# Problem № 10
# «Greenhouse»

***Team «12FM»***

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# The task

A hot object placed in the open air would gradually cool down. We can slow down this process by containing the object in a greenhouse. Compare different mechanisms of heat loss by the object and explain how the presence of a greenhouse affects them.

# Hypothesis

If we consider all of the heat transfer peculiarities while cooling of hot water, we can slow down this process and keep the warmth longer.

# Aim of the study

To conduct experimental comparison of different mechanisms of water heat transfer using greenhouses of different constructions.

# Objectives

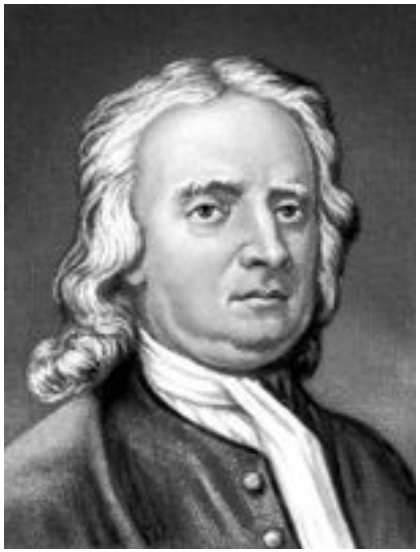
- To study scientific materials on the research
- To identify the dependence between the temperature of water during its cooling and the time.
- To observe the external factors effects on the liquid cooling speed. To simulate the phenomenon being studied.
- To create greenhouses with different constructions and measure the liquid cooling speed.
- To explain the effects of greenhouse presence on the heat loss on the experimental and theoretical basis.

# Theory

**The equation, which describes the dependence between cooling speed and temperature change of a heated body and its environment**

$$\frac{\Delta Q}{\Delta t} = \alpha \cdot A \cdot (T_S - T)$$

$\Delta Q/\Delta t$ — cooling speed, A — body surface area, throughout which the heat is being transferred, T — body temperature, $T_S$ — environmental temperature, $\alpha$ — heat transfer coefficient.



