Session 2633

Teaching Thermodynamics with the Aid of Web-Based Module

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Abstract

Over the past few years, with the availability and advancement in the multimedia technology, it provides opportunities for educators to revolutionize the teaching-learning enterprise and improve the quality of engineering education. This paper presents how multimedia can be implemented to enhance the learning experience of students here at the University of Oklahoma in studying Thermodynamics. A web-based module for Thermodynamics has been developed to present course materials in dynamic and interactive ways. This courseware also includes a review section to help students in preparing the Fundamentals of Engineering (FE) Exam. By delivering the course materials in a more visually appealing approach over the Internet, it manages to capture the attention of the wire-generation. In addition, students can gain access to the course materials anytime from anywhere. Since its first implementation in summer 2000, this module has received favorably responses from students.

I. Introduction

Due to the rapid advances in the computer technology in recent years, multimedia has now become an essential part of the World-Wide-Web (WWW). The integration of different media such as text, graphic, sound, motion video and animation into the teaching strategy provides an efficient tool for the educators and faculty. Nowadays more higher education institutes are engaging in Web-teaching of some sorts, particularly in engineering education. This paper describes the implementation of a Web-based multimedia module in teaching Thermodynamics at the University of Oklahoma.

By packaging the course materials in an interactive way through the Web, it not only enhances the learning experience of students dramatically, it also increases the effectiveness of faculty. In addition, students can access to the materials basically from any location where Internet services is provided and at their convenience. This is particularly useful since the incoming engineering students at the University of Oklahoma are required to have a laptop computer with the wireless network connection capability.

Previous efforts of utilizing multimedia in teaching Thermodynamics include an instructional module developed by Cobourn and Lindauer[1] at the University of Louisville. Their module was presented in a slide-show format. Uddin and Kuntscher[2] also created a software package to simulate the reversible and irreversible processes. Currently, a few coursewares are available for Thermodynamics. For example, these include the first pioneering work, TEST, by Bhattacharjee[3] that is available from the San Diego State University (http://thermal.sdsu.edu/testcenter/home.html/). Also available through the distribution of the Thermodynamics textbook by Çengel and Boles[4] is a courseware in CD-ROM by Anderson[5]. An interactive software developed by Intellipro, Inc.[6] is also available through the distribution of another Thermodynamics textbook by Moran and Shapiro[7]. However, little efforts have been devoted to develop a comprehensive Web-based module for Thermodynamics so far. Therefore, it is our objective to develop such a courseware to make use of the current multimedia technology to improve the quality of engineering education.

II. An Overview of the Course Page

A Web-based module for Thermodynamics has been developed at the University of Oklahoma. The main page for the course is shown in Figure 1. From the main page, students are informed of the important announcements (e.g., homework assignment due date and exam date) from the message board. The navigation system on the left frame provides students with the ability of browsing this course page in a non-sequential fashion.

