CHEM ENG 3A04 –Heat Transfer
Course Outline
Fall Term 2023

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Office hours: **Tuesdays 2:30 – 3:30 pm** or by appointment. My office hours are held virtually on MS Teams for your convenience.

Teaching Assistants:

Name	Email	Office Hour
Araf Al Rafi	rafia2@mcmaster.ca	Mondays 1 – 2 PM
Nikol Budisa	budisan@mcmaster.ca	Thursdays 12:30 – 1:30 PM
Sara Deir	deirs1@mcmaster.ca	Mondays 10 – 11 AM
Nagat El Rafei	elrefaen@mcmaster.ca	Wednesdays 11 AM – 12 PM
Shayan Jahangirifard	jahans14@mcmaster.ca	Wednesdays 12:30 – 1:30 PM

Some content and rules may be modified as we go through the course. Any changes will be communicated ahead of time with students and provide clarifications and reasoning behind any changes. It is the responsibility of the students to check Avenue to Learn daily during the term and to note any changes.

We consider the classroom to be a place where you will be treated with respect, and individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and non-visible differences are welcome. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

We will gladly honor your request to address you by an alternate name or gender pronoun. Please advise us of this preference early in the semester so that we may make appropriate changes to our records.

Course Objectives: This course will cover the principles of conservation of energy and heat transfer principles. Also, one of the areas of focus for this course is “Heat exchange Network Analysis” and “Heat Exchanger Design” which is the base for the course project. We will also learn of the similarity between heat transfer, mass transfer and fluid mechanics and how the solution in one field can often be used to obtain solutions in the others. We will also learn how to approach solving problems in the field and the use of both fundamental theory and empirical correlations to design equipment suitable for heat transfer across multiple applications.

Intended Learning Outcomes (ILOs):

1. Demonstrate the knowledge of the principles of conservation of energy
2. Identify and use the best empirical models/equation to define heat transfer rate coefficients
3. Convert the heat transfer problem sets into mathematical models/ equations
4. Analyze the heat exchanger network (HEN)
5. Design basic heat exchangers (sizing, coefficients, heat transfer rate)
6. Use of fundamental theory and empirical correlations to design equipment suitable for heat transfer
7. Employ modern computing software (Aspen Energy analyzer) which can aid in the modeling and design of HEN
8. Optimize heat exchanger network design (considering economic analysis)

The following CEAB (Canadian Engineering Accreditation Board) indicators will be addressed within CHEMENG 3A04. The learning outcomes are mapped with indicators and specific deliverables of the course will be used to evaluate students for each LO as well as indicator.

CEAB Indicator	Learning Outcomes
2.1 Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem.	All ILOs
4.4 Justifies and reflects on design decisions, giving consideration to limitations, assumptions, constraints and other relevant factors.	ILO5, ILO6
5.2 Successfully uses engineering tools.	ILO7
11.1 Applies economic principles in decision making.	ILO8
12.2 Seeks and acquires appropriate external information as required, including showing awareness of sources of information and ability to critically evaluate them.	ILO4, ILO8

TEXTBOOK: The e-book of the required text is available on Campus Bookstore. If for any reasons you prefer to have the print copy, you can buy it directly from the publisher or Amazon.

Book title: Fundamentals of Heat and Mass Transfer, 8th edition, Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incorporate, David P. DeWitt. Wiley and Sons, 2019

Campus store link for e-book: https://campusstore.mcmaster.ca/cgi-mcm/ws/txsub.pl?wsTERMG1=234&wsTERMDESC1=Fall+2023&wsDEPTG1=CHEMENG&wsDEPTDESC1=CHEMENG+-+Chemical+Engineering&wsCOURSEG1=3A04&wsSECTIONG1=DAY+C01&programG1=McMaster+Undergrad+and+Graduate&crit_cnt=1

Note: Previous editions of the book are very similar and include almost all of the materials to be covered in this course.

Website: The Avenue to Learn website will be used as the primary location for posting course materials including lecture slides, course notes, tutorial problems and solutions, assignments and solutions, announcements, etc. Marks will be disseminated through Avenue as well.

