MATRIX | RENEWABLES

Hydropower Energy

MATRIX

CP6370

www.matrixtsl.com

Contents

Introduction
Safety

Intended use

This equipment has been developed only for experimentation, education and demonstration purposes. Due to the use of low voltage equipment, the equipment is safe to use in almost every classroom and laboratory while carefully following the provided manuals and safety instructions. However, it is the sole responsibility of the customer to meet all local safety regulations and laboratory guidelines and to ensure safety during operation, maintenance and storage of the equipment.
In the educational process, this equipment can be used by students only under the supervision of the teaching staff. Teachers must ensure the proper handling of the system and perform the installation, maintenance and storage.

Prohibited use

This equipment cannot be used for:

Generating electricity for purposes other than those described in the Teacher's and Instructions manuals.
Connecting the to the main grid.

Safety measures

Only use supplied components unless otherwise stated in the manual.
Do not disassemble or inappropriately tamper with the components.
Pay attention to all local rules and safety concepts.
Respect all established safety concepts for handling electric current.
All students should be briefed before using products and never experiment alone.
Stop experimenting and contact your teacher/supervisor if a system is damaged.

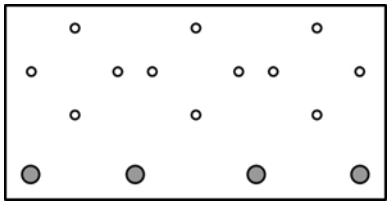
Symbols and signs

Although the experiments pose no immediate danger, safety precautions should be observed. Where applicable, the warning signs are given in the description of the experimental components and experiments. The following warning signs can be found in this manual:

Warning
If the provided instructions are not followed, damage to equipment may occur.

Information
Useful information and tips.

Base unit (1100-19)



The base unit is a breadboard on which up to three modules can be connected in series and parallel. Current flows along the wires on the bottom side. Four terminals at the lower end can connect the modules on the base unit with other components. To change between series and parallel connections, the modules have to be rotated by 90°.

Warning
Do not place a base unit on the conductive surface.

Water turbine housing (1900-02)

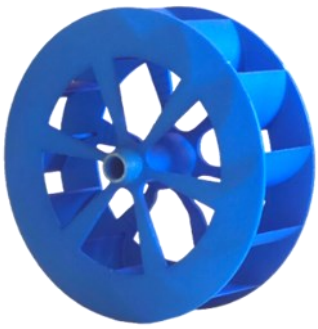
The turbine housing has two water supply inlets and one outlet. The three different turbines of the turbine set can be inserted into the turbine housing. A drive shaft connects the water turbine with the white magnet disk

The water turbine housing is delivered preassembled with manometer sets and hoses attached to the water inlets.

Tip!
The pictogram refers to the fully assembled water turbine complex.

Turbine set (1900-03)

Water wheel turbine **Cross-flow turbine** **Pelton turbine**


When experimenting with the water wheel and cross-flow turbine, the upper inlet of the turbine housing is used. The water should run through the lower inlet when using the Pelton turbine.

Induction generator hydropower (1905-02)

The generator consists of inductors, diodes and capacitors. While the turbine is spinning, the magnet disc also rotates. This changes the magnetic field in the inductors and induces a voltage. The sinusoidal voltage is rectified by the diodes and smoothed by the capacitors.

Warning!
Do not touch the induction generator during the experiments.

Manometer set 2 bar (1900-05)

Manometer set 4 bar (1900-06)

The manometer indicates the pressure at which the water flows into the turbine. The 4-bar manometer is installed on the lower inlet, and the 2-bar manometer is fitted to the upper inlet .

