

MechEng 4W03
Thermodynamics of Air Conditioning and Refrigeration Systems
Undergraduate Studies
Winter 2021/22
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

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

Eduardo BARBOSA LOUBACK - barbosae@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 bring continually updated by McMaster University to reflect the ongoing handling of the COVID crisis.

SCHEDULE

Tuesday, Thursday and Friday – 11:30 am to 12:30 pm

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

- 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

Mid Term Test #1	(after 4 weeks)	30%
Mid Term Test #2	(after 8 weeks)	30%
Final Exam	(after end of Course)	40%
Total		100%

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.

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 maybe 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 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.

STUDENT SUPPORTS

WELLNESS

Student Wellness Centre

On-Campus Support for Medical and Mental Health Concerns. Doctors and Counsellors available. Located in PGCL, 2nd Floor.

Mon-Fri 9AM-5PM 905-525-9140 ext. 27700
<https://wellness.mcmaster.ca/contact-us/>

Main St. West Urgent Care Centre

For immediate health concerns that do not require the emergency room.

690 Main St W - Mon-Sun 9AM-9PM

Emergency Rooms

For **immediate, serious** health concerns.

St. Joseph's Healthcare Hamilton
50 Charlton Ave E

McMaster Children's Hospital
Students 17 and under

Telehealth Ontario

Telehealth Ontario is a free, confidential service you can call to get health advice or information. A Registered Nurse will take your call 24 hours a day, seven days a week.

Toll-free: 1-866-797-0000 Toll-free TTY: 1-866-797-0007

Phone Lines

Good2Talk

Confidential helpline providing professional counselling, info and referrals for mental health, addiction, and well-being

1-866-925-5454

LGBT Youthline

Confidential, non-judgemental & informed LGBTQQ2SI peer support.

Sun-Fri, 4-9:30 PM, Text 647-694-4275

SACHA (SEXUAL ASSAULT CENTRE - HAMILTON AREA)

Confidential, anonymous 24-hour nonjudgmental telephone support for adults who have experienced sexual violence at any point in their lives; will provide accompaniment to hospital or police station for survivors wishing to seek medical attention or report; counselling services & public education

905-525-4162

Empower Me (Graduate Students)

24/7 accessible counselling services to empower you to thrive, crisis support, mental health and well-being services.

1-844-741-6389

Bounceback

CBT skills-building for mild to moderate depression and anxiety for people 15 or older. If accessed through self-referral, the client's primary care provider will be notified.

1-866-345-0224

INDIGENOUS STUDENTS

Indigenous Student Services

Academic & social counselling, employment aid
LRW 1010

ext. 23788

indigenous.admin@mcmaster.ca
indigenous.mcmaster.ca

INTERNATIONAL STUDENTS

International Student Services

Advising services for international students and exchange students
GH 104

ext. 24254

iss@mcmaster.ca
iss.mcmaster.ca

STUDENT SUPPORTS

ACADEMIC

Student Success Centre

Academic skills assistance, job search, volunteering
GH 110
ext. 24254
studentsuccess@mcmaster.ca

Student Accessibility Services

Disability services, assistive technology support
MUSC B107
ext. 28652
sas@mcmaster.ca

TutorOcean

Student to Student Tutoring Services
<https://mcmaster.tutorocean.com/>

FINANCIAL

Office of Student Financial aid and Scholarships

Emergency funding, government funds, OSAP assistance, scholarships, work programs
GH 120
ext. 24319
<https://registrar.mcmaster.ca/aid-awards/>

FOOD

Food Collective Centre (FKA Mac Bread Bin)

The Food Collective Centre is a service run by students dedicated to cultivating stronger food systems in the McMaster and surrounding community. (MSU Service)
macbreadbin@msu.mcmaster.ca
<https://www.msumcmaster.ca/services-directory/14-food-collective-centre>

Neighbour 2 Neighbour

Food bank, community kitchen, community counselling, help with paying for utilities, and more. Hamilton Mountain.
905-574-1334 <http://www.n2ncentre.com/>

