

Thermo-CD - An Electronic Text For The Introduction To Thermodynamics Course

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Introduction

The benefits of active learning have been well documented¹. Students are more effective problem-solvers in the classroom when they have had first-exposure to the material prior to the class meeting^{2,3}. Many engineering faculty encourage students to take advantage of this by assigning pre-class reading assignments. However, many students do not complete the reading assignments prior to class. This may be because they do not see the advantage of reading about the same material covered in class. Others do not see a connection between the reading assignment and in-class material and opt out of the reading assignments. Still other students complete the reading assignments, but have not read the material effectively and thus do not learn it at a level that enhances in-class problem-solving. In this paper, we describe our strategy for addressing the challenge of students' pre-class preparation and ensuring that their preparation is effective using an interactive, multimedia textbook replacement called Thermo-CD.

We first discuss the importance of first-exposure prior to class when active learning techniques are used in the classroom. We then describe Thermo-CD and its development in some detail. Next, we discuss the course mechanics for the Spring Quarter 2003 offering of the course. Last, we describe our strategy for assessing the impact of Thermo-CD on students' preparation and learning.

First-Exposure and Active Learning

Walvoord and Anderson state that *first-exposure* occurs "when the student first encounters new information, concepts, vocabulary, and procedures"². Few students move much beyond the first level of Bloom's Taxonomy⁸ in their first-exposure to engineering course content. In order for students to spend more class time developing and practicing higher-order thinking skills such as application, analysis and synthesis, students must have their first-exposure to content prior to the class meeting. Foertsch, et al.³ state, "Before students can be effective team members or problem-solvers, they need to have a basic understanding of the problem domain..."

In many engineering courses, the instructor assigns readings from the course textbook on a weekly or daily basis, but few track whether or when students complete the assignments or learn the material. When instructors do not have a sense of students' understanding, they risk unnecessarily repeating material in class that students have already mastered. This may lead the students to conclude that they might as well save valuable time by not reading at all. Both

instructors and students can become frustrated by the fact that more class time is not used to help students master more difficult material for which faculty expertise is most valuable.

Many students have admitted to Baratuci, off the record, that they rarely do the reading assignments before class in their engineering courses. Their reasons vary widely, but in general, students do not believe reading is an efficient use of their time for at least two reasons. They are reasonably sure that the instructor will discuss the content of the textbook in class. If this does not occur, then they feel that either the material was not important or that they can read the material later. Students are also keenly aware of how difficult it can be to learn engineering from a textbook. Many do not believe that they are capable of learning from their textbook, at least not in any reasonable amount of time.

Baratuci has used different types of short “pre-flight” quizzes at the beginning of class meetings to provide an incentive for students to do the assigned reading before class. These quizzes seem to have motivated most students to have first-exposure to material prior to class. This approach, however, has at least two drawbacks. Despite doing the assigned reading, the students do not always understand everything they need to know in order to solve problems and analyze processes in class. The second drawback is that the instructor does not become aware of the gaps in the students’ background knowledge until he or she scores the quizzes. By then, it is too late to correct the problem and be sure that all of the students get the most out of the problem-solving portion of the class meeting.

Thermo-CD was designed to help students learn better than they do from a textbook. This may help students come to class better prepared for activities designed to promote higher-level learning.

Thermo-CD

Thermo-CD, an interactive, multimedia instructional tool, was developed for the Introduction to Thermodynamics course to help students learn better than they do from a textbook. Thermo-CD includes a computer or web-based instructional tool and a workbook that serves to reach students with different learning styles and improve students’ preparation for in-class activities. Thermo-CD is combined with active learning in the classroom and frequent use of Classroom Assessment Techniques (CATs) ⁷ to provide the students and the instructor with immediate and useful feedback on students’ learning.

The discussion in the academic literature about computer-based (CBT) and web-based training (WBT) in engineering education has focused on the merits of CBT/WBT relative to face-to-face instruction ⁵. However, CBT/WBT can also be used to complement face-to-face instruction. In this complementary role, the discussion would focus on the merits of CBT/WBT relative to a traditional textbook. Thermo-CD is intended to replace the traditional textbook and to complement face-to-face instruction.

The content of Thermo-CD is organized into ten chapters. Each chapter is made up of 4-8 lessons and each lesson is presented in a series of separate pages or screens. Each chapter also includes a group of supplemental files called a First-Aid Kit. Data tables, printable solutions of example problems and equation summaries are collected in each First-Aid Kit.

