

**Physics Education
Laboratory
Lecture 11
PCK for Thermodynamics**

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Demonstrative experiment

A demonstrative experiment is an experiment that students watch when they are involved in the study of a phenomenon already explained. Thus, they do not make any measurements, nor they do not make predictions, nor make comparative analysis between measurements and prediction. Students do not construct by their own any qualitative or quantitative relationship.

Observation experiment

An observational experiment is an experiment that students perform when they are investigating a new phenomenon. Thus, they do not make predictions or have expectations about its outcome. Students need to collect data, analyze them and find a pattern in the data. They then need to explain the reasons for the pattern (if applicable), and/or construct a qualitative or quantitative relationship.

Testing experiment

In a testing experiment, students use an explanation or relationship to make a prediction of the outcome of the experiment. They also decide what additional assumptions they are making. Then they perform the experiment, and record the outcome. Based on the (dis)agreement of the prediction and the experimental outcome, and taking into account theoretical assumptions and experimental uncertainties, students have to make a judgment about the explanation or relationship that they are testing.

Students learn that when their prediction agrees with the experimental outcome, it only means that the explanation/relationship cannot be rejected. On the other hand, if their prediction does not agree with the experimental outcome, they have to either reject the explanation/relationship they tested, or reconsider the additional assumptions they made. Thus, the emphasis is on trying to disprove an idea

Application experiment

An application experiment typically involves solving a practical problem or determining an unknown quantity by performing experiments.

Students need to solve these experimental problems using at least two different methods and then compare the results. Often they need to perform additional experiments or make informed estimates to determine some physical quantities.

Video problems as Application experiment

A video problem is a subset of the category “application experiment”. From each video one can determine a physical quantity such as the coefficient of friction between two surfaces, the height of a table, etc. . . by two independent methods. The results determined from each method should agree with each other.

Lesson 1: Particles of Matter

1.1 Observe and Explain

Dip a piece of paper in rubbing alcohol (or rub the paper with alcohol) and place it on a table.

- Observe what happens and describe it in your own words.
- What do you need to **assume** about the makeup of alcohol to explain the *gradual* disappearance of alcohol from the paper?

1.2 Hypothesize

Think of possible **explanations** for the alcohol's *disappearance*. Suggest at least three different mechanisms. Fill in the table that follows.

Here's An Idea!

Coming up with explanations for this can be difficult but don't be afraid to use your imagination. There are no wrong ideas, only testable or non-testable ones!

For Example: The alcohol is still there but we just can't see it (Testable Idea)

Leprechauns came by, collected the alcohol, and left (Non-Testable Idea)

1.3 Test Your Idea

- Think of an experiment you can perform to rule out each explanation.
- Write a **prediction** for each testing experiment based on the corresponding explanation.
- Perform the experiments. Some possible testing experiments can be found at: <http://paer.rutgers.edu/pt3/experimentindex.php?topicid=7&cycleid=13>

1.4 Explain

Based on the outcomes of the testing experiments what judgment can you make about each explanation? Revise your hypothesis for the disappearance of the alcohol.

1.5 Test Your Idea

You and your lab partners have a glass of pure alcohol, a container with colored alcohol, and a dropper. One of your lab partners says,

"I think that the alcohol is made up of little tiny parts that are constantly in motion."

Your other partner disagrees. She says,

"No, I agree that the alcohol is made up of little tiny parts but they are definitely not moving!"

- Based on your experience from the previous activities, which explanation do you agree with? Why?
- How can you use the materials listed above to test these ideas?
- Write your prediction for each of your partners' mechanisms.
- Perform the experiments and record the outcomes.
- What judgment can you make about each explanation?

Did You Know?

Scientists call these little parts that make up objects **particles**. Although we cannot see the particles, we can discuss their properties. Understanding their properties will help us better understand the nature of the object as a whole.

Homework

1.6 Represent and Reason

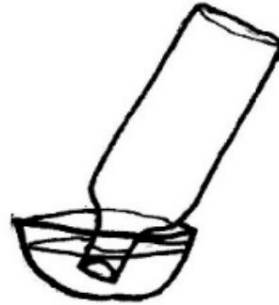
- Create a picture that represents what the particles are doing in the alcohol experiment.
- How do you think solids, liquids, and gases look at a particle level?

https://drive.google.com/file/d/1foYc9_g9Rr27W4iXb5kjJUDp0j0oDJgm/view?usp=sharing

Gas on line laboratory

Example of Observation Experiment

1. Describe what you observe
2. Draw force diagrams ...
3. Think of possible experiments
4. Estimate the temperature of hot water
5. Indicate any assumptions that you made.
6. Evaluate your result