Intake connector (1900-07)

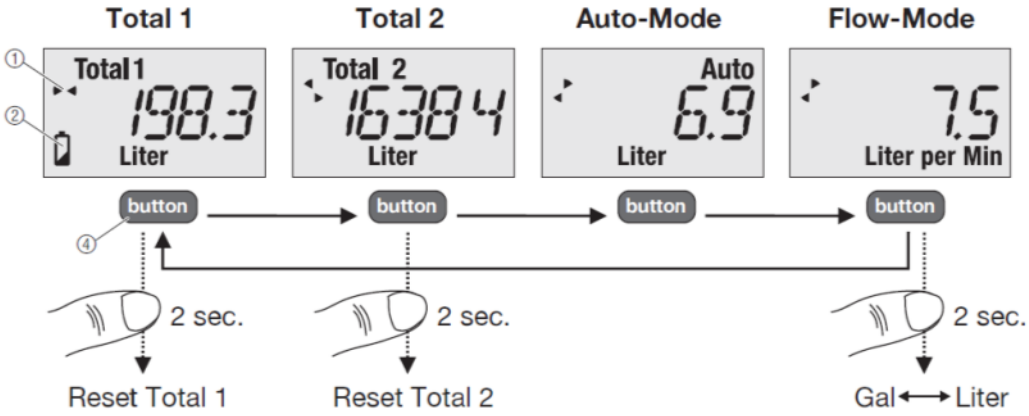
The intake connector links the upper and lower inlets. The control valves can be adjusted to regulate the flow rate of the used inlet.

Hose clamp (L2-05-131)
Hose clamp with rotary knob and hexagon screw, stainless steel (L2-05-135)

The hose clamps are used to secure and seal the inlet and outlet hoses. They are permanently fixed.
The outlet hose is fixed by the safety hose clamp with a hexagonal head for hand operation. At the beginning of the experiments with water turbine housing, the safety clamp should be loosened slightly so that the hose can be turned downwards and then secured with the clamp.

Flow meter (L2-02-066)

The flow meter is set on top of the intake connector. It has various modes, which can be chosen by pressing the orange button



Operation of the flow meter:

- Press button briefly: the display switches to the next display mode:
- Total 1: Water quantity is measured up to the reset (e.g. experiment session consumption).
- Total 2: Water quantity is measured up to the reset (e.g. season consumption).
- Auto-Mode: Water quantity is measured during water flow up to an interruption longer than 2 sec. At the next water flow, the display starts at zero again.
- Flow-Mode: Shows the current flow in l/min or gal/min
- Standby: No display (longer than 1 min. without flow or without the pressing of a button)

Special functions:

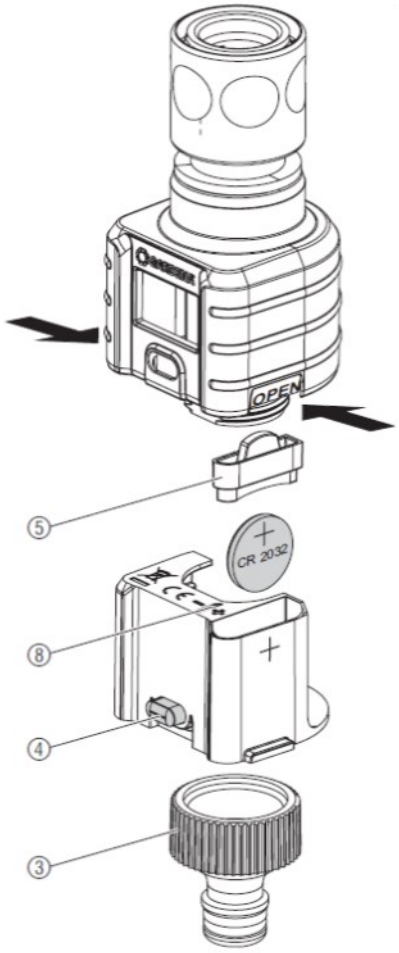
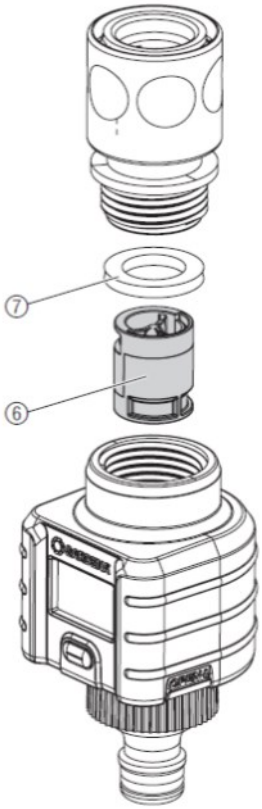
- Hold button pressed in Total 1- /Total 2 Mode for 2 sec.: The measured water quantity will be reset to 0 (Reset).
- Hold button pressed in Flow-Mode for 2 sec.: The display switches between litre and gallons (Gal). The measured water quantities will be reset to 0 (Reset).

