover, for the parallel connection, a Y-shape accessory is supplied with two ball-valves. This accessory is connected to both pumps and to the discharge device.
The module includes an easy connection system for the installation of pumps in series and in parallel.

PRACTICAL POSSIBILITIES

1.- H(Q) curve obtaining of a centrifugal pump.
2.- Series coupling of two pumps with the same characteristics.
3.- Parallel coupling of two pumps with the same characteristics.

SPECIFICATIONS

Centrifugal pump: 0.37 KW, 30 - 80 l/min at 20.1 - 12.8m., single- phase, 220V./50Hz or 110V./60 Hz.
Absolute pressure manometer placed at the pump admission. Range - 1 to 3 bar.
2 manometers (manometric pressure) placed one of them in the discharge and the another one in the discharge accessory. Range: 0 - 4 bar.
Membrane valve for flow regulating.
Two way valve: 2 positions: open or close.
Accessories:
Two flexible pipes with quick connections.
Reinforced pipe with quick connections.
Discharge accessory.
Easy and quick coupling system built-in.
Anodized aluminium structure.

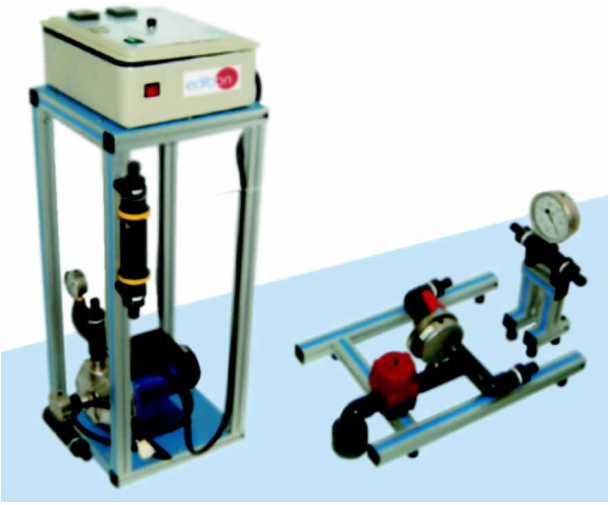
DIMENSIONS AND WEIGHT

Dimensions of FME12 module: 500 x 400 x 400 mm. approx.
Dimension of discharge accessory: 500 x 400 x 250 mm. approx.
Weight: 30 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Electrical supply: single-phase 220V/50 Hz or 110V./60 Hz.
Chronometer.

FME13. Centrifugal Pumps Characteristics



DESCRIPTION

The module has a centrifugal pump with similar characteristics to that in the Hydraulics Bench (FME00) and the Basic Hydraulic Feed System (FME00/B). It is armed with two Bourdon-type pressure manometers placed at the pump's inlet and outlet. There is another one in the discharge accessory supplied with the module.

The pump is driven by a three-phase asynchronous motor whose speed can be varied by a speed variator.

The module has visualization display that enables to know the r.p.m. and the power consumed.

It is included a discharge accessory, having a manometer, a flow control valve and a diffuser.

The variator's control panel allows varying the pump speed and the start.

PRACTICAL POSSIBILITIES

1.- Obtaining of the curves H(Q), N(Q), Eff%(Q) of a centrifugal pump.
2.- Making of the map of a centrifugal pump.
3.- Representation of the adimensional curves H*, N* and rpm*.
4.- Series coupling of two pumps of similar characteristics.
5.- Series coupling of two pumps of different characteristics.
6.- Parallel coupling of two pumps of similar characteristics.
7.- Parallel coupling of two pumps of different characteristics.

SPECIFICATIONS

Centrifugal pump: 0.37 KW, 30 - 80 l/min at 20.1-12.8m. Bourdon type manometers.
Speed variator.
Visualization display that enables to know the r.p.m. and the power consumed.
Discharge accessory, having a manometer, a flow control valve and a diffuser.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 450 x 500 x 1250 mm. approx.
Weight: 70 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Electrical supply: single-phase, 220V/50 Hz or 110V./60 Hz.
Chronometer.

FME14. Free and Forced Vortex

DESCRIPTION

The module has a cylindrical and transparent deposit with two inlet pipes diametrically opposed, slightly inclined to produce a whirl. This deposit has an outlet in the center of its base, where 3 mouthpieces with orifices of different diameters can be coupled. These mouthpieces generate the free vortex and a rotor blade creates the forced vortex acting like a flux strangler shaker.

The profile of the formed vortex is determined by a vortex height meter, placed in the cylinder's upper part, which measures the diameter of the vortex at different depths.

The total pressure can be measured by placing a Pitot's tube in the bridge of measurement.

It also has adjustable legs to level the module.

PRACTICAL POSSIBILITIES

1.- Study of forced vortex without discharge orifice.
2.- Study of forced vortex with discharge orifice.
3.- Study of the free vortex.

SPECIFICATIONS

Tank diameter: 300 mm.
Tank height: 300 mm
Mouthpieces orifice diameters: 8, 16 and 24 mm.
Distance between centers: 0, 30, 50, 70 90 and 110mm.
Pitot tube with measuring points at: 15, 20, 25 and 30 mm radius and a scale.
Measurement bridge.
Inlet pipes: 9 and 12.5 mm. diameter.
Diameter measurement system by Nonius.
Blind mouthpiece with X-shaped crosses.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 600 x 550 x 1400 mm. approx.
Weight: 10 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME15. **Water Hammer**

DESCRIPTION

The module is designed to demonstrate the effects of the instantaneous or gradual velocity variation in a fluid.

As a consequence of a quick change in the velocity of a fluid, the Water Hammer phenomenon can be studied.

PRACTICAL POSSIBILITIES

1.- Subduing of the water hammer effects.
2.- Study of the subduing in function of the diameter of the chimney.
3.- Calculations of the energy losses in pipes.

SPECIFICATIONS

Constant level deposit, in methacrylate.

Unload deposit, in methacrylate.

Pipe circuits in PVC.

Valves to select the circuit.

2 adjustable equilibrium chimneys and subjection clips.

Connections to the Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B) with fast plugs.

Easy and quick coupling system built-in.

Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 1215 x 270 x 1430 mm. approx.

Weight: 15 Kg. approx.

REQUIRES SERVICES

Hydraulics Bench (FME00)or Basic Hydraulic Feed System (FME00/B).

Chronometer.

FME16. **Pelton Turbine**

DESCRIPTION

This module comprises a miniature Pelton's Turbine with a retractile needle valve that enables to adjust the flow.

The Pelton's Turbine runner is clearly visible through the transparent cover of the turbine.

A manometer placed at the inlet of the turbine enables to measure the inlet pressure at that point (water discharge pressure).

A band brake, connected to two dynamometers allows varying the load supplied to the turbine by means of a connection device.

The turbine axis velocity is determined by an optic tachometer.

PRACTICAL POSSIBILITIES

1.- Determination of the operative characteristics of Pelton's Turbine.
2.- Determination of the operation mechanical curves.
3.- Determination of the operation hydraulic curves.
4.- Adimensionalization.

SPECIFICATIONS

Speed range: 0 - 2000 r.p.m.
Torque: 10 W.
Manometer range: 0 - 2.5 bar.
Number of buckets: 16.
Drum radius: 30 mm.
Dynamometers range: 0 - 20 N.
Easy and quick coupling system built-in.
Anodized aluminium structure.
Tachometer.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 400 x 750 mm. approx.
Weight: 15 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B) .
Chronometer.

