Internet Use in a Beginning Thermodynamics Course

Frederick H. Reardon
California State University, Sacramento

Abstract

Thermodynamics is a complex subject, involving many new concepts, complicated equations, and large amounts of data. Instructors are faced with the problem of how to present new concepts and reinforce old ones. The use of the Internet in a beginning thermodynamics course has proven to be helpful and effective. A web site is established for the course; it includes the course syllabus, with the goals and objectives, grading information, a course plan, and supplementary notes, classwork exercises, and homework assignments. The web page is designed so that it can be projected onto a screen in the classroom and can be downloaded by the students at home. Although the use of the Internet in teaching has many advantages, one problem is the amount of time required to prepare the web pages. Since the students like to download the notes, one must also be careful that the web pages print properly. Student reactions to the use of the Internet have been uniformly favorable. They say that it is very helpful in helping them to learn what is generally acknowledged to be a difficult subject.

Introduction

Thermodynamics is a complex subject. The study of thermodynamics involves grasping new concepts, learning how to find data, examining experimental results, manipulating equations, and more. One problem for the instructor is how to present new concepts and how to reinforce old ones. A good textbook is very important, especially since it is portable and requires no batteries. In class, the chalk or white board is invaluable, particularly combined with enthusiastic gestures by the instructor. However, complex figures or equations are difficult to draw accurately, especially while talking, and the students can take with them only what they are able to copy with the tools they bring to class. Overhead projection of transparencies allows important material to be prepared ahead of time, with thought given to the effectiveness of the layout. The students may still have trouble taking the material presented with them, unless copies of the transparencies are handed out.

The Internet offers a new approach to presenting and reviewing new concepts, data and problem-solving methods. In a study of web-based educational materials, Wallace and Weiner[1] conclude that these materials appear to offer flexibility in organizing classroom time. Kadiyala and Crynes[2], in their study of the effectiveness of information technology in education, report that multimedia presentations help students to visualize concepts. This author's experience with mechanical engineering technology students agrees with the data presented by Bernold, et al[3], that these students respond to the questions "how?" and "what?"and are sensory rather than intuitive learners. They respond well to visual input. The use of the Internet in the beginning

thermodynamics course for mechanical engineering technology students has proven to be helpful and effective.

How the Internet is Used

A web site is established for the course; its URL is given to the students at the beginning of the course. The web site, which is linked to that of the academic department and that of the instructor, includes, to start, the course syllabus, with the goals and objectives, grading information, and a course plan, as shown in Figure 1. Students are encouraged to use e-mail between class meetings for any questions or comments they may have. As the course progresses, various notes to supplement the text are added (Figure 2). These notes include diagrams, charts and text prepared by this professor (Figure 3), as well as links to other sites.

These notes are designed so that they can be projected onto a screen in the classroom and can be downloaded by the students at home. The projected images have been found to be effective in holding the students' attention. At any time during the course, it is easy to refer to the course objectives, course plan, and any notes previously discussed. When introducing a new topic, the web site is used to show how it is related to topics previously discussed. Every time the students access the web site, they can see the organization of the course topics (Figure 2).

Classwork, homework, and exams are also included on the web site (Figures 4 and 5). Sometimes, homework answers (not solutions) are given prior to the due date. In all cases, solutions are posted after the students' work has been turned in and graded. In this way, students can compared their solution techniques with the instructor's. They are invited to ask questions about differences in methodolgy and as well as numerical results.

Since CSUS has Internet links in each classroom, it is easy during each class to refer back to earlier notes, homework, or exams to answer questions and reinforce concepts, without having to carry all of the semester's transparencies to class each time. On occasion, it is helpful to open two windows so as to have a classwork problem and the appropriate notes or equations projected on the screen at the same time.

Problems

Although the use of the Internet in teaching has many advantages, one problem is the amount of time required to prepare the web pages. In the beginning, much of the information was already available in the form of transparencies. However, these had to be converted to digital form. Sometimes this was readily done simply by scanning. However, very often the scanned images were not of adequate quality and new ones had to be made. There is also a multiplying effect: when a web page seemed to work well in class, additional, new web pages were seen to be necessary. The digital format also can get one involved in more colorful illustrations, as well as the use of animation.

