University students' pre-instruction knowledge about temperature and adiabatic compression

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Introduction

We present results of an investigation of difficulties encountered before instruction by students at the University of Joensuu, when they were asked to define temperature and to solve a task about the adiabatic compression of an ideal gas.

Methods

At the beginning of a course on Thermal Physics, students were asked to describe some basic concepts and to solve a task about adiabatic compression of an ideal gas; 37 students (out of 48 total) performed both of these tasks.

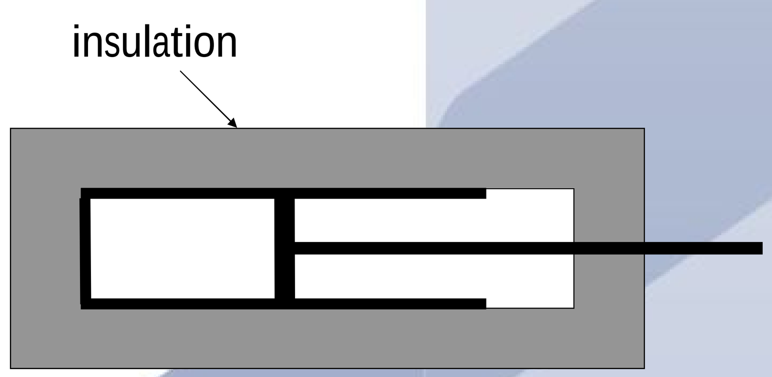
1. Express briefly what you think the following physical concepts/ quantities mean and describe.

…

Temperature:

…

2. There is a mol of ideal gas in a cylinder-piston system. The piston is dense so the gas cannot exit the cylinder. The friction between the piston and cylinder can be ignored. There is an insulating layer (insulation) in the cylinder so it is insulated from the environment.



The piston is used to compress the gas inside the cylinder. What happens to the temperature of the gas?

Explain carefully how you reached your conclusion.

Table 1. Cross tabulation of students' conceptions of temperature (columns) and reasoning involved in the task concerning adiabatic compression (rows), for students who responded that temperature would increase (N = 37). [Six responses which claimed temperature would decrease or remain constant during adiabatic compression are not represented in the table.]

Reasoning in adiabatic compression task \ Temperature definitions	Explanations related to thermal motion (correct)	Naive definitions of temperature	Temperature is the amount of heat or thermal energy
Incorrect explanations based on the ideal gas law	9	4	7
Inaccurate micro-level explanations (collisions, interaction, etc.)	10	4	3
"Almost correct" micro-level explanations	2	-	1
Work done on the gas (correct)	2	-	1
Wrong answers	1	2	2

Results

Students' categorized responses to the task, as well as their definitions of temperature, are presented in Table 1. In the case of adiabatic compression students were far more likely to incorrectly apply the ideal gas law than to make use of the first law of thermodynamics. They also had difficulties in describing, understanding and applying basic concepts such as temperature, often using them inconsistently. For example, ten students who defined temperature using explanations related to thermal motion reasoned, in another task, that temperature is caused by collisions between particles.

Discussion

Based on these and similar findings in the literature, we suggest that instruction should emphasize the importance of the first law and the differences between isothermal and adiabatic processes. Students' inaccurate micro-level conceptions should also be explicitly taken into account when teaching microscopic models in order to reduce or eliminate common misconceptions.

References

R. Leinonen, E. Räsänen, M. Asikainen and P. E. Hirvonen, "Students' pre-knowledge as a guideline in the teaching of introductory thermal physics at university," Eur. J. Phys. **30**, 593-604 (2009).

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