FME17. Orifice & Free Jet Flow

DESCRIPTION

The module consists of a cylindrical methacrylate tank that enables to maintain a constant level and that is fed by the Hydraulics Bench (FME00) or from the Basic Hydraulic Feed System (FME00/B).

Two nozzles with orifices of different diameters are provided. They are placed in the base of the tank, and can be easily interchanged.

The trajectory of the jet can be drawn by following the position of some vertical needles placed in the annexed panel. These are adjusted by means of some command screws.

This panel includes a silk-screen scale that enables to measure the profile of the jet.

Adjustable feet permit levelling.

PRACTICAL POSSIBILITIES

1.- Determination of the orifice velocity coefficient.
2.- Obtaining of the orifice discharge coefficient in permanent regime.
3.- Obtaining of the orifice discharge coefficient in variable regime.
4.- Obtaining of the tank discharge time.

SPECIFICATIONS

Orifices with diameters of 3.5 and 6 mm.
Jet trajectory Probes: 8.
Maximum height: 500 mm.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 600 x 550 x 1400 mm. approx.
Weight: 10 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B) .
Chronometer.

FME18. Flow Meter Demonstration

DESCRIPTION

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

There are several pressure taps connected to a panel of eight tubes.

The flow control valve permits the variation of the flow rate through the circuit, and its adjustment, along with the bench control valve, allows varying the system static pressure.

The pressure taps of the circuit are connected to an eight-bank manometer, which incorporates an air inlet valve at the top manifold which facilitates the connection to the hand pump.

This enables to adjust the levels in the manometer bank to a convenient level to suit the system static pressure.

PRACTICAL POSSIBILITIES

1.- Filling of the manometric tubes.
2.- Determination of the error in flow measurements using the Venturi.
3.- Determination of the C_d factor in the Venturi.
4.- Determination of the strangulation in the Venturi.
5.- Determination of the error in flow measurements using the orifice plate.
6.- Determination of the C_d factor in the orifice plate.
7.- Determination of the effective area in an orifice plate.
8.- Comparison of the energy loss in the three different elements.
9.- Comparison among the Venturi, orifice plate and flowmeter.

SPECIFICATIONS

Manometer range: 0 to 500 mm of water column.
Number of manometric tubes: 8
Orifice plate diameter: 25 mm.
Flowmeter: 2 to 30 l/min.
Venturi dimensions:
Throat diameter: 20 mm.
Upstream pipe diameter: 32 mm.
Downstream taper: 21°.
Upstream taper: 14°.
Orifice Plate dimensions:
Upstream pipe diameter: 35 mm.
Downstream orifice diameter: 19 mm.
Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 450 x 950 mm. approx.
Weight: 5 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B) .
Chronometer.

FME19. Cavitation Phenomenon Demonstration

DESCRIPTION

The module consists of a rectangular transversal section Venturi-pipe, with transparent wall for a better observation of the Cavitation Phenomenon.

It includes a manometer and a vacuum meter that are respectively connected to the inlet section and to the reduction throat section.

The existing pressure in the Venturi sections is transmitted by thin capillary tubes at the back of the frame.

PRACTICAL POSSIBILITIES

1.- Study of cavitation.

2.- Visualization of the cavitation phenomenon with forced conduction.

SPECIFICATIONS

Manometer range: 0 to 2.5 bar.

Vacuum gauge range: from-1 to 0 bar.

Throat section: 36 mm².

Normal section: 150 mm².

Easy and quick coupling system built-in.

Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 750 x 400 x 750 mm. approx.

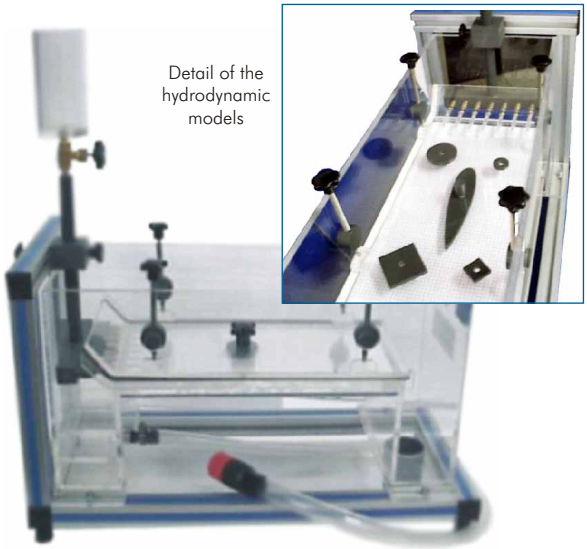
Weight: 5 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FM00) or Basic Hydraulic Feed System (FME00/B).

Chronometer.

FME20. Laminar Flow Demonstration



Detail of the hydrodynamic models

DESCRIPTION

This module allows a complete study of the bi-dimensional problems associated to the laminar flow. Thanks to an efficient system of dye injection we can observe the different models of flow. It consists on an enlargement of the device of Hele-Shaw.

Water is supplied to the accessory from the driving mouth of the Hydraulics Bench (FME00) or the Basic Hydraulic Feed System (FME00/B), by a flexible pipe. Then, water passes through a damping deposit that eliminates the turbulence.

It has a dye injection system, which consists of a deposit, a flow control valve and some needles that allow a better visualization of the flow around the different hydrodynamic models, placed in the central part of the channel.

The module can be levelled with the help of adjustable legs.

PRACTICAL POSSIBILITIES

1.- Ideal flow around a submerged cylinder.
2.- Ideal flow around a submerged profile.
3.- Ideal flow around a body in peak.
4.- Ideal flow in a convergent channel.
5.- Ideal flow in a divergent channel.
6.- Ideal flow in an elbow of 90°.
7.- Ideal flow in a sudden contraction.
8.- Ideal flow in a sudden broadening.
9.- Substitution of a line of current for a solid edge.

SPECIFICATIONS

Capacity of dye tank: 0.3 litres.
Width/length of the table: 400/210 mm.
Depth of the table: adjustable depending on the models.
Hydrodynamic models:
Two circular ones of 25 and 50 mm. diameter.
Two rectangular ones of 25x25 and 50x50 mm.
Wedge.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 870 x 450 x 400 mm. approx.
Weight: 10 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Vegetable Colouring (Fluorescein $C_{20}H_{12}O_5$).
Chronometer.

FME21. **Radial Flow Turbine**

DESCRIPTION

This module consist of a miniature Radial Turbine with two nozzles at 180° degrees respect to the perpendicular direction at the rotating axis. A Bourdon type manometer is placed at the inlet nozzle.

A band brake connected to a dynamometer allows determining the load given by the turbine.

A tachometer determines the velocity measurement.

PRACTICAL POSSIBILITIES

1.- Flow calculation.
2.- Obtaining of the M (n, H_o), N(n, H_o), η (n, H_o) curves.
3.- Obtaining of the M (n, Q), Nm(n, Q), η (n, Q) curves.
4.- Adimensionalization.

SPECIFICATIONS

Nozzles:
Inlet diameter: 21 mm.
Outlet diameter: 2.0 mm.
Discharge angle: 180°.
Turbine rotor:
External diameter: 69 mm.
Internal diameter: 40 mm.
Number of nozzles: 2.
Inlet angle to the nozzle: 180°.
Outlet angle to the nozzle: 180.°
Used material: aluminium.
Brake:
Pulley diameter:60 mm.
Effective diameter: 50 mm.
Easy and quick coupling system built-in.
Anodized aluminium structure.
Tachometer.

