ENGG*3430 Heat and Mass Transfer

01

Winter 2024
Section(s): 01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2024

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1 Course Details

1.1 Calendar Description

Analysis of steady and transient thermal systems involving heat transfer by conduction, convection and radiation and of mass transfer by molecular diffusion and convection. Other topics include the thermal analysis of heat exchangers and heat transfer systems involving a change of state.

Pre-Requisites:	ENGG*2230, ENGG*3260, MATH*2270
Restrictions:	Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

In Thermodynamics, you have learned that any form of energy can be transferred in the form of Work and Heat by interactions of a system with its surroundings. However, Thermodynamics provides no information regarding the nature of the interaction or the time rate at which the energy transfer occurs. Thermodynamics only deals with the end states of the process during which an interaction occurs. Heat and Mass Transfer is a basic engineering science that deals with rate of transfer of thermal energy. It has a broad application area ranging from biological systems to common household appliances, residential and commercial buildings, industrial processes, electronic devices, and food processing. The main goals of this introductory level course are (a) to cover the basic principles and concepts of heat and mass transfer, (b) to present real-world engineering applications to give students a feel for engineering practice, and (c) to develop an intuitive understanding of the subject matter by emphasizing the physics and physical arguments.

1.3 Timetable

Lectures

Sec 0101-0106:
Monday / Wednesday / Friday: 03:30pm - 04:20pm (Room: MCKN 117)
Instructor: Emily Chiang

Sec 0201-0206:
Monday / Wednesday / Friday: 04:30pm - 05:20pm (Room: ROZH 102)
Instructor: Shohel Mahmud

Tutorials/Quizzes

Please refer to Webadvisor for the exact time and location for your section

1.4 Final Exam

Final Exam:
Date: April 19, 2024
Time:11:30am to 1:30pm
Location: TBA

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Emily Chiang Ph.D., PEng
Email:	chiange@uoguelph.ca
Telephone:	+1-519-824-4120 x58217
Office Hours:	TBA

Sections 0101-0106

Instructor:	Shohel Mahmud Ph.D., PEng
Email:	smahmud@uoguelph.ca
Telephone:	+1-519-824-4120 x54058
Office Hours:	TBA

Sections 0201-0206

Lab Technician:	Michael Speagle
Email:	mspeagle@uoguelph.ca
Telephone:	+1-519-824-4120 x56803
Office:	THRN 1102

Office Hours: By appointment.
GTA:

Angesom Aregawi Gebretsadkan (agebrets@uoguelph.ca)
Katelyn Sysiuk (ksysiuk@uoguelph.ca)
Milad Norouzpour (mnorouzp@uoguelph.ca)
Mojtaba Safdari (msafdari@uoguelph.ca)
Karim Khafagy (kkhafagy@uoguelph.ca)

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
Course material, news, and announcements will be regularly posted to the ENGG*3430 Courselink site. You are responsible for checking the site regularly.

Heat and Mass Transfer: Fundamentals and Applications (Textbook)
Y. Cengel and A. Ghajar, 5th, or 6th Edition, McGraw-Hill.

3.2 Recommended Resources

Heat and Mass Transfer: Fundamentals and Applications (Textbook)
Y. Cengel and A. Ghajar, 4th Edition, McGraw-Hill, 2010.

Fundamentals of Heat and Mass Transfer (Textbook)
F.P. Incropera, D.P. DeWitt, T.L. Bergman, and A.S. Lavine, 6th Edition, John Wiley and Sons, 2007.

Introduction to Heat Transfer (Textbook)
V.S. Arpaci, S.H. Kao, A. Selamet, 1st Edition, Prentice Hall, 1999.

Heat Transfer (Textbook)
A. Bejan, 1st Edition, John Wiley and Sons, 1993.

Biological and Bioenvironmental Heat and Mass Transfer (Textbook)
A. K. Datta, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2002.

3.3 Additional Resources

Lecture Information: A summary of the lecture notes will be posted on the Courselink.

Lab Information: The lab manuals and lab schedule will be posted on the Courselink. You are responsible for printing the lab manuals and having them with you during the laboratory sessions.

Home Assignments: There will be approximately 13 problem sets posted in Courselink during the term. These problem sets will not be marked, but it is recommended that you do each

problem set, as practice problems are the best way to learn the course. All the solutions will be posted.

Miscellaneous Information: Other information related to Heat and Mass Transfer will be posted on the web page.

3.3 Note

Quiz, Midterm, and Final are open book exams. Therefore, you need a copy of the course textbook in order to successfully complete these tests and exams.

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4 Learning Outcomes

This course is to introduce the basic principles of heat and mass transfer with emphasis on their analysis and applications to practical engineering problems.