Display symbols:

- Flow-Symbol : display during active measurement.
- Battery-Symbol : display at low battery. Change battery.

Tip
For the experiments use the flowmeter in Flow-Mode set to “Liter per Min”

Introduction
Components

Exchange battery	Clean turbo-driven unit
	
Unscrew tap Connector ③ Press button ④ and remove insert below. Remove battery-compartment washer ⑤ . Exchange battery ⑧ (type CR2032). Ensure battery is the right way round.	Remove turbo-driven unit ⑥ with washer ring ⑦ . Clean under flowing water. Assemble the flowmeter back.

Specifications:

Water temperature: 5 – 40 °C
Flow area: 2 – 30 l/min
Ambient temperature: 5 – 60 °C
Operating pressure: 12 bar
Measurement tolerance: ± 5 %
Measuring range: (at least ± 0,5 l)
Flow max. 1800 l/h

Connection set 12 mm i.d. /18mm o.d. (L2-02-062)

The connection set links the water turbine complex with the water supply. With one end adjusted on top of the water flow meter and the other end to the water supply. You may need the help of a teacher or a technician to connect to the water supply.

An additional adapter may be needed depending on the country and the type of water supply (garden water tap, Indoor water tap, laboratory water tap).

Flow sets:

Flow set 4mm (1900-08)

Flow set 8mm (1900-09)

Flow set 12mm (1900-10)

Each flow set consists of a 1 m long hose with a 4/ 8 /12 mm diameter and a hose connector with a control valve. The flow set can be connected to the bottom of the flow box. The valve on the connector is used to open and close the water inlet:

Valve closed

Valve open

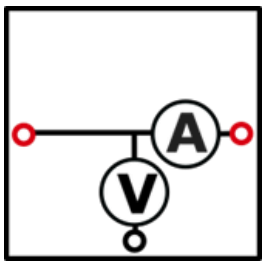
Flow box (1900-11)

The flow box has a drain where the flow sets can be plugged. Its inclined bottom allows water to flow continuously.

Collection box 6 l (L3-01-197)

The collection box captures the outflowing water of the flow sets.

AV-Module (9100-03)

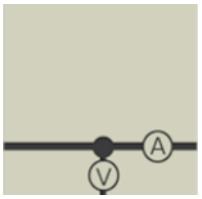


The AV-Module is a combined voltage and current meter. It has three buttons, the functions of which are described on the display. In idle mode, the display remains blank. The module can be switched on by pressing any button. With the top right button, one of the three modes can be selected:

Voltage mode

Current mode

Voltage-current mode



The circuit symbols on the display indicate the measurement mode and required cable connection. Take care that no current is applied to the right terminal in voltage mode. In voltage-current mode, the voltage can be measured with both the right and left terminals. The AV-Module can measure positive and negative current and voltage values depending on the current flow.

Warning: reverse installation!
Ensure that the AV module is installed correctly on the base unit.

In case of exceeding one of the maximum current or voltage, the module interrupts the current flow and shows "**overcurrent**" or "**overvoltage**". This error message can be confirmed by touching a button. The module will resume measuring when the values attain acceptable values. When „Bat" is displayed, the batteries must be replaced.

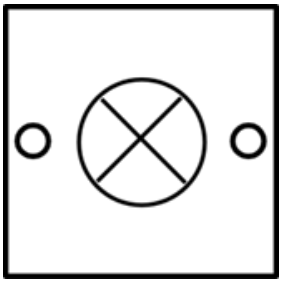
Warning: battery!
Pay attention to the polarity on the bottom of the battery case. Do not touch the button while inserting the batteries.

The module will switch off automatically after 30 minutes without pushing a button or after 10 minutes of measuring a constant value.

