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### **A Research-validated Approach to Transforming Upper-division Physics Courses<sup>1</sup>**

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At most universities, including the University of Colorado, upper-division physics courses are often taught using a traditional lecture approach that does not make use of many of the instructional techniques that have been found to improve student learning at the introductory level. We are transforming several upper-division courses using principles of active engagement and learning theory, guided by the results of observations, interviews, and analysis of student work at CU and elsewhere. In this talk I outline these transformations, including the development of faculty consensus learning goals, clicker questions, tutorials, modified homeworks, and more. We present evidence of the effectiveness of these transformations relative to traditional courses, based on student grades, interviews, attitude surveys, and through research-based assessments of student conceptual mastery. Our results suggest that many of the tools that have been effective in introductory courses are effective for our majors, and that further research is warranted in the upper-division environment. (See [www.colorado.edu/sei/departments/physics.htm](http://www.colorado.edu/sei/departments/physics.htm) for materials)

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