# 3.012 Fundamentals of Materials Science and Engineering

## Thermodynamics Component

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OVERVIEW AND GENERAL INFORMATION

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## Class lecture notes

We will use partially-completed lecture notes as a tool for covering the thermodynamics topics in lecture... with numerous blank spaces for you to fill in as we go over the material, and to take your own notes. There are disadvantages to this strategy of learning- it means you will have less to write during lecture, and taking notes is part of the learning process for many people. However, it has several powerful advantages: I can provide you with (sometimes) detailed graphical descriptions that make it easier to follow concepts, we can have long formulas pre-written (to avoid potential confusion if you miscopy an equation), and I can provide richer notes to complement our discussion during lecture- which may include digressions that help you see where theory is applied, interesting anecdotes from the history of this field, or detailed application examples.

The lecture notes will be available in the lecture notes section of the course. *It is your responsibility to download and print out the notes to bring to class.* This is not designed as a form of torture; rather, I hope you will take that opportunity to look over the topics that will be covered the next day and seed questions that you may want to raise during lecture. These notes will be your primary resource for the thermodynamics component of 3.012, and will be the basis for the problem sets and quizzes.

## Reading Assignments

Reading assignments will be made to complement each lecture in the thermodynamics and statistical mechanics component of 3.012. We will use the required text by Engel and Reid as a source for some of these assignments, while occasionally excerpts from other textbooks will be taken. While having a unified textbook is the ideal situation, a dilemma faced in every course, and particularly this course, is a lack of a good single source of information. Wherever possible, readings are being chosen from texts where the explanation is best made clear, is made at a level appropriate for a first course in thermodynamics/statistical mechanics, and uses examples relevant for you as future materials scientists & engineers. Readings from texts other than Engel and Reid will be provided in class or made available on the 3.012 stellar site.

In addition to the assigned readings, I will occasionally provide a 'supplementary reading.' These will not be handed out in class, but will be available for downloading on the web. *These are not required reading, and will not be tested in problem sets or quizzes.* They are simply extra sources that may help you understand concepts from lecture, provide a different way of explaining a given concept, or just demonstrate an interesting application of a topic we've covered. You should not feel obligated to read these, but they are there if you are interested in following up on topics from class.

## Additional Resources

3.012 has many topics that were adapted from Prof. Carter's course 3.00 *Thermodynamics of Materials*. Prof. Carter's lecture notes for 3.00 are available on the web[1], and are an excellent source of additional reading, which may help deepen your understanding of many topics.

In addition to the class notes and reading assignments, you may find it useful to read over our topics from other good textbooks. Seeing the presentation of a difficult concept from multiple points of view can sometimes make it clearer. The following are some suggested textbooks that are available in the library. I also have copies of most of these, which may be borrowed for short periods. Wherever these texts are explicitly used as a resource in the lecture notes, it has been indicated, as a guide if you want to follow up on a particular topic.

There are (literally) hundreds of textbooks on thermodynamics- particularly because thermodynamics underpins diverse fields including chemistry, physics, mechanical engineering, electrical engineering, chemical engineering, materials science & engineering, and even biology (!). I am listing below some of the better texts- there *are* texts in the library that you will find useless (or worse). Many of the reading assignments this term will be taken from a new textbook by Ken Dill and Sarina Bromberg.[2] This text is focused on applications for physical chemists and biologists, but has excellent explanations and many simple numerical examples that you may find helpful. The text by Denbigh[3] is a traditional text on classical thermodynamics- it is very rigorous, but in some parts difficult for a newcomer to thermodynamics. Zemansky's text[4] and the text by Lupis[5] are a good place to go for alternate explanations of difficult concepts, and are rooted in practical examples. The text by Bent[6] provides a very physical description of concepts and uses simple examples to help explain concepts. It teaches thermodynamics from a composite statistical mechanics/classical thermodynamics approach. For practice with practical problems, a good textbook is Gaskell[7], which has answers for the problems at the end of each chapter provided.

The text by Hill[8] is an introduction to statistical mechanics, but like Denbigh, its rigor may be difficult for you to follow at this stage. Callen[9] is a somewhat advanced treatment of classical thermodynamics, and likewise Chandler[10] is a somewhat advanced modern treatment of statistical mechanics.

1. Carter, W. C. *3.00 Thermodynamics of Materials Lecture Notes* http://pruffle.mit.edu/3.00/ (2002).
2. Dill, K. & Bromberg, S. *Molecular Driving Forces* (New York, 2003) 704 pp.
3. Denbigh, K. *The Principles of Chemical Equilibrium* (Cambridge University Press, New York, 1997) 494 pp.
4. Zemansky, M. W. & Dittman, R. H. *Heat and Thermodynamics* (McGraw-Hill, New York, 1997) 487 pp.
5. Lupis, C. H. P. *Chemical Thermodynamics of Materials* (Prentice-Hall, New York, 1983) 581 pp.
6. Bent, H. A. *The Second Law* (Oxford University Press, New York, 1965) 429 pp.
7. Gaskell, D. R. *Introduction to Metallurgical Thermodynamics* (Hemisphere, New York, 1981) 611 pp.
8. Hill, T. L. *An Introduction to Statistical Thermodynamics* (Dover Publications, Inc., New York, 1986) 508 pp.
9. Callen, H. B. *Thermodynamics* (Wiley & Sons, New York, 1960) 376 pp.
10. Chandler, D. *Introduction to Modern Statistical Mechanics* (Oxford University Press, Inc., New York, 1987) 274 pp.