Review of Foundations of Physics by Thomas Hsu

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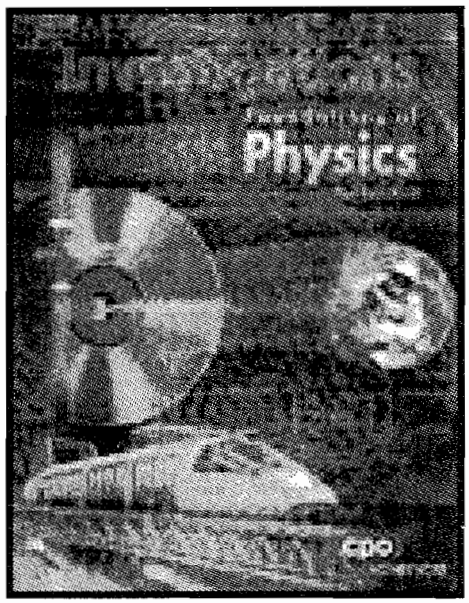

Foundations of Physics (2004) is an introductory physics textbook aimed at a high school audience. The book is published by CPO Science (formerly Cambridge Physics Outlet), best known for their plywood physics instructional equipment. I teach physics primarily to 9th graders at a selective private day school in Buffalo, NY, where all ninth graders are required to take physics in a "physics first" program (Lederman, 2001). I evaluated this textbook as a possible replacement for *Conceptual Physics* by Paul Hewitt (2002), the textbook we had used for six years in the freshman course.

Foundations of Physics is one of several physics textbooks by Thomas Hsu intended for different audiences and levels of physics. It is sold by CPO either separately or as part of a bundle that includes 25 textbooks and lab manuals, a teacher's toolkit, and a set of laboratory equipment (see Table 1 for details and pricing). This review focuses mainly on the hard bound textbook while also considering its part in the larger *Foundations of Physics* program.

In 684 pages, *Foundations of Physics* covers motion, forces, energy, momentum, waves, sound, light, optics, electricity and magnetism, thermodynamics, states of matter, and nuclear physics. Mathematics is at the level of elementary algebra and right-triangle trigonometry. Except for the right-hand rule for forces in electromagnetism,vectors are limited to one and two dimensions.

One of the strengths of the text is its layout. Pages are laid out in a distinctive "landscape" format, leaving room for a column of figures and graphs on the right and a column of paragraph title phrases on the left to bracket a central column of text. Each separate page contains a single subsection of the chapter; text from one sub-section never carries over to the next page. By breaking up the text into manageable chunks, providing related visuals, and cuing students with paragraph topic phrases, Hsu provides concrete reading aids. Unfortunately, some pages are "topped off" with distracting or confus-

ing filler material, such as the discussion of "g forces" on page 98, but in general the format works well. While Hsu is not able to achieve the folksy readability of *Conceptual Physics*, the language of the text is adequately clear for my students.

An advantage for New York State teachers is that Hsu employs equations and notation that are broadly compatible with those used in New York State's Regents Physics program. In addition, the CPO website provides a table that shows correlations among the textbook, lab manual, and New York state standards, showing how the textbook and lab program could be used to meet Regents requirements (www.cpo.com).

One concern I have regarding *Foundations of Physics* is that it includes misleading or confusing presentations of conceptually difficult material (also noted by Hubisz, n.d.). Hsu does not make good use of the accumulated wealth of knowledge about student misconceptions and learning difficulties (Arons, 1990; McDermott & Redish, 1999). For instance, the concepts of mass, weight, and inertia are known to be a source of confusion for students (Arons, 1990, pp. 57-64). In the discussion of mass, weight, and gravity Hsu states that "The word weight is used to describe the force of gravity acting on an object (Hsu, 2004, p. 96)." Two pages later, he continues: "An object is weightless when it feels no net force from gravity... A... way to become weightless is to be in *free fall* (p. 98)." The glossary defines free fall as movement that is due only to the force of gravity (p. 656). It left unclear how to reconcile feeling no net force from gravity (being weightless) and moving only due to the force of gravity (being in free fall; cf. Arons, 1990, p. 72) Hsu's difficulties continue in the description of force and inertia: "An object with a lot of inertia takes a lot of force to start or stop; an object with a small amount of inertia requires a small amount of force to start or stop (2004, p. 79)." Hsu's language here could easily lead students to think that inertia is a threshold to be overcome, a common and well-documented misconception (Halloun & Hestenes, 1985, p. 1057; Hestenes et al, 1992, p. 144). This difficult set of concepts is only one of many areas where this reviewer had trouble with Hsu's inattention to content subtleties and student learning difficulties; other areas include the wave phenomena of reflection and refraction (p. 270-271), potential energy (pp. 189-191), and voltage (p. 383, example on p. 400). Given the vast amount of research in the field of physics education, this is a fairly major oversight.

