DEVELOPMENT OF ENGINEERING THERMODYNAMICS CONCEPT INVENTORY INSTRUMENTS

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Abstract *¾ Preliminary instruments for the assessment of undergraduate engineering student understanding of fundamental thermodynamics concept are presented. The Thermodynamics Concept Inventory (TCI) instruments are patterned after the existing Force Concept Inventory (FCI) instruments. Numerous studies have supported the efficacy of pre- and post-course administration of the FCI as a means of assessing the effectiveness of educational reform activities. The objective of the work reported here is to develop similar instruments for the assessment of engineering thermodynamics. Like the FCI, the Thermodynamics Concepts Inventory (TCI) instruments should be brief, require minimal or no computation, should produce repeatable results across broad, diverse student populations, and should succinctly assess student understanding of fundamental thermodynamics concepts. The availability of such TCI instruments will allow faculty to compare the pre- and post-course performances of a class, to compare the performance of their class to that of classes at other institutions, and to evaluate the effectiveness of educational reform efforts. Although the preliminary ("beta") versions of the TCI reported here are aimed at mechanical engineering students, they should be suitable for use in other engineering disciplines with slight modification. In mechanical engineering, it is common to teach thermodynamics in a two-semester sequence of courses. Consequently, two versions of the TCI are presented, an introductory version and a more advanced version for second-semester students. Sample questions from the TCI instruments are exhibited here, and results of preliminary testing of the inventory on small student populations are discussed. Beta versions of the TCI are available at the FIE conference. The authors are seeking interested faculty to conduct beta tests during the 2001-2002 academic year.*

Index Terms ¾ assessment, continuous improvement, course concepts, evaluation, outcomes, thermodynamics

PAPER SUMMARY

This work is patterned after the influential, groundbreaking Force Concepts Inventory of Halloun and Hestenes [1]. As Hestenes contends, the design of an effective instructional strategy requires a thorough understanding of the "initial knowledge state" of students. The primary objective of this paper is to report the actual development of two thermodynamics concept inventories, corresponding to the traditional two-course thermodynamics sequence. The first TCI is aimed at measuring the "initial knowledge state" of sophomores as they begin a first thermodynamics course, and the second at juniors beginning a second course.

Development of each TCI was initiated by categorizing the subject matter and then identifying important concepts in each category. Both versions of the TCI include questions on properties and behavior of matter, work and heat, the First Law, and the Second Law, but the questions in the second TCI are more sophisticated. Common student misconceptions noted by the authors and their colleagues in teaching undergraduate thermodynamics formed the basis for question development. A typical question, e.g., determines if students perceive the constancy of pressure imposed by a constant-mass piston resting on a fluid with an invariant pressure above it:

H_2O is heated in the frictionless piston-and cylinder arrangement shown, where the piston mass and the atmospheric pressure above it are constant. The pressure of the H_2O will: (a) increase (b) remain constant (c) decrease (d) need more information.

Effective questions for a concept inventory ideally present the students with attractive "distractors," i.e., incorrect answers that appear correct in the light of common false mental models. Because it is difficult to develop a completely effective concept inventory test in a single iteration, many cycles of instrument design, testing, and redesign are necessary to develop a calibrated instrument that will yield repeatable results. Consequently, beyond the work reported here, future effort will be devoted to testing and refining the thermodynamic concept inventories, and to establishing performance norms. Depending on page limitations, the full paper will include the complete or large portions of the first usable versions of the inventories, suitable for "beta" testing.

REFERENCE

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