**North Dakota State University**
**Department of Mechanical Engineering**
**ME 751 – Advanced Thermodynamics**
**(3 credit)**
Syllabus (tentative)
2023 Fall Semester
Tu, TH 11 AM - 12:15 PM
ECE 123

**Instructor:** Dr. Jordi Estevadeordal
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Office Hours: Tu, Th 12:30 – 2 PM

**Course Prerequisites:** Thermodynamics (ME351), Fluid Dynamics (ME352), Heat Transfer (ME454)

**Course Catalog Description:**
Classical thermodynamics is used in the treatment of simple and complex systems and cycles, conservation of energy and entropy principles, fundamental relations of thermodynamics properties, phase-transitions and critical phenomena, equilibrium and stability criteria, multiphase, phase equilibrium, and reactive systems, and irreversibility and exergy analyses.

**Course Objectives:**
The goals include understanding and applying the fundamental concepts and laws to simple, complex, multicomponent, multiphase and reacting systems, analyzing entropy and exergy balances and minimization, irreversible thermodynamics, system equilibrium and stability conditions, equations of state applications, thermodynamic properties relations (Maxwell), single and multiphase systems relations (Euler, Gibbs-Duhem, Helmholtz, Gibbs), and the fundamental laws extension to the modern representation and postulates of thermodynamics.

**Textbook:**
None required; suggested references include the graduate level textbooks "Thermodynamics and an Introduction to Thermostatics", 2nd ed., by H. Callen, Wiley, NY, 1985 and "Advanced Engineering Thermodynamics'" 4th ed., by A. Bejan, Wiley, 2016, and the undergraduate textbooks "Fundamental of Thermodynamics," by C. Borgnakke and R. E. Sonntag, Wiley, 8th ed., 2013 and "Fundamentals of Engineering Thermodynamics," by M. J. Moran et al., Wiley, 9th ed., 2018.

**Anticipated Course Outcomes and Affected Program Outcomes:**
The anticipated course outcomes are listed below along with the affected engineering practice program outcomes in parenthesis. A student achieving a passing grade in this course will be able to do advanced thermodynamic analyses and calculations as is typical for a mechanical engineer with graduate degree. Upon completion of ME 751 students will be able to:

1. Understand and use the terminology, concepts, and equations of advanced thermodynamics (1, 7).
2. Understand the proper applications and balances of energy, entropy, and exergy and their impact in power generation, refrigeration, etc. devices and cycles (1, 2, 4, 7).
3. Use compressible flow substance property tables, software, and websites (1, 7).

4. Use flow process, state, system and control volume concepts for applications that include mass, momentum, and energy balances (1).
5. Understand the proper applications of the four laws of thermodynamics (1, 7).
6. Understand and will be able to apply communication skills in formal technical presentations (3, 4, 5).

**Assessment:**

Your level of success in attaining the anticipated course outcomes will be assessed during the semester by homework (HW) assignments, quizzes, exams, class participation, project, and final examination. The format of your solutions in homework assignments and the exams should be in acceptable engineering form.

**(a) Homework Assignments, Class participation:**

Homework assignments will be posted in the blackboard with instructions. Homework assignments will be due typically in a week after assignment. The homework grades will be 25% of the overall course grade. Late papers will not be accepted without a valid excuse. Problems should be completed on 8.5" x 11" paper stapled at the top left corner (NOT folded) and must be in acceptable engineering form including given and find statements and labeled drawings of the system being considered or will not be graded. They also need be submitted electronically in blackboard. Class participation by attendance and interactive participation will be counted towards the total homework grade.

**(b) Quizzes and Exams:**

During the semester there will be several quizzes and/or midterms with a total of 25% of the overall course grade. The two-hour final exam will be given on the date and time specified by the University Finals Schedule. The final exam is 25% of the overall grade for the course.

**(c) Term Project:**

Is to be a formal report on a subject of your research or interest areas in the area of thermodynamics. You might solve a problem, execute an experiment, review the literature of a particular subject, or do some substantial task we agree upon. It will be graded on substance, originality, and how well it is written and presented. The format guidelines will be posted in blackboard. It will have a 25% of the overall course grade

**Grading Policy:**

The grade distribution is:

| | |
|---|---|
| Quizzes and Exams | 25% |
| Final Exam | 25% |
| Term Project | 25% |
| Homework, Class Participation | 25% |
| **Total** | **100%** |

Final Course grades will be assigned according to the following scale:

| | |
|---|---|
| A | 90-100 |
| B | 80-89 |
| C | 70-79 |
| D | 60-69 |
| F | < 60 |

**Additional Information:**

1. Unless specifically stated otherwise, all assigned work is assumed to be performed individually.
2. Course assignments, calendar, announcements, reports and presentations guidelines, etc. will be posted on Blackboard on regular basis, you will need to login and check https://blackboard.ndus.edu for announcements and online assignments.
3. All work in this course must be completed in a manner consistent with NDSU University Senate Policy, Section 335: Code of Academic Responsibility and Conduct (http://www.ndsu.edu/policy/335.htm <http://www.ndsu.nodak.edu/policy/335.htm>) and the CEA Honor System (http://www.ndsu.edu/ndsu/cea/ <http://www.ndsu.nodak.edu/ndsu/cea/>).
4. Class and Presentation attendance is expected. See NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), for faculty and student responsibilities related to attendance, including for university –sponsored activities. Reasonable absences are those outlined in the NDSU Policy, Section 333 (e.g. participation in university sanctioned events, military duty).
5. Students who fall ill, or who know they will be missing an exam for a valid reason (e.g. family emergency) are encouraged to notify the instructor by phone or e-mail prior to the exam, if at all possible. Students missing the exam without a valid excuse will receive a grade of zero for that exam.
6. Any students with disabilities who need accommodation in this course are encouraged to speak with the instructor as soon as possible to make appropriate arrangements for these accommodations and contact the Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.
7. Family Educational Rights and Privacy Act (FERPA): Students personally identifiable information and educational records as they relate to this course are subject to FERPA.
8. Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.

**ACADEMIC HONESTY STATEMENT:**

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

**ME 751 Tentative Course Schedule *(subject to change)***
**2023 Fall Semester**

| Week | | Topic |
|---|---|---|
| **1** | 08/21 – 08/25 | Introduction to fundamental laws postulates and thermodynamics concepts of classical thermodynamics |
| **2** | 08/28 – 09/01 | Introduction to fundamental thermodynamics concepts Examples (pure substance, ideal gas, work, heat, cycles) |
| **3** | 09/04 – 09/08 | First law and applications; Postulate axiomatic formulations. |
| **4** | 09/11 – 09/15 | Second Law and applications |
| **5** | 09/18 – 09/22 | Entropy and Exergy Analysis |
| **6** | 09/25 – 09/29 | Multicomponent Systems |
| **7** | 10/02 – 10/06 | Single-phase Systems (equilibrium and relations) |
| **8** | 10/09 – 10/13 | Multiphase Systems (stability) |
| **9** | 10/16 – 10/20 | Reacting Systems |
| **10** | 10/23 – 10/27 | Power Generation |
| **11** | 10/30 – 11/03 | Refrigeration |
| **12** | 11/06 – 11/10 | Entropy Generation Minimization |
| **13** | 11/13 – 11/17 | Irreversible Thermodynamics |
| **14** | 11/20 – 11/24 | --- *Thanksgiving week* |
| **15** | 11/27 – 12/01 | Term Project Presentations |
| **16** | 12/04 – 12/08 | Term Project Presentations |
| **17** | 12/11 – 12/15 | FINALS |

**North Dakota State University**
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**Student Outcomes**

The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.