

A THERMODYNAMICS COURSE PACKAGE IN ONENOTE

JOHN L. FALCONER, GARRET D. NICODEMUS, J. WILL MEDLIN, JANET DEGRAZIA, KATHERINE P. MCDANEL
University of Colorado • Boulder, CO 80309

Numerous studies have shown that using active learning methods in class improves student learning.^[1-10] The fraction of engineering faculty who adopt these methods is small, however, and the two key barriers most often cited^[11-14] in faculty resistance to adopting best teaching practices are:

- (1) **Lack of resources for utilizing active-learning techniques.** Because most faculty are severely time-constrained, they tend to adopt teaching approaches that rely on previously used materials, especially old course notes that use a lecture format. Developing new content for active-learning approaches takes significant time.
- (2) **Lack of experience or familiarity with active-learning techniques.** A closely related problem is that many instructors are simply unaware of proven practices in education, and have not been trained on how to use them, nor do they have time to study effective teaching approaches. However, the central philosophy of our approach is that, like students, instructors learn best by doing. That is, they will be most likely to incorporate active learning into their teaching philosophy for future courses if they have used best practices in a loosely guided way.

Therefore we have developed an easy-to-use course package to fill the gap between teaching innovations and their implementation in engineering education in order to improve student learning and engagement in chemical engineering courses. Although this course package is aimed at encouraging a new generation of early-career faculty to use active-learning methods in their teaching, it also allows established faculty

to more easily adapt their teaching. This course package contains complete class notes that utilize ConcepTests with peer instruction^[1] and they are designed for instructors to use student response systems (clickers). The materials are

John L. Falconer is the Mel and Virginia Clark Professor of Chemical and Biological Engineering and a President's Teaching Scholar at the University of Colorado Boulder. He has published more than 220 papers and has 12 patents in the areas of zeolite membranes, heterogeneous catalysis, photocatalysis, and atomic and molecular deposition. He has directed the effort at the University of Colorado to prepare screencasts and ConcepTests for chemical engineering courses on <www.LearnChemE.com>.

Garret D. Nicodemus is a senior researcher in the Department of Chemical and Biological Engineering at the University of Colorado Boulder. He has taught courses in material and energy balances, fluid mechanics, separations and mass transfer, and senior design. He has been involved in developing ConcepTests, screencasts, and interactive simulations for chemical engineering courses on <www.LearnChemE.com>. His interests include curricular innovations and use of interactive media in education.

J. Will Medlin is an associate professor in the Department of Chemical and Biological Engineering and the ConocoPhillips Faculty Fellow at the University of Colorado. He teaches courses in kinetics, thermodynamics, and material and energy balances. His research interests are in the area of surface science and heterogeneous catalysis.

Janet deGrazia is a senior instructor in the Department of Chemical and Biological Engineering at the University of Colorado Boulder. She teaches a number of courses in the department including a course on technology for non-engineers. As chair of the Undergraduate Committee, her interests lie in curricular innovations and the use of technology in education.

Katherine McDanel has her M.S. from Purdue University and is a project assistant in the Department of Chemical and Biological Engineering at the University of Colorado Boulder. She has helped create and process more than 600 screencasts and 1,000 ConcepTests for chemical engineering courses on <www.LearnChemE.com>.

presented in Microsoft OneNote so they can be used directly in class. In addition, they are designed to be used in a flipped classroom,^[15-17] where content is delivered outside of class using textbooks, screencast videos, and pre-class homework sets, so that class time can be used for active learning. Thus, the course package incorporates suggested screencasts for each class. The course package also contains three to four semesters of assignments and exams, all of which can be modified. Suggested multiple-choice or short-answer reading quiz questions are provided for each class to help the instructor motivate students to be prepared for class. They can be entered into an online classroom management system (e.g., Blackboard, Desire2Learn) so that students can complete them before class, and faculty can use their responses to focus their teaching efforts during class [Just-in-Time Teaching (JiTT)].^[18] The course package also contains reading quizzes and learning goals for each chapter. It includes teaching hints, tips on creating and grading exams, recommendations for dealing with various classroom and student situations, an example syllabus and schedule, and screencasts on how to use the materials effectively.

