University of Victoria

Department of Mechanical Engineering

COURSE OUTLINE

MECH 443 Advanced Thermodynamics

Spring 2014

Course Web Site http://moodle.uvic.ca/course/view.php?id=22113

Instructor

Dr **Henning Struchtrup**
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Office Hours

Days: **Open door**
Time:
Location: **EOW 511**

Lectures

A – Section(s): A01
Days: TWF
Time: 10:30-11:20
Location: COR B111

Required Text

Title: MECH 443 Lecture Notes
Author: H. Struchtrup
Publisher: posted on moodle
Year:

Optional Text

Title: Thermodynamics
Author: Cengel & Boles
Publisher: McGraw-Hill
Year:
Or any other textbook with good tables

Assessment

Assignments	40	%		
Mid-Term	20	%	Mid-Term Date:	TBA
Final	40	%	Final Date:	TBA

NOTES: **(a) You must obtain a passing grade in the final examination to pass the course**
(b) Midterm and Final are open book examinations, you can bring books, class notes etc., and pencil, calculator.
(c) Assignments: Assignments will be posted weekly, and will be due one week after posting. The assignments will be discussed in class when necessary. Use the office hours to ask questions whenever you have trouble with the solutions!

Syllabus (tentative):

1. Thermodynamic potentials, Maxwell relations, measurement of properties (3 lectures)
2. Stability conditions, barometric formula, stability of atmosphere, (solar) chimney (4 lectures)
3. Phase equilibria, chemical potential, ideal mixtures, entropy and disorder (4 lectures)
4. Osmosis and reverse osmosis, reversible and irreversible mixing (2 lectures)
5. Gibbs phase rule, Raoults law, phase diagram, distillation, etc (4 lectures)
6. Activity and fugacity (2 lectures)
7. Reacting mixtures, stoichiometric coefficients, law of mass action (4 lectures)
8. Enthalpy and entropy constants, third law (2 lectures)
9. Combustion, maximum work, entropy generation, losses in steam power plant (3 lectures)
10. Fuel cells, open circuit voltage, ohmic losses, efficiencies, mass transfer loss (3 lectures)
11. Activation of reaction, activation overpotential, exchange current (3 lectures)
12. Fuel cell types and design, fuel cell systems (3 lectures)

Course outcomes:

Students who successfully complete this course will be able to:

- **Properties and potentials—Evaluation of the Gibbs equation**
  1. Use Gibbs equation and multivariable calculus to identify thermodynamic potentials, find relations between thermodynamic properties and produce their own property tables.
- **Equilibrium conditions**
  2. Determine equilibrium states by maximizing/minimizing appropriate thermodynamic system properties.
- **Mixtures, Chemical potential**
  3. Formulate and apply mass balance, 1st law and 2nd law to inert and reacting mixtures.
  4. Explain and determine mixing volume, heat of mixing, entropy of mixing, and the chemical potential.
- **Mixing and separation**
  5. Determine entropy generation and work loss in mixing.
  6. Determine the work requirements in desalination, CO2 sequestration and other separation processes; estimate contribution of irreversible processes.
  7. Determine power available in controlled mixing, apply to osmotic power generation plants.
- **Phase equilibrium**
  8. Formulate and apply equilibrium conditions for ideal and non-ideal mixtures.
  9. Draw phase diagrams.
  10. Explain and evaluate phase diagrams for distillation processes and absorption refrigeration.
- **Reacting mixtures, law of mass action**
  11. Derive and apply the law of mass action; determine shift of equilibrium state with changing properties (Le Chatelier).
- **Activation of reactions**
  12. Use simplified mathematical models to explain metastable states, speed of reactions, and the need for catalysts.
- **Combustion**
  13. Use property tables and tables for enthalpy of formation to extract required property values.
  14. Determine heat of reaction, heat exchange in combustion processes.
  15. Explain the irreversible process nature of combustion and determine associated work losses.
- **Thermodynamics of Fuel Cells**
  16. Compare and contrast reaction prcesses in fuel cells with combustion.
  17. Use thermodynamic laws to determine open circuit potential.
  18. Use concepts of non-equilibrium thermodynamics to assess irreversible losses due to mass transfer, resistance and activation.
  19. Analyse electrolysers as inverse fuel cells.
  20. Assess feasibility of hydrogen as a fuel in the hydrogen chain.

Final Grade
The final grade obtained from the above marking scheme will be based on the UVic percentage-to-grade point conversion:

90 ≤	A+	≤	100	
85 ≤	A	<	89	
80 ≤	A-	<	84	
77 ≤	B+	<	79	
73 ≤	B	<	76	
70 ≤	B-	<	72	
65 ≤	C+	<	69	
60 ≤	C	<	64	
50 ≤	D	<	59	
35 ≤	E	<	50	Fail, conditional supplemental exam* - <u>for undergraduate courses only</u>.
	F	<	35	Fail, no supplemental exam.
	N			Fail, did not write examination or otherwise complete course requirements by the end of the term or session; no supplemental exam.

* The rules for supplemental examinations are found on page 80 of the current 2013-14 Undergraduate Calendar.

Term in which E Grade was obtained:	Application Deadline for Supplemental Exam	Supplemental Exam Date
First term of Winter Session (Sept – Dec)	Following February 28	First week of following May
Second term of Winter Session (Jan – Apr)	Following June 30	First week of following September
Summer Session (May – Aug)	Following October 31	First week of following January

Deferred exams will normally be written at the start of the student's next academic term; i.e., approximately 4 months following the deferral of the exam.

Guidelines on Religious Observances

1. Where classes or examinations are scheduled on the holy days of a religion, students may notify their instructors, at least two weeks in advance, of their intention to observe the holy day(s) by absenting themselves from classes or examinations.
2. Instructors will provide reasonable opportunities for such students to make up work or missed examinations.
3. Students will cooperate by accepting the provision of reasonable opportunities for making up work or missed examinations.
4. The University Secretary's Office will distribute a multi-faith calendar to each academic unit annually.

Commitment to Inclusivity and Diversity

The University of Victoria is committed to promoting, providing and protecting a positive, supportive and safe learning and working environment for all its members.

Standards of Professional Behaviour

You are advised to read the Faculty of Engineering document Standards for Professional Behaviour at http://www.engr.uvic.ca/policy/professional-behaviour.php which contains important information regarding conduct in courses, labs, and in the general use of facilities.

Cheating, plagiarism and other forms of academic fraud are taken very seriously by both the University and the Department. You should consult

http://web.uvic.ca/calendar2012/FACS/UnIn/UARe/PoAcI.html for the UVic policy on academic integrity. *"The University reserves the right to use plagiarism detection software programs to detect plagiarism in essays, term papers and other assignments." Pg 32, University Calendar*

Late Assignments: No late assignments will be accepted unless prior arrangements have been made with the instructor at least 48 hours before the assignment due date.

Coursework Mark Appeals: All marks must be appealed within 7 days of the mark being posted.

Attendance: We expect students attend all lectures and labs. It is entirely the students' responsibility to recover any information or announcements presented in lectures from which they were absent.

Electronic Devices: No unauthorized *audio* or video recording of lectures is permitted. Calculators are only permitted for examinations and tests if explicitly authorized and the type of calculator permitted may be restricted. No other electronic devices (e.g. cell phones, pagers, PDA, etc.) may be used during examinations or tests *unless explicitly authorized*.