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### **Physics Education Research at the Upper Division at the University of Maine<sup>1</sup>**

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Researchers from the University of Maine Physics Education Research Laboratory are conducting several investigations of the learning and teaching of physics beyond the introductory level. Content topics include intermediate mechanics, electronics, thermodynamics and statistical mechanics. One focus of our work is the identification and addressing of specific student difficulties with topics such as damped harmonic motion, bipolar junction transistor (BJT) circuits, work, entropy, and the Boltzmann factor. Student understanding and use of the underlying mathematics has been one important emerging theme, including definite integrals, partial derivatives, and linear differential equations. Recent work in mechanics has focused on understanding the interplay of mathematical and physical reasoning when describing damped harmonic motion, including framing and representational issues. In electronics, there has been an ongoing investigation of student understanding of the behavior of basic BJT follower and amplifier circuits as well as related issues of signal and bias. In thermal physics, student understanding of state functions, heat engines and the Carnot cycle, the First and Second Laws of thermodynamics, and the macroscopic and microscopic perspectives on entropy have been investigated. The greater content sophistication in these courses has drawn attention to the specific needs, constraints, and advantages of instructional materials tailored to the upper division. Future directions include more attention to interdisciplinary topics across mathematics, physics, and engineering in particular, as well as metacognition in the laboratory.

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