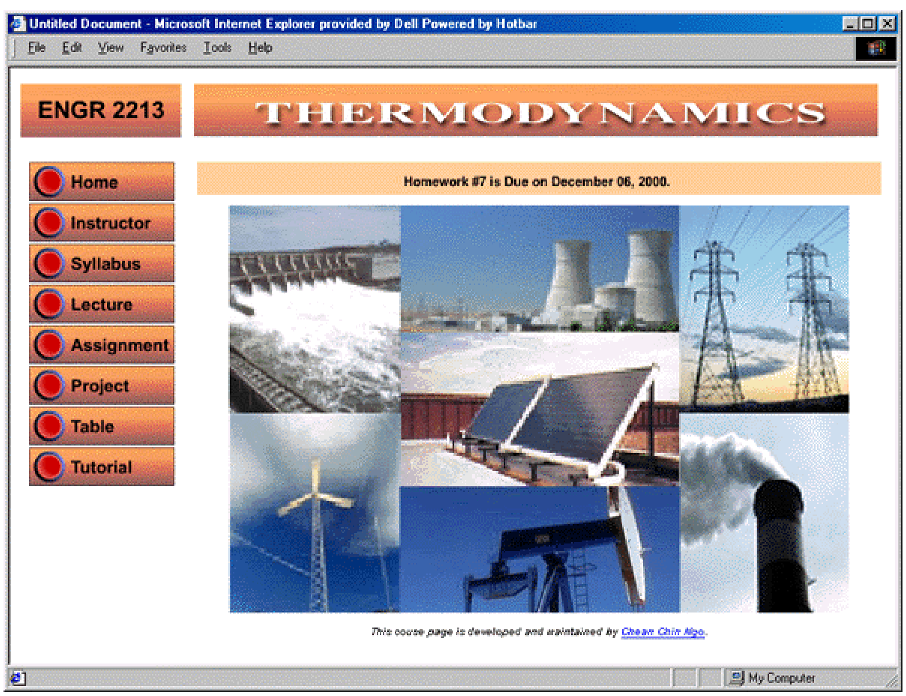


Figure 1. Main page of the course module.

From this course page, students can find general information such as the course syllabus and instructor profile. Detailed lecture notes along with the solutions to the homework assignments are also available in this module. This course page is used to reinforce materials introduced in the classroom. In addition, a tutorial session has been developed to help students in preparing the Thermodynamics portion of the FE/EIT examination.

III. Features of the Course Module

In the following sections, some key features of this course module are described and demonstrated.

<u>Lectures</u>

Lectures notes from the actual classroom meeting are posted on this course page. They are presented in a more visually appealing manner with the use of pictures, animations, and interactive simulations. Lectures notes are divided into 22 separate sections so that the download time for each lecture file is greatly minimized.

With the course materials available from the Web, students are encouraged to preview them before the regular meeting. Students can simply learn better by doing so. Streaming video of actual class lectures will be added to this course module in the future.

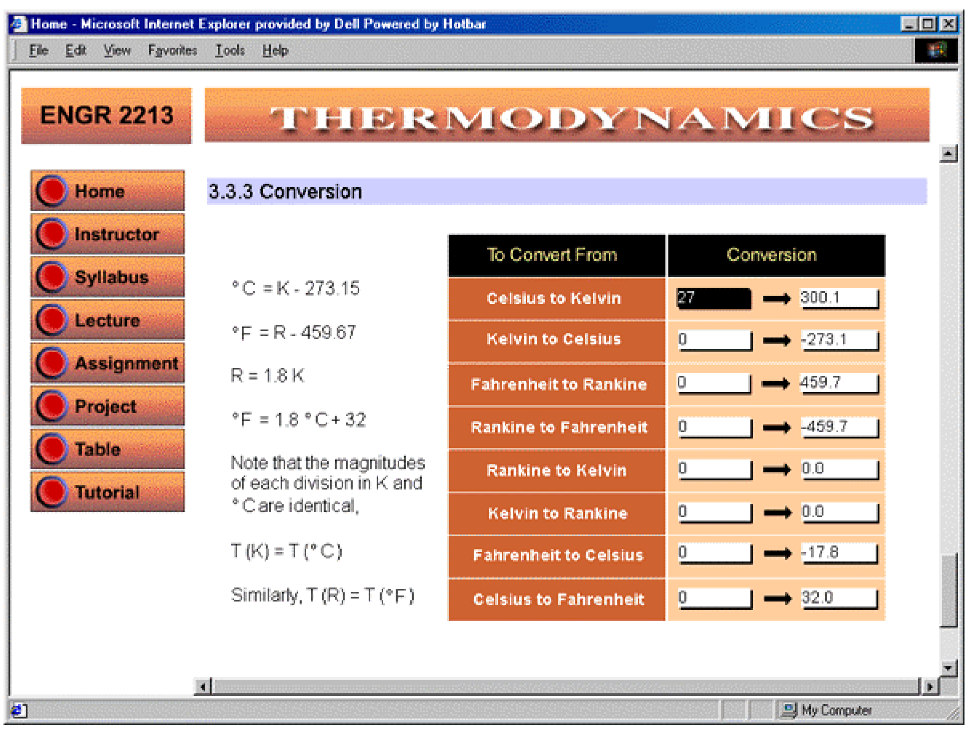


Figure 2. A typical interactive simulation.