The course package focuses on integrating active-learning methods into the course; each class is designed using ConcepTests. These conceptual multiple-choice questions are used during class to improve student understanding of the important concepts and to challenge their misconceptions.^[5,6] Studies have shown that using ConcepTests and peer instruction^[1-7] instead of standard lectures dramatically improve functional understanding (“ability to interpret and use knowledge in situations different from those in which it was originally acquired”).^[8] Typical science and engineering courses emphasize solving quantitative problems, and thus students have difficulty applying the knowledge to new situations.^[8] Student responses with clickers provide the instructor (and all students) immediate feedback about student understanding, so that the instructor can use class time to concentrate on confusing concepts. This approach creates a more engaged learning environment, and allows students to determine how well they understand key concepts. It also allows them to learn from as well as teach their fellow students. Students prefer this mode of instruction; class discussions are livelier, attendance is higher, and students are more motivated to be prepared.^[1-9]

In flipped classrooms, the traditional approach of presenting lectures in class and having students solve problems at home is inverted. Information delivery can be done through screencasts, which are short videos that include narration by an instructor, and are made using software that captures the images on a computer screen. Screencasts introduce a topic, solve an example problem, explain a concept or a diagram, demonstrate the use of course software, or review for an exam. Interactive screencasts have been prepared that allow students to assess their conceptual understanding through interaction with a screencasts-based ConcepTest. Flipped classrooms

can be implemented by aligning appropriate screencasts to each class, along with questions to answer while watching the videos. Some reasons to use screencasts include:

- *They improve student learning: 1) directly, as indicated by studies in literature,^[19,27] and 2) indirectly, by freeing up class time for active learning exercises (e.g., ConcepTests, clickers, peer instruction, group exercises) that improve student learning.^[1-5,23]*
- *Students watch them even when screencasts are not assigned. Statistics from our online screencasts (1.8 million views in the last 12 months) show extensive screencast use. Any learning materials that result in students spending more time on a course are likely to result in more learning.*
- *Student feedback is overwhelmingly positive. Although students' opinions are not sufficient to indicate how useful screencasts are for learning, anything that has such positive feedback and focuses on course learning goals while motivating students to take initiative in their learning is beneficial.*

COURSE PACKAGE DESIGN

The overall course package structure is a digital notebook that combines textbook resources with those of a practiced professor. Combining active-learning tools into one central, user-friendly notebook provides faculty with a valuable teaching tool. In addition, the course package allows for modifications and updates as classes and resources are improved. Microsoft OneNote is used to host the course package as it is user-friendly, simple to learn, easy to access because it is a component of Microsoft Office, and can be used in class with a tablet PC instead of PowerPoint. Thus, class presentation materials, homework assignments, exams, and instructor explanations are all included in one educational suite. Requesting free access to the restricted course package is done through the “Instructor Resources” webpage at <www.learncheme.com>.

Implementation of the course package is straightforward. A new faculty member simply opens a section, becomes familiar with the topic (*i.e.*, the learning goals, student misconceptions, areas of difficulty), and then uses the class notes that utilize active-learning methods. For example, a section for a given day would include pre-class reading questions, course notes to use in class (ConcepTests, explanations, diagrams, etc.), hyperlinks to online resources, and suggested homework problems. Information for distribution to students is assembled so that it can be easily configured to post online. Since the notebooks are dynamic, they provide desired instructor flexibility^[11]; faculty can easily customize them by removing or adding to the sections and pages, building assignments, and modifying what to present in class. Additional sections on active learning and good teaching practices help frame the importance of these methods

