

Mechanical Engineering 2W04: Engineering Thermodynamics
McMaster University, Faculty of Engineering, Winter 2024

INSTRUCTOR

Dr. Jim Cotton, JHE 212a, ext. 24889, cottonjs@mcmaster.ca
Please email me if you would like to see me at a particular time.

OBJECTIVES

To teach the fundamental concepts in thermodynamics and the application of these principles in engineering.

CALENDAR DESCRIPTION

Mech Eng 2W04: Introduction to the principles of thermodynamics, and applications in engineering. Basic concepts: energy systems, properties of pure substances, entropy. Laws of thermodynamics, power and refrigeration cycles. Three lectures, one tutorial;

PRESCRIBED TEXTBOOK

- Thermodynamics – An Engineering Approach: Eighth, Ninth or Tenth Edition, Yunus A. Cengel, Michael A. Boles, McGraw Hill. (Chapters 1-7 and 10)

COURSE WEBSITE

Avenue to Learn: <http://avenue.mcmaster.ca/>

- Avenue - You can view and download course information from this site.
- Students are expected to stay abreast of announcements and schedule changes made in lectures and posted on Avenue to Learn.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 3 classroom-based live lectures per week
- 1 tutorial 2 hours/week
- 8 assignments
- 2 midterm tests (2 hours)
- 1 final exam (2.5 hours)

LECTURES

Tuesday, Thursday & Friday – 11:30 to 12:30 hours – MCDL 1105

TUTORIALS

Tutorial participation is a mandatory aspect of course assessment. Evaluation is based on participation in 10 of the 11 tutorials

T03 Group A-	Monday	10:30 - 12:20pm	@ BSB 121
T04 Group B-	Monday	10:30 - 12:20pm	@ BSB108
T01 Group C-	Wednesday	10:30 - 12:20pm	@ BSB 121
T02 Group D-	Wednesday	10:30 - 12:20pm	@ BSB 104

Grade allocation of an MSAF Tutorials Assignments will be redistributed to the remaining Tutorials

ASSIGNMENTS

8 Assignments - Problem sets are planned for roughly every week. Schedule on page 5.

MID-TERM

Mid-term examinations: There will be two tests of 2 hour duration.

Midterm #1: Tuesday February 13, 2024 – 6:30pm – 8:30pm

Location: T13 123 & T13 127

Midterm #2: Tuesday March 19, 2024 – 6:30pm – 8:30pm

Location: T13 123 & T13 127

Final examination: 2.5 hours in duration.

The final exam will cover all lecture material.

Calculators: Only McMaster Standard Calculator (Casio fx-991) may be used during term tests and the final examination.

ASSESSMENT

The following distribution of marks will be used unless there is a valid and compelling reason to use an alternative weighting. Missed assignments and tests will have a grade of zero entered without legitimate and documented reason. **The course of action for missed mid-terms with Associate Dean's (MSAF) approval is the weight of the mid-term or assignment will be re-distributed to the final exam.**

Tutorials	10%
Problem sets:	10%
Mid Tests:	30%
Final Exam:	50%

DETAILED COURSE DESCRIPTION

Introduction:

- Definitions
- Defining Systems (closed, open)
- Fundamental Properties (intensive, extensive),
- Forms of Energy
- Temperature & Pressure
- Problem Solving Methodology

Properties of Pure Substances

- Phase Change Process of Pure Substances
- Property Diagrams & Tables
- The Ideal Gas Equation of State
- Specific Heats

Energy Transfer

- Heat Transfer
- Mechanical Forms of Work
- Non-Mechanical Forms of Work
- Conservation of Mass Principle
- Flow Work and Energy

First Law of Thermodynamics:

- Fundamental Concepts
- Energy Balance for Closed Systems
- Energy Balances for Steady-Flow Systems
- Steady-Flow Engineering Devices
(nozzles, turbine, compressors, pumps, heat exchangers)
- Energy Balances for Unsteady-Flow Systems

Second Law of Thermodynamics:

- Thermal Energy Reservoirs
- Heat Engines
- Clausius statement, Kelvin-Planck statement
- Reversible/Irreversible processes
- 'Black-box' Cycles : heat pumps, refrigerators, power cycles
- Carnot Cycles
- The Carnot Principles

Entropy:

- Clausius Inequality,
- The Increase of Entropy Principle
- Entropy Change of a Pure Substance
- Isentropic Processes
- Process Diagrams Involving Entropy
- Entropy Data (steam tables), TdS equations
- Special Cases: ideal gas, incompressible substance
-

Vapor Power Cycles

- The Carnot Vapor Cycle
- Rankine Cycle
- Deviations of Actual Cycle from Ideal
- Methods to Increase the Efficiency of Rankine Cycle