***Isaac Newton 4.01.1643 – 31.03.1727 , English mathematician, physicist, alchemist***

***Georg Richmann 22.07.1711 — 8.08.1753, Russian physicist***

***Considering that heat quantity is*** **$\Delta Q = cm\Delta t$, we get the following form**

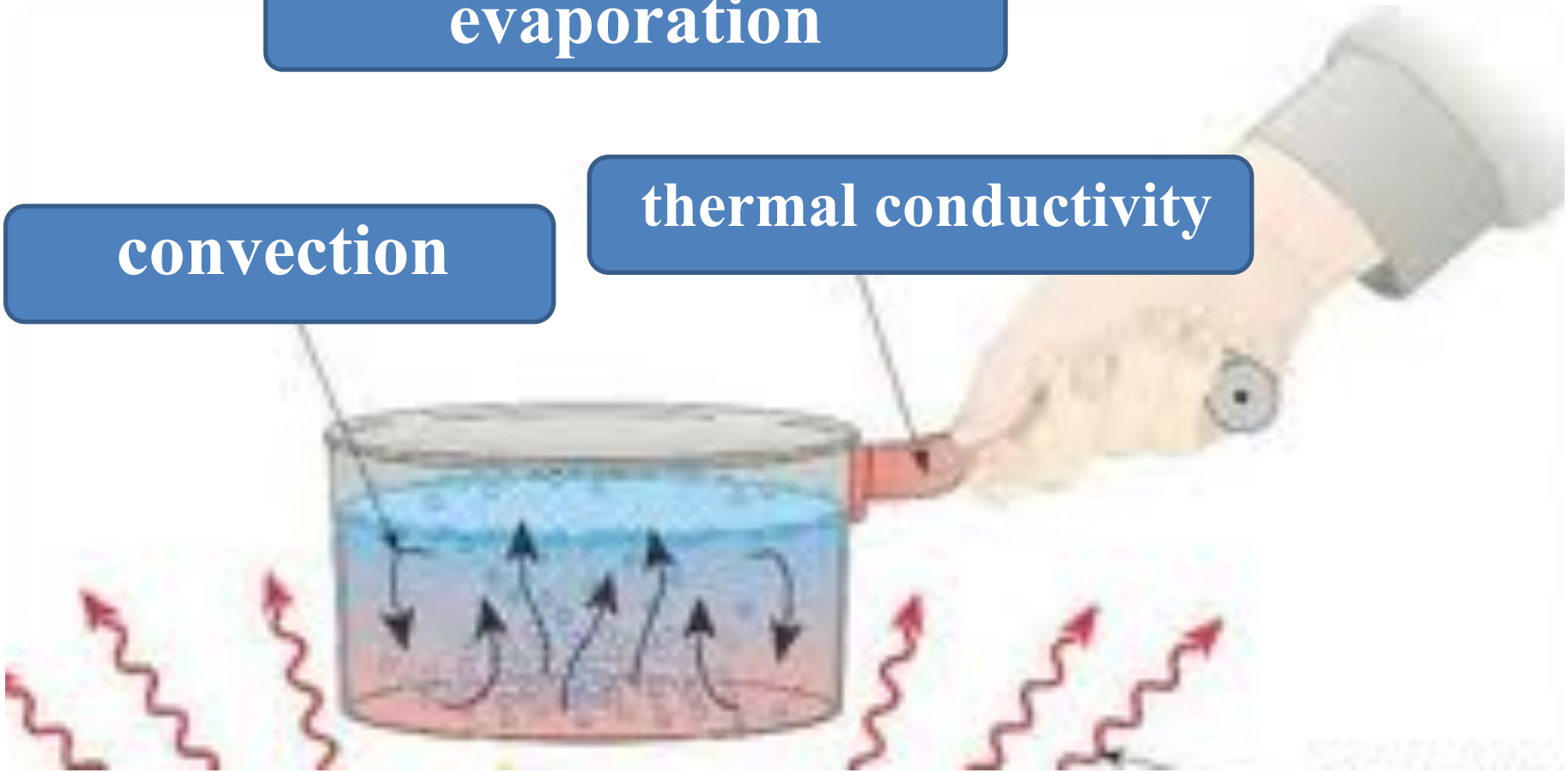
$$\frac{\Delta T}{\Delta t} = \frac{\alpha \cdot A}{C}(T_S - T) = k(T_s - T)$$

