

PHYSICS

Cooling Hot Buildings

Subject Area: Physics students **Grade Levels:** 11 - 12 **Date:** October, 2009

ACE students

10 -12

Lesson Overview

The students will verify through experimentation that moist, humid air is cooled more efficiently than dry, arid air. The report of the experiment will be presented in a power point, including pictures of the experiment setup and graphs of the data analysis.

Materials Included in this Lesson

- PASCO Scientific Equipment – humidity and temperature probes
- PASCO software for data analysis and graphs

Other Materials for this Lesson

- Refrigerant coils, hair dryer
- Notebook, Physics Textbook
- Meters to measure electricity consumption
- computer research on cooling systems and energy efficiency

Skills the Student will Learn

- Correct use of PASCO Scientific Equipment
- Procedures for determining the humidity of air
- Ability to follow experiment set-up and procedures
- Use PASCO software to analyze and graph data

Student Deliverables

- Power point Presentation which will include pictures of experiment set-up and graphs of data analysis
- Story board of cooling systems research and experiment results

Length of Lesson: 3 Days

Activity Day One

Students will be assigned a homework research project:

- How air conditioning systems function
- What are the various ways in which air can be cooled
- What are the energy efficiencies of each type of cooling system
- What is the energy required for an average home (2000 sq. ft.), both gas and electric

Activity Day Two

Students will conduct the experiment.

- Begin with set-up of equipment: PASCO humidity and temperature probes, refrigerant coils, hairdryer, container of water, analog and digital meters to measure electricity consumption
- **TRIAL 1:** Students will first measure changes in the air humidity and temperature from the hair dryer passing over refrigerant coils, by placing probes between the dryer and the coil and on the other side of the coil; the hair dryer will be in a circuit with an analog or digital meter to measure voltage and amperage; the data will be collected for 3 minutes
- **TRIAL 2:** Students will repeat the procedure now using water to cool the coil
- Data from the probes will be entered into PASCO software and graphed
- Students will analyze the cooling rates of each trial: temperature vs. time, humidity vs. time; data from the meters will be analyzed to determine the efficiency of each process
- The experiment's report will be written in their lab notebooks

Activity Day Three

Students will, as a homework assignment, create a power point presentation of the experiment. The presentation will include pictures of students conducting the experiment, graphs of their data, results and conclusions of the experiment.

Enrichment Suggestions

Enrichment suggestions: Students can explore the green energy solutions to home cooling systems, manufacturers of new technology, skills necessary for installation of cooling systems.

Student Resources

Comfort Zone – Beutler’s Home Technology Showroom (now open to the public), internet

State Standards Met

Investigation and Experimentation Standards

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

- a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
 - 1. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

PHYSICS – Heat and Thermodynamics

- 3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:
 - 3a. Students know heat flow and work are two forms of energy transfer between systems.
 - 3g. Students know how to solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.

Lesson Plan Relevance To Externship

What is needed in central California and the southwest is an energy efficient means of cooling homes and businesses in hot climates. Being able to reduce cooling costs, reduce energy demand and yet remain comfortable in our homes and businesses is critical in the current economic circumstances. At Beutler Corporation, I was shown a new “Ultra-Efficient Evaporative Condensing System” called AquaChill; this air conditioner is manufactured at their McClellan facility.

I decided to try to design an experiment that would demonstrate the heat and thermodynamic principles underlying the idea of how water cooled air is more efficient than ambient cooled air. In addition to the design of the experiment, additional background information for students to explore would include the skills needed to work in sheet-metal manufacturing, assembly and delivery of products, HVAC systems installation, maintenance and repair.

Rubric for the Cooling Hot Buildings Experiment

Student Deliverables	4 Exceeds Expectations	3 Meets Expectations	2 Approaches Expectations	1 Fails to meet Expectations
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Research	Stds. able to produce completed research on time, all questions are answered, few text errors	Stds. able to produce research on time, most questions answered, some text errors	Stds. not able to produce work on time or few questions answered, multiple text errors	Stds. fail to produce research and/or are unable to adequately answer questions
Experiment	Stds. able to work with their team, independently assembling equipment, conducting experiment in a safe manner, replacing all equipment when done, writing report in lab books	Stds. able to work with their team, but need some assistance assembling equipment, need reminders to stay on task, conducting experiment in a safe manner, replacing all equipment when done, writing report in lab books	Stds. not able to work with their team, need significant amount of assistance in assembling equipment, need reminders to follow safety procedures, neglect to replace equipment, uncompleted report in lab books	Stds. unable to work as a team, unable to assemble equipment, do not follow safety procedures, forced to stop lab because of inappropriate behaviour
Power Point presentation and/or storyboard	Stds. team produces presentation, meeting deadlines, includes pictures from the lab experiment, graphs from the data analysis are well designed. The summary is well written, containing references to the research, and reaches a supported conclusion	Stds. team produces presentation, meeting deadlines, may not include pictures from the lab experiment, graphs from the data analysis are adequate. The summary contains errors, may not contain references to the research, and reaches a supported conclusion	Stds. team produces presentation, may not meet deadlines, may not have pictures from the lab experiment, graphs may not have appropriate scales or data is missing. The summary contains errors, may not have research references.	STDS. team does not produce a presentation because they were unable to finish the experiment.