Interactive Simulations

One of the unique features of using multimedia in engineering education is the use of interactive simulations. For instance, the unit conversion table for temperature as shown in Figure 2 was programmed using Macromedia Director 7 and saved in the Shockwave format for posting on the Web. Students can learn how to perform unit conversion easily through this type of simulation.

Animations

Animations are incorporated throughout the course page to help illustrate a certain concept that is not easily explained or visualized. For example, an animated piston-cylinder assembly can be used to illustrate the concept of the Carnot power cycle (Figure 3). The motion of the piston can be visualized through this animation for each process of the power cycle.

Examples

Throughout this course module, numerous examples are included to further illustrate the principle or theory of a particular topic. Figure 4 shows a typical interface for examples used in this course module. Students can navigate between the problem statement and solution using the buttons on top of the menu. Detailed solution procedures with a systematic approach are provided to improve students' problem solving skills.

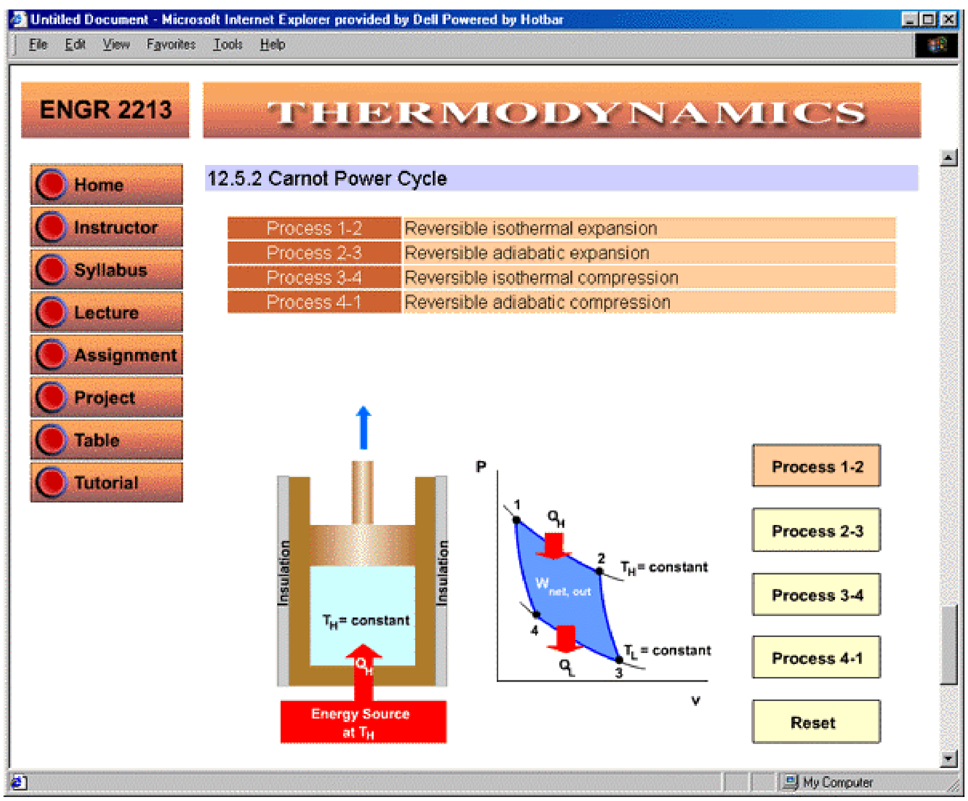


Figure 3. A typical animated simulation.