STEP 1: Dip bottle mouth
into soapy water

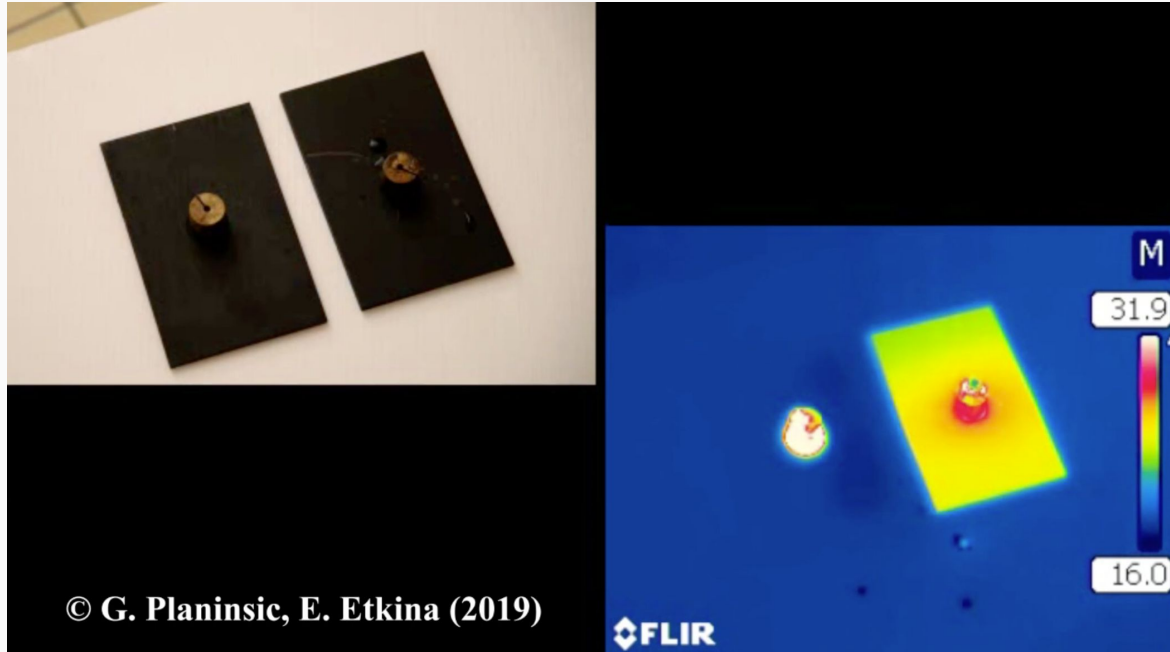


STEP 2: Lower the
bottle in hot water

https://drive.google.com/file/d/1YOWDDJujMnD_BY5gw60eDNtxqjeiPXjN/view?usp=sharing

First law of thermodynamics

Example of Observation Experiment



Example of Testing Experiment

8. Testing experiment: Aluminum vs wood

Goal: To test an explanation

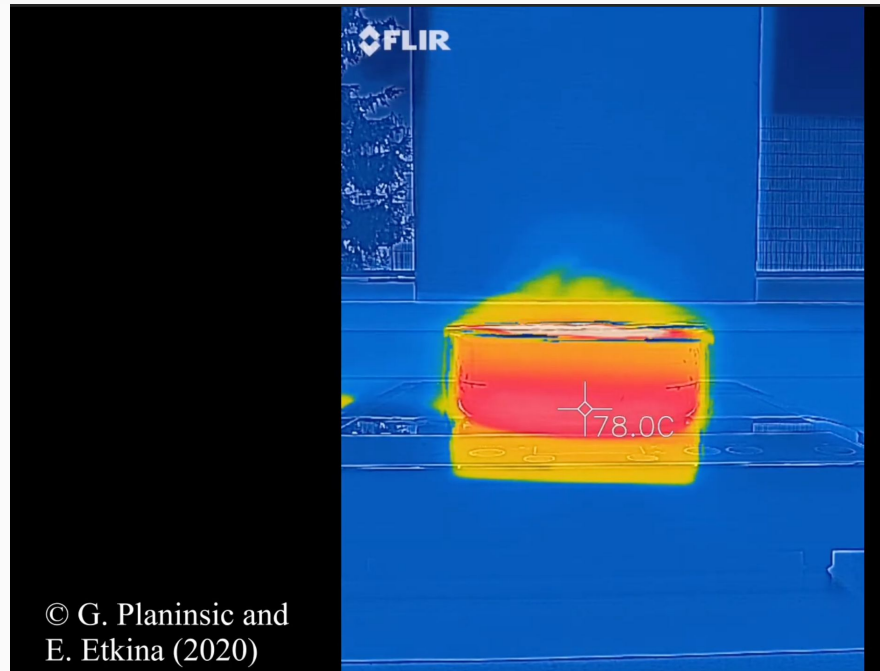
Equipment: none

Rubrics for self-assessment: Ability to conduct a testing experiment C1, C4, C5, C7, and C8.

You use the same plates as in Experiment 1, but this time you place an ice cube on each one.

- a. Use the explanations you made in Experiment 7 to predict what you will observe.
- b. View the video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-7-3] and compare the outcome to your predictions. Do you need to revise your explanation?

Example of Application Experiment



<https://forms.gle/uqGg2X1f9JkjkEf76>