TAs' Office Hours: TA's will each be available for 1 hr/week, that means you have 5 hours of TA time each week. The office hours will be announced on Avenue during the first week of classes. All office hours are held on MS Teams as well. Please note that TA office hours may change during the semester. All changes will be announced on Avenue.

Grading:

Weight (%)	Component
20%	Assignments (5 assignments in total, 4% each)
25%	Design Project
20%	Midterm
35%	Final Examination

Notes:

- You have to receive a passing grade (50%) on the 1) design project, and 2) final exam. If you do not pass one of these components, you will fail the course and your grade will be the one you have received on the failed component.
- If you MSAF an assignment, the weight will be transferred to the rest of the assignments.
- If you MSAF your midterm exam, the weight will be transferred to your final exam.
- You cannot MSAF the design project.

Important dates: The following is a list of important dates related to this course. Further details about the course schedule can be downloaded in calendar form on Avenue to Learn. If any changes happen it will be announced in class and on Avenue.

September 6 – First Lecture
September 11 – First week of tutorials
October 9-15 – Midterm Recess (no classes/ tutorials)
October 18 – **Midterm**
November 24: Project due – This is a hard deadline and won't be extended
December 6 – Last lecture

Course Schedule

Here is the general schedule for the course including lectures. The topics are subject to change based on the general flow of the course.

Week	Lectures	
1	Sep 6	Course Intro
	Sep 7	Heat Transfer (Conduction vs convection) & Introduction to Conduction
		Energy Balance, 1D SS Conduction
2	Sep 11	1D SS Conduction Case studies with different BC
	Sep 13-14	Thermal Resistance & Composite Walls
		Intro to Convection & Combined case studies
3	Sep 18	Fourier's law, Temperature Gradient, Heat rate in Plane wall and tubes, temperature distribution
	Sep 20-21	Heat flux in sphere, Concept of U
		Introduction to heat exchangers, conduction-convection, U values, Temperature gradient, LMTD, general equations
4	Sep 25	Intro to ASPEN - Project Introduction
	Sep 27-28	T-H Diagram & Composite Curves
		HEN - Problem Table Algorithm (PTA)
5	Oct 2	Heat Exchanger Network (HEN) Calculation
	Oct 4-5	HEN Analysis
		Transient Conduction - Lumped system
Midterm Recess-No Class		
6	Oct 16	Midterm Review & Q/A
	Oct 18	**Midterm Exam**
	Oct 19	Bi number for walls & radial systems + Case studies
7	Oct 23	Convection, boundary layer
	Oct 25-26	Nu, Pr, Appendix tables (state of materials and values)
		External Convection
8	Oct 30	External Convection - Radial system
	Nov 1-2	External Convection - Case studies
		Tube banks
9	Nov 6	Internal Convection
	Nov 8-9	Internal Convection Case studies
		Heat Exchanger Design, LMTD and NTU
10	Nov 13	Project Q/A
	Nov 15-16	Free Convection
		Case studies
11	Nov 20	Fins and extended surfaces, Different BC for fins, fins efficiency
	Nov 22-23	Heat sink and fin graphs
		2D Heat Transfer - Shape Factor - Finite element
	Nov 25	**Project Report Due**
12	Nov 27	Case studies

Week	Lectures	
	Nov 29-30	Course and Exam Review
13	Dec 4	
	Dec 6	

Assignments

The course assignments are in a two-stage format. For the first stage, students work individually on the assignment questions and **submit the work by Wednesday night of the assignment week**. The second stage of the assignment will be conducted during the tutorial time the week after. Stage 2 of the assignment has the same questions as stage 1 but will be done in a group of 2 or 3 students. Participation in the second stage of the assignment is not mandatory. **The full mark of each assignment is based on stage one ONLY.** However, students who attend the assignment tutorials and participate in the second stage of the assignment, have the opportunity of getting up to 2% bonus mark on their final grade of the course. A demo on how assignments will be conducted in two-stage is delivered on first tutorial class.

All of the assignments should be submitted as ONE pdf file, with the naming convention of ChE3A04_Assignment X_Student number, where X is the assignment number. The pdf file should be submitted via the Dropbox folder created on the Avenue by the due date defined on the assignment.