# Theory

evaporation

convection

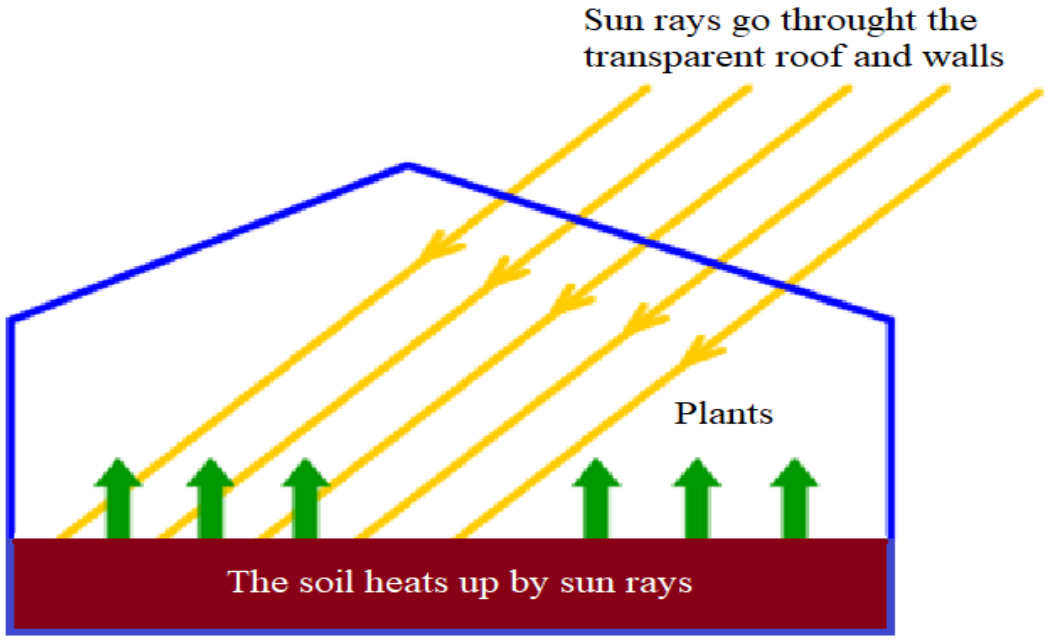
thermal conductivity



radiation

# Theory

**Greenhouse** - a covered structure that protects the plants from extensive external climate conditions and diseases, creates optimal growth microenvironment, and offers a flexible solution for sustainable and efficient year-round cultivation.




