School of Engineering
University and Guelph
ENGG-3260 Thermodynamics

Course Outline: Fall 2011

1. INTRODUCTION

Ever wondered how the refrigeration process, mechanical engines, or power plants work or why chemical reactions go one way and not the other? The answer to many such curious questions is the study of "Thermodynamics". Thermodynamics is a study of energy and energy transfers. It examines thermal properties of materials and how some of the properties are changed as the substance receives or dumps energy. A good comprehension of the various thermodynamic processes is essential to the practice of engineering. A quick look around will convince you that these processes are omnipresent in our modern society: refrigerators, the power cycle in all sort of power plant, the thermal processes present in a heating, ventilation and air conditioning (HVAC) system and the simple process of phase change encountered daily.

This thermodynamics course serves as an introduction and is the first one, and perhaps the only one, that you will encounter during your undergraduate study in engineering. This course deals with the fundamentals of thermodynamics, the properties, states, processes and cycles encountered in engineering and with the laws necessary to understand them.

2. LEARNING OBJECTIVES

2.1 General learning objectives

Knowledge base	X	Design	X	Team work	X
Problem analysis	X	Engineering tools	X	Individual work	X
Life long learning	X	Impact on society	X	Economics and project management	
Investigation	X	Professionalism			
Communication		Ethics and equity			

2.2 Specific learning objectives

Acquire the skills needed to properly understand and solve problems encountered in thermodynamics. At the conclusion of this course, the student will be able to:

- Define the thermodynamics properties; temperature, pressure, entropy etc;
- Describe the type of thermodynamic systems, isolated, open and closed systems;
- Describe the thermodynamic processes, cyclic, reversible, non-reversible, adiabatic, isentropic, throttling, polytropic processes etc. ;
- Distinguish between extensive and intensive properties;
- Describe the processes of sublimation, vaporization, condensation and fusion;
- State and apply the first and second law of thermodynamics;
- Evaluate system and component efficiencies using T-s or h-s diagram;
- Differentiate between the path for an ideal process and that for a real process on a T-s or h-s diagram;
- Apply the ideal gas laws to solve for the unknown pressure, temperature, or volume;

- Calculate the work done in constant pressure and constant volume processes;
- Apply the steady-flow energy equation or the First Law of Thermodynamics to a system of thermodynamic components (heaters, coolers, pumps, turbines, pistons, etc.) to estimate required balances of heat, work and energy flow;
- Apply ideal cycle analysis to simple heat engine cycles to estimate thermal efficiency and work;
- Explain the physical content and implications of the second law in non-mathematical terms;
- Define entropy and use entropy calculations as a tool for evaluating irreversibility (lost work) in engineering processes;
- Evaluate the performance of gas power, vapour and combined power, and refrigeration cycles;
- Understand psychometric chart and perform mass and energy balance to various air-conditioning processes; and
- Obtain a basic physical intuition for the thermodynamic performance of real power devices as indicated by recognition of what good, average, and poor performance is.

3. INSTRUCTOR

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Teaching assistants and Tutorials:

Idris Sule (isule@uoguelph.ca) Mon 2.30-4.20 pm and Thur 7.00-8.50 pm
Maxime Moisan (mmoisan@uoguelph.ca) Tues 8.30-10.20 am and Thur 8.30-10.20 am
Jeffrey Snider-Nevin (jsnidern@uoguelph.ca) Fri 2.30-4.20 pm and Tues 7.00-8.50 pm
Cynthia Mason (cmason01@uoguelph.ca) Tues 10.30-12.20 pm and 1.30-3.20 pm
Liang Li (lli04@uoguelph.ca)

Lecture schedule: M, W, F 12:30 – 1:20 pm Thrn 1200
Tutorials: Consult the WebAdvisor

Students are not allowed to change their tutorial sections without the approval of the instructor.

Prerequisites: As stated in the U of G Calendar
Textbook: Yunus A. Çengel and Michael A. Boles. Thermodynamics – An Engineering Approach, 7th edition, McGraw Hill Higher Education

4. RESPONSIBILITIES AND TASKS

During this class, the student is considered to be *an engineer in formation.* His/her work is not only to get good grade, but to also get prepared to skillfully assume his/her future job as engineer. With this in mind, the student does have the full responsibility to plan and manage his/her learning. Keep in mind that fundamental engineering knowledge/thinking is acquired by repetition and problem solving. Here are the three main tasks under the responsibility of the student.