DIMENSIONS AND WEIGHT

Dimensions: 800 x 500 x 600 mm. approx.
Weight: 50 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME22. **Venturi, Bernoulli and Cavitation Unit**

DESCRIPTION

This module is designed for demonstrating some practical possibilities with the Venturi's tube. This Venturi is made of transparent methacrylate for a better visualization.

It consist of a circular transverse section Venturi tube with 6 taps (Divergent/Convergent). Being transparent, gives a better visualization of the cavitation phenomenon.

It includes a manometer and a vacuum gauge, as well as 5 manometric tubes.

PRACTICAL POSSIBILITIES

1.- How to fill the manometric tubes.
2.- Flow calculation.
3.- Determination of the exact section in Venturi's tube. Bernoulli's theorem study.
4.- Cavitation study.
5.- Pressure reduction in a tank.
6.- Aspiration pump.
7.- Aspiration pump for mixing two liquids.
8.- Using for air and water mixing.

SPECIFICATIONS

Manometer (type Bourdon), range: 0-2.5 bar.
Manometer(type Bourdon), range: 0-(-1) bar.
2 tanks, height:135 mm and internal diameter: 64 mm.
Venturi tube with 6 tappings (Divergent/ Convergent).
Differential manometers: 0-500 mm.
5 manometric tubes.
Quick connection system incorporated.
Anodized aluminium structure and panel in painted steel.

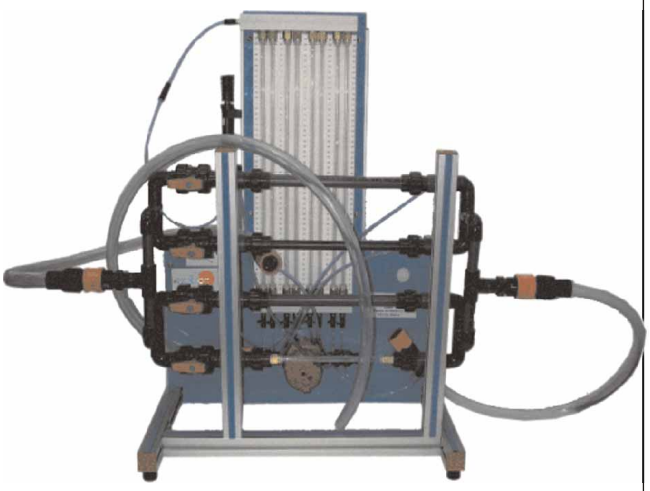
DIMENSIONS AND WEIGHT

Dimensions: 750 x 400 x 850 mm. approx.
Weight: 10 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench(FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.
Vegetable Colouring (Fluorescein $C_{20}H_{12}O_5$).

FME23. Basic Pipe Network Unit



DESCRIPTION

This pipe network module is designed for the study of pressures and flows created by interconnected pipes, i.e. in network.
The objective of this module is to simulate the problems that could be originated in pipe networks, having these pipes different lengths and diameters, as it happens in cities.
With this study, the distribution and arrangement of the networks will be understood, in order to obtain the necessary flows and pressures in them.
The module is formed by a pipe network, valves, their connection systems, water manometers and anodized aluminum structure where the pipes network is located and the subjection panel of the manometers.

PRACTICAL POSSIBILITIES

Some practical possibilities:
1.- Load loss in a PVC pipe.
2.- Load loss in a methacrylate pipe.
3.- Study of the load loss in pipes made of the same material.
4.- Study of the load loss in function of the material.
5.- Friction coefficient in a PVC pipe.
6.- Friction coefficient in a methacrylate pipe.
7.- Study of the friction coefficient in function of the material.
8.- Study of the friction coefficient in function of the diameter.
9.- Configuration of network in parallel for pipes of the same material and different diameter.
10.- Configuration of network in parallel for pipes of the same diameter and different material.

SPECIFICATIONS

Anodized aluminum structure where the pipe network is located and the subjection panel of the manometers.
Pipe network. This pipe network has been mounted with 4 pipes, each one with a valve to let the flow of water run through the corresponding pipe.
Test pipes:
Two 20mm wide PVC pipes.
One 16mm wide PVC pipe.
One 10mm wide methacrylate pipe.
8 eight pressure intakes, connected to a manometric tubes panel of pressurized water.
The pressurization in made by a manual pump.
Manometric tubes panel:
Number of manometric tubes: 8.
Range: 0 to 470 mm of water.
Inlet pipe. Outlet pipe.
Regulation valve for controlling the flow through the network.
Adjustable legs for leveling the unit.
Easy and quick coupling system built-in.

DIMENSIONS AND WEIGHT

Dimensions: 600 x 350 x 800 mm. approx.
Weight: 50 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME24. Unit for the study of Porous Beds in Venturi Tubes (Darcy's Equation)

DESCRIPTION

The module is formed by a circular section conduct with a truncated cone shape, transparent, and with pressure taps that allow measuring simultaneously the values of static pressure corresponding to any point of different sections.
It has also another three conducts, full of sand of different diameters of grain.
The conduct ends can be extracted, so they can be placed in a convergent or in a divergent way in function of the flow direction.
There is a probe (Pitot's tube) moving along the section in order to measure the height of each section (dynamic pressure).
The flow velocity in the module can be modified by adjusting the control valve and by using the Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).

PRACTICAL POSSIBILITIES

1.- Demonstration of Bernoulli's theorem and its limitations in divergent - convergent position.
2.- Demonstration of Bernoulli's theorem and its limitations in convergent-divergent position.
3.- Direct measurement of the static height and total distribution of heights in Venturi's tubes.
4.- Determination of the exact section in a Venturi's tube.
5.- Head losses in the porous bed (elements FME24/A, FME24/B and FME24/C).

SPECIFICATIONS

Manometer range: 0-300 mm. water.
Number of manometric tubes: 8.
Strangulation diameter upstream: 25 mm.
Narrowing:
upstream: 10°.
downstream: 21°.
Venturi's tube with Pitot tube.
Venturi's tube with porous bed of a grain diameter of 1.0 to 1.5 mm (FME24/A).
Venturi's tube with porous bed of a grain diameter of 2.5 to 3.5 mm (FME24/B).
Venturi's tube with porous bed of a grain diameter of 5.5 to 7.0 mm (FME24/C).
Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 800 x 450 x 700 mm. approx.
Weight: 15 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME25. Flow Channel, 1m. length.

DESCRIPTION

This module has been designed for studying the behaviour of water flowing through a one-meter channel.
It is basically constituted by a channel of rectangular section with transparent walls, through which water is made to circulate.
It has a mechanism that allow to vary the shape of the channel and it can be placed directly on the Hydraulics Bench.
Water is taken from the tank of the Hydraulics Bench (FME00) or the Hydraulic Feed System (FME00/B) by means of a pump and, by the pipe, it is driven to the tank, where there is a soothing of flow, after which circulates through the channel that discharges in the reception tank, returning finally to the storage tank, therefore the closed circuit is completed.
There is a mechanism (worm gear) that allows to adjust the slope of the channel.

PRACTICAL POSSIBILITIES

Some practical possibilities:
1.- To study and demonstrate the properties of fluids in open channels.
2.- Measurement of water height and velocity along the channel.
3.- Flow control by floodgates.
4.- Level control using syphons.
5.- Calculation of water flow.
Other possible practices:
6.- Filling of the Pitot tube.
7.- Use of markings for measuring the water height.

