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Investigations of Upper Division Student Understanding of Thermal Physics[1]

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In research on the teaching and learning of upper-level (junior-senior) thermal physics, we are probing student understanding of topics that are taught at the introductory level (e.g., work, heat, the first and second laws of thermodynamics, entropy) as well as more advanced topics (e.g., thermodynamic potentials, the Maxwell relations, chemical potential). Many of our findings are consistent with prior work at the introductory level [1,2], however we find some differences for 2nd law topics. Preliminary results suggest that upper-level undergraduates often enter a thermal physics course with little understanding of entropy, and emerge from the course with an ability to apply some features of entropy and the 2nd Law appropriately. Difficulties with specific properties of entropy persist, especially with the state function property. Another aspect of this research deals with student functional understanding of mathematical concepts applied in the context of thermal physics (e.g., path integrals, partial differentiation). Most system properties can be represented as partial derivatives of one variable with respect to another while holding appropriate others fixed. Our findings indicate that although students are able to take partial derivatives easily, many students have difficulty understanding the mathematical and/or physical significance of their differentiation, even after instruction. I will present data regarding student understanding of mixed second-order partial differentiation in general, and the Maxwell relations in particular. Finally, I will discuss the development of instructional materials to address specific difficulties found in our research. 1. M.E. Loverude, C.H. Kautz, and P.R.L. Heron, Am. J. Phys. 70, 137 (2002). 2. D.E. Meltzer, Am. J. Phys. 72, 1432 (2004).

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