



Applied Thermodynamics (MAAE3400) Winter 2023 (TENTATIVE, 2023-01-15)

Course Description: Thermodynamics is one of the most interesting and widely applicable subject areas in all of engineering. Familiar examples and applications include diverse topics such as power generation, refrigeration, energy conversion, combustion, and psychrometry. In this course, we will first introduce basic concepts of gas and vapour power cycles: reheat, regeneration, combined gas/vapour cycles, cogeneration. Heat pump and refrigeration cycles: vapour compression cycles, absorption refrigeration and gas refrigeration. Mixtures of perfect gases and vapours: psychrometry and combustion.

Prerequisites: You should have passed MAAE 2400 before taking this course. This is a demanding course, and you should dedicate at least 9 h/week (3 h lectures, 3 h reading and preparation, 3 h labs & problem analysis sessions) to it.

Graduate Attributes: Knowledge Base (CEAB Graduate Attribute 1): Understanding the application of thermodynamic principles to the design and optimization of engineering systems. Ability to apply the 1st and 2nd laws of thermodynamics to vapour power cycles, gas power cycles, refrigeration and heat pump cycles, mixtures and psychometrics, and combustion processes. Problem Analysis (CEAB Graduate Attribute 2): Ability to make assumptions to solve engineering problems in thermodynamics.

Lectures and Instructors:

Section B (ME4499)
Professor Reza Kholghy
RezaKholghy@cunet.carleton.ca
Wed-Fri, 11.35-12.55
Course Coordinator

Section C (SH304)
Professor Larry Kostiuk
LarryKostiuk@cunet.carleton.ca
Tue-Thu, 8.35-9.55

Office hours: Please send an email to your instructor to set up a time.

Grading: This course has an optional midterm. Midterm and final exam are closed-book, although you may bring a two-side 8.5"x11" formula/notes sheet. Standard calculators can be used but no other electronic devices will be permitted. Missing the midterm will move its weight to your final exam. You MUST submit all three lab reports on the Brightspace page of your lectures within 7 days of performing each experiment to pass the course. Late submissions will not be accepted and will result in a 0% mark for the lab experiment. Lab reports are professional documents of individual work and students must not share their reports with each other. Lab reports will be submitted electronically as a PDF file with the posted template and must be typed. 30% of their mark is dedicated to the style and organization of the writing. Pass is 50% in the final exam, labs and an overall 50%. Consult Carleton Central for the schedule and location of the lectures and PA sections for which you are registered. Information will be provided on the schedule and structure of the laboratory sessions during the first few weeks of lectures. Attendance is mandatory for all lectures, lab sessions and PA sessions. Students who arrive late (5 minutes past the starting time of the session) during the lab session will not be allowed to enter the room.

Practice Problems: Practice problems will be assigned through WileyPLUS on a regular basis to reinforce the lecture material. PA sessions start from the Week of January 16th. Labs start from the Week of Feb 6th.

| Item | Weight | Option | Date | Content |
|------------|--------|-----------|--|----------------------------------|
| Midterm | 25% | Optional | March 11 th (Saturday) 12h00 to 14h00 Minto 2000 & ME3380 (PMC students) | up to & including Week 7 |
| Lab 1 | 5% | mandatory | Due one week after performing the experiments Refer to the lab schedule | Vapour Compression Refrigeration |
| Lab 2 | 5% | mandatory | | Cooling Tower |
| Lab 3 | 5% | mandatory | | Gas Calorimeter |
| Final Exam | 60% | mandatory | TBA | All lectures and Labs |



Lecture Topics:

| Week # | Content | Text chapter | PA session |
|--|--|--------------|------------|
| Week 1 09/01 to 13/01 2 Lectures | Review: Closed and open systems, Evaluating thermodynamic properties, 1 st law of thermodynamics, 2 nd law of thermodynamics, Entropy | #1 - 6 | N/A |
| Week 2 & 3 16/01 to 27/01 5 Lectures | Vapour power cycles: Carnot cycle, Rankine cycle; reheat; regeneration, Binary cycles, Cogeneration | #8 | |
| Week 4 & 5 30/01 to 10/02 3 to 4 Lectures | Gas power cycles: Brayton cycle; regeneration; reheat; intercooling, Otto, Diesel, Ericsson, and Stirling cycles, Combined cycle | #9 | |
| Week 6 & 7 13/02 to 17/02 27/02 to 03/03 4 Lectures | Refrigeration & heat pumps: Carnot cycle Vapour compression cycles Cascade and multi-stage cycles Absorption cycles Heat pumps Brayton refrigeration cycles | #10 | |
| Winter Break 20/02 to 24/02 | No Lectures, PA or Lab sessions | | |
| Week 8 to 10 06/03 to 24/03 5 Lectures | Mixtures & psychrometrics: Analyzing properties of ideal gas mixtures Analyzing systems involving mixtures Specific and relative humidity; dew point; adiabatic Saturation Wet-bulb and dry-bulb temperatures Psychrometric charts Application to air-conditioning processes & cooling towers | #12 | |
| Week 11 to 13 27/03 to 12/04 5 Lectures | Combustion: Chemical reactions Stoichiometry and excess air Enthalpy of formation Enthalpy of combustion Adiabatic flame temperature Dissociation | #13 | |
| Final week (tentative) | Exergy Analysis: Availability Exergy of a system Exergy rate balance for control volumes at steady state Exegetic (second law) Efficiency | #7 | N/A |



Textbook: Fundamentals of Engineering Thermodynamics, 8th or 9th Edition, Moran & Shapiro (mandatory).

License for WileyPLUS electronic resources for Moran & Shapiro (mandatory).
Material posted on cuLearn.

The Moran & Shapiro textbook and WileyPLUS license are bundled together at the Carleton Bookstore:

ISBN 9781119190868 for a hard cover book with the WileyPLUS license
ISBN 9781119190981 for a binder version of the book with the WileyPLUS license.

Alternatively, students may purchase a WileyPLUS license directly from Wiley at <http://www.campusbookstore.com/wiley/carleton/>. This includes access to the electronic version of the book.

If you previously purchased a WileyPLUS license for MAAE 2400 you do not need to purchase another license. The system will remember you as a previous user when you click on any WileyPLUS link from within the MAAE 3400 cuLearn course. If you require any assistance with this, contact Wiley Technical Support by going to www.wileyplus.com/support.

Additional References:

Energy conversion engineering: Towards Low CO₂ Power and Fuels. Ahmed, F.Ghoniem., 2021. CAMBRIDGE University Press.

Teaching Assistants:

1. Ethan Hunt (ethanhunt@cmail.carleton.ca)
2. Thomas Manser (tommanser@cmail.carleton.ca)
3. Ali Shahrouzian (alishahrouzian@cmail.carleton.ca)
4. Khashayar Ghanizadegan (khashayarghanizadega@cmail.carleton.ca)
5. Zack Milani (zacharymilani@cmail.carleton.ca)

Academic accommodation: You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy or religious obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see [Student-Guide-to-Academic-Accommodation](#).

Academic accommodations for students with disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally scheduled exam (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/equity/sexual-assault-support-services>



Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

Academic integrity:

Plagiarism: The University Academic Integrity Policy defines plagiarism as “*presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.*” This includes reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, artworks, laboratory reports, **research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.**

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else.
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment.
- using another’s data or research findings without appropriate acknowledgement.
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one’s own; and
- failing to acknowledge sources using proper citations when using another’s work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course’s instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of “F” for the course.

Intellectual Property: Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copy protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s). Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).



Link to Excel file to add your name to of the groups. **Deadline to add your name is January 20th**. If a spot has already been taken, you cannot take that and once the file is finalized, no deviations to this schedule can be accommodated.

https://cmailcarletonca-my.sharepoint.com/:x/g/personal/rezakholghy_cunet_carleton_ca/EUH4GSkVxLBPvHolijZJRNUBPSHVxLcwqgxNj5crMGuWKg?e=18SDhH

All Laboratory Experiments will be performed in ME2232 (Thermodynamics Laboratory). PA sessions for L1, L2, L# and L4 take place in SA406, SA415, SA404 and SA404, respectively. The duration of each PA session is 80 minutes. From the week of Feb 6th to the week of March 20th when laboratory experiments are happening, during the first 80 minutes of each PA session, one group of students attends the PA session and the other group (based on the names entered in the excel file) attends the lab to perform the experiments. Then two groups switch positions for the remaining 80 minutes.

Students MUST familiarize themselves with the university's [lab safety manual](#) prior to conducting your first experiment.