SPECIFICATIONS

Channel of rectangular section with transparent walls in methacrylate, length: 1 m.
Rigid and flexible pipes.
Regulating valves.
Storage tank.
Tank with soothing of flow.
Easy and quick coupling system built-in.
Anodized aluminium structure.

DIMENSIONS AND WEIGHT

Dimensions: 1500 x 500 x 500 mm. approx.
Weight: 40 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

AVAILABLE ACCESSORIES

FME25TP. Pitot tube.
FME25CV. Vertical plane gate.
FME25SDL. Syphon.
FME25RMC. Markings for measurement of the water height.

FME26. Depression Measurement System (vacuum gauge)

DESCRIPTION

Anodized aluminium structure that supports a vacuum gauge whose reading gives us the measurement.

Two quick connections at both sides of the vacuum gauge allow connecting reinforced flexible pipes.

PRACTICAL POSSIBILITIES

1.-To measure the depression caused for the fluid aspiration by an hydraulic pump.

2.-We can observe the different negative readings due to the different methods of fluid aspiration for its subsequent impulsion.

SPECIFICATIONS

Anodized aluminium structure.

Pressure-vacuum gauge adjusted from -1 to 0 bar.

Quick connections.

DIMENSIONS AND WEIGHT

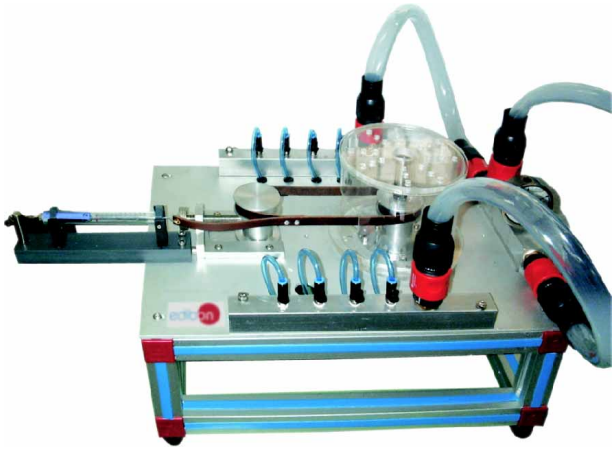
Dimensions : 220 x 110 x 420 mm. approx.

Weight: 2 Kg. approx.

REQUIRED SERVICES

Reinforced flexible pipes.

FME27. **Axial Flow Turbine**



DESCRIPTION

This module consists of an Axial Turbine, in miniature, with 8 inclined nozzles at 20° and 30° degreed respect to the perpendicular direction at the rotating axis.
The pallets of turbine runner are clearly visible through the transparent tank.
A band brake connected to one load cell varying the load given to the turbine by means of a connection device.

PRACTICAL POSSIBILITIES

1.- Flow calculation.
2.- Determination of the discharge coefficient of the nozzle.
3.- Determination of the curve N(Q,n), P_m(Q, n) and η(Q, n); (20° nozzle).
4.- Determination of the curve N(Q,n), P_m(Q, n) and η(Q, n); (30° nozzle).
5.- Adimensional analysis.

SPECIFICATIONS

Nozzle:
Inlet diameter of the throat:2.5 mm.
Outlet diameter of the throat:2.5 mm.
Discharge angle: 20° and 30°.
Turbine Rotor:
External Diameter:53 mm.
Internal Diameter: 45 mm.
Number of blades:40.
Inlet angle of the blades: 40°.
Outlet angle of the blades:40°.
Used material: Brass.
Brake:
Pulley diameter: 60 mm.
Real diameter:50 mm.
Bourdon type manometer.
8 ball valves.
Easy and quick coupling system built-in.
Anodized aluminium structure.
Tachometer.

DIMENSIONS AND WEIGHT

Dimensions: 800 x 500 x 600 mm. approx.
Weight: 50 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME28. **Francis Turbine**

Detail of the turbine

DESCRIPTION

This unit consists of a miniature Francis turbine. The water inlet flow is controlled by a valve situated in the Hydraulic Bench (FME00) or Basic Hydraulic Feed System (FME00/B). It is provided with a distributor with adjustable guide vanes that permits to control the water angle of incidence in the turbine. To adjust the turbine distributor, the unit has a lever on the front of the same. It also has a braking system, connected to two dynamometers, that permits to vary the load supplied to the turbine. It is provided with a draft tube that consists of a conduction that joins the turbine with the outlet channel; its objective is to recuperate at the maximum level water kinetic energy when it gets out of the turbine.
The inlet pressure of the turbine is measured with a manometer situated at the turbine inlet. The feed or spiral chamber is provided with a damping cover and two tubes to avoid the water to overflow. Its name indicates that it is spiral-shaped, and for this reason, it is known as snail chamber. Thanks to its design, the water flows at a constant velocity without forming swirls. This way, there are no load losses. The turbine's axis velocity is determined by a tachometer.

PRACTICAL POSSIBILITIES

1.- To determine the operating characteristics of a Francis turbine at different velocities.
2.- Determination of the typical turbine curves (operating mechanical curves and operating hydraulic curves).
3.- Turbine power output versus speed and flow rate at various heads.
4.- Effect of guide vane setting on turbine performance.
5.- Adimensionalization.

SPECIFICATIONS

Functional model of Francis turbine.
Velocity range: 0-1200 r.p.m. Power: 5 W.
Diameter of the turbine: 52 mm.
Number of blades of the turbine: 15.
Number of adjustable guide vanes of the distributor: 10.
Manometer range: 0-250 mbar.
Braking system connected to 2 dynamometers:
dynamometers range: 0-10 N.
Feed chamber.
Draft tube.
Easy and quick coupling system.
Anodized aluminium structure.
Tachometer.

DIMENSIONS AND WEIGHT

Dimensions: 500 x 350 x 600 mm. approx.
Weight: 20 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME29. **Kaplan Turbine**

Detail of the turbine

DESCRIPTION

This unit consists of a miniature Kaplan turbine. The water inlet flow is controlled by a valve situated in the Hydraulic Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
It is provided with a distributor with adjustable guide vanes that permits to control the water flow in the turbine. It has a braking system, connected to two dynamometers, that permits to vary the load supplied to the turbine. The feed or spiral chamber is provided with a damping cover and two tubes to avoid the water to overflow; its name indicates that it is spiral-shaped, and for this reason, it is known as snail chamber; thanks to its design, the water flows at a constant velocity without forming swirls; this way, there are no load losses.
It is also provided with a draft tube that consists of a conduction that joins the turbine with the outlet channel; its objective is to recuperate at the maximum level water kinetic energy when it gets out of the turbine. The inlet pressure of the turbine is measured with a U-manometer situated at the turbine inlet. The turbine's axis velocity is determined by a tachometer.

PRACTICAL POSSIBILITIES

1.- Determination of the operative characteristics of Kaplan Turbine at different velocities.
2.- Flow calculation.
3.- Determination of the operation mechanical curves.
4.- Determination of the operation hydraulic curves.
5.- Adimensional analysis.

SPECIFICATIONS

Functional model of Kaplan Turbine.
Velocity range: 0-1000 r.p.m. Power: 10 W.
Number of blades of the turbine: 4.
Turbine diameter: 52 mm.
Number of adjustable guide vanes of the distributor: 8.
U-Manometer range: 0-200 mm. of water.
Braking system connected to 2 dynamometers: dynamometers range: 0-10 N.
Feed chamber.
Draft tube.
Easy and quick coupling system.
Anodized aluminium structure.
Tachometer.

