Closed greenhouses – teacher guide

Abstract

The purpose of a greenhouse is to regulate the climate (temperature and light) for growing plants. Light is generated by the sun as well as by additional lamps, this also generates heat. The temperature can rise significantly if there is direct sunlight on the greenhouse. If it gets too hot inside, windows can be opened and much of the heat will disappear. As a result, most greenhouses are not very energy efficient. The latest development is the closed greenhouse, where the windows are always closed. It has a heating system that can also generate electricity and a way to use groundwater for cooling. Students work on the problem: how, under changing weather conditions, can you regulate the climate (temperature and light) in a closed greenhouse so that energy costs are as low as possible.

Discipline: Mathematics
Duration: 480 minutes
Target Group: upper secondary school
Age range: 15 - 18

WoW context: Horticulturist in greenhouses

Introduce the context of the closed greenhouses. You may use the pictures and text from the assignment or you can show a video on (closed) greenhouse – these can be found on the internet.

Student task

Students design a model and investigate how, under changing weather conditions, they can regulate the climate (temperature and light) in a closed greenhouse so that energy costs are as low as possible.

Extra information

This task was originally designed for the mathematics A-lympiad: a real-world-mathematics-problem-solving competition for teams of students from upper secondary schools. The open assignments are designed by the A-lympiad committee, a committee residing at the Freudenthal Institute of Utrecht University in the Netherlands, that organizes the Mathematics A-lympiad since 1989. The aim is to elicit students to think mathematically, to solve open-ended unfamiliar problems in a creative way, to model, structure and represent problems and solutions, to work collaboratively and to communicate about mathematics. The task is set in a non-mathematical real life (often work related) situation that asks for mathematical modelling and problem solving. The final product is a report fitting the real-life context of the task. These reports are assessed by taking into account:

- The completeness and correctness of the answers for the various parts;
- the representation of calculations and the method used;

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- the use of math;
- the argumentation and the justifications of choices and decisions;
- the depth to which the various assignments have been answered;
- originality and creativity in methods and solutions;
- elements like: lay-out, readability, language, illustrations etc..

Lesson plan example:

Because the assignment is originally meant for a competition the role of the teacher can be limited to giving guidance on the planning and the group-processes. In a regular classroom setting the teacher may of course decide to build in opportunities for classroom discussions, reflection or clarification.

15 min Acquaint your students with the WoW context by using the introduction to the assignment (see student worksheet). You may also use other materials such as video's related to the WoW-context or a presentation by a vocational specialist.

15 min Talk to students about the way to work on the assignments. This can also be found on the first page of the assignment.

- First read the full text of the assignment so you will know what you have to do in the seven hours you have for this assignment.
- Divide tasks where possible and consult in your group when needed.
- Keep an eye on the time when you work on the different parts.
- Be sure to have enough time left to draw up the report and prepare for the presentation

400 min Students work for about 7 lessons in teams of 3 or 4 on the tasks in the assignment. You may want to build in some classroom discussions to reflect on the process and discuss issues.

Allow about 5 hours for the introductory tasks and final assignment 1. Final assignment 1 should be finished before the data for final assignment 2 are presented to the students.

Allow about 2 hours for final assignment 2 and the design of the presentation. For assignment 2 additional information is needed. This is available at the end of this document as appendix 1.

60 min In a plenary session, students present their results.

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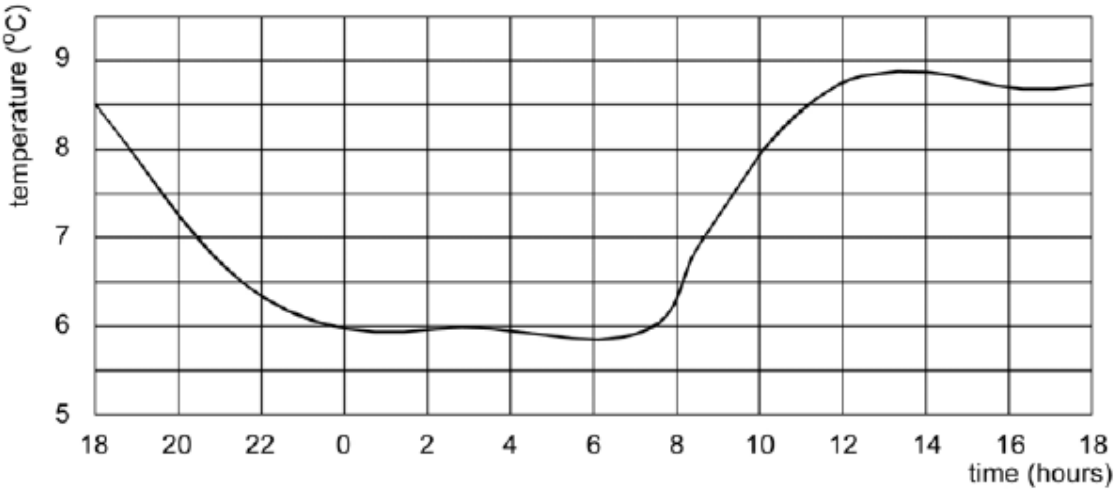
Appendix 1

A day in October



Sunrise: 7.53 h
Sunset: 19:01 h

It was raining all day long. One of these boring autumn days that we know so well in the Netherlands.

At the moment the greenhouse is used for an experiment to grow a special kind of Japanese pear: the Nashi. The temperature is kept at 25 °C. Because it is an experiment, the grower tries to keep this temperature as steady as possible. The Nashi pear needs a lot of light.