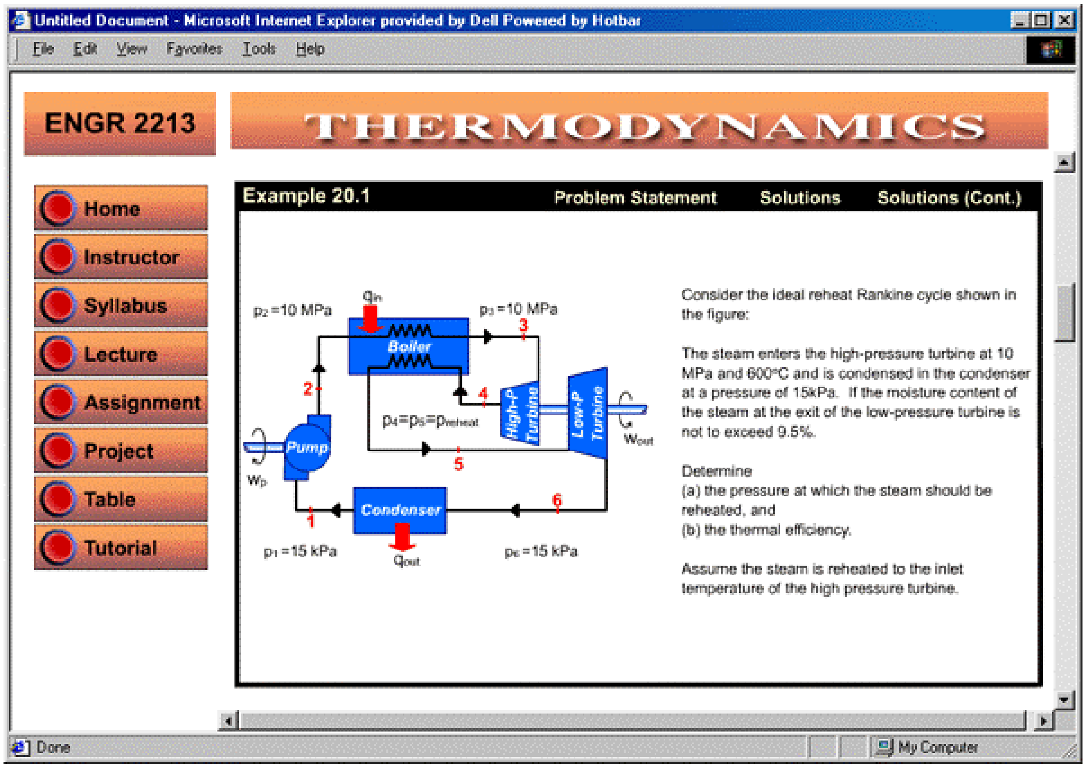
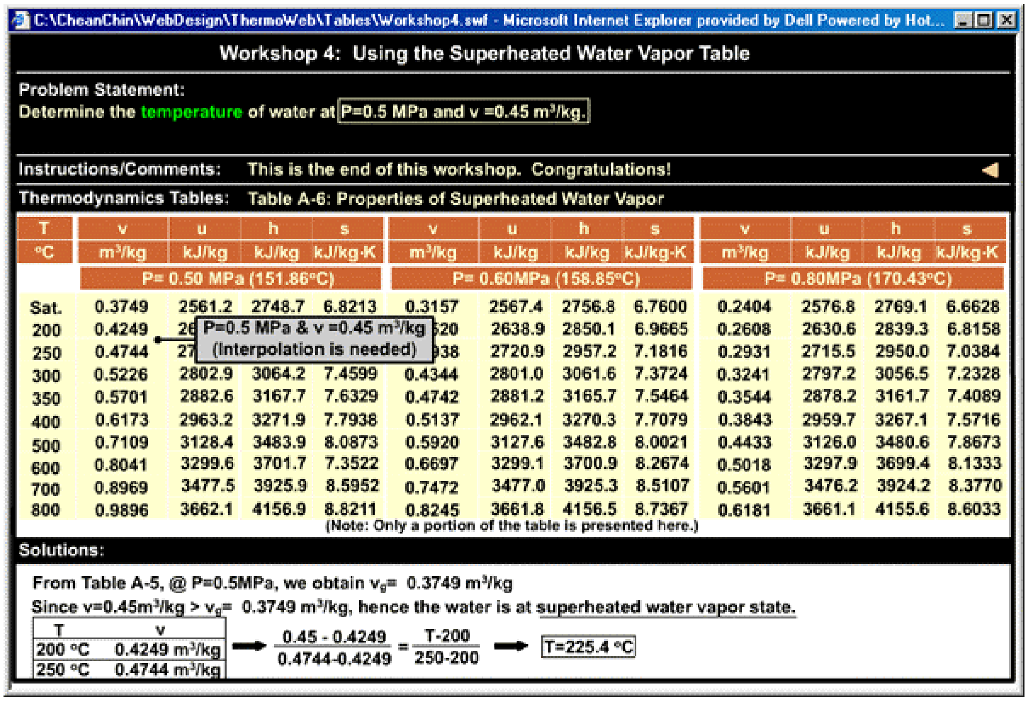


