EXPERIMENTAL EXAMINATION
Problem A

Capillary rise between two glass plates

1. The problem.

A liquid in contact with air forms an interface resembling a thin elastic membrane. This is characterised by **surface tension**, the tangential surface force per unit length. It explains everyday observations: why can some insects walk on water, and why does clothing wet faster in soapy water than pure water? The aim is to **determine a liquid's surface tension.**

2. Theoretical basis.

Between two glass plates forming a narrow vertical wedge (Figure 1), liquid rises by **capillary action**. Its height is set by equilibrium between weight and the vertical surface-tension force.

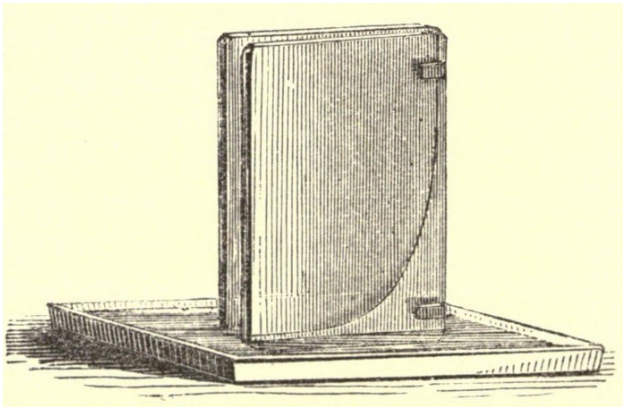


Fig. 1 – From Benjamin Silliman's 1860 general-physics text, Principles of physics: or, Natural philosophy; designed for the use of colleges and schools.

For a thin fluid column of height y and width Δx (Figure 2), the vertical force F is $F = \gamma \Delta x$, where γ is surface tension. Balancing it against the fluid's weight gives the following relation between height y and distance x from the wedge vertex (Figure 3):

$$y = \left(\frac{2\gamma L}{\rho a g} \right) \frac{1}{x}$$

where $\rho = 1{,}00 \times 10^3$ kg/m^3 is the liquid density, $g = 9{,}8$ m/s^2 is gravitational acceleration, and a is the plate separation at $x = L$.

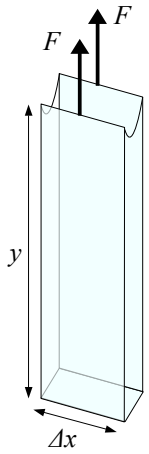


Fig. 2 – Liquid column

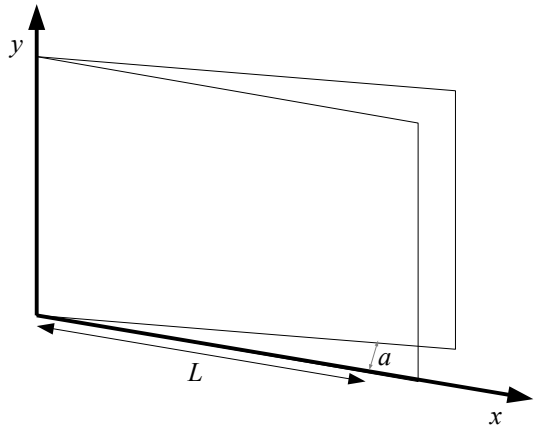


Fig. 3 – Wedge formed by the glass plates.

3. Equipment:

- 2 glass plates.
- 1 metal spacer of thickness $a = (1{,}20 \pm 0{,}05)$ mm.
- 4 paper clips.
- 1 gridded transparency (acetate). Take the grid spacing as 1 mm.
- 1 marker pen.
- Tray.
- Small amount of coloured liquid.
- Graph paper.
- Ruler.

4. Procedure.

Build the wedge in Figure 1 with the metal spacer between the plates at the right-hand vertical edge. Clip the plates and transparency together with the lower and left edges **exactly** aligned, so x and y can be measured.

Place the clips so the assembly stands vertically and stably on the tray.

Pour a little liquid into the tray and place the assembly on it so liquid can rise between the plates.

Wait about five minutes for the level to form a curve like Figure 1. If irregularities occur, gently press the plates briefly. Once a clear curve forms, mark the transparency and measure liquid height from $x = 3$ cm onward.

5. Precautions

- Handle the glass very carefully.
- Do not touch the inner plate surfaces. Dirt can affect capillary rise.

- Avoid moving the table and disturbing other participants' experiments.

6. At the end, submit:

1) Measurement table and gridded transparency (dry it carefully with paper towel). (3 points)

2) Data analysis and graph. (3 points)

3) Surface tension with its uncertainty. (4 points)

Final instruction: Leave the equipment as you received it.

EXPERIMENTAL EXAMINATION: Problem B

The grey box RxCx

1. The problem.

A sealed box contains a capacitor and a resistor. Determine whether they are connected in series or parallel and find capacitance C_x and resistance R_x.

2. Equipment:

- Sealed grey box with red and black leads.
- Holder with four 1,5 V AA cells.
- Multimeter of internal resistance $1{,}00\,M\,\Omega$, usable only as a voltmeter.
- Digital stopwatch.
- Two crocodile leads (red and black).
- Resistors: $100\,k\,\Omega$ (brown–black–yellow–gold), $220\,k\,\Omega$ (red–red–yellow–gold), $470\,k\,\Omega$ (yellow–violet–yellow–gold).
- Graph paper.

3. Procedure

Determine the capacitor-discharge time constant using circuits made with the supplied resistors. *Suggestions:*

- In an RC circuit, voltage decays exponentially, $V(t)=V_0 e^{-t/\tau}$, with $\tau = RC$.
- In experimental physics, a functional relation is usually established by taking several measurements of both variables.

4. Precautions

- A few seconds connected to the source is enough to charge the capacitor. *Always join red to red and black to black.*
- Use the multimeter *only as a voltmeter*. Other modes risk damage and their measurements will not be marked.

5. At the end of the examination

1) State whether the circuit is series or parallel; justify your answer and include diagrams of the circuits used. (4 points)
2) Provide measurement tables and corresponding graphs. (3 points)
3) Determine R_x and C_x; uncertainty analysis is not required. (3 points)

Final instruction: Leave the equipment as you received it.