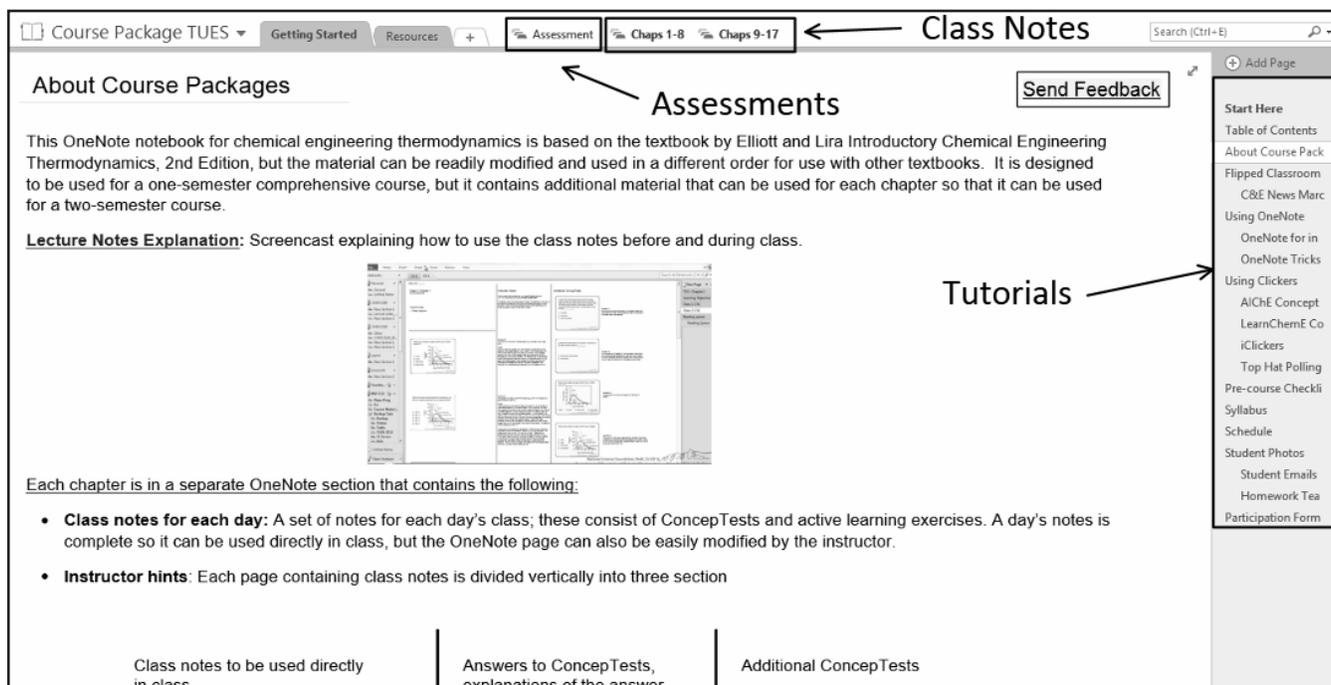


Figure 1. Example screenshot showing overview of information provided in each course notebook.