Infrared radiation, which is emanating from the sun and heating pipes, warms the plants and soil inside the greenhouse. The air heated from the inner surface is held inside the structure by a roof and walls.

# Experiment 1

**Purpose:** to define the dependence between the temperature change and the type of greenhouse cover.

**Equipment:** 4 plastic containers, 5 cups with the volume of 30 ml, plastic cup, foil, black marker, temperature sensors NOVA, kettle.

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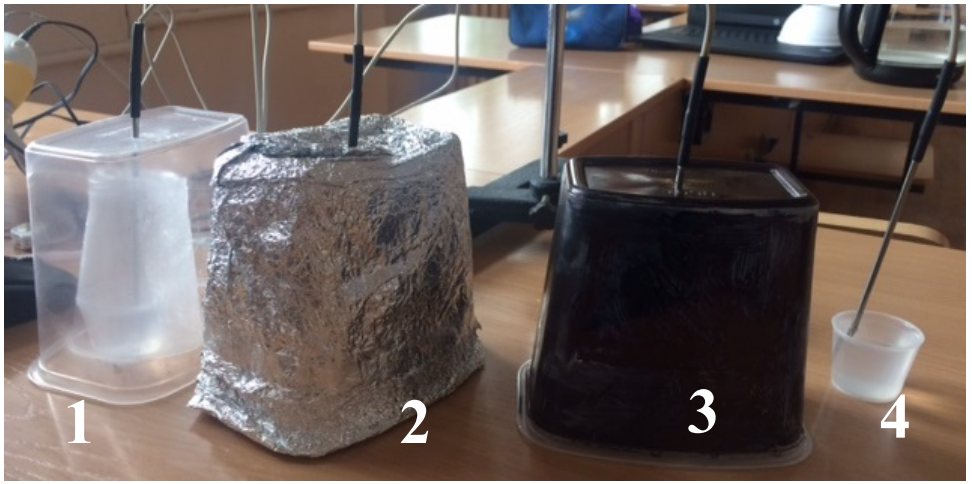
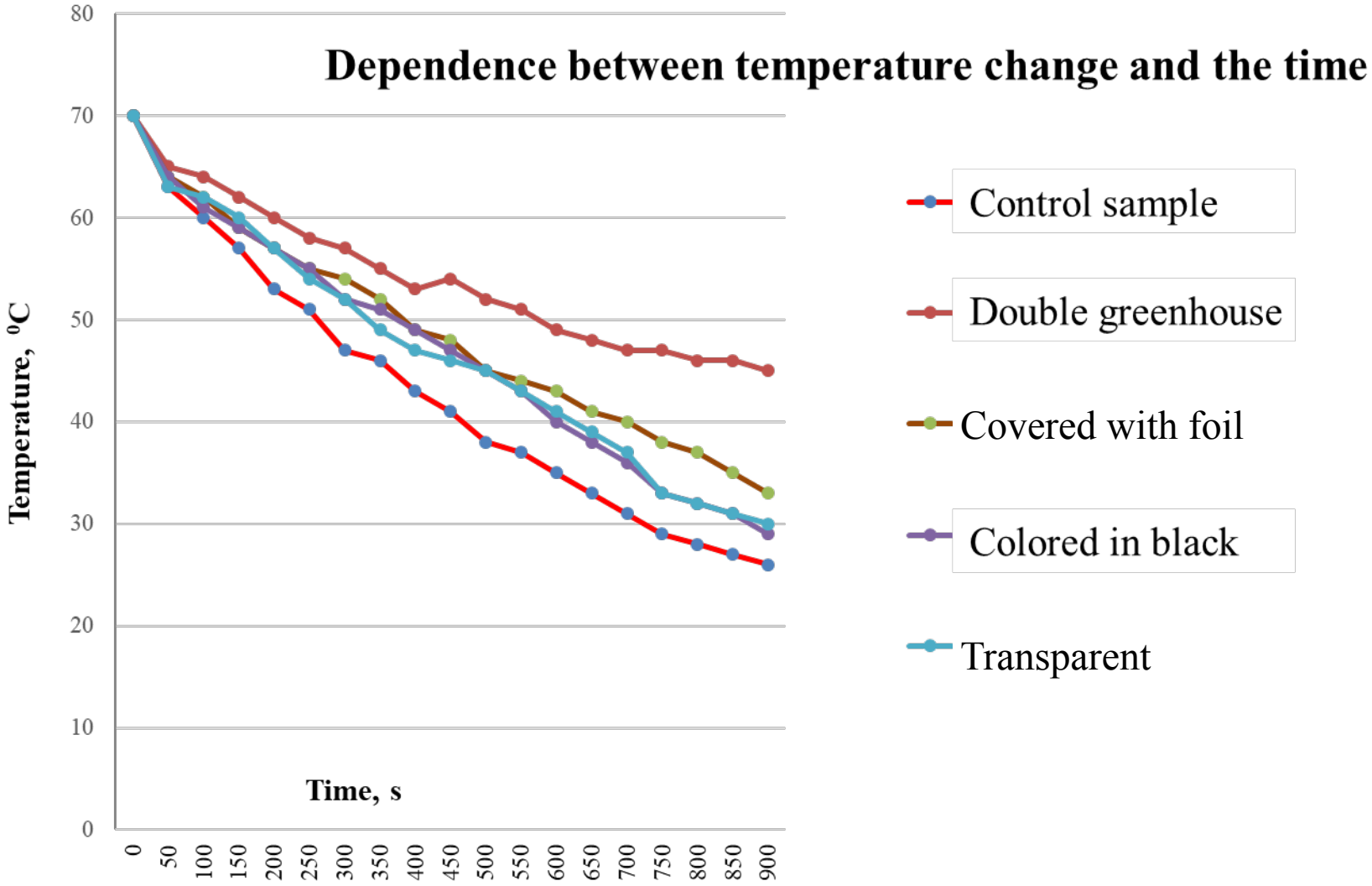