Water-Cooled Air

by

Ellen Hoffmann

River City High School

Physics students at River City High School conducted an experiment testing the theory that water is an effective means of cooling hot air.

Theoretical Background

Every substance has a unique value of specific heat capacity. This value is defined as the amount of heat energy (joules) needed to raise or lower the temperature of 1 kilogram a substance by 1° Celsius.

Water has the highest value of specific heat capacity.



For the purposes of heating and cooling systems, water is an excellent “heat sink”. The unique nature of water allows it to absorb and store large amounts of heat energy.



Inspiration for this experiment came from viewing the patent-pending “AquaChill” Ultra-Efficient Evaporative Condensing System at the **Beutler Corporation**.

The AquaChill is an innovative air conditioner designed for home use.



7 groups of students volunteered to come after school and conduct the “Water-Cooled Air” experiment.

The trials were designed to use hair dryers (source of hot air) to blow across a screen (or fin) of water. In theory, the water should absorb heat energy from the heated air, thus producing cooler air on the other side of the screen. Thermometers were placed on both sides of the water screen.



The data was digitally recorded using PASCO Scientific equipment and software. Both temperatures were simultaneously graphed as a function of temperature versus time.

The initial experimental trials failed to yield the theoretically expected results. Students who were unable to attend the afternoon session expressed disappointment at missing this opportunity. The entire class was enlisted the next day to repeat the experiment, with modifications to the design.



Of the second round of trials, one group was able to successfully conduct the experiment. These students were adept at the art of improvisation, and employed the adage that necessity is the mother of invention. They are here with us tonight to share their success:

Sarah Aguilar

Monica Anaya

Fowzia Atebar

Thomas Thao



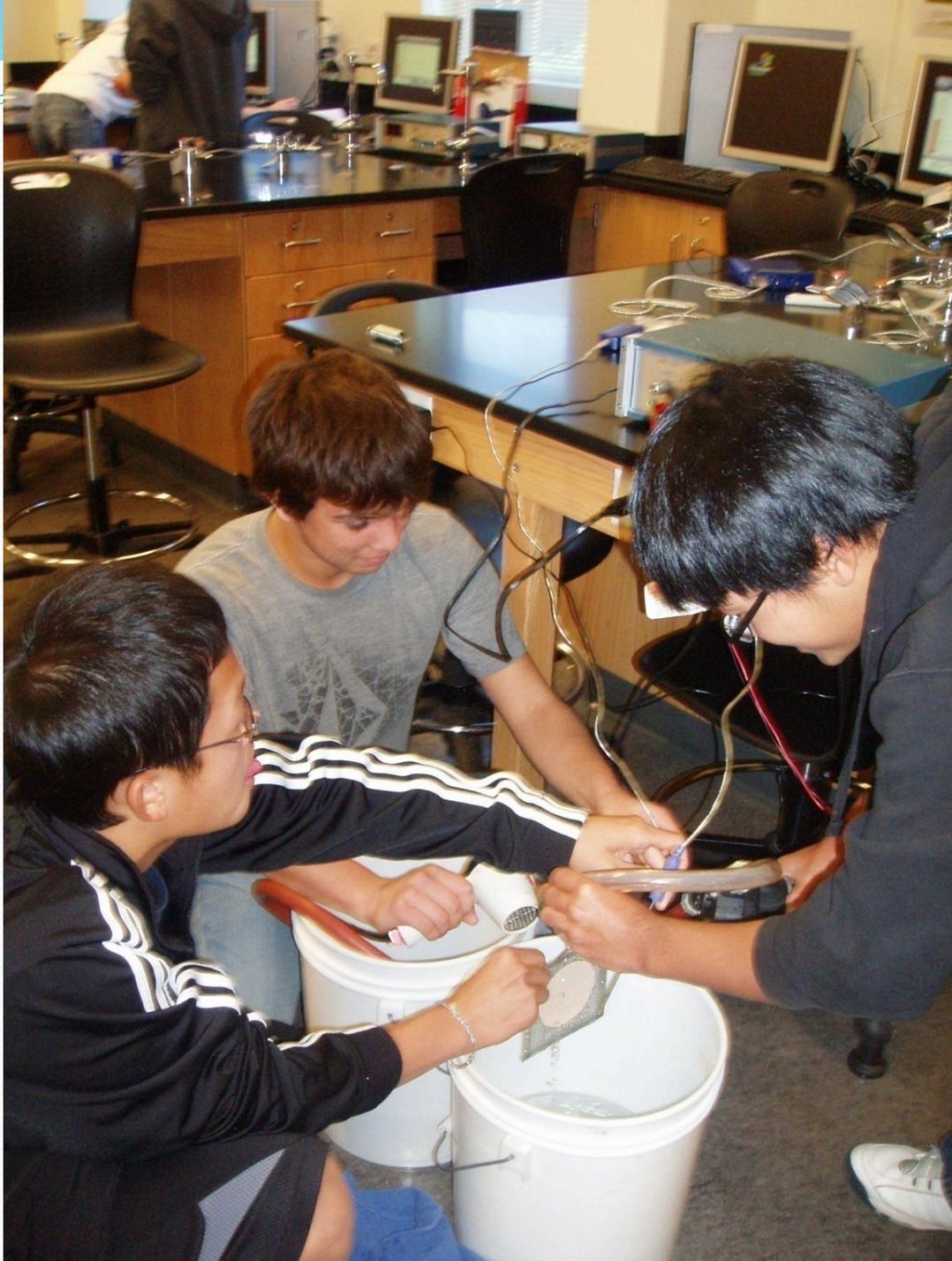
EXIT



MOSMET MULTIMETER MODEL 5000

DIGITAL MULTIMETER MODEL 5000A













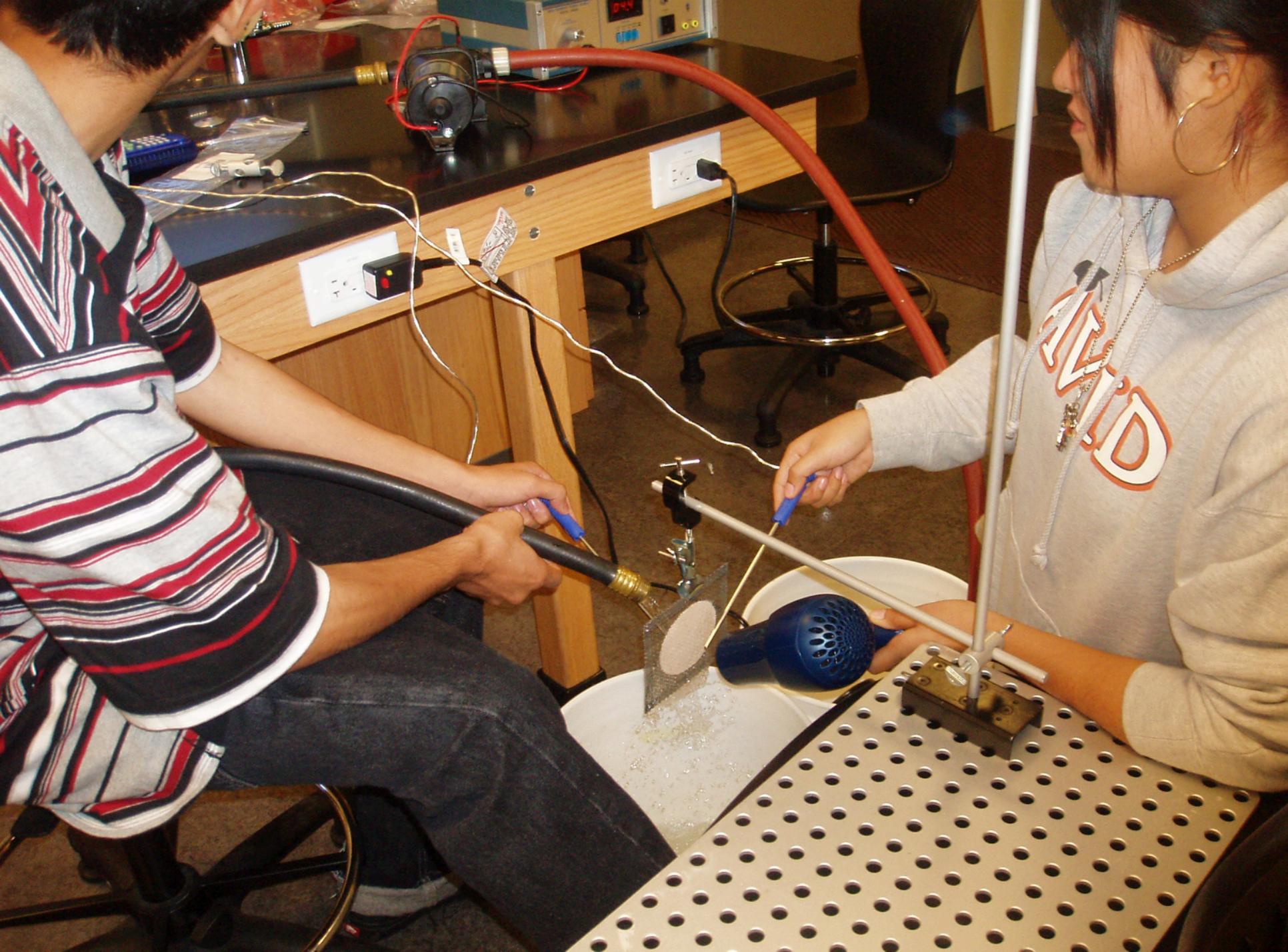