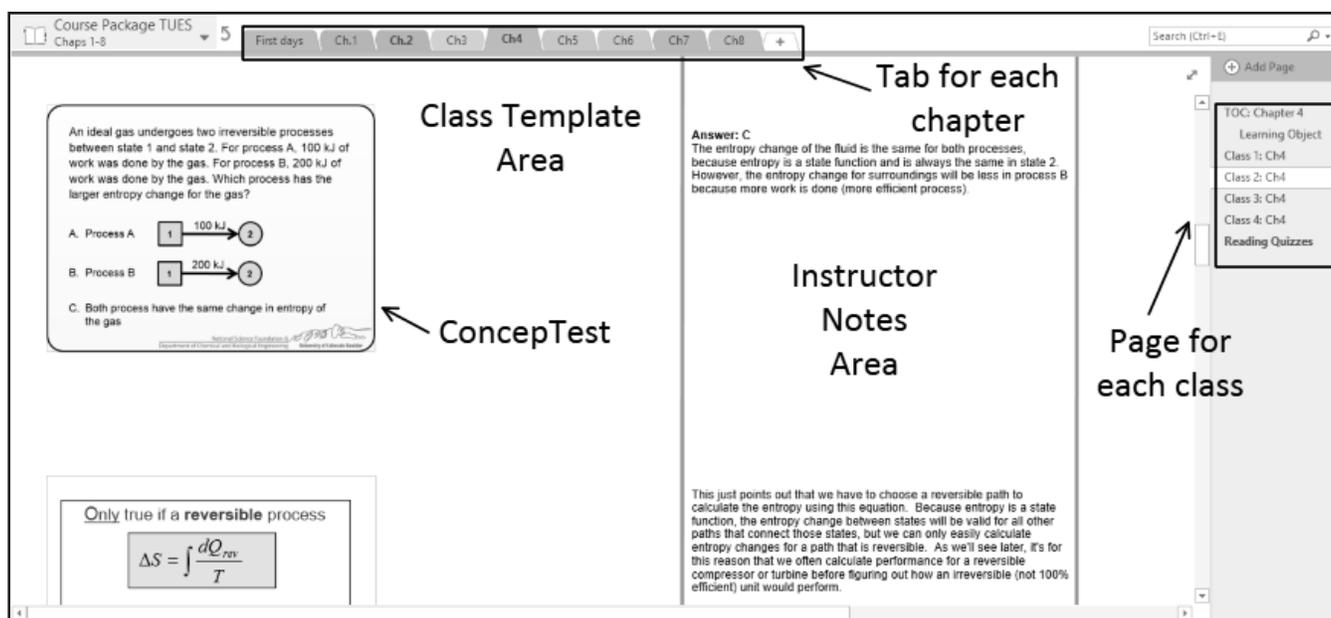


Figure 2. A class page in OneNote. Tabs at the top are for chapters. Tabs at right contain learning goals, links to screencasts, notes to be used in class, reading quizzes, handouts, and links to interactive simulations.

as well as explain to an instructor the reasoning behind the proposed approach. Once five or six weeks have passed, he or she opens a section that contains six to eight sample exams with solutions in a format such that individual questions can be compiled/configured/modified to create an original exam. Figures 1 and 2 are screenshots of the notebook, which is organized by the table of contents of the textbook selected for use.

COURSE PACKAGE CONTENTS

The thermodynamics course package was developed for one textbook initially, but similar packages are being developed for other thermodynamics textbooks. The course package contains the following:

- *Daily class notes:* A set of notes is included for each day; this consists of announcements, daily topics,

Course Package TUES
Chaps 1-8

First days Ch.1 Ch.2 Ch.3 Ch.4 Ch.5 Ch.6 Ch.7 Ch.8 +

Search (Ctrl+E)

+ Add Page

TOC: Chapter 5
Learning Objectives
Class 1: Ch5
Class 2: Ch5
Reading Quizzes

Reading Quizzes

5.1 The Carnot Steam Cycle

What does the area inside the T-S diagram equal to?

- The heat added to the turbine.
- The net work done for one cycle.
- The net intake of energy as heat for one cycle.
- The total entropy change for one cycle.

Answer: C

5.2 The Rankine Cycle

What statement correctly describes the difference between a Carnot cycle and Rankine cycle?

- The Carnot cycle is an isentropic process, but the Rankine cycle is a isenthalpic process.
- The total energy input in the Carnot cycle is more than that in the Rankine cycle.
- In the Rankine cycle, vapor leaving the boiler is superheated, but it is not in the Carnot cycle.
- The total entropy change is the same for both cycles.

Answer: C
Answer C can be confusing since the Carnot cycle does not have a phase change. There is vapor in the Carnot Cycle but it is just not superheated.

When steam is used in an energy cycle, why is the steam not compressed and then fed to the boiler as a high pressure gas?

Figure 3. Reading quiz questions for chapter 5 material. These align with the learning objectives and prepare students for in-class activities.

ConcepTests, and active-learning exercises. Each day's notes can be used directly in class, but the OneNote page can also be easily modified by the instructor.