Figure 4. A typical interface for examples.

Workshops
In the study of Thermodynamics, students need to learn how to obtain thermodynamics properties from the thermodynamics tables. To ensure that students can acquire this important skill at the early stage of the course, five interactive workshops have been developed to help them to become familiar with the use of thermodynamics tables.

All the workshops were created using Macromedia Flash 4. A typical workshop interface (in a separate browser window) is shown in Figure 5. Although the size of the browser window is fixed initially, users can resize the window at their will without changing the resolutions of the graphics (pixelization). Another advantage of using Flash is that the generated Flash Player movie file (.swf) is usually small in size, and hence can be easily downloaded through the Web.

Five interactive workshops are designed to teach students how to use the thermodynamics tables such as the saturated water tables (temperature and pressure tables), superheated vapor table and compressed liquid table. For each workshop, students are directed to follow a series of step-by-step instructions. Through these workshops, students will also learn to interpolate the table values if necessary. Interactive workshops such as these provide a more effective way of engaging students in learning compared with a lengthy discussion found in a textbook.



T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P= 0.50 MPa (151.86°C)				P= 0.60MPa (158.85°C)				P= 0.80MPa (170.43°C)			
Sat.	0.3749	2561.2	2748.7	6.8213	0.3157	2567.4	2756.8	6.7600	0.2404	2576.8	2769.1	6.6628
200	0.4249	26			520	2638.9	2850.1	6.9665	0.2608	2630.6	2839.3	6.8158
250	0.4744	27			938	2720.9	2957.2	7.1816	0.2931	2715.5	2950.0	7.0384
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724	0.3241	2797.2	3056.5	7.2328
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464	0.3544	2878.2	3161.7	7.4089
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079	0.3843	2959.7	3267.1	7.5716
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021	0.4433	3126.0	3480.6	7.8673
600	0.8041	3299.6	3701.7	7.3522	0.6697	3299.1	3700.9	8.2674	0.5018	3297.9	3699.4	8.1333
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107	0.5601	3476.2	3924.2	8.3770
800	0.9896	3662.1	4156.9	8.8211	0.8245	3661.8	4156.5	8.7367	0.6181	3661.1	4155.6	8.6033

(Note: Only a portion of the table is presented here.)

Solutions:

From Table A-5, @ P=0.5MPa, we obtain v_g= 0.3749 m³/kg

Since v=0.45m³/kg > v_g= 0.3749 m³/kg, hence the water is at superheated water vapor state.

T	v
200 °C	0.4249 m³/kg
250 °C	0.4744 m³/kg

$$\rightarrow \frac{0.45-0.4249}{0.4744-0.4249} = \frac{T-200}{250-200} \rightarrow T=225.4\ °C$$

Figure 5. A typical interface for workshops.

<u>Tutorial Session for FE/EIT Examination</u>

In the United States, in order to become a professional engineer (PE) who can offer consulting services, one needs to be certified through an engineering registration process. The first step of the registration process is to pass the Fundamentals of Engineering Examination (FE), also known as the Engineer-In-Training Examination (EIT). Approximately ten percent of the questions in both morning and afternoon sessions of the FE exam are from the subject of Thermodynamics. Therefore, a tutorial session has been developed to prepare students for the Thermodynamics portion of the FE exam.

