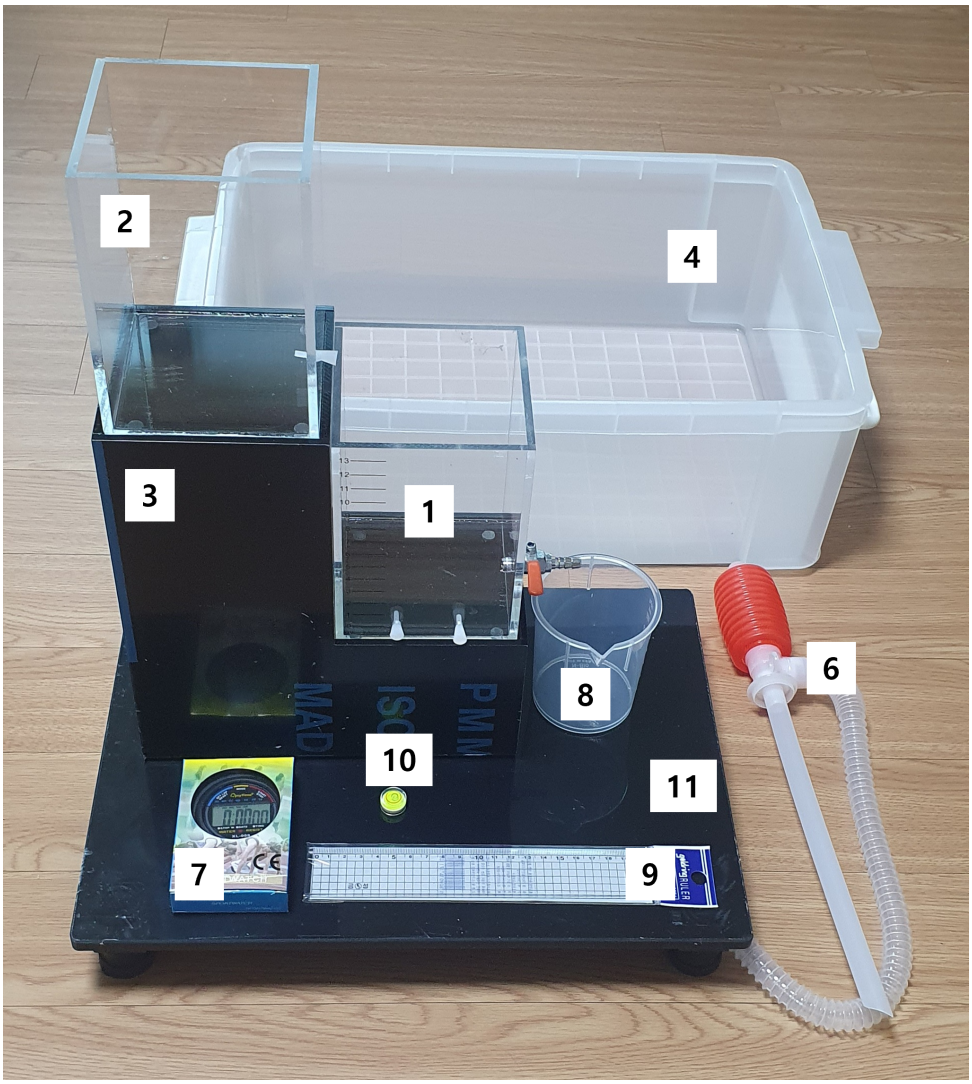
Water Clock Experiment

A. Introduction

Time can be measured using periodic or continuous physical processes. Before the development of modern atomic clocks, various methods were used for timekeeping, such as sundials, pendulum clocks, and water clocks.

A water clock measures time through the controlled flow of water. In this experiment, you will investigate the physical principles governing water flow and apply them to construct a water clock.