Specifications:
Battery: 2x AA battery (1.2 – 1.5V)

Voltage metering:	**Current metering:**
range: 0 - 12 V	range: 0 - 2 A
accuracy: 1 mV	accuracy: 0,1 mA (0-199 mA), 1 mA (200 mA - 1 A)
automatic shutoff in case of overvoltage >12 V	automatic shutoff in case of overcurrent >2 A

Light bulb module (1100-26)

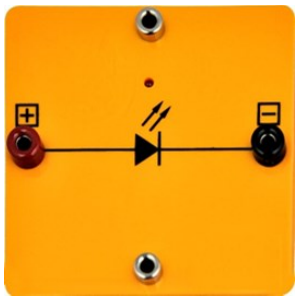


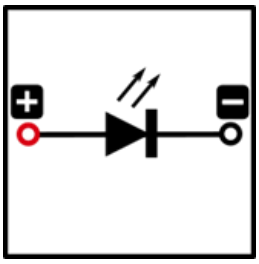
Specifications:

Light bulb P_{typ} = 200 mW (at 3.5 V)

Fuse protection via voltage limiter (6 V)

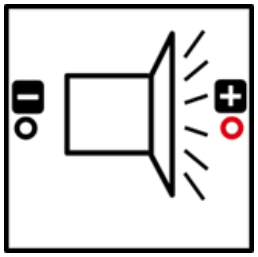
LED-Module (1400-08)





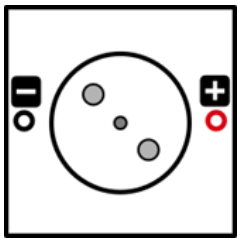
The LED module has a red LED with a wavelength of 697 nm. To light up the diode, a voltage of at least 1.6 V must be applied.

Buzzer module (1100-25)



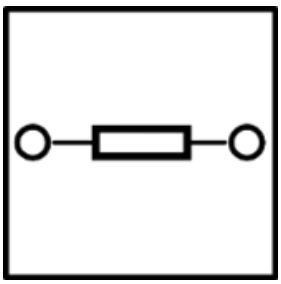
The buzzer starts making a noise at 0.7 V and 0.3 mA.

Motor module (1100-27) with colour discs set 1 (1100-28)



The motor module contains a DC motor that rotates in different directions depending on the direction of applied voltage. It requires a minimum voltage of 0.35 V to start up. Colour discs can be attached to the motor module with the blue plastic disc. The colour discs can be used to demonstrate optical illusions and additive colour mixing. A set of discs is included: red-green-blue, red-blue, red-green, green-blue, red colour disc, relief, and stroboscope disc.

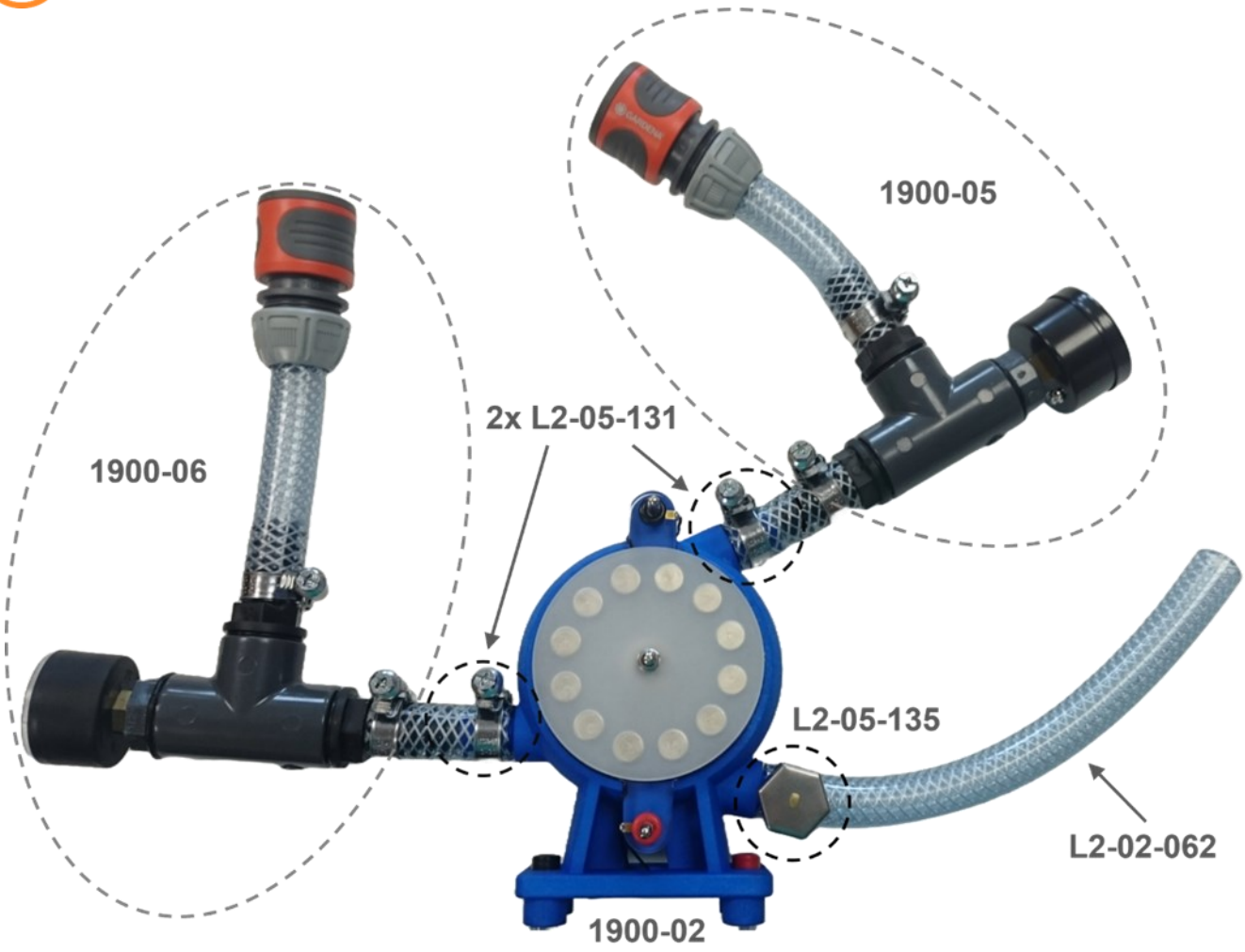
Resistor module (1100-22)



