

**MechEng 4W03**  
**Thermodynamics of Air Conditioning and Refrigeration Systems**  
**Undergraduate Studies**  
**Winter 2023/24**  
**Course Information Handout**

**OBJECTIVE**

To understand principles of applied thermodynamics in the air conditioning and refrigeration systems and their system components.

**PRE-REQUISITES AND ANTI-REQUISITES**

Pre-requisites: MechEng 2W04 – Thermodynamics  
Anti-Requisites: None

**CALENDAR/COURSE DESCRIPTION**

**Mech Eng 4W03:** *Re-examination of laws of thermodynamics, multicomponent systems, psychrometry, air conditioning, mechanical vapour compression refrigeration, absorption refrigeration, heating and cooling load calculations, air quality and human thermal comfort.*

**INSTRUCTOR**

Sumanth Shankar  
office: JHE/102  
voice: (905) 525-9140, ext. 26473  
mobile: (905) 512-1324 (Preferred)  
e-mail: [shankar@mcmaster.ca](mailto:shankar@mcmaster.ca)

**OFFICE HOURS**

Contact me at any time (24/7) through my email, mobile phone or text to discuss or book an appointment to meet. DO NOT CONTACT ME THROUGH MY OFFICE PHONE.

**TEACHING ASSISTANTS**

Mirzaei, Sara → [mirzas27@mcmaster.ca](mailto:mirzas27@mcmaster.ca)

**COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION**

<http://avenue.mcmaster.ca/> → Avenue to Learn (A2L)  
All communications will be sent by email and announcements in A2L course shell. It is mandatory for the students to check the A2L several times during a week when this course is in progress.

The online virtual content of the course shall be offered in MSTeams within the McMaster University. All data and information related to the course including online

video recordings of lectures shall be available as links in the course shells in both A2L and MSTeams, alike. Students are encouraged to check the course shell in MSTeams several times a week during the course progression.

All student marks and grades shall be communicated through the course shell in A2L after each examination.

The format of lectures shall be either virtual live in the MSTeams software or in the classroom; both, during the allocated course times during the week. McMaster Policy on this matter shall guide the choice between the two style of communication; these policies are being continually updated by McMaster University to reflect the ongoing handling of the COVID crisis.

### **SCHEDULE**

Monday and Thursdays – 12:30 to 13:30 hours - BSB/104

Tuesdays – 13:30 to 14:20 hours - DSB/AB103

### **TEXT BOOK**

Thermal Environmental Engineering – Thomas H Kuehn, James W Ramsey and James L Threlkeld, Prentice Hall.

### **REFERENCES**

- Thermodynamics – An Engineering Approach: Fifth Edition, Yunus A. Cengel, Michael A. Boles, McGraw Hill.
- Fundamentals of Engineering Thermodynamics, Fifth Edition, M. Moran and H. Shapiro, John Wiley and Sons Inc., 2004
- Thermodynamics for Engineers - Schaum's Outline Series, Merle C. Potter, Craig W. Somerton, Schaum's Outline Series, McGraw Hill.
- Thermodynamics – An Integrated Learning System, Philip S. Schmidt, Ofodike A. Ezekoye, John R. Howell, Derek K. Baker, John Wiley & Sons, Inc..
- Heating, Ventilating, and Air Conditioning – Analysis and Design: Fifth Edition, Faye C. McQuinston, Jerald D. Parker, Jefferey D. Spilter, John Wiley & Sons, Inc..
- Thermal Environmental Engineering: Third Edition, Thomas H. Kuehn, James W. Ramsey, James L. Threlkeld, Prentice Hall, New Jersey.
- Thermal Engineering, P.L Ballaney, Khanna Publishers, Delhi, India.
- Advanced Engineering Thermodynamics, Second Edition, Adrian Bejan, John Wiley & Sons, Inc.
- A textbook of Thermal Engineering: Two Colour Edition, R. S. Khurmi, J. K. Gupta, S. Chand & Company Ltd., New Delhi, India.
- An Introduction to Combustion - Concepts and Applications: Second Edition, Stephen R. Turns, McGraw Hill.

## COURSE FORMAT AND EXPECTATIONS

- Suggested → Three (3) Examinations – Midterm #1, Midterm #2 and Final Examinations
- Weekly Homework assignments shall be given and respective solutions posted a week later – Not for grading. Students are encouraged to solve problems in their weekly homework assignments so as to gain an improved understanding of the knowledge being transferred in this course.
- Only the McMaster recommended CALCULATOR could be used in the course during examinations.