DIMENSIONS AND WEIGHT

Dimensions: 500 x 350 x 600 mm. approx.
Weight: 20 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Chronometer.

FME30. **Vortex Flow Meter**

DESCRIPTION

This unit is used for studies and experiments on various methods of measuring volumetric and mass flow rates and for the comparison of continuous and discontinuous flow meters.
The water supply can be done from the Hydraulics Bench "FME00" or from the Basic Hydraulic Feed System "FME00/B".
Two continuous and two discontinuous methods are introduced.
The continuous methods have a vortex flow meter and a variable flow meter. In the vortex flow meter an oscillating angle is produced and using dye or colouring it is made visible. Using a regulation valve we can adjust the volumetric flow rate.

PRACTICAL POSSIBILITIES

1.- Study and experiments with a vortex flow meter.
2.- Study and experiments with a variable area flow meter.
3.- Measurement of volumetric volume flow rate.
4.- Measurement of gravimetric volume flow rate.
5.- Comparison of methods on several volumetric and mass flow measurements.
6.- Flow meters calibration.

SPECIFICATIONS

Vortex flow meter.
Dye or colouring container with metering valve.
Variable area flow meter.
Range: 0-30 l./min. approx.
Valves.
Graduated measuring vessel (2 l. capacity approx).
Digital scale.
Collecting tank with constant height.
Chronometer.
Easy and quick coupling system.
Anodized aluminium structure and panels in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 1000 x 400 x 1000 mm. approx.
Weight: 30 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Colouring.

FME31. Horizontal Osborne-Reynolds Demonstration

DESCRIPTION

This unit is designed for the study and observation of laminar and turbulent flow.

It basically consists of a horizontal transparent pipe section with stream lined inlet section.

The flow rate of the water can be regulated with a valve in the experimental pipe section.

Depending on the flow velocity, the transition from laminar to turbulent flow can be observed.

It has an dye or colouring injection system. The dye is injected from the container into the flow to make a flow line visible.

The water supply can be done from the Hydraulics Bench "FME00" or from the Basic Hydraulic Feed System "FME00/B".

PRACTICAL POSSIBILITIES

1.- Observation of the laminar, transition and turbulent regime.
2.- Study of the velocity profile, reproducing the Osborne-Reynolds's experiment.
3.- Reynolds's number calculation.

SPECIFICATIONS

Horizontal transparent pipe section:
Internal diameter: 16 mm.
Length: 700 mm.
Dye or colouring tank.
The colouring is regulated with a valve.
Supply tank for the generation of a constant initial pressure, capacity: 2 litres.
Flow regulation valve.
Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 1000 x 500 x 700 mm. approx.
Weight: 20 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).
Colouring.
Chronometer.

FME32. Pitot Static Tube Module

DESCRIPTION

With this unit the change in flow speed within a tube can be determined.

The Pitot static tube can be moved across the whole cross-section of the tube, and thus to measure the pressure profile.

This tube is connected to manometers via hoses.

On a scale the position of the measuring head relative to the bottom edge of the tube can be measured.

The water supply can be done from the Hydraulics Bench "FME00" or from the Basic Hydraulic Feed System "FME00/B".

PRACTICAL POSSIBILITIES

1.- Study of the function of a pitot static tube.
2.- To use a pitot static tube.
3.- Determination of tube flow speed profiles.
4.- Demonstration that the flow speed is proportional to the pressure difference between the total pressure and the static pressure.

SPECIFICATIONS

Pitot static tube:
Head diameter: 2.3 mm.
Transparent pipe:
27 mm. internal diameter and 600 mm. length approx.
Hose connections.
Water manometer.
Easy and quick coupling system built-in.
Anodized aluminium structure and panel in painted steel.

DIMENSIONS AND WEIGHT

Dimensions: 860 x 500 x 800 mm. approx.
Weight: 7 Kg. approx.

REQUIRED SERVICES

Hydraulics Bench (FME00) or Basic Hydraulic Feed System (FME00/B).

FME33. **Pascal's Module**

DESCRIPTION

The Pascal's module enables the demonstration that the pressure in an incompressible fluid varies with depth and does not depend on the shape of the vessel. It also allows the quantitative determination of the hydrostatic pressure and the investigation of the linear relation between pressure and filling height.

This module is designed to demonstrate Pascal's principles and is mounted on a metallic structure.

FME33 consists of a body incorporating a horizontal diaphragm to which a glass vessels can be fitted. The diaphragm transmits the force to a lever arm with a sliding weight, and a level measures force at the base of the vessel.

Three diferent vessels are supplied and the diameter at the base of each vessel is common but the shape of each vessel varies.

A movable index in a vertical rod enables the height of water in the vessels to be set at the same level.

PRACTICAL POSSIBILITIES

1.- Demonstration of Pascal´s principles.

2.- To demonstrate that the pressure in a liquid contained in a vessel varies with depth is not affected by the shape of the vessel by comparing three different vessels.

SPECIFICATIONS

This module is mounted on a metallic structure.

Body incorporating a horizontal diaphragm to which a glass vessels can be fitted.

Lever arm with a sliding weight, and a level to measure the force at the base of the vessel.

Three different vessel, with common diammeter at the base but with different shape.

Movable index in a vertical rod to enable the height of water in the vessels to be set at the same level.

DIMENSIONS AND WEIGHT

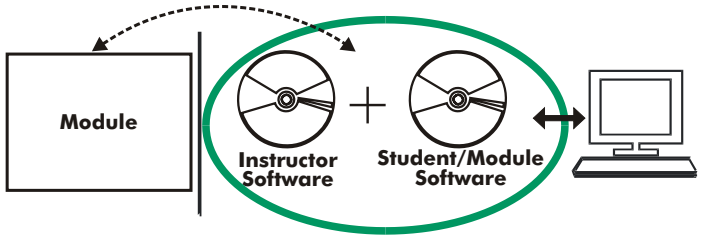
Dimensions: 600 x 250 x 450 mm. approx.

Weight: 3 Kg. approx.

REQUIRED SERVICES

It can work in autonomous way.

③ CAI. Computer Aided Instruction Software System



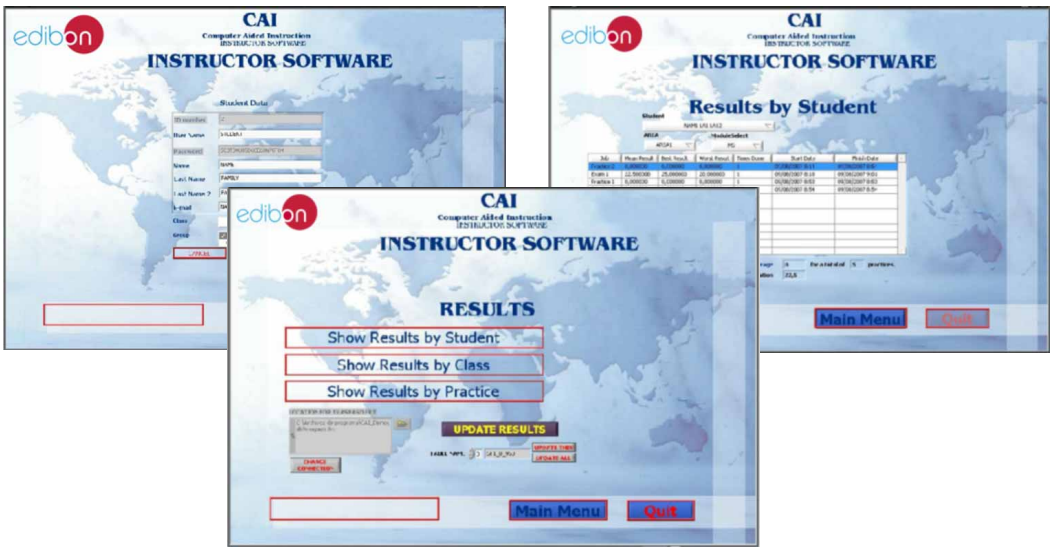
With no physical connection between module and computer, this complete package consists on an Instructor Software (INS/SOF) totally integrated with the Student/Module Software (FME../SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students. These, on the other hand, get a virtual instructor who helps them to deal with all the information on the subject of study.