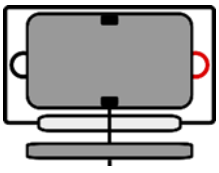
The resistor module contains an ohmic resistor of 33 Ω (± 5%). The maximum power dissipation can be up to 2 W.

Assembled water turbine housing

The water turbine housing is delivered preassembled, as shown in the picture below. Please do not take it apart!

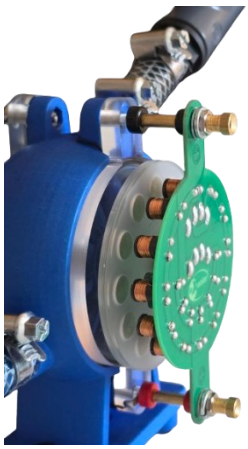


In the experiments, the water turbine housing is always used together with the induction generator, a turbine, the intake connector, the flow meter and the connection set.



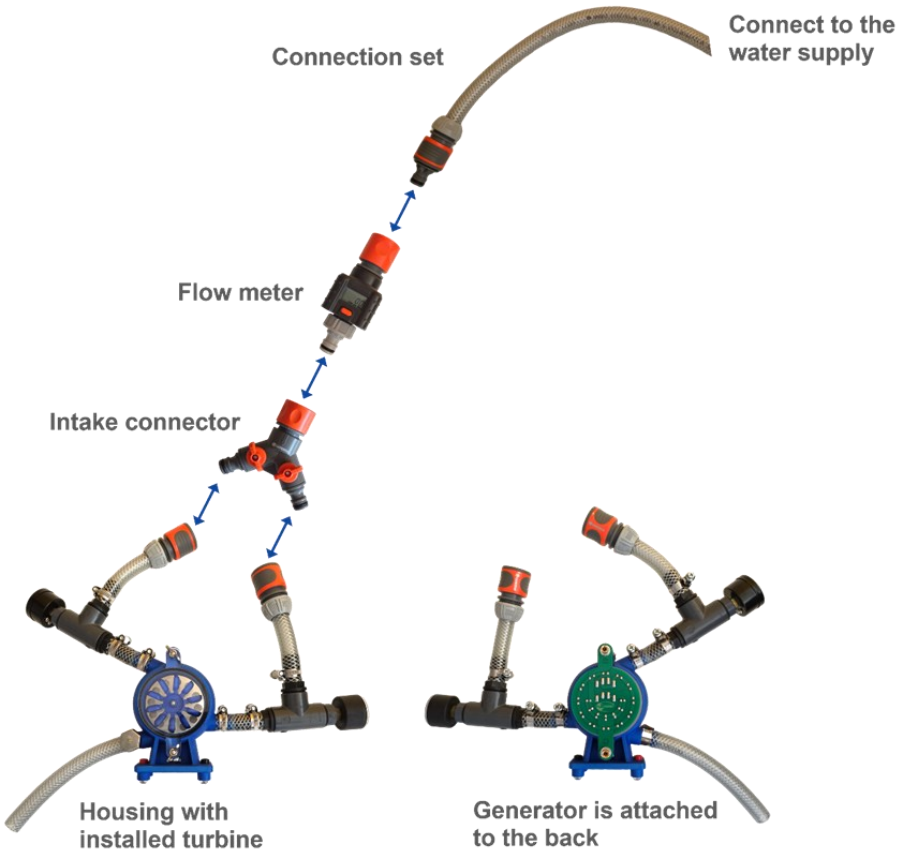
For this reason, only the following symbol for the entire water turbine complex is used in the instructions:

Installation of the water turbine:

	Unscrew the wing screws with washers and put them aside. Remove the transparent cover.
	Install the selected turbine in the housing. The hexagonal nut of the drive shaft must securely sit in the water turbine. The turbine and the magnet disc must rotate freely. Ensure the black O-ring is in place.
	Put the transparent cover back. Place the washers on the cover and screw the wing screws.
	Attach the generator to the back side of the housing and push it completely onto the housing's plugs. Pay attention to the polarity of the connections!

Assembly of the water turbine complex

1. Install the water turbine into the housing. Information is available in “Installation of the water turbine.”
2. Plug the generator onto the back side of the housing.
3. Attach the intake connector. Ensure both of the valves are closed.
4. Connect the water flow meter. Use the flow meter in Flow Mode and set it to “Liter per Min.” The “Operation of the flow meter” provides more information.
5. Plug the housing onto the base unit. Make sure the base unit is placed on the non-conductive surface.
6. Loosen the safety clamp on the outlet hose. Turn the hose to face downwards and tighten the clamp again.
7. Position the base unit with the outlet hose directed to the drain (sink or the collection box). The collection box is only suitable for the low (2-4 l/min) flow rate. Empty the collection box after each measurement!
8. Attach the connection set to the water supply.
9. Attach the connection set to the flow meter.



An additional adapter may be needed depending on the country and the type of water supply (garden water tap, Indoor water tap, laboratory water tap).

Disassembly of the water turbine complex

Disassembling the water turbine complex works the opposite way as its assembly. Pay attention that the intake connecter disconnects by turning the fixator anticlockwise, while the water flow meter and the hose connectors are opened by pulling the fixator backwards.

Checklist for the experiment:

For the experiments to work as intended, you will need a pressure of at least 4 bar or or 12 l/min at the water inlet. Use a water tap without a pressure reducer or connect to the water pipe. Ask your teacher or a technician for advice.

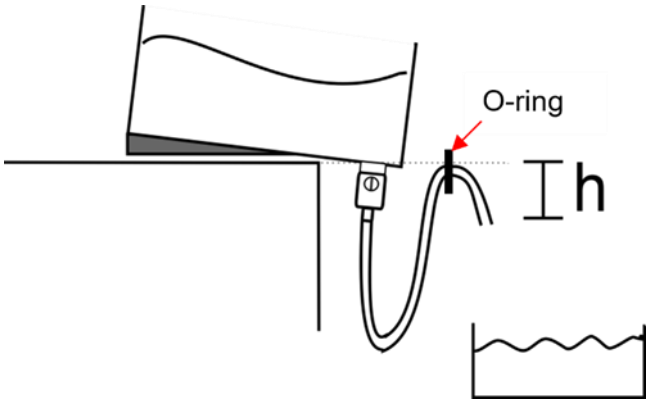
1. Before starting the experiments, check if all components used in contact with water are properly sealed. This applies particularly to the water turbine housing.
2. Check that the outlet hose is directed to the drain (sink or the collection box). The collection box is only suitable for the low (2-4 l/min) flow rate. Empty the collection box after each measurement!
3. Make sure the base unit is placed on a non-conductive surface. Stainless steel sinks and drainers are not suitable without an additional cover.
4. Check that all control valves on the intake connector, as well as the water supply, are closed.
5. Have a towel ready in case of leakage or splashing water.
6. When you have finished experimenting, allow all the components to dry before putting them back in the case.