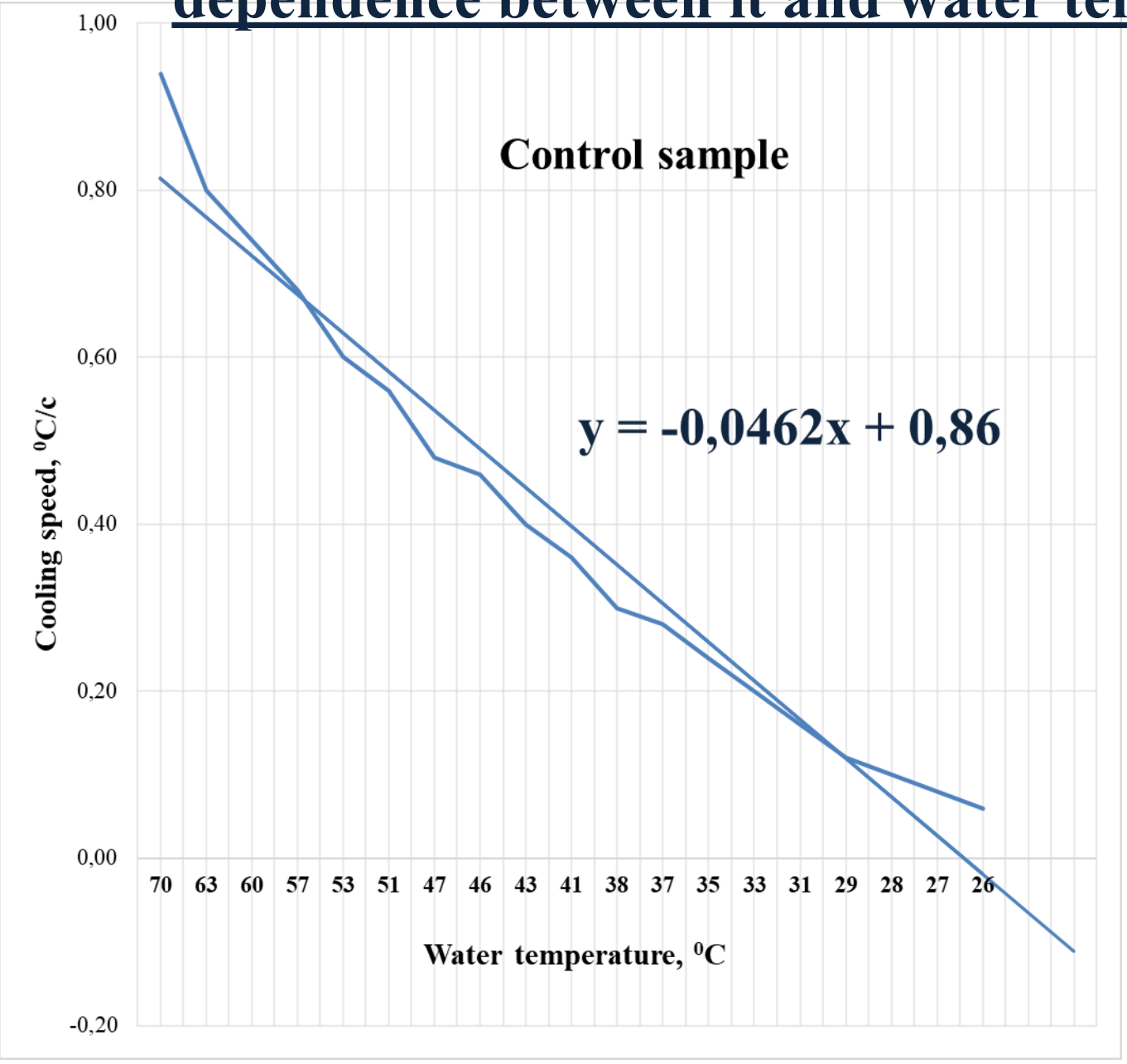

***1 – double plastic container;***
***2 – covered with foil container;***
***3 – colored in black container;***
***4– control sample.***

# Experiment 1

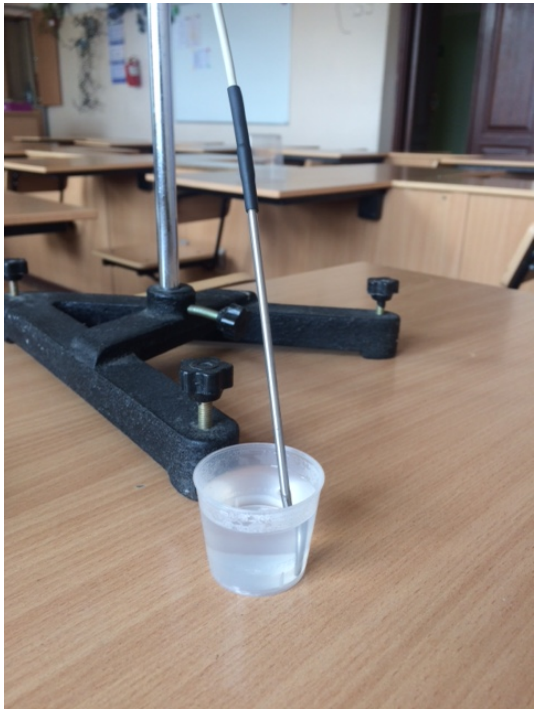



**Conclusion:** placing hot water inside the greenhouse will slow down the process of temperature change, especially, if the green house has double wall structure.