4.1 Course Learning Outcomes

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

1. Identify important thermal processes, and derive the basic expressions for heat conduction, convection, and radiation based on the First Law of Thermodynamics
2. Analyze heat transfer processes using electrical resistance network analogy
3. Determine steady state and transient temperature distribution in various solid geometries of practical importance
4. Understand the physical significance of dimensionless parameters in convective heat/mass transfer
5. Select and apply the appropriate correlation for different heat and mass convection processes
6. Analyze and perform the thermal design of heat exchangers using conventional methods
7. Determine radiation exchange within an enclosure based on the view factor method
8. Apply appropriate numerical techniques to solve complex heat transfer problems
9. Conduct Heat and Mass Transfer laboratory tests through collecting and analyzing data using the appropriate sensors and instruments and write clear, concise and professional laboratory reports
10. Demonstrate effective skills in teamwork during group activities; demonstrate respectful interactions with peers, lab technician, teaching assistants, and instructor, self-assessment

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 3, 4, 5, 7
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2, 3, 4, 5, 7
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2, 3, 4, 5, 7
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 3, 4, 5, 7
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 3, 4, 5, 7
2	Problem Analysis	2, 3, 5, 6, 7, 8
2.1	Formulate a problem statement in engineering and non-engineering terminology	2, 3, 5, 6, 7, 8
2.2	Identify, organize and justify appropriate information, including assumptions	2, 3, 5, 6, 7, 8
2.3	Construct a conceptual framework and select an appropriate solution approach	2, 3, 5, 6, 7, 8
2.4	Execute an engineering solution	2, 3, 6, 7, 8
2.5	Critique and appraise solution approach and results	6, 8
3	Investigation	9
3.1	Propose a working hypothesis	9
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	9
3.3	Analyze and interpret experimental data	9
3.4	Assess validity of conclusions within limitations of data and methodologies	9
5	Use of Engineering Tools	9
5.1	Select appropriate engineering tools from various alternatives	9
5.2	Demonstrate proficiency in the application of selected engineering tools	9
5.3	Recognize limitations of selected engineering tools	9
6	Individual & Teamwork	10
6.1	Describe principles of team dynamics and leadership	10

#	Outcome	Learning Outcome
6.2	Understand all members' roles and responsibilities within a team	10
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	10
6.4	Apply strategies to mitigate and/or resolve conflicts	10
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	10
7	Communication Skills	9, 10
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	9, 10

5 Teaching and Learning Activities

5.1 Lecture

Topics:

Time	Lecture Topics	Tutorial-Lab activities
Week 1	• Introduction • Basic Heat Transfer	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Thermodynamics
Week 2	• Heat conduction equation	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 1 Lecture
Week 3	• Steady heat conduction	• Problem solving (30 min. approx.) • Quiz (20 min. approx.):

Time	Lecture Topics	Tutorial-Lab activities
		Week 2 Lecture
Week 4	• Transient conduction	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 3 Lecture
Week 5	• Fundamentals of heat convection	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 4 Lecture
Week 6	• External forced convection	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 5 Lecture
Week 7	• Internal force convection	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 6 Lecture
Week 8	• Natural convection	Lab Experiments
Week 9	• Heat exchangers	Lab Experiments
Week 10	• Fundamentals of	• Problem solving (30 min.

Time	Lecture Topics	Tutorial-Lab activities
	thermal radiation & Radiation heat transfer	approx.) • Quiz (20 min. approx.): Week 7, 8 Lecture
Week 11	• Mass Transfer	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 9, 10 Lecture
Week 12	• Review	• Problem solving (30 min. approx.) • Quiz (20 min. approx.): Week 11 Lecture

5.2 Lab

Topics: Labs:

The purpose of performing the Heat and Mass Transfer Lab is to verify a portion of the theoretical learning in your lectures by conducting experiments. Heat and Mass Transfer Lab is located inside the "Sustainable Energy Lab (THRN 3402)". **WEEK-8 and WEEK-9** tutorial/lab time will be used for performing the Experiments. Experiments are designed to cover most of the basic aspects of Heat and Mass Transfer. The 'Lab Manual' will be available in courselink. A total 15% mark is allocated for performing all lab components. It is mandatory to attend the Heat Transfer Lab and perform all experiments successfully.

Lab 1: Investigation of modes of heat transfer
Description: Conduction through solid walls; Natural convection from vertical wall; Radiation from different colored surfaces; Thermal contact resistances; Energy balance; Isoflux and convection boundary conditions

Engineering Tool Introduced: Thermocouple, infrared thermometer, thermistor, heat flux sensor, panel meter, heat source, thermal cavity

Lab 2: Radiation heat transfer and inverse square law
Description: Radiation from point source; Radiation intensity as a function of distance; Temperature of a point source
Engineering Tool Introduced: Radiation sensor, mili-volt meter, pyrometer, point thermal source

Lab 3: Convection due to density gradient
Description: Natural circulation due to density gradient; Thermal stratification
Engineering Tool Introduced: Salinity meter, long-probe thermometer

Lab 4: Convection due to salinity gradient
Description: Natural circulation due to salinity gradient; Thermal stratification
Engineering Tool Introduced: Salinity meter, long-probe thermometer

Note: Each student must submit one complete report for all experiments individually. All lab reports are due by April 07, 2024 at 11:59 PM. Please submit the lab reports in the Dropbox folder provided on Courselink.

5.3 References

Y. Cengel and A. Ghajar, **Heat and Mass Transfer: Fundamentals and Applications**, 5th Edition, McGraw-Hill, 2014.

5.4 Other Important Dates

Please refer to Undergraduate Calendar.