- **Instructor hints:** On the right side of the class notes are explanations of each *ConcepTest*, including why an answer is correct and what might confuse students about wrong answers. Also included are suggested readings before class, suggested screencasts to watch, hints, and substitute *ConcepTests*. At the top of each page is a link to the AICHE Concept Warehouse,^[28] which provides a large selection of *ConcepTests* for chemical engineering courses. A new instructor can use the course package without modification the first time he/she offers the course, and then can easily revise the course materials in subsequent offerings.
- **Chapter learning objectives:** These are of the form described by Felder^[29] and indicate what students should be capable of doing after completing the chapter.
- **Hyperlink index (table of contents):** This index contains hyperlinks to pages in OneNote that are used often (e.g., course schedule, syllabus, grading scheme, student list, information for teaching assistant, resources on teaching styles).
- **Screencasts:** These screencasts are available on YouTube and can be used to provide a starting point for understanding the chapter and/or to create flipped classrooms. They include introductions to topics and explanations of concepts that traditionally have been presented in class. They also provide example problems worked out

completely. Links with descriptions of the screencasts are provided on the appropriate OneNote pages. Note that these screencasts are short (average of 7 minutes) so that they focus on one aspect and minimize cognitive overload.

- **Reading quizzes:** These are questions that the students answer online before class to encourage them to read the assigned sections or watch the assigned screencasts. When students are motivated to prepare for class, classroom time can be spent explaining the material that students find difficult rather than presenting it for the first time. Quizzes also make the *ConcepTests* in class more effective, as the clicker questions are based on material that students should read or view prior to class. The reading quizzes are organized by textbook sections (Figure 3).
- **Homework assignments:** These are located under the assessment section (Figure 4) and include suggested book problems as well as a variety of other problems with solutions. Distribution of the solutions will need to be controlled to continue to make them useful. Problem solutions accessible to students will make these materials less effective.
- **Sets of exams:** As with the assignments, five or six sets of exams (exam #1, exam #2, final exam) and their solutions are included.
- **Exam study guides:** Detailed study guides related to the learning goals are included, with links to recommended screencasts to watch for review.
- **Exam preparation:** Some suggestions on creating exams

Course Package TUES Assessment 5 Homework Exams + Search (C)

Assignment 4

Assignment 4 Due:
Assignment to be completed in assigned homework groups.

1. E-L 2nd, 6.2 (c), (d), (f), (h)
2. Describe an experimental setup and the experiments that will measure the partial derivative of enthalpy with respect to pressure at constant temperature for a non-ideal gas.
3. Design a vapor compression refrigeration system to cool a system to $-5\text{ }^{\circ}\text{C}$ with the capability for up to 20 kW of cooling. You have a reservoir at $20\text{ }^{\circ}\text{C}$ to reject heat to. Refrigerants and their properties can be found at <http://webbook.nist.gov/chemistry/fluid/>
4. An ideal Rankine cycle operates with the following design: 100 kg/s of steam enters a turbine at 30 bar and $500\text{ }^{\circ}\text{C}$ and is condensed at 0.1 bar. Determine the power produced and the efficiency of the cycle.
5. Evaluate the partial derivative of H with respect to V at constant T and P for a pure species that obeys the van der Waals equation of state.
6. Present a physical process on a system that is described by the partial of U with respect to P at constant S. Describe the process as completely as needed. Based on this process, do you think this partial derivative is positive, negative, or zero? Justify your answer.
7. Gas A expands through an adiabatic turbine. The inlet stream flows in at 100 bar and 600 K, while the outlet stream is at 20 bar and 445 K. Calculate the work produced by the turbine. For gas A, the ideal gas heat capacity is $30.0 + 0.02T$, where the heat capacity is in J/mol-K and the temperature is in Kelvin. The equation of state for gas A has the following form: $P(V-b) = RT + aP^2/T$ where $a = 0.001\text{ (m}^3\text{-K)/(bar-mol)}$ and $b = 8 \times 10^{-5}\text{ m}^3\text{/mol}$.