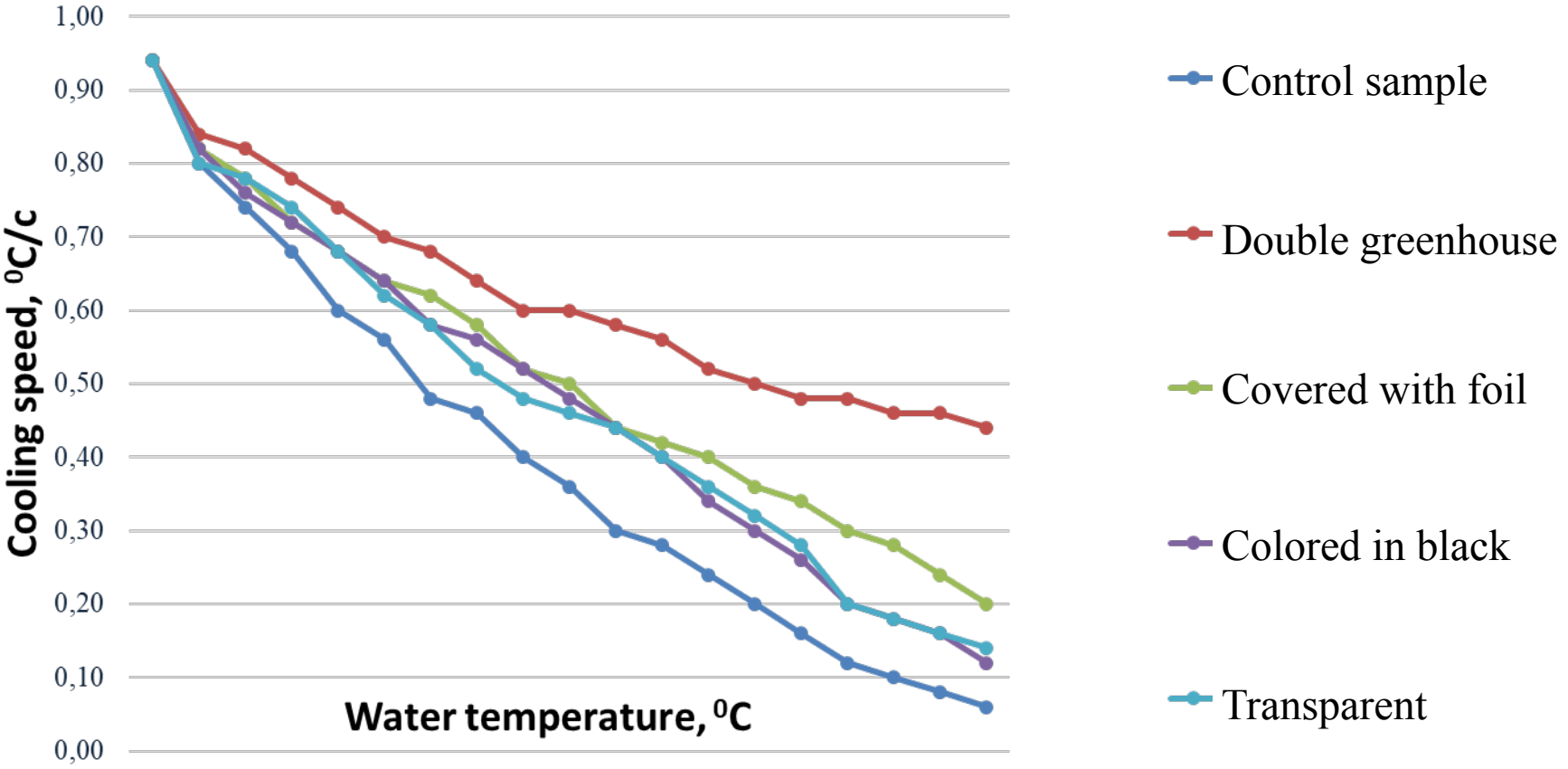
# Calculation of cooling speed and defining the dependence between it and water temperature.