Very few "hard copy" handouts are used in this course, resulting in a great saving in terms of paper and copying time. The disadvantages of this approach are that students cannot make notes on key illustrations while they are being discussed in class and that whether or not students have

copies of these key illustrations is completely up to the students. One must also be careful that the web pages print properly. Scrolling of a long web page works quite well in the classroom, but that page may have page breaks that cut graphics in inopportune ways.

It is necessary to have the teaching materials that are on the web in some other form, such as transparencies, as backup in case the computer, the projector, or the Internet connection becomes unavailable during class. A backup lesson plan is also desirable.

Often it is helpful to use a PowerPoint presentation in class or to discuss a spreadsheet, TK Solver, or other computer model of a thermodynamic process. Such resources are linked to the web page so that they are available for download by the students. There have occasionally been complaints that the PowerPoint presentations take too long (more than five minutes) to download. When computer models are used in class, they are downloaded to the local computer, so that the students know that they have access to the same models. Since the models can be modified, it is possible to examine the results of different assumptions.

E-mail has been effective in answering questions outside of class and office hours. However, to date only about 1/3 of the students have made effective use of e-mail, even though e-mail was checked at least once daily and responses to student questions were sent shortly after the questions were received. Of course, there are always some students who will e-mail a crucial question at 3 a.m. on the day of an exam, expecting an immediate answer.

Student Reactions

Student reactions to the use of the Internet have been uniformly favorable. The following are comments included in the course evaluation from Spring, 2000:

"I think the use of the internet in this class is nice. It's good to be able to look at lecture notes and reference material online." "Internet usage is very helpful…Online solutions after homework is completed is nice…Online answers or hints before homework is completed is nice." "Web pages were a big help!" "I really think that the use of the web…was the extra bonus to understanding this class." "The Internet format, notes and illustrations are extremely useful during course study work. Prof. Reardon's prompt response to e-mail questions is a tremendous help in working through problems outside of class." "By putting his notes, h.w. assignments, and other things pertaining to the class on the web, it is a lot easier for me to look back at what we discussed and to see what I missed. Also, with the notes on the web, I don't find myself getting writer's cramp from trying to write down everything he says. I can concentrate more on what is being taught rather than writing down something that is already written." "The web page is great. I was never a computer fan, but since I have used it for this class I have started using it more and more, being able to print out notes and homworks and solutions." "The Internet web site is very helpful and the use of e-mail for Q and A is quick and efficient."

The students also had suggestions for additional web use, such as: "Have online quizzes or multiple choice questions online, for terminology." Students report that they check the web site outside of class on a regular basis. They like to look at new note pages prior to class and again

after class. Some students print out new notes before class and use them for taking notes during class.

Conclusions

The Internet is a helpful tool in teaching a complex subject such as thermodynamics. The students have the course objectives, schedule, key notes, homework assignments, and sample problem solutions available to them in the same format as they were presented in class. The students have responded well to this use of the Internet. They say that it is very helpful in helping them to learn what is generally acknowledged to be a difficult subject.

Bibliography

1. Wallace, D.R., & Weiner, S. T. How Might Classroom Time Be Used Given WWW-Based Lectures? *Journal of Engineering Education*, Vol. 87, No. 3 (July 1998).
2. Kadiyala, M. & Crynes, B. L. A Review of Literature on Effectiveness of Use of Information Technology in Education, *Journal of Engineering Education*, Vol. 89, No. 2 (April 2000).
3. Bernold, L. E., Bingham, W. L., McDonald, P. H., and Attia, T. M., Impact of Holistic and Learning-Oriented Teaching on Academic Success, *Journal of Engineering Education*, Vol. 89, No. 2 (April 2000).

FREDERICK H. REARDON

Fred Reardon is Professor of Mechanical Engineering and Coordinator of the Mechanical Engineering Technology Program at California State University, Sacramento. He received his B.S. and M.S. degrees in Mechanical Engineering from the University of Pennsylvania and his Ph.D. in Aeronautical Engineering from Princeton University (1961). He joined the faculty of CSUS in 1966 and has served as department chair and associate dean.