The textbook is part of an integrated, potentially affordable larger package including lab manuals, a teacher's guide, and laboratory equipment (details in table, see page 44). This has both strengths and weaknesses. The teacher's guide is devoted primarily to providing step-by-step guidance for each page of the investigations manual: an overview, a sample teacher-student dialog, an image of the investigation

page, and examples, data, and answers.

The dialogs, in particular, are a strength for teachers "new to the subject area, as [the dialogs] identify possible student misconceptions and highlight important learning content (Hsu, 2009, p. viii)." On the other hand, they also suggest a weakness: although the *Foundations of Physics* program claims to be "inquiry centered" (Hsu, 2004a, p. i), the lab manual "investigations" are as carefully scripted as the teacher's guide dialogs and contain little in the way of student-directed inquiry. It could be argued that by limiting the program's electronic data collection technology component to photogates and timers, Hsu reduces the problem of students using a "black box" about which they have no real understanding. However, this comes with a corresponding loss of capability for real-time graphing of motion data, which has been extensively shown to benefit student learning (Brasell 1987, Sokoloff et al, 2007). Finally, the per-student cost of the program varies widely, a strength or weakness that depends on the number of students involved (details in Table 1, pg 44). In summary, the full program provides a tightly integrated, highly scripted laboratory program that has both assets and weaknesses depending on the goals, resources, and circumstances surrounding the course being taught.

Foundations of Physics is an intriguing entry in the field of textbooks for introductory high school physics. Its layout, math level, and price all seem geared to appeal to a broad high school audience, requiring no advanced reading or mathematics skills. The comprehensive classroom set of texts with equipment provides a thorough, highly prescribed lab program, the cost of which is reasonable for a school ordering a large number of texts but not for one ordering only a single set. However, the text misses out on the opportunity to incorporate the fruits of physics education research, providing problematic presentations of many key concepts. The tightly integrated lab program and scripts provided by the teacher's guide would make the Foundations of Physics program worth considering for a novice physics teacher except for the text's persistent difficulties providing clear conceptual presentations. For the same reason, it is difficult to recommend the textbook itself on its own merits.

Acknowledgement: This review was written in partial completion of PHY 690: Masters Project in Physics Education supervised by Dr. Dan MacIsaac, with guidance from Dr. David Abbott.

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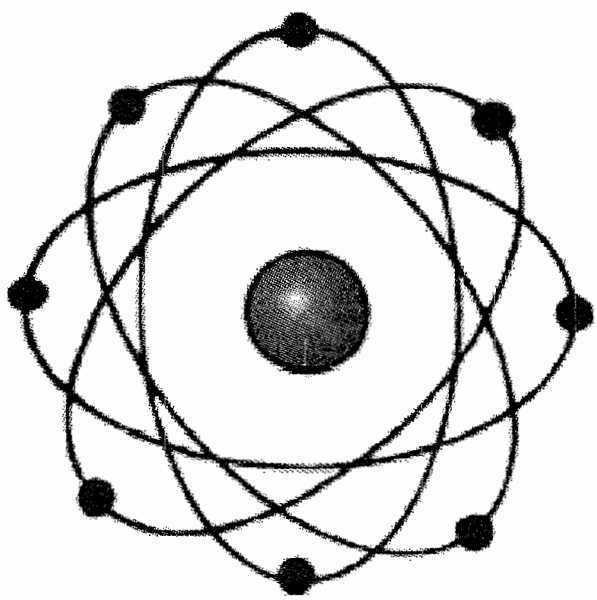

TABLE 1. Cost of Foundations of Physics Program and components

Foundations of Physics Program and Prices (As of May 28, 2010)			
	Price	**Notes**	
Foundations of Physics - Textbook	$68	$87 per student together	
FOP Investigations - Lab Manual	$19		
Teacher's Guide and Toolkit (test bank, worksheets, planning guide, etc.)	$398	Teacher's guide is central to making the program lab-based	
Equipment Kit *	$2062	Sufficient for 1-2 lab groups**	
Price of Entire FOP Package (25 texts & manuals, 1 equipment kit, 1 teacher's kit)	$2175	$87 per student	
	Packages	**Equipment Kits**	**Total/ Per Student Costs**
Total Cost for 24 Students: 1 section of 24 working in groups of 4	1 = $2175	5 = $10,310	Total: $12,485 Per Student: **$520**
Total Cost for 120 Students: 5 section of 24 working in groups of 4***	5 = $10,870	1 = $2062	Total: $12,937 Per Student: **$108**
* Equipment kit includes one of each of the following, except as specified: Timer and (2) photogates, straight track, loop track, colliding pendulum, electric motor, spectrometer, atom building game, friction block, ultimate pulley, spring scales, tape measure, compass, tuning fork, physics stand, and materials for investigating sound and waves, light and optics, basic electric circuits, and RC circuits.			
** Assumes typical lab group size of 2 to 4 students per group			
*** Assumes that each section meets at different times, so all classes share same lab equipment			