Worksheet
Flow characteristics depending on different heights

Task

Investigate the power and the velocity of the water flow depending on the height difference.

Setup



Required Equipment

Flow box
Flow set 12 mm
Flow set 8 mm
Collection box

Additionally needed:
Stopwatch
Measuring beaker
Measuring tape

Execution

1. Find a suitable location where two containers can be placed at a height difference of approximately 50-70 cm (e.g. table and floor). Position the flow box on top of the table. The hose connector should protrude over the edge of the table. Place the collection box on the floor.
2. Connect the 12 mm flow set to the flow box. Ensure the control valve is closed.
3. Use a measuring tape to measure the 10 cm from the free end of the hose. Mark this position by moving the black O-ring there.
4. Fill the flow box with 5 litres of water.
5. Hold the hose with the O-ring on the edge of the table so that only the free end of the hose points downwards (see the diagram).
6. Check that the collection box at the bottom is well-positioned to catch the water. As soon as you open the control valve, the water will start to flow.
7. Start the stopwatch and open the valve at the same time. Stop the time when the hose starts sucking in the air, causing the water to stop flowing into the collection box.
8. Measure for all fall heights given in the table. Enter your measurements in the table.
9. Repeat the experiment with the 8 mm flow set.

Worksheet
Flow characteristics depending on different heights

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Evaluation

Write the equation for calculating the potential energy of water:

Write the equation to calculate the usable power of the water:

Write the equation for calculating the velocity of the water through the cross-section:

Calculate the cross-sectional area of the hose with 12 mm inside diameter: A12 mm =

Calculate the cross-sectional area of the hose with 8 mm inside diameter: A8 mm =

Measurements

Hose with **12 mm** diameter

Height **h** in **cm**	10	20	30	40	50
time $\mathbf{t_{12\ mm}}$ in **s**					
Flow velocity $\mathbf{v_{12\ mm}}$ in **m/s**					
Potential energy $\mathbf{E_{pot}}$ in **J**					
Power $\mathbf{P_{12\ mm}}$ in **W**					

