

**CBE 3322: Heat Transfer Operations**  
**Course Outline (Fall 2023)**

**Description**

Introduce chemical engineering students to the basics of heat transfer, including conduction, convection, radiation. This knowledge will be used for the design of various types of equipment such as heat exchangers with and without phase change, agitated reactors, evaporators, condensers.

CEAB graduate attributes assessed

Problem Analysis		Indiv. &Teamwork	D	Ethics and Equity	
Investigation		Communication		Economics and Project Management	
Design	D	Professionalism		Life-long learning	D
Engineering Tools		Impact on Society			

**Prerequisites:** CBE 2220A/B, CBE 2221A/B or registration in the Integrated Engineering program

Unless you have the requisites for this course or written special permission from your Dean to enrol, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees if you are dropped from a course for failing to have the necessary prerequisites.

**Corequisite(s):** CBE 3395Y or registration in the Integrated Engineering program.

**Antirequisite(s):** None.

**Contact Hours:** 3 lecture hours, 1 tutorial hour, 0.5 course.

**Instructor:** Kibret Mequanint

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**Teaching Assistants:**

- Satyam Dixit ([sdixit7@uwo.ca](mailto:sdixit7@uwo.ca))
- Leila Bakhtiari ([lbakhtia@uwo.ca](mailto:lbakhtia@uwo.ca))
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**Undergraduate Assistant:** Brandy Hunter

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**Required Course Textbook:**

- Fundamentals of heat and mass transfer. Bergman, Theodore L., Frank P. Incropera, and Adrienne S. Lavine. John Wiley & Sons, 8<sup>th</sup> Ed. Digital copy link:  
<https://learn.wileyplus.com/courses/122938/sections/135241>
- Please register by entering **B76736** in the WileyPLUS Course Finder

- **Course Notes:** The chapters that will be covered in this course are taken from the required textbook; thus, no other course notes will be provided. Additional PPT slides and some summary Tables may be provided by the instructor through the OWL website as needed. However, solutions to the problems presented in class will not be posted in the course website. It is expected the solutions to these problems will be recorded by the students during the lecture.

### **Primary Learning Outcomes**

- i. Learn the terminology and physical principles associated with heat transfer operations.
- ii. Define applicable heat transfer phenomena for a studied process or system.
- iii. Use essential inputs to calculate heat transfer rates and/or material temperatures.
- iv. Prepare and evaluate representative models of actual heat transfer processes or systems and draw conclusions regarding their design and/or performance.

### **Specific Learning Objectives**

- Basic principles of heat transfer mechanisms and equations (**conduction – Fourier’s law, convection – Newton’s law of cooling, and radiation – Stefan-Boltzmann equation**) (all of Chapter 1 and Section 2.2 of Chapter 2)
- **Conduction:** Derivation of the heat diffusion equation and boundary conditions, steady state conduction, thermal resistance, heat conduction through composite solid and/or variable area such as cylinder and sphere, conduction in bodies with heat sources, heat transfer from extended surfaces (fins), and transient heat conduction. (Chapters 2, 3, and 5)
- **Forced Convection:** Boundary layers, laminar and turbulent flow, forced convection for simple geometries, external (flow over flat plate, flow across cylinder, flow past a sphere, flow across tube banks, packed beds) and internal (circular pipes and ducts) flows. (Chapters 6-8)
- **Heat Exchangers:** Overall heat transfer coefficients, log mean temperature difference, thermal contact resistance, design procedure for double pipe and shell and tube heat exchangers, effectiveness and NTU method for heat exchanger analysis. (Chapter 11)
- **Natural convection heat transfer:** Buoyancy-driven flows; combined natural and forced convection; applications. (Chapter 9)
- **Heat transfer with phase change:** Boiling modes (free convection, nucleate, transition, film), condensation (laminar or turbulent, dropwise). (Chapter 10)
- Details of Radiation Processes and Properties (Chapters 12 and 13) – self learning – reading

### **Evaluation**

The final course mark will be determined as follows:

- |                                     |     |
|-------------------------------------|-----|
| • Class participation:              | 5%  |
| • Problem analysis assignments (5): | 15% |
| • HX Group Design Project (1):      | 15% |
| • Midterm exam (1):                 | 25% |
| • Final exam (1):                   | 40% |

All exams will be closed book, nonetheless an equation sheet will be provided or may be allowed by the instructor during the examinations. Only non-programmable calculators will be permitted. The midterm examination will be 2.5 hours and the final examination will be 3 hours.