Typical screens from Thermo-CD are shown in Figures 1-4. The focus is on presenting information in 1-minute to 3-minute mini-lectures while the students view equations, graphics, text and animations. A typical lesson consists of 10-25 screens, includes one or two example problems, and should be completed in 30-60 minutes. The first page of each lesson provides the motivation for the lesson and presents an overview of the material to be covered. Example problems are solved in great detail and the solutions follow a problem solving procedure developed in one of the early lessons. The last page of each lesson is a summary and provides a link to a quiz on the material covered in the lesson. A typical quiz consists of three to five questions that may have multiple parts. Quizzes include a variety of types of questions ranging from multiple-choice questions to problems equivalent to homework problems. The student's response to each question is evaluated in real time and scored. Engineering students seem to love to have their work scored as long as the score does not affect their grade in the course. Feedback and a detailed solution for each question are provided after the student's answer has been evaluated.

Thermo-CD has a bookmark tool and a hyper-linked glossary of terms. The bookmark feature allows each student to create one or more sets of bookmarks that are stored on a floppy disk. Students can add comments to each bookmark and can edit their bookmarks from most screens in the Thermo-CD program. The glossary provides definitions of terms used in Thermo-CD as well as links that take the student to the page on which each term was first used.

Thermo-CD also includes a workbook, in a three-ring binder, that is used in conjunction with the website. A page from the workbook is shown in Figure 5. Each page contains two screen-shots from consecutive pages in Thermo-CD. Half of the space on each page is left blank. Students will be encouraged to keep the workbook in front of them while using Thermo-CD and to take notes in the blank space below each screen-shot.

The main tool used to develop Thermo-CD was Macromedia Authorware. Authorware provides an environment in which text, graphics, video and sound can be integrated and organized for consistent presentation to students. It provides a level of interactivity, structure and record keeping capabilities that are very difficult to produce in a website that only uses HTML. Figures 1 through 4 display screens captured from Thermo-CD. They are included at the end of this paper so that the reader can get a feel for the nature of the user interface.

The drawback to using Authorware to build a WBT program such as Thermo-CD is that a browser plug-in is required in order to view the software modules. Fortunately, the plug-in can be downloaded for free. Authorware modules can also be packaged as executable files, which can be delivered on CD-ROM. This eliminates the need for a browser plug-in. Thermo-CD is currently available on both CD-ROM and the internet.

Several other programs were also used to develop Thermo-CD. The audio clips were edited with Sound Forge XP from Sonic Foundry. Microsoft Word was used to create simple graphics and to the workbook. Adobe Photoshop was used for more sophisticated image preparation and manipulation. Adobe Acrobat was used to prepare compact PDF documents for the students to download. Finally, Microsoft Excel was used to solve all example and quiz problems and to present the calculations in a well-organized form. The instructor's solution manual consists of a group of Excel spreadsheets. These spreadsheets are designed to make it very easy to create and solve variations of the homework problems included in Thermo-CD.

Course Structure and Assessment Plan

Two sections of the Introduction to Thermodynamics course are offered each spring at the University of Washington. In 2003, one section will use a textbook and a traditional lecture format. The other section will use Thermo-CD and active learning techniques in the classroom.

Classroom Mechanics

Introduction to Thermodynamics meets three times per week for 50 minutes plus a 110-minute recitation. There will be two tests and eight homework assignments during the 10-week quarter, plus a final exam. Homework will be reviewed and exams given in the recitation. Lessons from Thermo-CD will be assigned for most of the three class meetings in a week.

In order to encourage students to use Thermo-CD to prepare for class, a short, online warm-up quiz will be given for each Thermo-CD assignment. The students will take the quizzes online and will be allowed to use their workbook or other notes during the quizzes. The goal is to encourage the students to use Thermo-CD, take good notes and to come to class well prepared. The students will complete each quiz no later than one hour prior to the start of class. This will give the instructor time to review the quiz results and prepare a short lecture to help fill any gaps in the students' preparation for class. The students will spend the remainder of the class time, hopefully 30 minutes or more, engaged in problem solving and other forms of active learning. This method of using online quizzes to help an instructor tailor his or her classroom activities is a major component of just-in-time teaching⁴.

The WebQ tool, created by the *Catalyst* program at the University of Washington (<http://catalyst.washington.edu/>), makes it easy to create, administer and automatically score online quizzes. WebQ provides a summary report that makes it relatively easy to determine how well the class understands the material on which they were quizzed.