MET 140 Thermodynamics for Engineering Technology, Spring 2000

GOALS:

Understanding of the art and science of engineering thermodynamics and having the basic tools and skills necessary to obtain quantitative solutions to common engineering applications involving energy and its conversion, conservation, and transfer.

OBJECTIVES:

By the end of the semester, the student will be able to

1. Describe the three-element structure of thermodynamics:
    a. The Principles that govern all energy transactions
    b. The Properties that describe the thermodynamic states of materials
    c. The Processes that are carried out by thermodynamic systems
2. Use the basic working equations needed to study thermodynamic processes, devices, and systems;
3. Demonstrate effective problem-solving skills, especially those relevant to engineering thermodynamics;
4. Discuss the fact that effective utilization of our energy and other natural resources in engineering design always involves two of the most important laws of nature, namely, the First and Second Laws of Thermodynamics.

TEXT:

Burghardt and Harbach, "Engineering Thermodynamics", Fourth Edition, Cornell Maritime Press, 1999

GRADING:

- Homework 40%
- Mid-term Exams (2) 40%
- Final Exam 20%

MISCELLANEOUS INFORMATION:

- Professor: Frederick H. Reardon
- Office: ECS 4024F
- Telephone: (916) 278-6727
- Fax: (916) 278-7713
- E-mail: freardon@csus.edu
- Office Hours: Monday, Wednesday, 10:30-11:30 am; Friday, 1:00-2:00 pm; or by appointment

COURSE PLAN

Figure 1. Initial Web Page

NOTES

Basic Concepts

Thermodynamics Triangle
Thermodynamic System Concept Map
System Definition---Examples
Equilibria Among Three Thermodynamic Systems

Problem-Solving:

Solving Problems in Thermodynamics

Principles:

Notes on Conservation of Mass and First Law
Conservation of Mass and First Law--Summary
Notes on the Second Law
Second Law
Entropy Equations

Processes:

Thermodynamic Processes

Properties:

Notes on Phase Equilibrium (Saturation)
Properties of a Pure Substance
Orthographic Projections of Liquid-Vapor Regions for Water
Procedure for Finding Properties from Tables
P-V-T Relationships for a Gas
Properties of an Ideal Gas

Cycles:

Otto Cycle
Diesel Cycle
Brayton Cycle
Rankine Cycle
Refrigeration Cycles

Figure 2. Links to Supplemental Notes

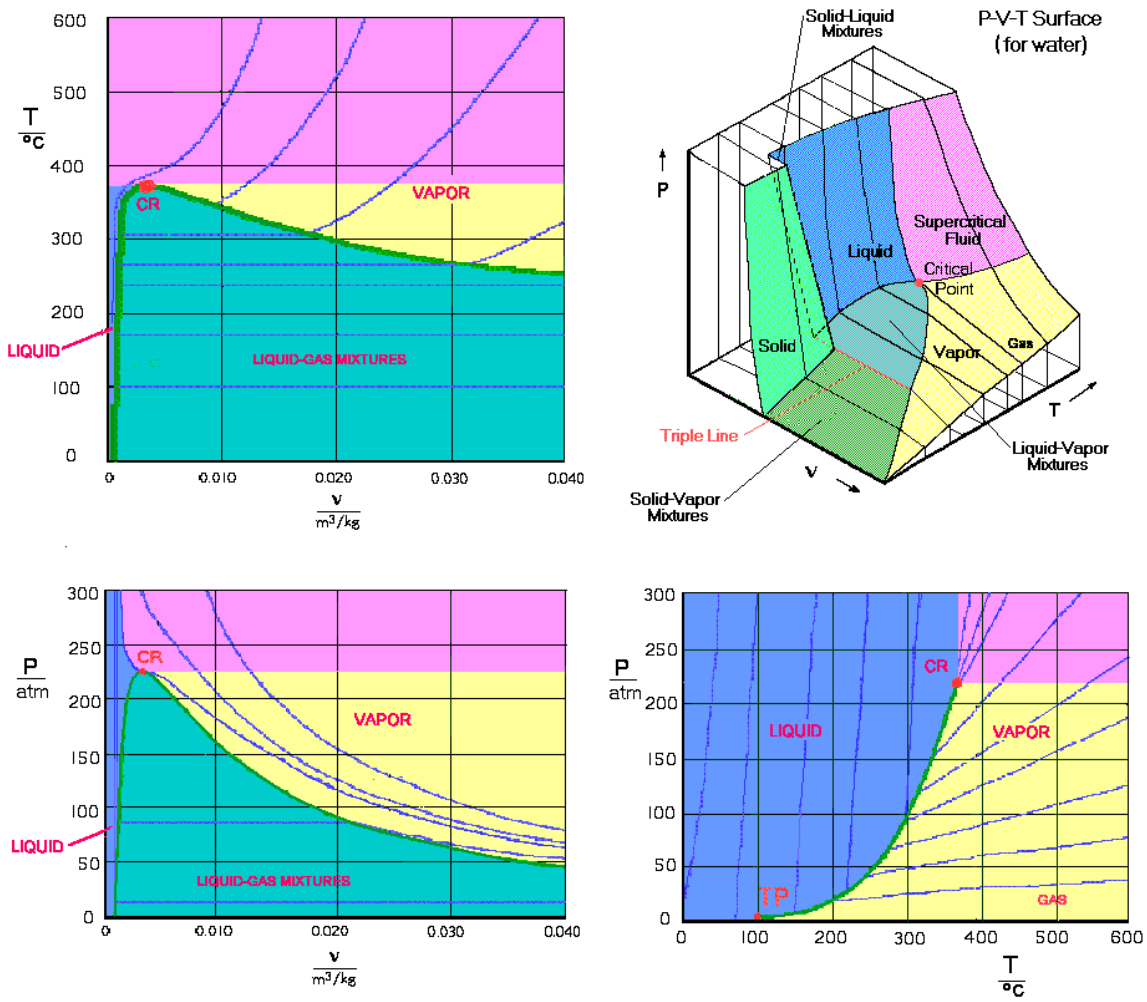

Figure 3. Orthographic Projection of Liquid, Vapor Regions for Water

CLASSWORK

Classwork-Homework #1 answers
Classwork-Homework #2 answers
Classwork for April 3, 2000

HOMEWORK

Homework #1
Homework #2 answers
Homework #3 Solutions
Homework #4 Solutions
Homework #5 Solutions
Homework #6 Solutions
Homework #7 Solutions
Homework #8 Solutions
Hints and Comments on Homeworks #7 and #8
Homework #9 Solutions

EXAMS

Sample Exam #1 with Solutions
Exam #1 with Solutions
Practice Exam #2 with Solutions
Exam #2 with Solutions
Practice Final Exam with Answers

Prof. Reardon's home page

Figure 4. Links to Classwork, Homework, Exams

MET 140 THERMODYNAMICS FOR ENGINEERING TECHNOLOGY
SPRING, 2000
Homework #9
(due May 17)

1. An ideal spark-ignition (Otto) cycle has the following characteristics:

Pressure at start of compression = 80 kPa
Temperature at start of compression = 20 C
Compression ratio = 9
Heat added by combustion process = 2800 kJ/kg

Assume that the working fluid is air and that the specific heats are constant and have the values given in Table A.1. Find:

a. The pressure and temperature at each state.
b. The work and heat transfer (per kg) for each process.
c. The thermal efficiency of the cycle

Solution:

Use the equations for the principles, processes, and properties given in Otto Cycle to find the properties at each of the states and the heat and work for each process.

States	1	2	3	4	Units
P	80	1733	11316	522	kPa
T	293	705	4605	1913	K
v	1.051	0.117	0.117	1.051	m^3/kg
u	210.4	506.3	3306.3	1373.8	kJ/kg
s	0.0508	0.0508	1.3981	1.3981	kJ/kg-K

Processes	1-2	2-3	3-4	4-1	SUM
DELTA u	295.9	2800.0	-1932.5	-1163.4	0.0
q	0.0	2800.0	0.0	-1163.4	1636.6
w	-295.9	0.0	1932.5	0.0	1636.6

Thermal Efficiency = 58.45%

Figure 5. Homework Problem Solution