B. Experimental Components



The following equipment is provided:

1. Tank A (lower tank, equipped with a valve and two hole plugs)
2. Tank B (upper tank, for water supply and a hole plug)
3. Tank support
4. Water collection container
5. Two water bottles, 2 L each (Not shown in the picture)
6. Siphon pump

7. Stopwatch
8. Beaker
9. Ruler
10. Spirit level (Bubble level)
11. Adjustable support base
12. Towel (Not shown in the picture)

*The towel is for a souvenir, please take it after the exam is over.

Adjusting support level

There are four screw pedal below the plate of adjustable support. You can change the heights each pedal by rotating it.

Siphon pump

If the water container fills up with a lot of water, you can remove it using a siphon pump. Insert the straight hose into the water, and put the flexible hose into the water bottle. Then, by applying force to the red handle, you can transfer the water into the water tank.

NOTE:

Ensure that the adjustable support and tanks are level before starting any measurements so that you can measure the heights correctly.
Empty the collection container regularly to prevent floating of the apparatus.
Dry your hands before writing on the answer sheet or handling other experimental equipment.
Inform a supervisor immediately if leakage, malfunction occurs or losing the hole plug.

C. Experiment

Water discharge through a valve (5 pts)

1. Place the adjustable support base in the water collection container.
2. Set the adjustable support base horizontally by adjusting the screw pedals.
3. Place tank support on the adjustable support.
4. Place tank A on the tank support.

Tank A has three outlets: one diameter 5 mmhole, one 4 mm diameter hole and one 4mm diameter valve.

In part A, use only the valve.

A.1	Measure the internal dimensions of Tank A. Measure the width ,length and the spacing between the height markings on the tank. Note that the marking is from the center of the valve and the holes.	0.5 pt

A.2	Fill Tank A with water to a height of 5.0 cm. Open the valve fully. Measure the time with uncertainty required for the water level to decrease from 5.0 cm to 4.0 cm. Use the mark on the tank for the heights.	1 pt

A.3	Repeat the measurement in A.2 for at least four different initial water heights over 3 cm. At the lower initial heights, for example 1 to 3 cm, it takes too long for the experiment. For each measurement, record your experimental data and average time required for the water level from each height to decrease by 1.0 cm.	1.5 pt

A.4	Find the average speed v_v at which water flows out as it decreases by 1 cm from each initial height. NOTE : You can use a calculator provided.	1 pt

A.5 Assume that the averge speed satisfies 1 pt

$$v_v = C_1 h^x \quad (1)$$

Plot a suitable graph to determine the exponent x. What is the exponent x obtained from your graph?
Note that it is better to use the center value between initial and final heights to determine the exponent x.

Water discharge through a hole (3 pts)

In this part, use the **smaller hole** in tank A, which has a **diameter of 4 mm.**

And the valve used in part A should be closed.

B.1 For at least five different initial water heights h, measure the time required for the water level to decrease by 1.0 cm. 1.5 pt

B.2 Determine the average speed v_h of the water leaving the hole for each initial water height.
Use the same method as in A-4. 0.5 pt

B.3 Compare the average flow speed through the valve $v_v$and through the hole v_h. 1 pt
Assume that, $v_v = C_2 v_h$
Determine the constant C_2.

Construction of a water clock (2 pts)

Construct a water clock using Tanks A and B.

Arrange the tanks as follows:

Tank A (with valve) is placed below. Tank B (with 5 mm hole) is placed above.

Tank B supplies water to Tank A.

Tank A discharges water through the valve which is fully open.

For stable operation, Tank A must remain full or overflowing by the supplied water from tank B.

C.1 Let h_c be the minimum water height from the center of the hole in Tank B required to keep Tank A full or overflowing. Design an experiment by yourself and perform it. Record your experimental data and estimate h_c by your experimental result. 1 pt

C.2	Tank B must be refilled periodically to operate water clock. Design an experiment by yourself.Draw your experiment setup and write what did you measure. Determine the maximum time interval between refills experimentally while maintaining continuous operation of the water clock.	1 pt