With the **INS/SOF. Classroom Management Software Package (Instructor Software)**, the Teacher has a whole range of options, among them:

- Organize Students by Classes and Groups.
- Create easily new entries or delete them.
- Create data bases with student information.
- Analyze results and make statistical comparisons.
- Print reports.
- Develop own examinations.
- Detect student's progress and difficulties.

...and many other facilities.

The Instructor Software is the same for all the modules, and working in network configuration, allows controlling all the students in the classroom.



FME../SOF. Computer Aided Instruction Software Packages (Student/Module Software).

It explains how to use the module, run the experiments and what to do at any moment.

Each module has its own Student Software package.

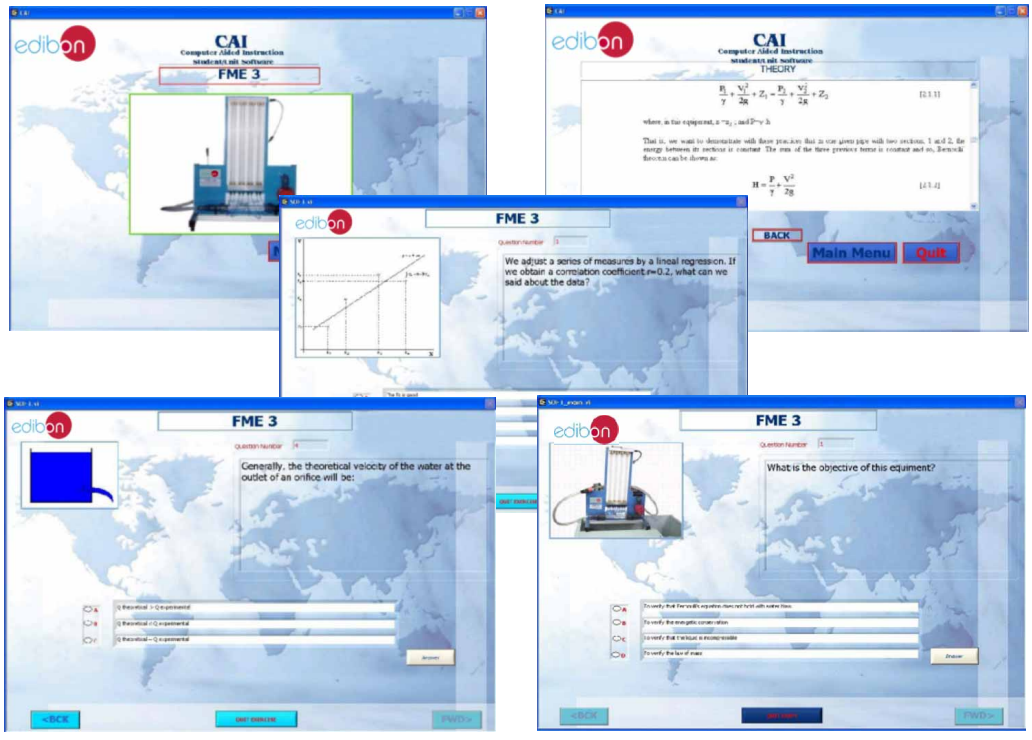
- The options are presented by pull-down menus and pop-up windows.
- Each Software Package contains:

  Theory: that gives the student the theoretical background for a total understanding of the studied subject.

  Exercises: divided by thematic areas and chapters to check out that the theory has been understood.

  Guided Practices: presents several practices to be done, alongside the modules, showing how to complete the lab exercises and get the right information from them.

  Exams: set of questions presented to test the obtained knowledge.



∗ Both Instructor Software and Student/Module Software are available in English and Spanish. Any other language available on request.

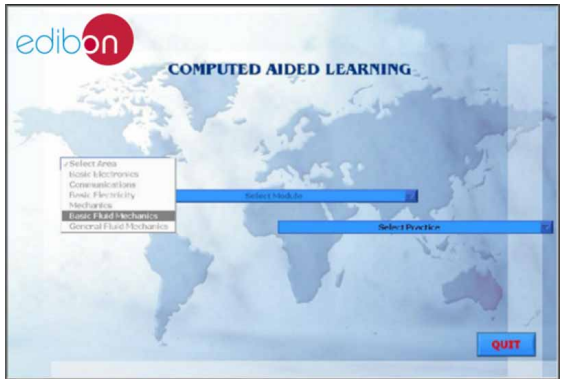
Available Student/Module Software Packages:

- FME01/SOF. Impact of a Jet.
- FME02/SOF. Flow over Weirs.
- FME03/SOF. Bernoulli's Theorem Demonstration.
- FME04/SOF. Orifice Discharge.
- FME05/SOF. Energy Losses in Bends.
- FME06/SOF. Osborne-Reynolds Demonstration.
- FME07/SOF. Energy Losses in Pipes.
- FME08/SOF. Hydrostatic Pressure.
- FME09/SOF. Flow Visualization in Channels.
- FME10/SOF. Dead Weight Calibrator.
- FME11/SOF. Metacentric Height.
- FME12/SOF. Series/Parallel Pumps.
- FME13/SOF. Centrifugal Pumps Characteristics.
- FME14/SOF. Free and Forced Vortex.
- FME15/SOF. Water Hammer.
- FME16/SOF. Pelton Turbine.
- FME17/SOF. Orifice and Free Jet Flow.
- FME18/SOF. Flow Meter Demonstration.
- FME19/SOF. Cavitation Phenomenon Demonstration.
- FME20/SOF. Laminar Flow Demonstration.
- FME21/SOF. Radial Flow Unit.
- FME22/SOF. Venturi, Bernoulli and Cavitation Unit.
- FME23/SOF. Basic Pipe Network Unit.
- FME24/SOF. Unit for the Study of Porous Beds in Venturi Tubes (Darcy's Equation).
- FME25/SOF. Flow Channel, 1m. length.
- FME26/SOF. Depression Measurement System.
- FME27/SOF. Axial Flow Turbine.
- FME28/SOF. Francis Turbine.
- FME29/SOF. Kaplan Turbine.
- FME30/SOF. Vortex Flow Meter.
- FME31/SOF. Horizontal Osborne-Reynolds Demonstration.
- FME32/SOF. Pitot Static Tube Module.
- FME33/SOF. Pascal's Module.