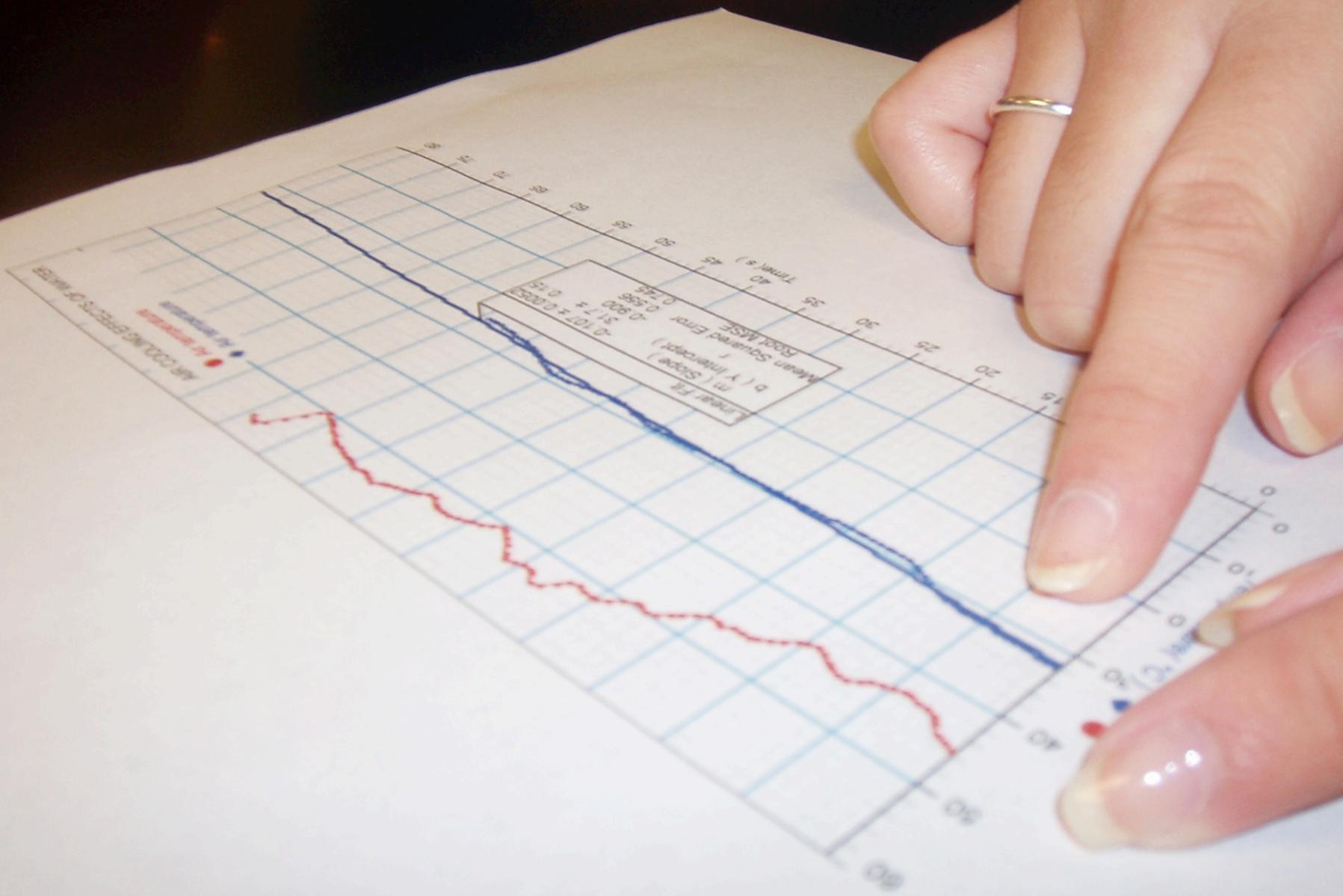












The Result

The graph of the data in this experiment verifies that water can quickly and effectively cool hot air. The cooling rate in this graph is

0.9°C per minute