The entire tutorial session was created using Macromedia Flash 4. A typical tutorial interface is shown in Figure 6. This tutorial interface provides randomly selected questions from the existing database. Each time when a student accesses the tutorial, ten questions will be randomly selected. Each question is designed to cover a specific topic in Thermodynamics. There are a total of 250 questions presently available in the database, and more questions will be added into the database in the future. All questions in this tutorial session are in SI units since the National Council of Examiners for Engineering and Surveying (NCEES), which produces, distributes and scores the FE exam, intends to fully implement the metric units and phase out the English units in the FE exam on or before October 2008.[8]

For each practice session, students are advised to answer all ten questions in twenty minutes to simulate a real-time exam experience. At the end of the tutorial session, a scorecard with the correct answers to the questions is presented (Figure 7). Students are then given the opportunity to rework the problems that they missed. They can also choose to review the solution procedures for the problems if they desire.

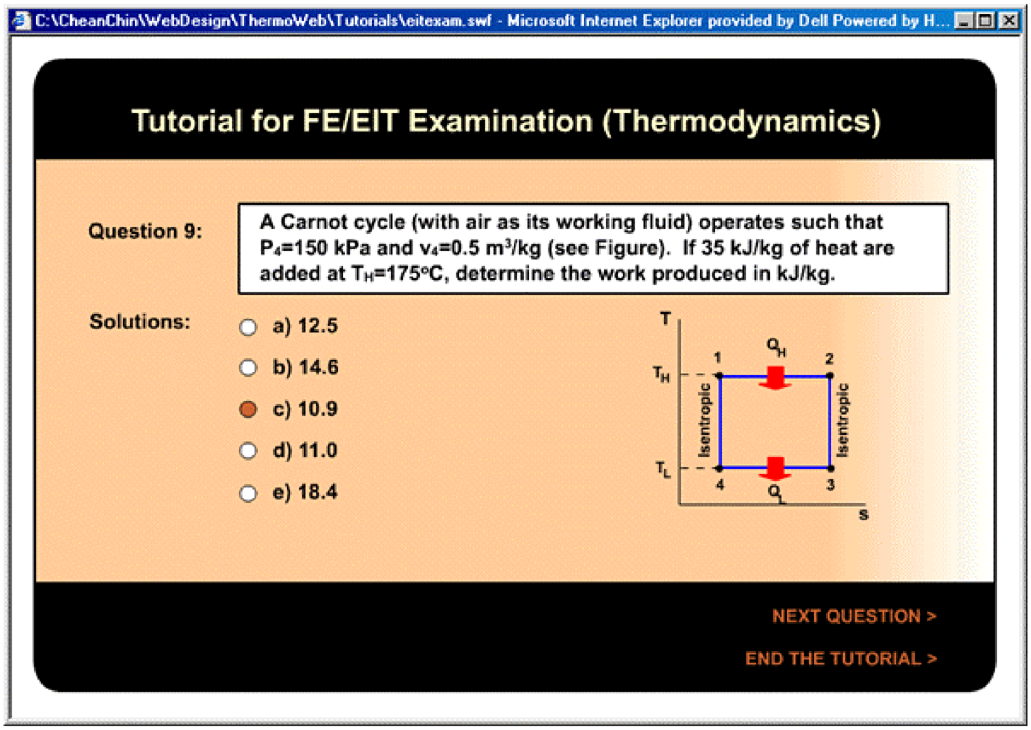


Figure 6. A typical tutorial interface for the practice session.