④ FME/CAL. Computer Aided Learning Software (Results Calculation and Analysis)

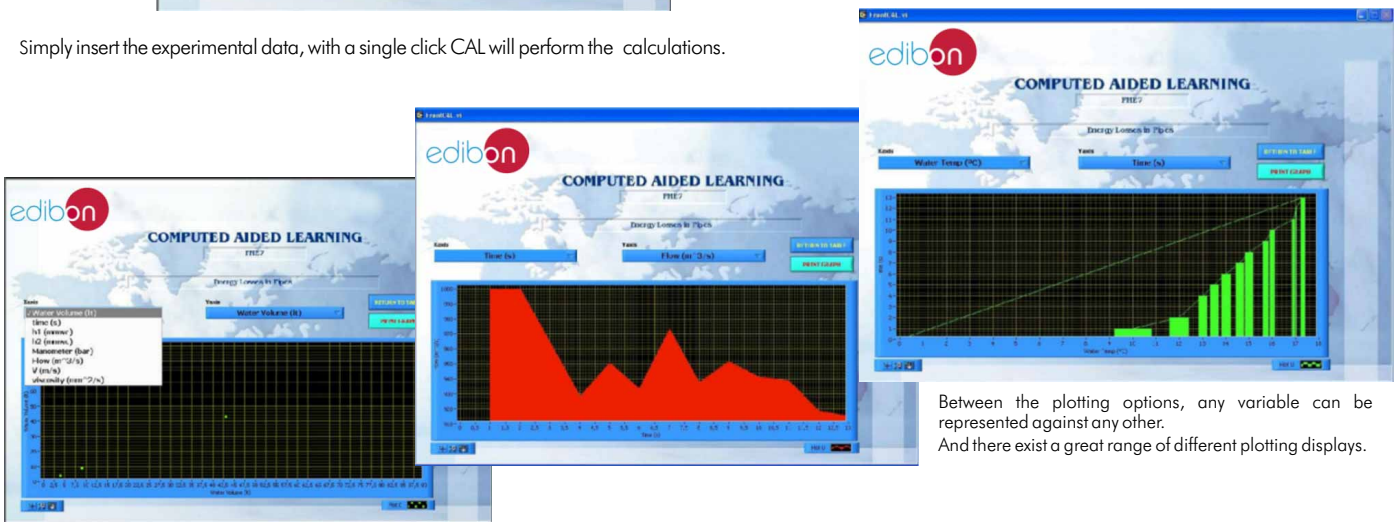
This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use specifically developed by EDIBON. It has been designed to cover different areas of science: Basic Electronics, Communications, Basic Electricity, Mechanics, Basic Fluid Mechanics and General Fluid Mechanics*.
*Although only the purchased areas will be activated and ready to use.

CAL is a class assistant that helps in making the necessary calculations to extract the right conclusions from data obtained during the experimental practices.
With a single click, CAL computes the value of all the variables involved. Also, CAL gives the option of plotting and printing the results.



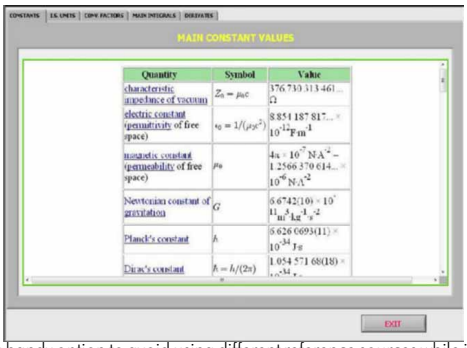
Once the Area of study is selected, the right module can be chosen among a wide range, each one with its own set of lab exercises.

Simply insert the experimental data, with a single click CAL will perform the calculations.

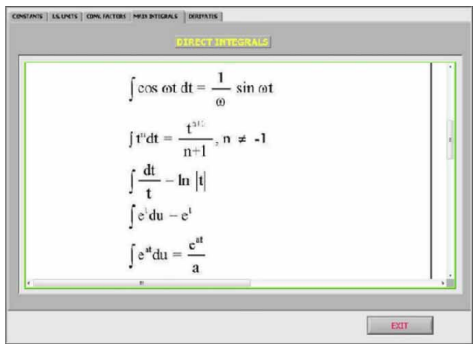


Between the plotting options, any variable can be represented against any other.
And there exist a great range of different plotting displays.

Among the given choices, an additional help button can be found, which offers a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.



It provides a handy option to avoid using different reference sources while in process. For example: the values of Physical constants, their symbols and right names, conversion factors...



...and the very useful integral and derivative tables.

Available Software Packages:

- FME01/CAL. Impact of a Jet.
- FME02/CAL. Flow over Weirs.
- FME03/CAL. Bernoulli's Theorem Demonstration.
- FME04/CAL. Orifice Discharge.
- FME05/CAL. Energy Losses in Bends.
- FME06/CAL. Osborne-Reynolds Demonstration.
- FME07/CAL. Energy Losses in Pipes.
- FME08/CAL. Hydrostatic Pressure.
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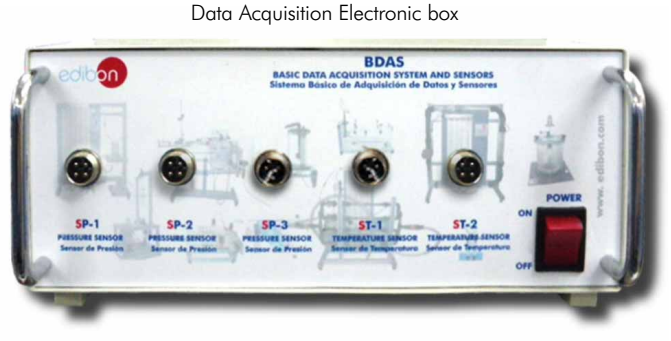
- FME18/CAL. Flow Meter Demonstration.
- FME19/CAL. Cavitation Phenomenon Demonstration.
- FME20/CAL. Laminar Flow Demonstration.
- FME21/CAL. Radial Flow Turbine.
- FME22/CAL. Venturi, Bernoulli and Cavitation Unit.
- FME23/CAL. Basic Pipe Network Unit.
- FME24/CAL. Unit for the Study of Porous Beds in Venturi Tubes (Darcy's Equation).
- FME25/CAL. Flow Channel, 1m. length.
- FME26/CAL. Depression Measurement System.
- FME27/CAL. Axial Flow Turbine.
- FME28/CAL. Francis Turbine.
- FME29/CAL. Kaplan Turbine.
- FME30/CAL. Vortex Flow Meter.
- FME31/CAL. Horizontal Osborne-Reynolds Demonstration.
- FME32/CAL. Pitot Static Tube Module.
- FME33/CAL. Pascal's Module.