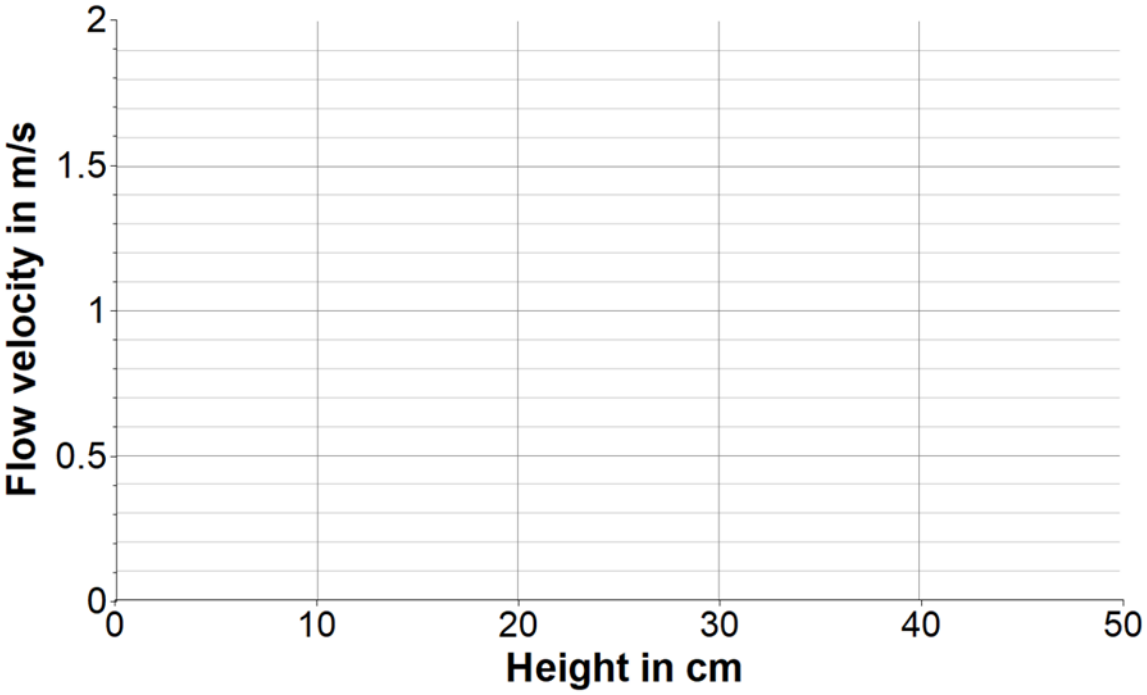
Hose with **8 mm** diameter

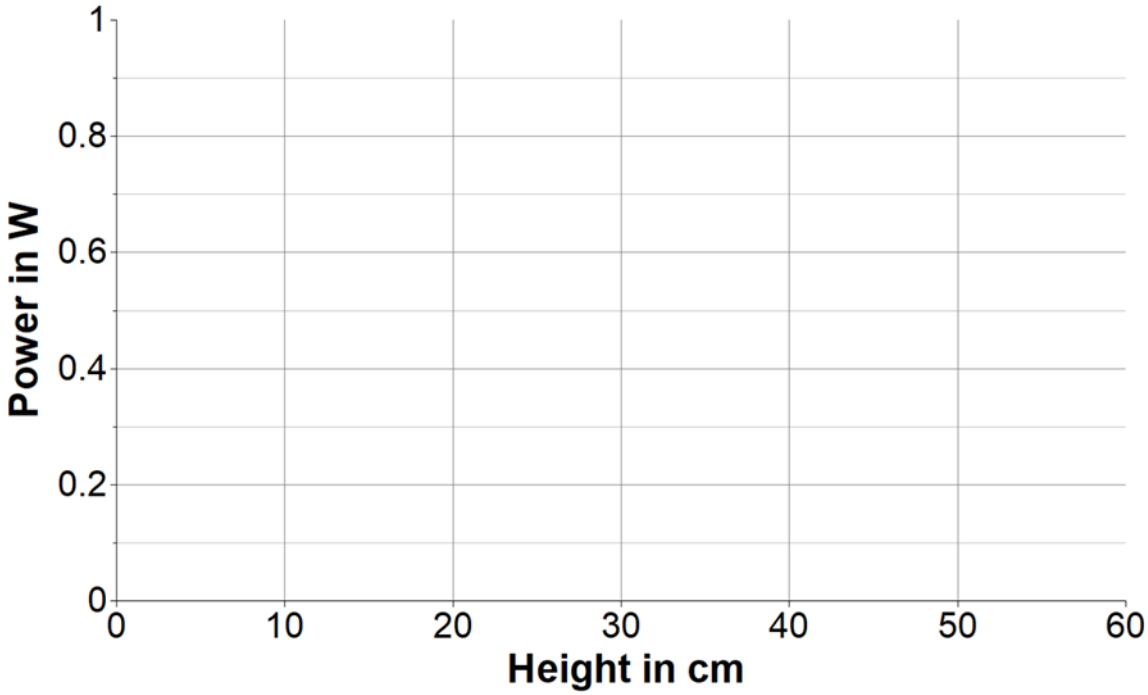
Height **h** in **cm**	10	20	30	40	50
time $\mathbf{t_{12\ mm}}$ in **s**					
Flow velocity $\mathbf{v_{12\ mm}}$ in **m/s**					
Potential energy $\mathbf{E_{pot}}$ in **J**					
Power $\mathbf{P_{12\ mm}}$ in **W**					

Worksheet
Flow characteristics depending on different heights

Evaluation

1. Calculate the remaining values in the table.
2. Plot the flow velocity and power as a function of the fall height.





Worksheet

Flow characteristics depending on different heights

3. What is the relationship between the distance of the O-ring from the end of the hose and the drop height of the water? Explain your answer

_____
_____
_____
_____
_____
_____

4. What is the relationship between the flow velocity and power on the fall height?

_____
_____
_____
_____
_____
_____
_____

The full version of this curriculum is available upon purchase of the kit.

Please see contents for a full list of experiments from the full version.