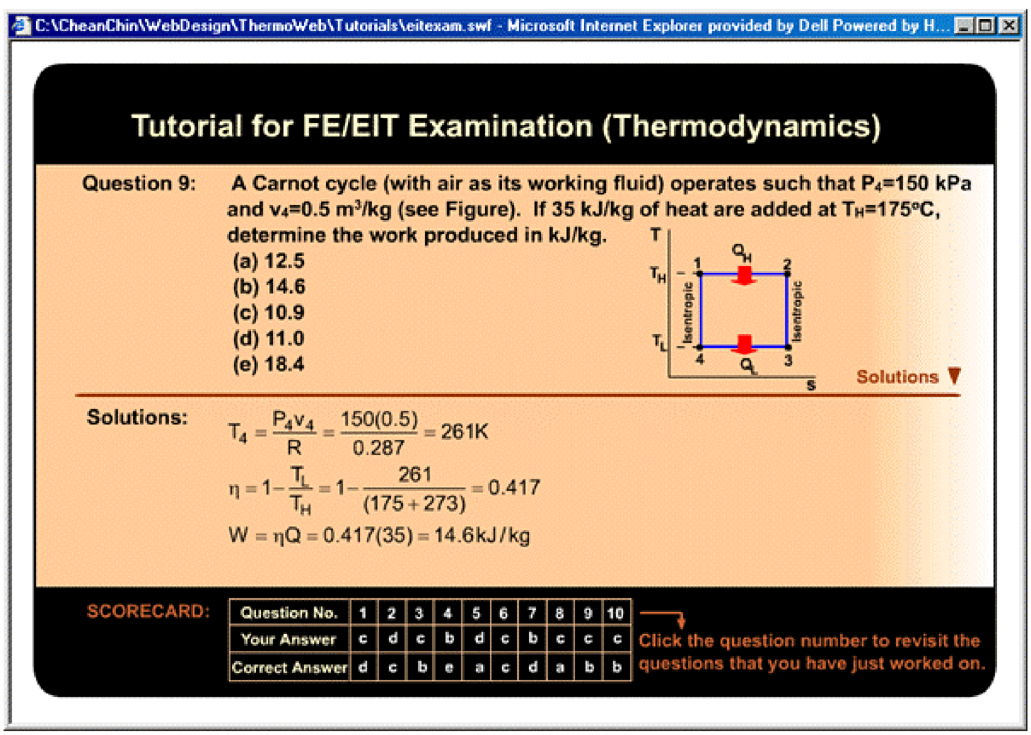


Figure 7. A typical tutorial interface for the solution.

IV. Response from Students

This course module was made available to students enrolled in Thermodynamics in the summer and fall 2000. Although the course module was not fully developed to include features such as the interactive workshops and FE/EIT tutorials at that time, it still gained favorably responses from the students. In general, students found it useful to review lecture notes for any missed classes and obtain solutions for the homework assignments.

V. Conclusions

A Web-based module has been developed and integrated into the teaching of Thermodynamics at the University of Oklahoma. This course module includes detailed lecture notes which are presented in an interactive way and a tutorial session to help students in preparing the FE/EIT examination. It has received favorable response from students.

Acknowledgement

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References

1. Cobourn, W. G. and Lindauer, G. C., "A Flexible Multimedia Instructional Module for Introductory Thermodynamics," *Journal of Engineering Education*, Vol. 83, pp.271-277, 1994.

2. Uddin, M. and Kuntscher, J., "Simulation and Data Visualization of Reversible and Irreversible Processes in Thermodynamics Classroom Teaching," *ASEE 1995 Conference Proceedings*, Vol. 2, pp.2220-2224, 1995.

3. Bhattacharjee, S. S. (San Diego State University), The Expert System for Thermodynamics (TEST), URL http://thermal.sdsu.edu/testcenter/home.html.

4. Çengel, Y. A. and Boles, M. A., *Thermodynamics: An Engineering Approach*, 3rd ed. (New Media Version), WCB/McGraw-Hill, New York, 1998.

5. Anderson, E., *Interactive Introduction to Thermodynamics Tutorial*, WCB/McGraw-Hill, New York, 2000.

6. Intellipro, Inc., *Interactive Thermodynamics v2.0*, John Wiley & Sons, Inc., 2000.

7. Moran, M. J. and Shapiro, H. N., *Fundamentals of Engineering Thermodynamics*, 3rd ed., John Wiley & Sons, Inc., New York, 1999.

8. Lindeburg, M. R., *EIT Review Manual: Rapid Preparation for the General Fundamentals of Engineering Exam*, Professional Publications, Inc., Belmont, 1999.

Biography

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