$$\frac{\Delta T}{\Delta t} = k \cdot T_S - k \cdot T$$



# Calculation of cooling speed and defining the dependence between it and water temperature.

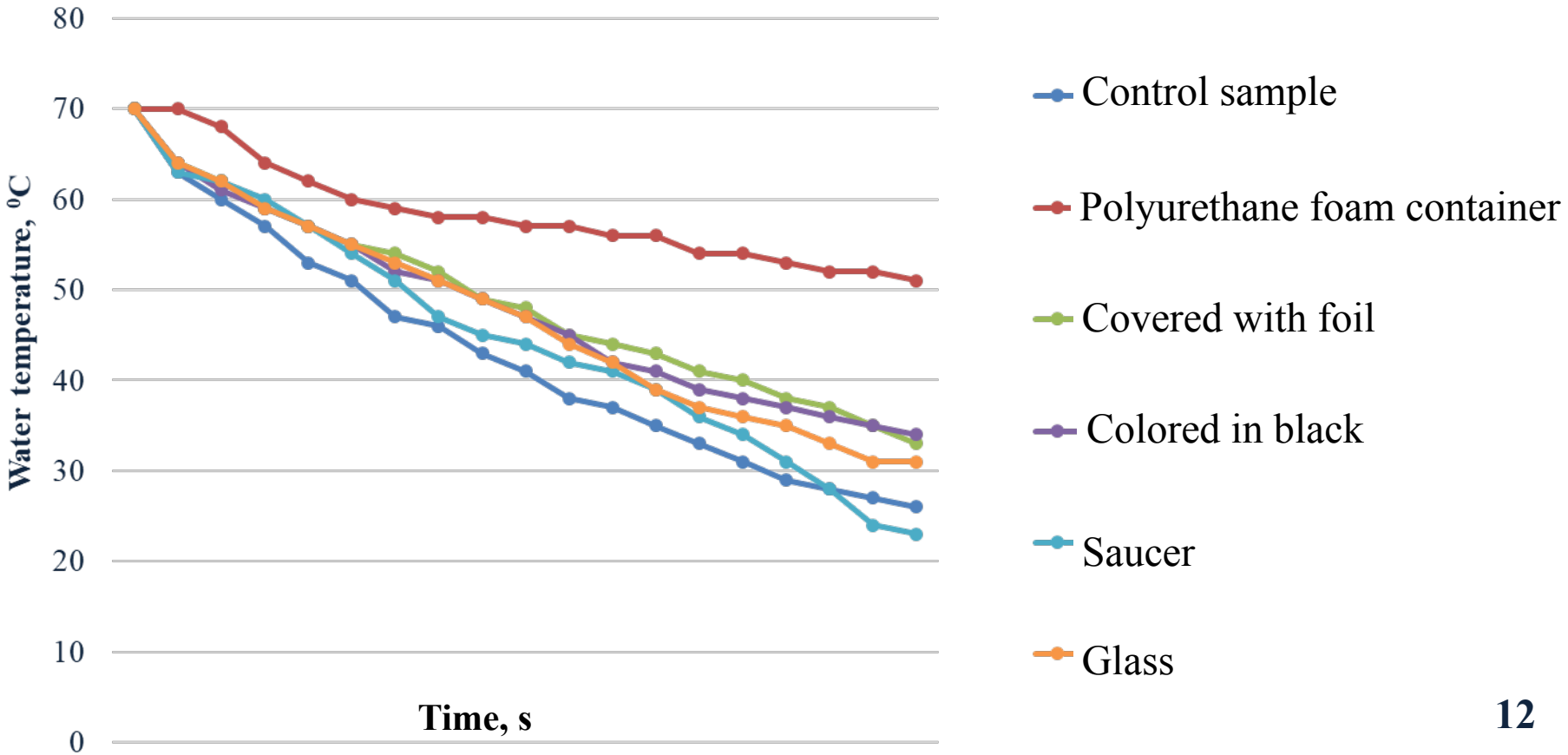



| Control sample | Double container | Covered with foil | Colored in black | Transparent container |
|---|---|---|---|---|
| - 0,0462 | - 0,0256 | - 0,0372 | - 0,0419 | - 0,0428 |

# Experiment 2

**Purpose:** to determine the dependence between the water cooling speed and the container peculiarities .

**Equipment:** plastic containers(covered with foil, colored in black, polyurethane foam container), saucer cups with volume of 30ml, kettle, temperature sensors NOVA;



# Experiment 2

**Conclusions:**

- In comparison with the ordinary plastic glass of water, expanding the water free area leads to convection and evaporation role increasing.
- We can increase the cooling speed by coloring the container walls into black. This process will increase the heat loss by radiation. To decrease it we can cover the walls with the foil.
- If we cover the container by the roof we will decrease the convection and evaporation role, so that the cooling speed decreases.
- Thermal insulation of the container walls and bottom also decreases thermal exchange and heat loss.