## EXAMINATIONS AND ASSESSMENTS

Term Test #1 (Ideal Gas Mixtures)	15%
Term Test #2 (psychrometry)	15%
Term Test #3 (Air Conditioning)	30%
Final Exam (Refrigeration)	40%
<b>Total</b>	<b>100%</b>

## COURSE TOPICS

- 1. Recap of Thermodynamics (Mech Eng 2W04) (1 Lecture + Handout)**
  - 1.1. Introduction and First Law of Thermodynamics
  - 1.2. Energy and Application of Energy
  - 1.3. Second Law of Thermodynamics and Application
  - 1.4. Entropy and Application of Entropy
- 2. Multi-Component Systems (6 lectures)**
  - 2.1. Thermodynamic Analysis of Ideal Gas Mixtures
  - 2.2. Multicomponent Analysis of Ideal Gas-Vapour Mixtures
    - 2.2.1. Psychrometry
    - 2.2.2. Thermodynamic properties of moist air
    - 2.2.3. Mixing of Air-Water Vapour Streams
  - 2.3. Psychrometric Chart
    - 2.3.1. Heat Transfer with Constant Specific Humidity
    - 2.3.2. Humidification and Dehumidification
- 3. Air Conditioning (10 Lectures)**
  - 3.1. Summer and Winter Air Conditioning
    - 3.1.1. Single Zone
    - 3.1.2. Multiple Zone
  - 3.2. Humidification and Dehumidification Principles
  - 3.3. Spray Washer Efficiency
  - 3.4. Off-Design Conditions

- 3.4.1. VAV systems
- 3.4.2. Face and By-Pass Systems
- 3.4.3. Water Temperature Control Systems
- 4. Refrigeration (10 Lectures)**
  - 4.1. Mechanical Vapour Compression Refrigeration**
    - 4.1.1. Comparison of Various Types of Compressors
    - 4.1.2. Compressor Design and Efficiency Evaluation
  - 4.2. Absorption Refrigeration**
    - 4.2.1. Thermodynamics of Binary Mixtures
    - 4.2.2. Aqua-Ammonia Absorption System
    - 4.2.3. Lithium Bromide – Water Absorption System.
    - 4.2.4. Rectification and Principal Operating Lines
- 5. Heating and Cooling Load Calculations in Buildings (5 Lectures)**
  - 5.1. Winter Design Heat Loss
  - 5.2. Instantaneous Heat Gain
  - 5.3. Instantaneous Cooling Load
  - 5.4. Energy Estimation Methods
- 6. Indoor Air Quality and Human Comfort (5 Lectures)**
  - 6.1. Human Body and Environmental Parameters
  - 6.2. Prediction of Human Thermal Comfort
  - 6.3. Airborne Contaminants
  - 6.4. Infiltration and Acceptable Indoor Air Quality
  - 6.5. Modeling Indoor Contaminant Concentration

#### **DISCLAIMER**

"The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes."

#### **Equity, Diversity, and Inclusion**

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and celebrated. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

Please feel free to discuss any matter related to Equity-Diversity-Inclusion-Accessibility with your course instructor and expect to be treated with kindness, empathy and compassion. Your instructor shall treat your personal well being as being paramount in this exercise of knowledge transfer during this course.

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](#).

### Physical and Mental Health

For a list of McMaster University's resources, please refer to the [Student Wellness Centre](#).

### 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](#), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. 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](http://www.mcmaster.ca/academicintegrity).

### **Courses with an On-Line Element**

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

*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**

Online proctoring software may be used 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 A2L, 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.

### **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](mailto:sas@mcmaster.ca) to make arrangements with a Program Coordinator. For further information, consult McMaster University’s [Academic Accommodation of Students with Disabilities](#) policy.

### **Course Policy on Missed Work, Extensions, and Late Penalties**

1. It is the students’ responsibility to regularly check the course webpage on A2L for updates and announcements.

2. The weight of any missed work that has been properly reported and approved using MSAF will be automatically added to the weight of the final examination. No other accommodation will be provided for missed work.

### Submission of Request for Relief for Missed Academic Work

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”.

#### 1. Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:

- Use the [McMaster Student Absence Form](#) (MSAF) on-line self-reporting tool. No further documentation is required.
- Students may submit requests for relief using the MSAF once per term.
- An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
- The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
- The MSAF cannot be used for academic work that has already been completed attempted.
- An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
- The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

#### 2. For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:

- Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
- If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

### 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.