CRISIS SUPPORT

Barrett Centre for Crisis Support

Provides a safe environment in the community and responds to the needs of individuals, 16 years of age or older, who experience a mental health crisis and do not require a hospital stay. Confidential and free services 24/7/365
24 Hour Crisis Line: 905-529-7878, Toll Free: 1-844-777-3571

COAST (Crisis Outreach and Support Team)

Hamilton's crisis line is answered 24 hours a day, 7 days a week. The COAST mobile team, consisting of a mental health worker, and a police officer, will respond to crisis calls between the hours of 8 a.m. and 1 a.m. daily.
905-972-8338

Oakville Distress Centre

Distress Centre Halton provides telephone and online support to people to better cope with crisis, loneliness, and emotional stress. Also serves the Hamilton area.
905-849-4541

Assaulted Women's Helpline

Free, anonymous and confidential telephone and TTY crisis telephone line to all women in the province of Ontario who have experienced any form of abuse. Provides crisis counselling, safety planning, emotional support, information and referrals accessible 24/7/365.
Toll-free: 1-866-863-0511 TTY: 1-866-863-7868

Crisis Resources in the GTA

The CAMH Distress Crisis Resources web page lists a number of phone lines, response teams and hospitals in the GTA.
<https://www.camh.ca/en/health-info/crisis-resources>

STUDENT SUPPORTS

OTHER

Student Assistance Plan (Undergraduate)

Psychological counseling (offered in-person, over the phone, or over secure video) and academic-life services (legal consultation, financial consultation, life coaching, nutrition consultation and wellness resources offered virtually or in-person)

<https://www.msumcmaster.ca/services-directory/36-health-and-dental-insurance/student-assistance-plan>

Ombuds Office

Advice for students, staff, and faculty regarding academic and non-academic concerns.

MUSC 210

ext. 24151

ombuds@mcmaster.ca

mcmaster.ca/ombuds

SWHAT - Walk Safe Program

The Student Walk Home Attendant Team (SWHAT) is a volunteer service within the McMaster Students Union that will walk or bus with students during the evening hours 7 days a week, in all kinds of weather! (MSU Service)

Ext. 27500

swhat@msu.mcmaster.ca

Student Support and Case Management

Student rights & responsibilities

GH 207

ext. 23845

studentconduct.mcmaster.ca

Chaplaincy Centre

Pastoral support with personal counselling and bereavement support groups.

MUSC 231

ext. 24207

McMaster Engineering Society

Support from other McMaster Engineering Students

<https://www.macengsociety.ca/>

MSU PEER SUPPORT SERVICES

MSU Maccess

Maccess is a service that aims to build and maintain a campus that celebrates, advocates, and ensures inclusivity in the area of disability. A central aspect to Maccess is the provision of peer support by trained volunteers with lived experiences with disability such as chronic illness, mental illness, mental health concerns, neurodivergence, and additional identities.

Student Health Education Centre

SHEC is a peer-run health promotion, education, and referral service for McMaster University students. SHEC focuses on engaging with students about health-related issues through performances, peer support, fundraisers, and events. The service offers peer support, anonymous and confidential pregnancy testing, a resource library, condoms, lubricant, and menstrual products. SHEC's space is located in MUSC 202.

Women + Gender Equity Network

WGEN is a service that caters to women, transfolk, people who identify outside the gender binary, and all survivors of sexual assault. WGEN provides a safe(r) space and resource library on campus in MUSC 204. Volunteers in the space offer peer support and the service also runs a support group for survivors of domestic and intimate partner violence.

Pride Community Centre

The Pride Community Centre is a service of the McMaster Students Union. We provide a contact point for McMaster students that may identify as gay, lesbian, bisexual, transgender, queer, and/or any of the other diverse identities that make up our community. We offer educational programming and access to resources of interest, as well as peer support and a physical space for students to meet and socialize with each other. As advocates for gender & sexual diversity, the PCC's mandate upholds that LGBTQ+ students are entitled to a safe and supportive campus, absent of homophobia and transphobia, where the expression of one's gender & sexual identity is welcomed and respected.