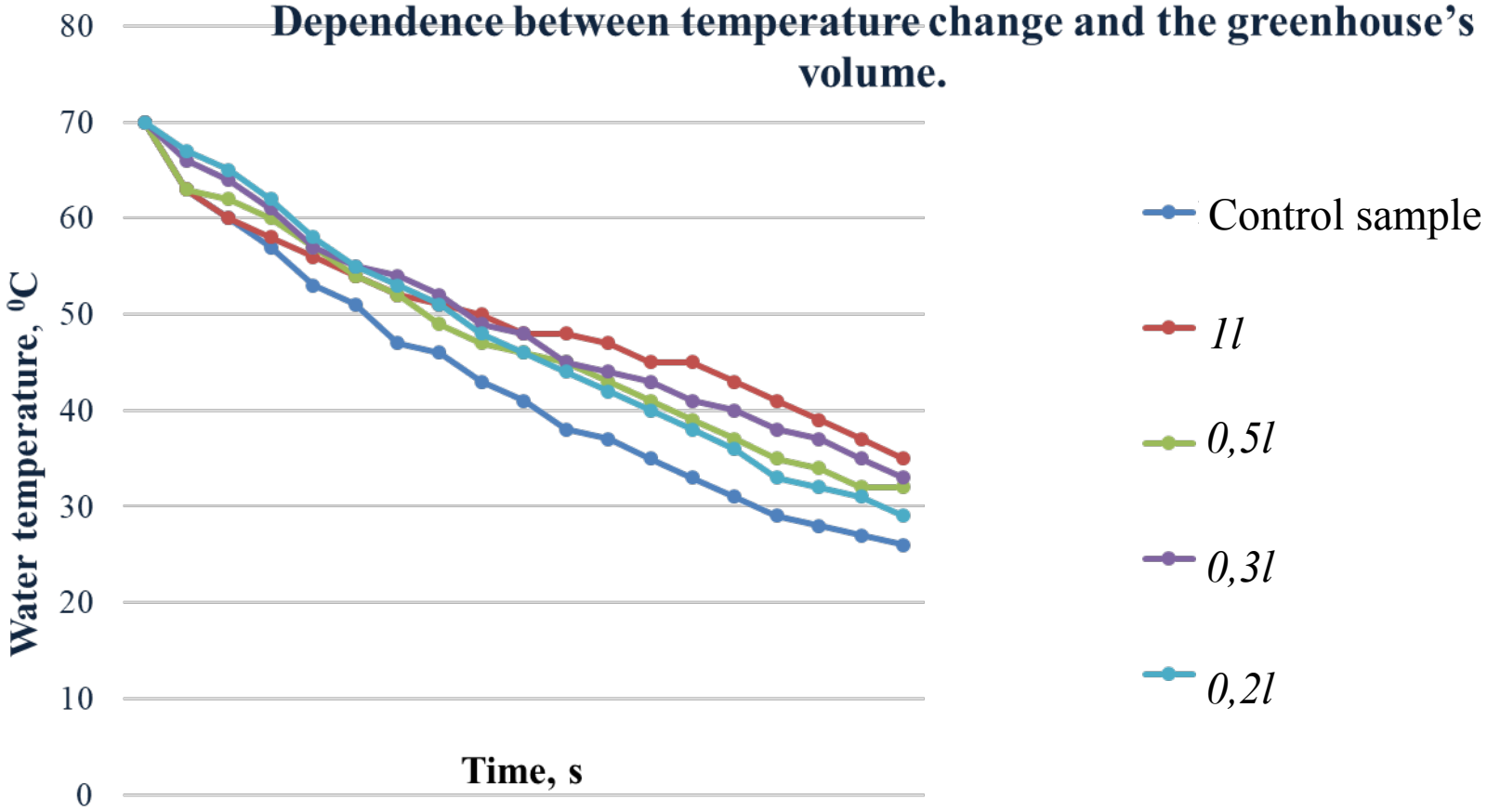
# Experiment 3

**Purpose:** to determine the dependence between the cooling speed and the greenhouses' size.

**Equipment**: plastic containers with volume of 0,2; 0,3, 0,5 and 1 liters, cups with volume of 30 ml, kettle, temperature sensors NOVA.

***Containers that were used in the experiment.***

# Experiment 3




**Conclusion:** cooling goes faster in big container at the beginning of observation and then slows down. It can be explained that way: big greenhouse contains more air inside, so the water has to give away more heat, but then, when the air is totally heated, it starts to isolate the water from environment, so the cooling speed decreases.

# Conclusions

- Exponential dependences, which can be theoretically explained, were defined.
- Proportional coefficients were determined; it was proved that the bigger the coefficient, the faster water cools.
- It was found out that, in comparison with a conventional glass of water, an increase in the area of the free surface in several times leads to an increase in the role of convection and evaporation. To increase the speed of cooling we can change the color of the walls to black, to reduce - cover with foil. This affects the heat loss by radiation. If you cover the glass with a lid and reduce convection and evaporation, the cooling speed will decrease. Thermal insulation of the walls and bottom of the cup reduces the thermal conductivity and significantly reduces losses.
- We found out that cooling speed increases, if increase the volume of water and free cooling area.

# References


- https://ru.wikipedia.org/wiki/%D0%A2%D0%B5%D0%BF%D0%BB%D0%B8%D1%86%D0%B0
- https://ru.wikipedia.org/wiki/%D0%9F%D0%B0%D1%80%D0%BD%D0%B8%D0%BA
- http://fb.ru/article/181474/vidyi-teplits-i-ih-konstruktsii-foto#image736060
- https://geektimes.ru/post/246716/
- http://panoramov.livejournal.com/87459.html

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