MAAE3400 Monday Laboratory Sections

| MAAE3400 Lab Section L3 | | | | | |
|-------------------------|----|--------|----------------|----------------|----------------|
| | TA | Group# | Experiment 1 | Experiment 2 | Experiment 3 |
| Group | #1 | G1.L3 | Feb 6 | Feb 27 | March 13 |
| | | G2.L3 | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| | #1 | G3.L3 | Feb 6 | Feb 27 | March 13 |
| | | G4.L3 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |
| | #1 | G5.L3 | Feb 13 | March 6 | March 20 |
| | | G6.L3 | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| | #1 | G7.L3 | Feb 13 | March 6 | March 20 |
| | | G8.L3 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |

- The length of the body of the lab report for each experiment (introduction to conclusions) must not exceed ten (10) typewritten double-spaced pages or the equivalent; only the first ten pages will be marked. See lab manual for report guidelines.
- your typed report in pdf file format is to be submitted within 7 days after you perform the experiment through the Brightspace portal of MAAE3400. Late reports will not be accepted.
- Students must enter the lab on time. After 5 minutes past the official start time of the lab session, TAs will not allow any student to enter the lab.



MAAE3400 Wednesday Laboratory Sections

| MAAE3400 Lab Section L1 | | | | | |
|-------------------------|----|--------|----------------|----------------|----------------|
| Group | TA | Group# | Experiment 1 | Experiment 2 | Experiment 3 |
| | | #3 | G1.L1 | Feb 8 | March 1 |
| G2.L1 | | | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| #3 | | G3.L1 | Feb 8 | March 1 | March 15 |
| | | G4.L1 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |
| #3 | | G5.L1 | Feb 15 | March 8 | March 22 |
| | | G6.L1 | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| #3 | | G7.L1 | Feb 15 | March 8 | March 22 |
| | | G8.L1 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |

| MAAE3400 Lab Section L2 | | | | | |
|-------------------------|----|--------|----------------|----------------|----------------|
| Group | TA | Group# | Experiment 1 | Experiment 2 | Experiment 3 |
| | | #4 | G1.L2 | Feb 8 | March 1 |
| G2.L2 | | | 18.05 to 19.25 | 18.05 to 19.25 | 18.05 to 19.25 |
| #4 | | G3.L2 | Feb 8 | March 1 | March 15 |
| | | G4.L2 | 19.35 to 20.55 | 19.35 to 20.55 | 19.35 to 20.55 |
| #4 | | G5.L2 | Feb 15 | March 8 | March 22 |
| | | G6.L2 | 18.05 to 19.25 | 18.05 to 19.25 | 18.05 to 19.25 |
| #4 | | G7.L2 | Feb 15 | March 8 | March 22 |
| | | G8.L2 | 19.35 to 20.55 | 19.35 to 20.55 | 19.35 to 20.55 |

- The length of the body of the lab report for each experiment (introduction to conclusions) must not exceed ten (10) typewritten double-spaced pages or the equivalent; only the first ten pages will be marked. See lab manual for report guidelines.
- your typed report in pdf file format is to be submitted within 7 days after you perform the experiment through the Brightspace portal of MAAE3400. Late reports will not be accepted.
- Students must enter the lab on time. After 5 minutes past the official start time of the lab session, TAs will not allow any student to enter the lab.



MAAE3400 Friday Laboratory Sections

| MAAE3400 Lab Section L4 | | | | | |
|-------------------------|----|--------|----------------|----------------|----------------|
| | TA | Group# | Experiment 1 | Experiment 2 | Experiment 3 |
| Group | #2 | G1.L4 | Feb 10 | March 3 | March 17 |
| | | G2.L4 | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| | #2 | G3.L4 | Feb 10 | March 3 | March 17 |
| | | G4.L4 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |
| | #2 | G5.L4 | Feb 17 | March 10 | March 24 |
| | | G6.L4 | 14.35 to 15.55 | 14.35 to 15.55 | 14.35 to 15.55 |
| | #2 | G7.L4 | Feb 17 | March 10 | March 24 |
| | | G8.L4 | 16.05 to 17.25 | 16.05 to 17.25 | 16.05 to 17.25 |

- The length of the body of the lab report for each experiment (introduction to conclusions) must not exceed ten (10) typewritten double-spaced pages or the equivalent; only the first ten pages will be marked. See lab manual for report guidelines.
- your typed report in pdf file format is to be submitted within 7 days after you perform the experiment through the Brightspace portal of MAAE3400. Late reports will not be accepted.
- Students must enter the lab on time. After 5 minutes past the official start time of the lab session, TAs will not allow any student to enter the lab.