The first task is to do the necessary work in order to understand and learn the concepts seen in class. This work consists in reading the suggested material prior to and after class. The lectures purpose is to present, explain and complete the information in relation to the main concepts presented in class. The second task is to actively participate in the activities taking place in the classroom. Discussions and problem solving (alone or in a team) are the principal activities in which the participation of the student is demanded and advised. Finally, the student's third task is to use all the resources at his/her disposition in order to master the fundamental knowledge and the concepts needed to analyze and model the thermodynamic processes studied.

The instructor's responsibility is to organize and manage the environment in which the student is coming to learn. To this end, he/she will present the necessary learning resources and will animate the class activities. He/she is also available to help students with any kind of problem they could have regarding the content of the class. As usual, he/she plays a role in the grading process.

Attendance

The best leaning experience will be achieved if you attend lecture and tutorial regularly. Scientific studies have proven that a student success rate is strongly related to his/her class attendance. Those who attend classes and tutorials have higher success rates than those who do not.

5. METHODOLOGY

Every lecture will be organized in a way that favors a good comprehension of the presented concepts and an active appropriation of knowledge. Generally, the instructor's formal lecture will alternate with problem solving presentations and period of questions and answers. In order for the student to actively participate during the lectures, they would need to have read the class materials before hand.

6. CLASS CONTENT

The following table contains the tentative schedule of lecture topics and reading assignments. **It is strongly suggested that you scan the reading materials prior to the lectures.**

Tentative Course Outline

Week (s)	Topics	Chapter in Class Notes
Week 1	Introduction, Basic Concepts, units, dimensional homogeneity, Closed and open systems, Control volumes, Equilibrium Pressure, Temperature, manometer, atmospheric pressure	Chapter 1 Introduction and basic concepts
Week 2	Energy transfer, energy analysis chpt. 2 Forms of Energy, heat, work, Mechanical forms of work, first law of thermodynamics, Energy efficiencies	Chapter 2 Energy, energy transfer, and general energy analysis
Week 3	Properties of Pure Substances, phase change, Property diagrams and tables, Property tables, ideal gas equation, other equations of state	Chapter 3 Properties of pure substances
Week 4	Energy analysis of closed systems chpt.4 Energy analysis of closed systems, moving boundary work, energy balance, Specific heats, internal energy, enthalpy Ideal Gas	Chapter 4 Energy analysis of closed systems

Week 5	1st law control volumes, conservation of mass, flow work, Energy analysis of steady flow, SS devices, unsteady flow	Chapter 5 Mass and energy analysis of control volume

Week 6: Reviews of chapter 1-5 and Mid-term on October 21, 2011 at Thrn 1200 between 7-9 pm

Week 7	Intro to 2nd law of thermodynamics, Thermal reservoirs, heat engines, Refrigeration & heat pumps, perpetual motion machines, reversible and irreversible processes, Carnot cycle, principles, temperature scale, Carnot heat engine, Carnot Refrigeration and heat pump	Chapter 6 The second law of thermodynamics
Weeks 8-9	Entropy, increase of entropy principles, Entropy change in pure substances, isentropic process, Tds relations, Reversible steady-flow work, isentropic efficiencies of steady flow devices, entropy balance	Chapter 7 Entropy
Weeks 10-11	Analysis of Power Cycles, Carnot Cycle, Air standard assumptions, Otto cycle, Diesel cycle, Rankine cycle, Rankine cycle, deviations from ideal efficiency, Ideal Reheat Rankine cycle, Ideal Regenerative Rankine cycle, combined gas-power cycles	Chapter 9 Gas power cycles Chapter 10 Vapor and combined power cycles
Weeks 11-12	Refrigerators and heat pumps, revised Carnot cycle, Ideal and actual vapour-compression refrigeration cycles, The Psychometric Chart and air-conditioning processes	Chapter 11 Refrigeration cycles Chapter 14: Gas-vapor mixtures and air-conditioning
Weeks 12-13	Review	

Final Exam: December 08 between 7-9 pm

7. Tutorials and Review Problems

Tutorials will be used to strengthen students' understanding of thermodynamics through reviewing examples. The main purposes of the tutorials are two-fold: 1) to allow an opportunity to explore issues and ask questions about the material covered in the lectures, text and previously assigned material that requires further clarification; 2) to write a short quiz dealing with the problems recommended for that particular week.