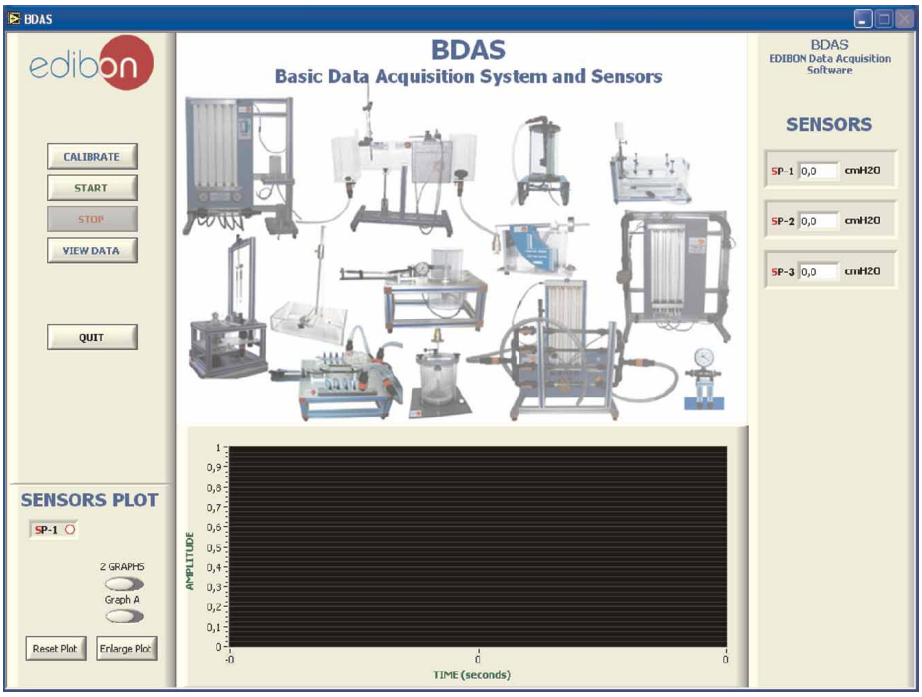
For being used with modules type "FME".
Content: Data Acquisition Electronic Box, Sensors (will be included in the modules) and Data Acquisition Software.

Data Acquisition Electronic box

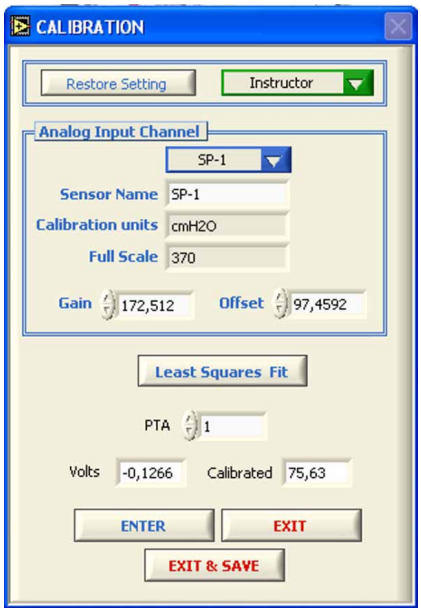


Software screens

Example of main screen



Example of calibration screen



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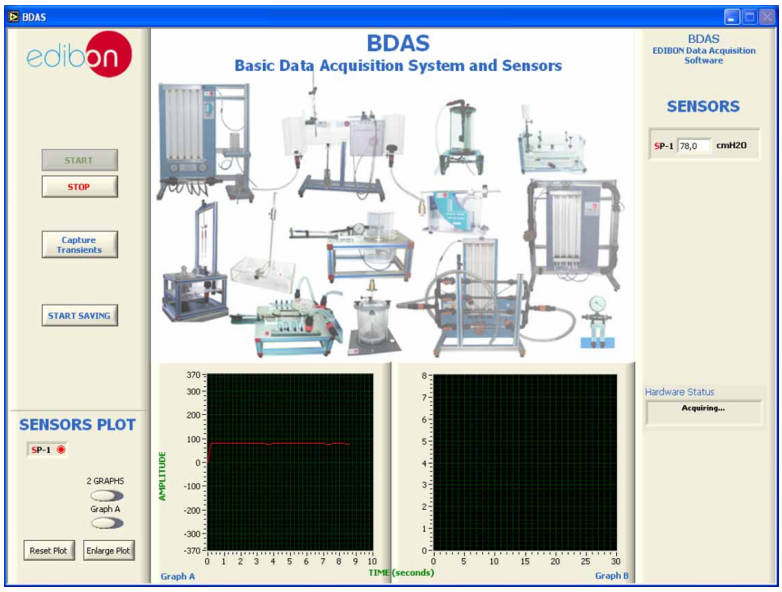
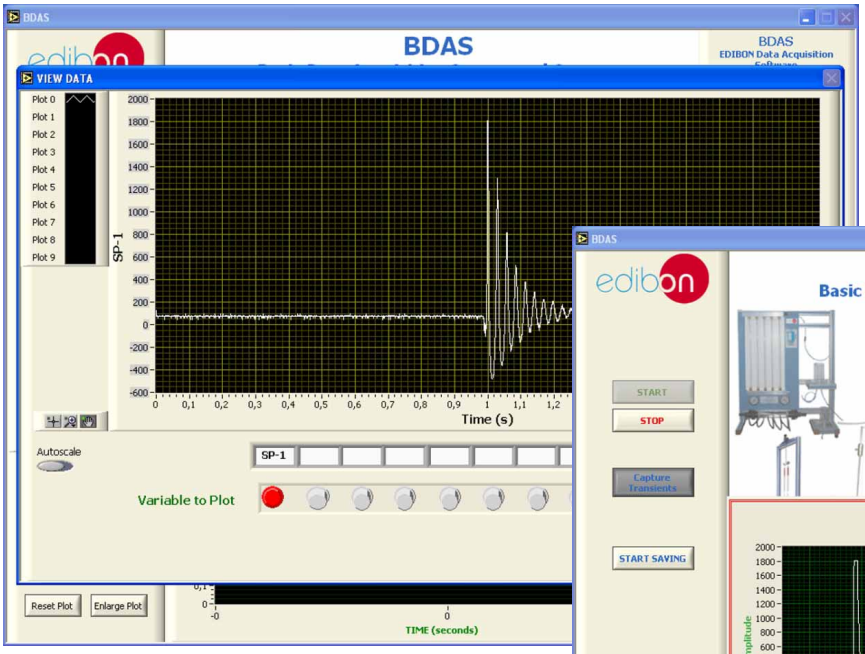
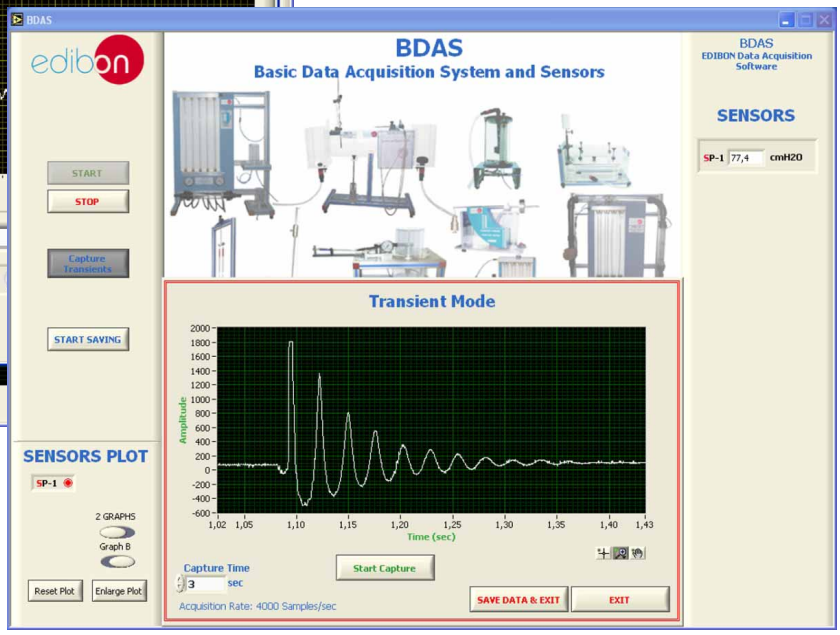
Example of some typical exercises results working with FME15 Module







✱ Specifications subject to change without previous notice, due to the convenience of improvements of the product.

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Issue: ED01/12
Date: January/2012

REPRESENTATIVE: