ME4V03
Thermo-Fluids System Design and Analysis

Undergraduate Studies
Fall/Winter 2025/26
Course Outline

CALENDAR/COURSE DESCRIPTION

The objective of the course is to integrate material learnt in prior themo-fluid courses, and to provide students with an introduction to system-oriented design methods. The design, operation and performance of mechanical equipment commonly used in thermo-fluid systems will be reviewed. Methods in system simulation and optimization will be introduced. Prior courses in Thermodynamics, Fluid Mechanics and Heat Transfer are a prerequisite for this course.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ME2W04, ME3R03, ME3O04

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Chan Y. Ching
chingcy@mcmaster.ca

Office Hours:
Tues & Thurs 12:30PM to 1:30PM
JHE103

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

The Teaching Assistant information will be provided on the course website when available.

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca/

COURSE INTENDED LEARNING OUTCOMES

By the end of this course, students should be able to:

1. Analyze fluid systems and design piping systems and select appropriate pumps.
2. Analyze and select heat exchangers for thermal systems.
3. Perform system analysis and obtain performance characteristics of common thermal systems.
4. Model and perform system simulation of thermal systems.
5. Optimize thermal system performance under different constraints.
6. Integrate exergy analysis into system performance.

MATERIALS AND FEES

Recommended Additional Texts:
Introduction to Fluid Mechanics, Fox, R.W., McDonald, A.T and Pritchard, P.J.
Fundamentals of Engineering Thermodynamics, M. Moran and H. Shapiro.
Introduction to Heat Transfer, Incropera, F.P., Dewitt, D.P.
Design and Optimization of Thermal Systems, Jaluria, Y.
Thermal Design and Optimization, Bejan, A., Tsatsaronis, G. and Moran, M., J.
Design of Fluid Thermal Systems, Janna, W.S.
Design of Thermal Systems, Stoecker, W.F.

Calculator:
Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 3 classroom-based lectures per week
- 1 tutorial per week
- 10 homework assignments
- 2 midterm tests
- Final Exam

ASSESSMENT

Component	Weight
Homework	10%
Mid Term Tests (20% each)	40%
Final Exam	50%
Total	100%

If Mid Term Test I is missed due to a MSAF, its weight will be distributed to Mid Term Test II (increased to 30%) and the Final Exam (increased to 60%).

If Mid Term Test 2 is missed due to a MSAF, its weight will be added to the Final Exam (increased to 70%).

Course Outline

1. **Review of Piping Systems, Pumps and Compressors**
    - 1.1 Fundamental Equations, Friction Factors, Head Losses
    - 1.2 Valves and Fittings
    - 1.3 Types of Pumps and Pump Characteristics
    - 1.4 Cavitation and Net Positive Suction Head
    - 1.5 Pump-System Operation
2. **Heat Exchangers**
    - 2.1 Review of Heat Transfer
    - 2.2 Types of Heat Exchangers
    - 2.3 Analysis of Heat Exchangers
3. **Power Generation Systems**
    - 3.1 Review of Thermodynamics
    - 3.2 Vapor Power Systems
    - 3.3 Gas Power Systems
    - 3.4 Other Power Systems
4. **Exergy Analysis**
    - 4.1 Exergy of Systems
    - 4.2 Closed and Open System Exergy Balance
    - 4.3 Exergetic Efficiency
    - 4.4 Thermoeconomics
5. **Thermal Systems Design**
    - 5.1 The Design Process
    - 5.2 Life-Cycle Design
    - 5.3 Thermal System Design Aspects
    - 5.4 Environmental, Safety and Reliability Aspects
6. **System Simulation and Optimization**
    - 6.1 Modeling Thermal Equipment
    - 6.2 Description of System Simulation
    - 6.3 Methods of Simulation
    - 6.4 Simulation of Thermal Systems
    - 6.5 Optimization Procedures
7. **Design Optimization and System Performance Evaluation**
    - 7.1 Thermodynamic Optimization
    - 7.2 Economic Optimization
    - 7.3 Design Evaluation
    - 7.4 Performance Evaluation

Suggested Texts

Introduction to Fluid Mechanics, Fox, R.W., McDonald, A.T and Pritchard, P.J.
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ME 4V03 – THERMO-FLUIDS SYSTEMS DESIGN AND ANALYSIS

NOTES ON HOMEWORK SOLUTIONS

Homework policies/procedures

1. Homework is due by 11:59PM on the date assigned. Homework must be submitted online to AVENUE. Late submissions will **NOT** be accepted.

2. Solutions to the Homework problems will posted on the course site on AVENUE.

3. Performance on homework assignments comprise 10% of a student's final grade; consequently individual work is required on all homework problems. Students are encouraged to discuss with one another the general principles involved in the homework sets, but solutions to each problem must be attempted individually. Duplicate solutions indicating copying among students will be considered cheating and will be dealt with strictly.

Homework format

1. A legible PDF of the solutions must be submitted. Make sure your name (**as given on AVENUE**), MAC ID and student number is on the first page of the solutions.

2. Start each problem on a new page.

3. Clearly label each step of the solution (KNOWN, FIND, SCHEMATIC, ASSUMPTIONS , ANALYSIS etc.)

4. Develop the analysis as far as possible before substituting numerical values.
   If possible, give the answer algebraically before computing the final numerical answer.

5. Clearly indicate your final answer.
   Be sure to include appropriate units.

6. Attach a listing of any computer program(s) used in the solution.

Homework grading

Most problems will be graded on a 10-point scale, with points awarded in the following typical distribution.

Use of proper format, steps clearly labeled	1
Schematic, complete with appropriate control volume	1
Appropriate assumptions	1
Clearly-developed and correct analysis	5
Algebraic solution (if possible)	1
Numerical result (if required), with appropriate units	1

		Thermo-Fluids Systems Design and Analysis - Fall 2025	
PERIOD	**DATE**	**TOPIC**	
1	Tue Sep 02	Introduction to Thermal System Design	
2	Th Sep 04	Review Piping Systems	
3	Fri Sep 05	Fluid Machinery	
4	Tue Sep 09	Turbomachinery Analysis/Euler Turbomachine Equation	
5	Th Sep 11	Performance Characteristics	
6	Fri Sep 12	Fluid Systems	
7	Tue Sep 16	Review/Heat Transfer Fundamentals	
8	Th Sep 18	Double Pipe Heat Exchangers	
9	Fri Sep 19	Shell and Tube Heat Exchangers	
10	Tue Sep 23	Design of Heat Exchangers	
11	Th Sep 25	Review/Thermodynamic Principles	
12	Fri Sep 26	Vapor Power Systems, Rankine Cycles	
	Tue Sep 30	**National Day for Truth and Reconciliation: No Classes**	
13	Th Oct 02	Superheat and Reheat /Regenerative Vapor Power Cycles, Binary Cycles	
14	Fri Oct 03	Gas Power Systems, Internal Combustion Engines	
15	Tue Oct 07	**MID TERM TEST I [6:30PM to 8:00PM]**	
16	Th Oct 09	Otto and Diesel Cycles/Air-Standard Dual Cycle	
17	Fri Oct 10	Gas Turbines, The Brayton Cycle	
		Reading Week (Oct 13 to Oct 17): No Classes	
18	Tiue Oct 21	Regenerative Gas Turbines	
19	Th Oct 23	Gas Turbines for Aircraft Propulsion	
20	Fri Oct 24	Vapor-Compression Refrigeration Cycles	
21	Tue Oct 28	Heat Pumps, Gas Refrigeration Systems	
22	Th Oct 30	Exergy of Systems	
23	Fri Oct 31	Exergy Balance	
24	Tue Nov 04	Exergetic Efficiency	
25	Th Nov 06	Thermoeconomics	
26	Fri Nov 07	Thermal System Design	
27	Tue Nov 11	Design Considerations/Codes and Standards	
28	Th Nov 13	Modeling Thermal Equipment	
29	Fri Nov 14	Overview of System Simulation	
30	Tue Nov 18	**MID TERM TEST II [6:30PM to 8:00PM]**	
31	Th Nov 20	Methods of System Simulation	
32	Fri Nov 21	System Simulation Programs	
33	Tue Nov 25	System Optimization	
34	Th Nov 27	Optimization Procedures	
35	Fri Nov 28	Lagrange Multiplier Methods	
36	Tue Dec 02	Review	
37	Th Dec 04	Review	

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 Engineering Physics 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.

MENTAL HEALTH & WELLNESS

For a list of McMaster University's resources, please refer to the Student Wellness Centre.
Talkspot is a non-crisis mental health resource specifically for students in the Faculty of Engineering.

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.

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.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. Late submissions on Assignments will NOT be accepted or graded.
2. An MSAF is required for a missed assignment.
3. An MSAF is required for a missed Mid Term Test.

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.