A major objective of this course is to prepare students to solve engineering problems that involve thermodynamic processes. A large number of assignments and review problems with solution will be made available to the students. It is thus important for you to work out each problem by **yourself** to gain deeper appreciation for the fundamentals of the subject and build your confidence in applying these fundamentals to the solution of engineering problems. Do not deny yourself the joy of self-discovery.

Laboratory Experiments *:
1. Temperature measurement and calibration.
2. Bomb calorimeter for heating value calculation
3. Heat pump demonstration
4. Steam power plant demonstration
5. Air-conditioning demonstration

* Laboratory experiments will be conducted subjected to availability of equipments

8. EVALUATION AND GRADING

Various exams and assignments will be used to evaluate the understanding of the student during the term. A description of each of these exams and assignments is here presented:

GRADING SCHEME

Quizzes (5-7 weekly) (property tables booklet)	20 %
Midterm (property tables booklet and one page note)	30 %
Final Exam (property tables booklet and one page note)	50 %

You are also allowed to use a **non-programmable** calculator during the tests and exams. Text book is not allowed in the exams.

1. Quizzes (20%)

The quizzes will typically last 15 minutes and will be given towards the end of the tutorial sessions. Students should clearly understand concepts in order to prepare for any tests rather than simply memorizing the solution schemes.

2. Mid-Term Exam (30 %)

The content covered by this exam will correspond to what has been covered in class the before the exam. The exam will present two types of questions: comprehension questions and problems to solve. They will be of the open book variety.

3. Final exam (50 %)

A final exam will be given at the end of the term (during the final examination period). This exam will be built in order to verify that the student acquired the skills and knowledge needed by an engineer. This exam will be comprehensive. It will also be of the open book variety. Open books means you are allowed to use property tables booklet and one page note.

MISSED QUIZZES AND MIDTERM

If you miss a **quiz** due to illness, please inform your TA. The quiz will not be counted in determining the overall quiz grade.

If you miss the midterm and have an acceptable, properly written reason in accordance with University Calendar, the weight of the midterm will be added to the weight of the final exam. Please note that all other university policies specified in the Undergraduate Calendar 2010/11 will be followed.

9. BIBLIOGRAPHICAL REFERENCES

TEXTBOOK

CENGEL, Y.A., BOLES, M.A. (2006) *Thermodynamics, an Engineering Approach*, 7th edition, McGraw-Hill, 1018 p.

ADDITIONAL REFERENCES

SONNTAG, R.E., BORGNAKKE, C., VAN WYLEN, G.J. (2003) *Fundamentals of Thermodynamics*, 6th edition, John Wiley & Sons, 794 p.

MORAN, M.J., SHAPIRO, H.N. (2004) *Fundamentals of Engineering Thermodynamics*, 5th edition, John Wiley & Sons, 874 p.

SONNTAG, R.E., BORGNAKKE, C. (2007) Introduction to Engineering Thermodynamics, 2nd edition, John Wiley & Sons, 617 p.

Materials posted on the courselink.

Note:

- Students who need course adaptations or accommodations because of a disability, or who have emergency medical information to share, please speak to me during the first two weeks of classes.
- Students who require accommodation on the basis of religious obligations are referred to the policy at: http://www.uoguelph.ca/hre/hr/hrreligious.shtml.
- I would also like to draw your attention to the regulations and procedures on Academic Misconduct contained in the undergraduate calendar at: http://www.uoguelph.ca/undergrad_calendar/c08/c08-amisconduct.shtml.

Disclaimer

The instructor reserves the right to change any or all of the above in the event of appropriate circumstances, subject to University of Guelph Academic Regulations.