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignments	0
Quizzes in Tutorials	14
Labs	16

Name	Scheme A (%)
Midterm Exam	25
Final Exam	45
Total	100

6.2 Assessment Details

Assignments (0%)

Learning Outcome: 1, 2, 3, 4, 5, 7
Approximately 13 Problem Sets

These assignments will be provided so students can practice more, there is no mark assigned to this set of assignments.

Quizzes and Tutorials (14%)

Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8
Each tutorial is divided into two parts. In the first part (approximately 30 minutes), your TA will solve and discuss one problem. In the second part of your tutorial (approximately 20 minutes) you will be asked to solve a problem. At the end of each tutorial you must submit your solution to your TA for marking. A total 14% mark is allocated for such problem solving activities.

NOTE:
1. You **MUST** attend your Registered Section of tutorial regularly. Writing Quizzes in other than your section is **NOT Permitted** and you will receive a **Zero Grade** for this.
2. There are **NO** make-up quizzes, the best seven quizzes (out of ten) will be counted toward the final quiz mark. Three waivers are given to each student for accommodations.
3. Each quiz must be submitted to your GTA at the end of your tutorial time, a late submission will receive a zero grade.

Labs (16%)

Learning Outcome: 9, 10
The purpose of performing the Heat Transfer Lab is to verify a portion of the theoretical learning in your lectures by conducting experiments. Four experiments are designed to cover most of the basic aspects of Heat and Mass Transfer. 'Lab Manual' will be available on Courselink. **Each student must submit one complete report for all experiments individually.** A total 16% mark is allocated for performing all lab components. **All lab reports are due by April 07, 2023 at 11:59 PM and should be submitted in the Dropbox folder provided on Courselink.**

Midterm Exam (25%)

Learning Outcome: 1, 2, 3, 4, 5, 8
Open the required textbook only (no writing on the book)

Midterm Exam (25%):
Date: Saturday, February 10, 2024

Time: 3:00pm to 5:00pm
Location: Virutual (Webex or ZOOM or Teams)

If you miss the midterm exam due to grounds for granting academic consideration or religious accommodation, the weight of the missed midterm will be added to the final exam. **There will be no make-up midterm exams.**

Final Exam (45%)
Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8
Open the required textbook only (no writing on the book)

Final Exam (45%):
Date: April 19, 2024
Time: 11:30am to 1:30pm
Location: TBA

6.3 Note

For the exams, students are allowed to use the course textbook but not the notes and problem set solutions (If you copy solutions to the problem sets into your textbook, you will not be allowed to use it during the various tests). You are also allowed to use a **non-programmable** calculator during the tests and exams.

If any student uses other materials (except what is mentioned above) the case will be considered as academic misconduct.

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7 Course Statements

7.1 Course Grading Policies

Missed Midterm Exam: If you miss any of the midterm exams due to grounds for granting academic consideration or religious accommodation, the weight of the missed midterm will be added to the final exam. **There will be no make-up midterm exams.**

Lab Work: You must attend and perform lab activities during Week-8 and Week-9.

Late Lab Reports: Late submissions of lab reports will not be accepted. A grade of zero will be given.

Tutorial Quizzes: Writing Quizzes in other than your section is not permitted and you will receive a zero grade for this. There are NO make-up quizzes, the best eight quizzes (out of ten) will be counted toward the final quiz mark. A late submission will receive a zero grade.

Passing Grades: The passing grade of this course is 50% of the total mark. However, every student must obtain 50% or higher on Final Exam in order for the laboratory report and quizzes portion of the course to count towards the final grade.

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

7.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*2230: Steady and unsteady state; 1st law and Bernoulli equation; fluid flow rate and friction; laminar and turbulent flows; non-dimensional parameters (e.g., Reynolds number)
ENGG*2400: Modeling of engineering systems
MATH*2270: Solving differential equations
ENGG*3260: System and control volume; work and heat and their interaction with the boundary and direction; energy efficiency and effectiveness of systems; thermodynamic losses;

Follow-on Courses:

ENGG*3370: Foundation for analysis of thermo-fluid systems
ENGG*3470: Foundations of energy balances, thermal flow, thermal properties; Mass transfer through fluid flows (convection), thermal fluid properties
ENGG*3830: Foundations of heat and mass balance and bioreactor design
ENGG*4230: Foundations for design of energy conversion processes
ENGG*4300: Foundations for design of food engineering process
ENGG*4330: Foundation for performance analysis of combustion systems

7.3 Lab Safety Specific for ENGG*3430

At the beginning of your first lab experiment session (Week 8) the Sustainable Energy Lab Technician and GTA will deliver a short lecture on the lab safety in general and specific to

ENGG*3430. **You must attend this safety lecture session and sign the signature sheet available in the lab.**

Your Lab Technician and GTA will train you before the first use of any critical instrument.

You must read the experiment manuals carefully. You will find additional safety requirement related to specific experiment in the manuals. Follow them accordingly.

You must read and follow safety rules posted on the door of the Sustainable Energy Lab (THRN3402).

Always wear safety glasses during lab time.

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is

required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).