Assessing the Course

The course has been designed to incorporate numerous opportunities for continuous assessment of student learning and for gathering feedback from students. We use a combination of CATs, graded student work, such as homework, tests and exams, and end-of-term student evaluations of teaching.

Feedback will be collected in-class using strategies like the One-Minute Paper or Muddiest Point, in which students are asked to respond to questions about the most important or most confusing aspects of the class session⁷. Students' self-confidence will be assessed using instruments developed by CELT researchers. We will also use beginning- and end-of-term "Knowledge Probe" surveys and a Mid-Term Class Interview^{5,6}. In the latter, students respond in small groups and a whole-class discussion to the questions: "what is helping you learn in this course?" "what could be changed to improve the course?"

Conclusions

We have designed the Thermo-CD instructional tool and the course mechanics for the Introduction to Thermodynamics course with the goal of improving the effectiveness of active learning in the classroom. We have also prepared an assessment plan that will help us understand whether our efforts helped the students learn. In our presentation at the ASEE Conference, we will summarize our efforts and present the results of this assessment plan.

Acknowledgements

We would like to thank Professor Kevin Hodgson for permitting us to interact with students in his section of the Introduction to Thermodynamics course in the Spring Quarter of 2003. The data gathered was most helpful in assessing the effectiveness of Thermo-CD.

Thermo-CD is a product of B-Cubed. The program, workbook, homework problems and instructors guide were developed by William Baratuci, Jennifer Kilwien, Kory Mills, Susan Fisher and Michael Harrison. The price of the workbook and online access to Thermo-CD is \$75. Students can purchase a copy of the program on CD-ROM, instead of online access, for an additional charge of \$10. Instructors can request access to Thermo-CD online as well as an inspection copy of the workbook and CD-ROM. Visit <http://www.ThermoCD.com> to obtain more information.

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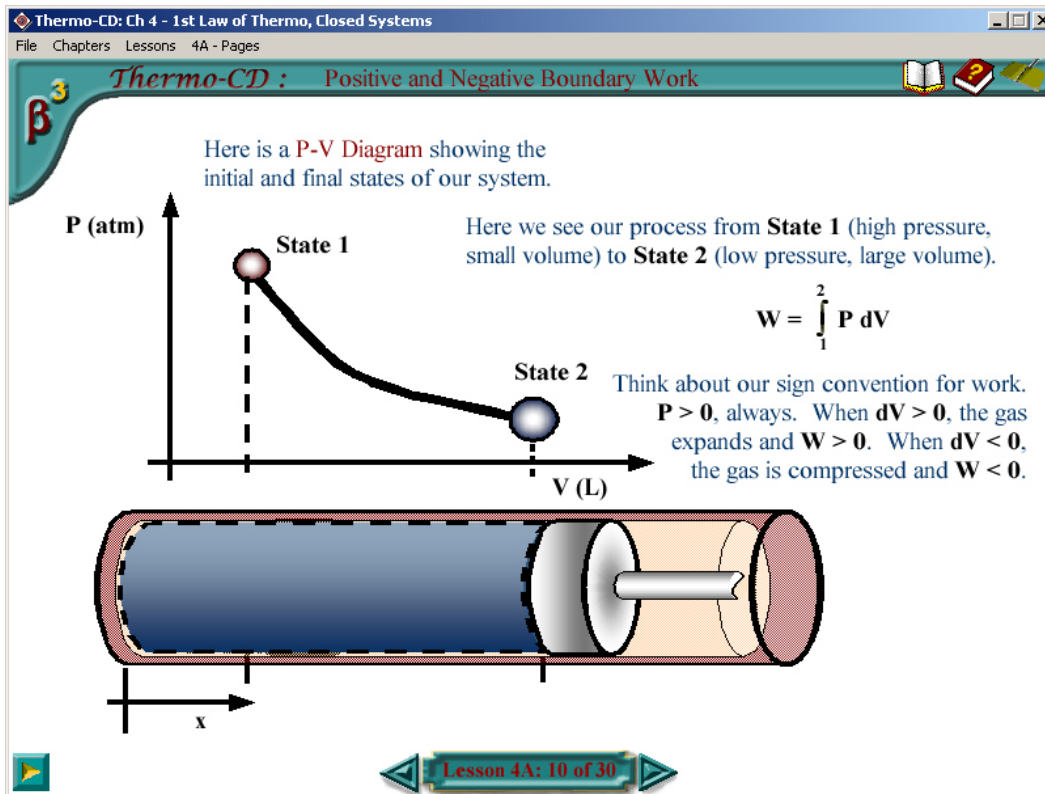


Figure 1 - Sample page from Thermo-CD. Chapter 4, Lesson A – Work, page 10 of 30.