Homework Sets
2010 Assignments
Assignment 1
#1 Solutions
Assignment 2
#2 Solutions
Assignment 3
#3 Solutions 2010
Assignment 4
#4 Solutions
Assignment 5
#5 Solutions 2010
Assignment 6
#6 Solutions 2010
Assignment 7
#7 Solutions 2010
Assignment 8
#8 Solutions 2010
Assignment 9
#9 Solutions 2010
Assignment 10
#10 Solution 2010
2009 Assignments
2006 Assignments
2005 Assignments

Figure 4. Example homework assignment. Assignments from four years of classes are inventoried with hand-written solutions.

(so they are easier to grade, are of the appropriate length, and test the appropriate material) and preparing students to take exams are provided.^[30,31]

- **Suggested syllabus and schedule:** This section includes pages with proposed schedules for 14-, 15-, and 16-week semesters, suggested grading scales, and possible course policies.

Each notebook contains a getting-started section that demonstrates how to download the course package (access through <www.learncheme.com>), navigate through the materials, and use OneNote. Much of this information is demonstrated with screencasts. For example, the navigation screencast shows the instructor how to use the course notes for a specific day, including the instructor explanations that are included as part of the notes. One notebook section contains educational articles and website links^[28,32] on active learning. Part of the first day of class is dedicated to showing students the motivation for using ConcepTests and peer instruction in class. Note that although the course package includes a large variety of tools that can be used in instruction, instructors are able to tailor the tools to their own style. For example, although the resources provided will be sufficient to institute a true flipped-classroom approach, instructors can personalize their notebooks to make only periodic use of active-learning techniques. We expect that instructors who are new to active-learning approaches may use a more modular approach as they gradually adopt new teaching practices.

USING ONENOTE

Microsoft OneNote is a powerful software program that improves faculty efficiency by providing a means to organize a large amount of information. It is a component of Microsoft Office and consists of digital notebooks that are divided into sections, which are further divided into pages (and sub-pages). Text can be added to a OneNote page just like in a word processor, figures can be copied onto pages, files can be printed to them (or saved as icons that can be opened from the page), emails can be readily sent to them from Microsoft Outlook, handwritten text or figures can be added using a tablet PC, and links to other OneNote pages, to web pages, or to files, can be inserted. A page can be essentially any length. OneNote provides the following advantages that are important for the course package:

- It is easy to learn how to use.
- All text in the notebooks is searchable.
- Everything is continuously saved, and backup copies are created automatically.
- Moving between pages, sections, and notebooks is much faster than opening new Word, PowerPoint, or other files.
- Notebooks can be shared with others, and this can be much more efficient than email for working with graduate students, teaching assistants, or staff. It provides an efficient method to delegate that is easy to follow up.
- Files are easily printed to OneNote; it shows up as a printer in the printer list.

- A new project is easily started by creating a new One-Note page or section.
- A OneNote page can be converted into a Word or PDF file or it can be directly emailed.
- Files, programs, or websites that are used repeatedly can be opened by creating a link on a OneNote page. Opening a Word file that is used often is much faster from OneNote than searching through file folders and subfolders for the file.
- It can be viewed on PCs, iPads, and phones and synced between them.

OneNote can be used to present material instead of PowerPoint in class; this mode of instruction is used by the developers of the package, where the OneNote page essentially provides an electronic “board” using a tablet computer to write notes in between prepared visuals. However, this mode of instruction is not required to use the course package. Content from OneNote can easily be copied to other applications such as PowerPoint.

INITIAL FEEDBACK

A beta version of the thermodynamics course package was used by a few faculty members in the fall of 2013. Feedback has been very positive. A new faculty member at another institution teaching thermodynamics for the first time stated: “I am so thankful that I had the thermo course package you developed. It certainly helped a lot!” Other faculty have expressed their appreciation for the materials to help them design their course. Further assessments to collect faculty suggestions and student feedback are being done to strengthen the course package. Interested faculty should request free access through the <www.learncheme.com> website under “Instructor Resources.”

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