LEARNING OUTCOMES: Upon successful completion of the course the student are expected to demonstrate the ability to:

1. Identify the unique vocabulary associated with thermodynamics and explain the basic concepts of thermodynamics
2. Determine thermodynamics properties of pure substances, apply the ideal-gas equations, account for compressibility and equations of state.
3. Solve the first law of thermodynamics and mechanisms of energy transfer to and from a system and for common steady-flow and unsteady devices.
4. Solve the conservation of mass principle on various systems including steady- and unsteady-flow control volumes.
5. Apply the Second Law and Carnot principles and solve for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, refrigerators and solve for isentropic efficiencies for various steady-flow devices.
6. Analyze vapor power cycles in which the working fluid is alternately vaporized and condensed.

GRADUATE ATTRIBUTES: This course provides the students opportunity to develop the following measures of graduate attributes

Graduate Attributes	Learning Objectives where it is measured
Knowledge base for Engineering (Indicator 1.03)	1-6
Problem Analysis (Indicator 2.02)	3-6

TEACHING ASSISTANTS

Ethan Chariandy	chariane@mcmaster.ca
Hams Hefny	hefnyh@mcmaster.ca
Eduardo Barbosa Louback	barbosae@mcmaster.ca
Eduardo (Akira) Shiguemoto	shigueme@mcmaster.ca
Oorja Nilesh Dorkar	dorkaro@mcmaster.ca
Anurag Jha	jhaa14@mcmaster.ca
Francois (Frank)Albert	albertf@mcmaster.ca
Nada Zaher	zahern1@mcmaster.ca

ASSIGNMENTS COLLECTION AND EVALUATION

Assessment: TOTAL 10% of Grade

Assignments will be evaluated out of 10 marks.

Missed assignments will have a grade of zero entered without legitimate and documented reason.

Home Work No.	Due Date	Day	Marking TA In-Charge*
1	January 24	Wednesday	Anurag
2	January 31	Wednesday	Akira
3	February 7	Wednesday	Eduardo
4	February 28	Wednesday	Oorja
5	March 6	Wednesday	Anurag
6	March 13	Wednesday	Eduardo
7	April 3	Wednesday	Oorja
8	April 10	Wednesday	Akira

*MARKING TA SUBJECT TO CHANGE, CHANGES WILL BE POSTED IN AVENUE.

ASSIGNMENT SOLUTIONS FORMAT AND EVALUATION

Format: All homework submissions should adhere to the following format. Adherence to format will help us grade faster and more efficiently. So, help us give you a better grade.

- Use a clean, white, lined or grid 8-1/2" x 11" (letter size) paper.
- Follow the approach to problem solving described below:
 - Problem Statement
 - Schematic and Given Data
 - Assumptions
 - Physical Laws
 - Know Data & Properties
 - Analysis/Calc's – with Units
- Numerical substitutions should be made after an algebraic solution has been formulated. You may get a good grade even if your numerical answer is wrong but your algebraic approach is reasonable. Try restraining yourself from numerical substitutions as long as you can.
- **Highlight** your final answer and be sure to not forget the **UNITS**.

If a computer program is used to attain a solution, attach a copy of the program and the data sheet.

ASSIGNMENT SUBMISSIONS

All homework should be submitted to Avenue to Learn\Assessments\Assignment\ by 11:59pm on the due date.

NO late submissions will be accepted without permission from the Associate Dean's Office (MSAF).

Grade allocation of an MSAF Assignments will be redistributed to the completed Assignments

Procedure for Remarking Term Test Answer Books:

In the event that a student has an issue with the way in which a term test has been evaluated, he/she may lodge their objections within a week of returning the marked papers.

Please follow the steps below while submitting material for remarking:

Compare your solutions to that posted on the course website. Write your concern in a separate piece of paper or email memo indicating: (i) Problem number(s) you have concerns about, (ii) Detailed nature of the discrepancy, and (iii) The marks you think you should have received, in reference to the solution/marking scheme posted on the course website. Please submit this along with your answer book personally to the instructor or TA.

The student will receive a written response from the TA that marked the paper; if the student does not agree with the response, the student may submit the whole documentation to the instructor for arbitration/remarking.

ACADEMIC INTEGRITY

*You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.***

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

- *plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.*
- *improper collaboration in group work.*
- *copying or using unauthorized aids in tests and examinations.*

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

*Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.*

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

*As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.***

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you. The Department of Mechanical Engineering is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office .

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact [Student Accessibility Services \(SAS\)](#) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's [Academic Accommodation of Students with Disabilities](#) policy.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the [RISO](#) policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.