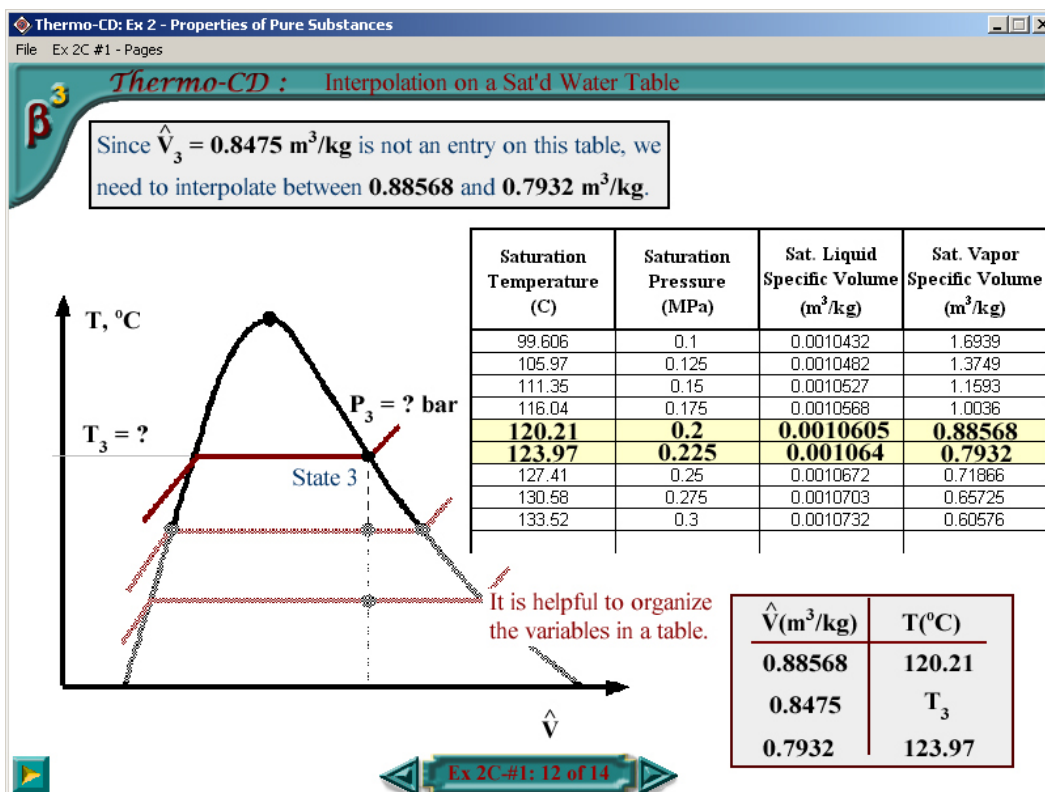


Figure 2 - Sample page from Thermo-CD. Chapter 2, Lesson C – Obtaining Data From Tables, Example Problem #1, page 12 of 14.

Thermo-CD: Quiz 4 - 1st Law of Thermo, Closed Systems

File Chapters Quizzes by Chapter Ch4 Quizzes Quiz 4F Problems

Thermo-CD : Application of the First Law

1. A thermodynamic cycle consists of four processes. Fill in the missing values in the table below. Assume $\Delta E_k = \Delta E_p = 0$. **Hint-** do not solve for **Process 1-2** first can you see why?

PROCESS	Q	W	ΔU
1-2	690	500	190
2-3	-300	-350	50
3-4	60	425	-365
4-1		0	125
CYCLE			

Problem: 1 / 8
Quiz : 1 / 20

Quiz 4F: 1 of 3

Continue

Figure 3 - Sample page from Thermo-CD. Chapter 4, Lesson F – Thermodynamic Cycles, quiz problem #1 of 3.

Thermo-CD: Quiz 4 - 1st Law of Thermo, Closed Systems

File Chapters Quizzes by Chapter Ch4 Quizzes Quiz 4F Problems

Thermo-CD : Cycle Analysis and Efficiency

2. Consider the thermodynamic cycle on the right where $Q_c = 500 \text{ MJ}$ and $W_{\text{cycle}} = 200 \text{ MJ}$.

(a) This thermodynamic cycle is a **POWER** cycle.