It is the student's responsibility to ensure that assignments are correctly submitted to the correct location (e.g. correct Dropbox), on time. **No late or wrong submissions will be accepted**. Any submission with wrong naming convention or file format is subject to 10% (each) grade deduction.

Each student must submit their own solutions as the first stage submission. Solutions that are identical or close to identical will be penalized (usually zero and the infraction will be reported to the Academic Integrity office, McMaster).

The assignments are meant to prepare you for the tests and the final exam. To this end, please follow these guidelines:

- ✓ The work must be neat with intermediate calculations and assumptions shown (the final answer typically has very little value toward the total mark for the question).
- ✓ Failing to submit neat, legible assignments, the TA has the right to deduct up-to 30% off the final mark of the assignment.
- ✓ Consistent units must be shown at each step of your calculations.
- ✓ Use diagrams as part of your solution whenever possible.

No make-up assignments will be arranged. In the event of an **excused** missed assignment, the full percentage allotted to assignments in the final grade will be assigned by taking the average of all other assignments submitted.

Tutorials:

Tutorials begin on the week of September 11th. There are 3 types of tutorials for this course:

- Regular: In this tutorial, TAs will go through sample questions related to the topics that are covered in the lectures.
- Assignment – Stage 2: During the tutorial, students work as a group (of 2 or 3 students) on the second stage of the assignment with the same questions and submit one solution per group on Avenue Dropbox. In the remaining time of the tutorial, TAs will go through the solutions of the assignment.
- Aspen / Project: During this tutorial you will be introduced to Aspen Plus software and will be trained on using the Aspen Energy Analyzer for your design project. You can use part of this tutorial time to work on your project as well.

Tutorials Schedule

Week of	Activity
Sep 11	Regular
Sep 18	Assignment 1 – stage 2
Sep 25	Regular
Oct 2	Assignment 2 – stage 2
Oct 9	Midterm Recess – No tutorial
Oct 16	Aspen / Project
Oct 23	Aspen / Project
Oct 30	Aspen / Project
Nov 6	Assignment 4 – stage 2
Nov 13	Regular
Nov 20	Aspen / Project
Nov 27	Regular
Dec 4	Assignment 5 – stage 2

Tests and Final Exam

The midterm and final exams are open book. An open book means that you are allowed to use the course textbook and lecture, tutorial notes, and your own notes. You are not allowed to have solution manuals with you. Any evidence of copying or use of unauthorized aids will be treated as a case of academic dishonesty. The instructor reserves the right to adjust marks on tests or exams at his discretion. The tests and final exam instructions will be posted on Avenue closer to the date.

Design Project

The design project will be announced in September. You can work on the project during the term. Keep in mind that you will need to use the knowledge learned during the semester to complete the design project, so do not expect to be able to complete the project too early in the semester. Projects may be done in groups of up to 3 people, provided all names and student numbers are shown and a declaration is included on the last page that all group members contributed equally to the completion of the project. No late submission or MSAF will be accepted for the design project. The details of instructions on how to do the design project will be posted with project package.

Course Statements

Missed Tests

Absence without a valid excuse for a test or exam will result in a grade of zero. If you have a legitimate medical/personal reason for missing a test or exam, you must complete the McMaster Student Absence Form and forward it to the instructor **within one week** of missed class activity to receive consideration for waived tests; otherwise, a mark of zero will be applied. No make-up tests will be arranged. See "Grading Section" for a full description of policies.

Electronic Communication

Class announcements will be communicated orally in class and via the message board on Avenue to Learn. You are responsible for monitoring Avenue for course updates; failure to do so will *not* be considered a valid reason for missed work.

Grade Appeal

All queries or appeals of marks received on course work should be directed to Hassan no later than **one week** after releasing the grades. Any request after the deadline will not be accepted.

University Policy Reminders

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-proceduresguidelines/

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. Avenue to Learn, 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, 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.

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

In the event of an absence for medical or other reasons, students should review and follow the Policy on 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, Avenue to Learn and/or McMaster email.

The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership
- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.