The start temperature at 18.00 h in the greenhouse is 25 °C.

梨 (NASHI)

Author: *Mathem*

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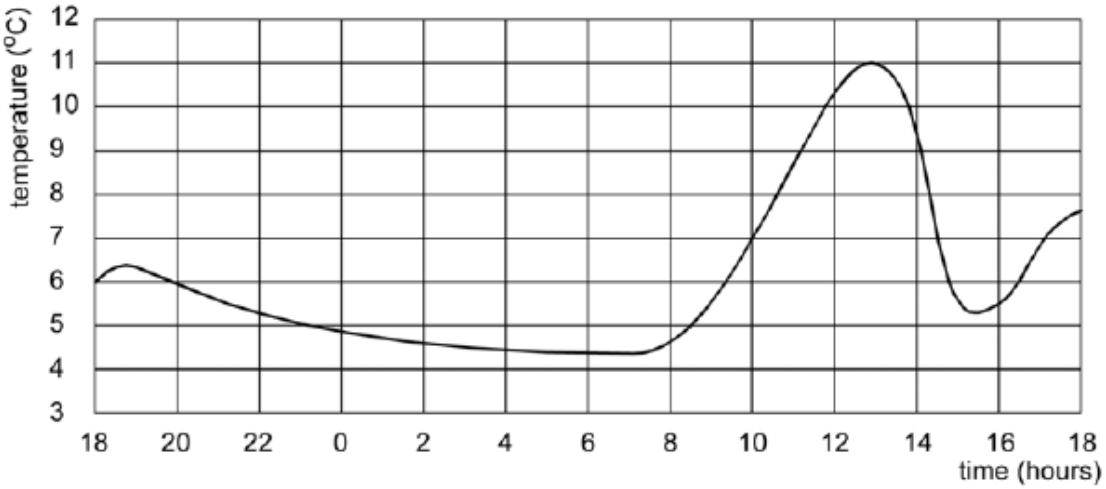
A stormy day in March



Sunrise: 7.01 h
Sunset: 18:40 h

After a quiet night a sunny morning followed. At 13.00 h a severe depression with heavy weather and thunderstorms reached the country. After two hours the weather calmed down and even the sun returned for the rest of the day.

Another Japanese fruit, the Biwa, is grown in the greenhouse. In Japan it is an autumn fruit, so the temperature may vary from 15 °C to 25 °C. The Biwa also needs a lot of light.

The start temperature at 18.00 h in the greenhouse is 25 °C.

枇杷 (BIWA)

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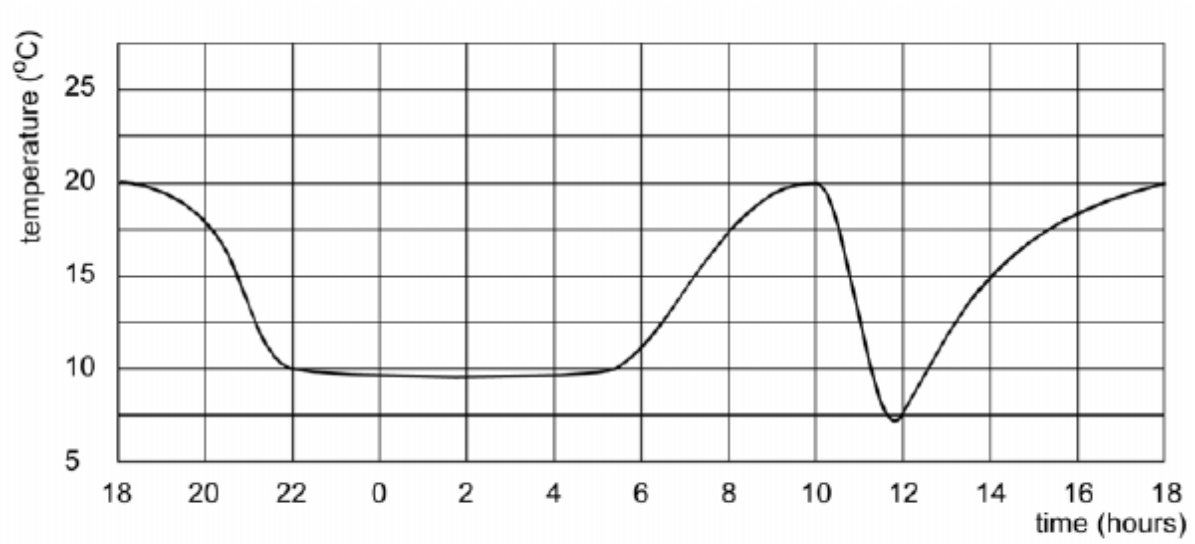
An unstable day in May



Sunrise: 5.27 h
Sunset: 21.48 h

After a humid day a thunderstorm occurred at 20.00. This resulted in a relative cold night, followed by a sunny morning. But at 10.00 h another thunderstorm occurred . Fortunately, at noon the nice spring weather returned.

The Gooya, a cucumber like vegetable from Okinawa, the southern part of Japan, is growing in the greenhouse. The Gooya doesn't really have a preferred constant temperature; biologists think it grows best when there is a certain fluctuation in night and day temperature. In the greenhouse this is simulated with a difference between night and day temperature of 10 °C.

The start temperature at 18.00 h in the greenhouse is 25 °C.

ゴーヤ（GOOYA）

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