(b) Determine the heat transfer in the system:
 $Q_H = 700 \text{ MJ}$

(c) Determine the thermal efficiency of the power cycle:
 $\eta = 28.8 \%$ **Great Job!**

Problem: 7 / 7
Quiz : 9 / 20

Quiz 4F: 2 of 3

Continue

Figure 4 - Sample page from Thermo-CD. Chapter 4, Lesson F – Thermodynamic Cycles, quiz problem #2 of 3.

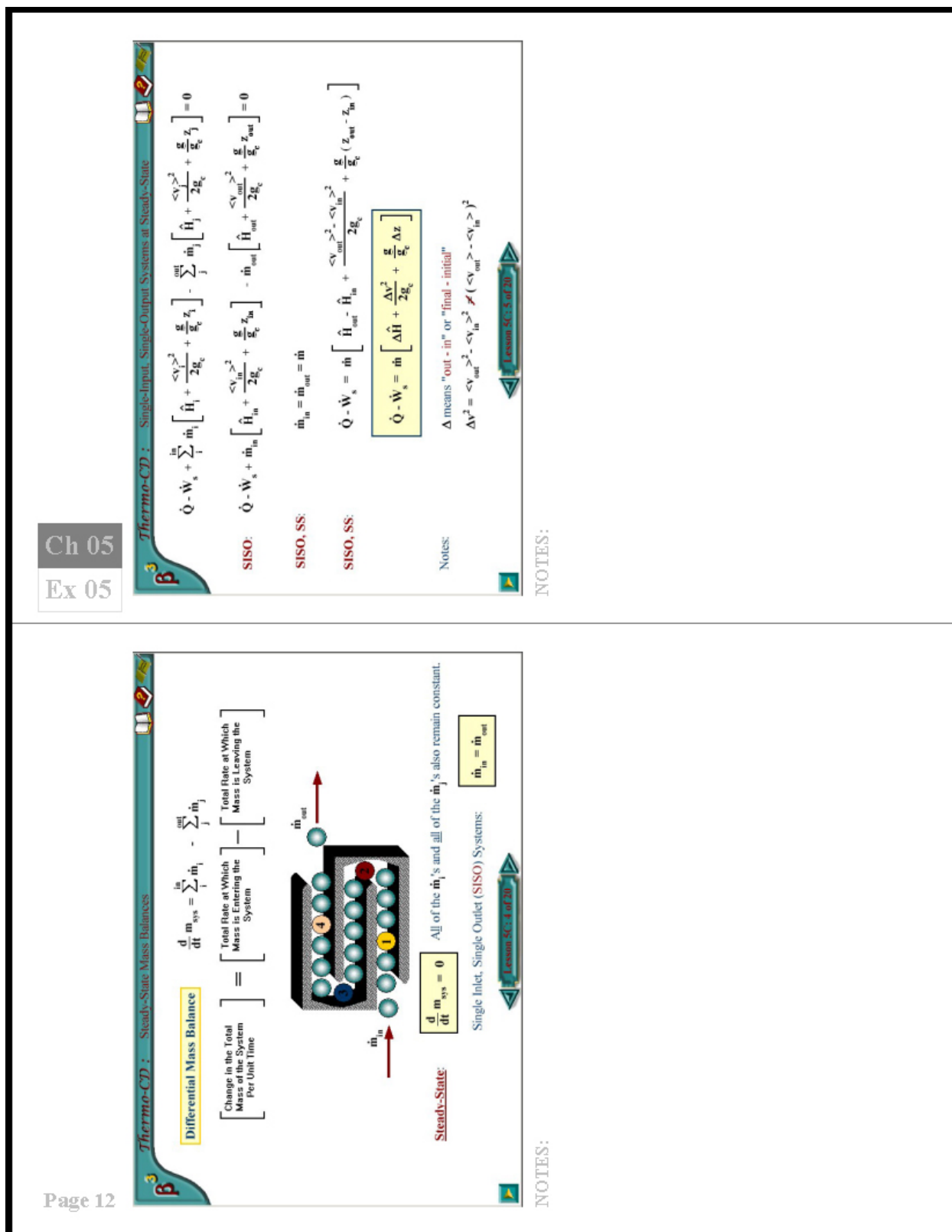


Figure 5- Sample page from the Thermo-CD Workbook. The blank space is intended to encourage students to take notes while using Thermo-CD. The workbook provides structure and organization for the student's notes.