**Notes:**

- 1) There will be no make-up midterm exams. If you are unable to write the midterm exam for medical or any other reasons, you must provide the appropriate documentation and the weighting of the final exam will be adjusted accordingly. Failure to provide adequate documentation will result in a mark of 0.
- 2) Assignments and group project reports must be submitted electronically on the course OWL site on the stipulated due date.

**Repeating All Components of the Course**

In accordance with Senate and Faculty Policy, students who have failed an Engineering course (i.e., <50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years

**Use of English**

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Attendance**

Attendance in all lectures and tutorials is mandatory. Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

**Cheating**

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning (see Scholastic Offence Policy in the Western Academic Calendar).

**Plagiarism**

Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

**Conduct**

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

**Sickness and Other Problems**

Students should immediately consult with the instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented. The student should seek advice from the instructor or Department Chair regarding how best to deal with the problem. Failure to notify the instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at 661-2111 x 82147 for any specific question regarding an accommodation.

**Notices**

Students are responsible for regularly checking their Western email and notices posted on the OWL website.

**Consultation**

Students are encouraged to discuss problems with their teaching assistants and/or instructor in tutorial sessions. Other individual consultation can be arranged by appointment with the instructor.

**Accreditation (AU) Breakdown**

Engineering Science = 70 %

Engineering Design = 30 %



### **STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE**

Western [is committed to reducing incidents of gender-based and sexual violence](#) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, [here](#). To connect with a case manager or set up an appointment, please contact [support@uwo.ca](mailto:support@uwo.ca).

### **INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED**

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

#### **A. GENERAL REGULATIONS & PROCEDURES**

1. All first-year students will report to the Undergraduate Services Office by submitting the [Academic Consideration Request Form](#), for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting [Academic Consideration Request Form](#). Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.
3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.
4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.
5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

#### **B. TERM/MIDTERM TESTS**

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.
2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the [Academic Consideration Request Form](#). If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed

by the Undergraduate Services Office.

3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.

### C. **FINAL EXAMINATIONS**

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the [Academic Consideration Request Form](#) and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must submit an "[Application for a Special Exam](#)" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

**PLEASE NOTE:** It is the student's responsibility to check the date, time and location of the Special Examination.

### D. **LATE ASSIGNMENTS**

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to submit the [Academic Consideration Request Form](#) and provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.

- ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

#### E. **SHORT ABSENCES**

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

#### F. **EXTENDED ABSENCES**

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

#### G. **DOCUMENTATION**

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.**

**In Case of Serious Illness of a Family Member:** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**In Case of a Death:** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**For Other Extenuating Circumstances:** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

**Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).**

#### H. **ACADEMIC CONCERNS**

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).
2. You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

**Calendar References:** Check these regulations in your 2023 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

**Absences Due to Illness:**

[https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_135](https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_135)

**Academic Accommodations for Students with Disabilities:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_10](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10)

**Academic Accommodations for Religious or Holy Days:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_16](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16)

**Course Withdrawals:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page\\_75](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75)

**Examinations:**

<http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=>

**Scheduling of Term Assignments:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading\\_78](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78)

**Scholastic Offences:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_20](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20)

**Student Medical Certificate:**

<https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf>

**Engineering Academic Regulations:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page\\_86](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86)

**Note:** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

**Add Deadlines:**

First term half course (i.e. "A" or "F"):	September 15, 2023
Full courses and full-year half course (i.e. "E", "Y" or no suffix):	September 15, 2023
Second term half course (i.e. "B" or "G")	January 16, 2024

**Drop Deadlines:**

First term half course without penalty (i.e. "A" or "F")	November 13, 2023
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Full courses and full-year half courses without penalty (i.e. “E”, “Y” or no suffix) November 30, 2023  
Second term half or second term full course without penalty (i.e. “B” or “G”) March 7, 2024

**Contact Information:**

Undergraduate Services Office: SEB 2097 Phone: 519-661-2130 E-mail: [engugrad@uwo.ca](mailto:engugrad@uwo.ca)  
Chemical & Green Process Engineering: TEB 477 Phone: 519-661-2131 E-mail: [cbeugrad@uwo.ca](mailto:cbeugrad@uwo.ca)  
Civil Engineering: SEB 3005 Phone: 519-661-2139 E-mail: [civil@uwo.ca](mailto:civil@uwo.ca)  
Computer, Electrical, Mechatronic Systems & Software Engineering; TEB 279 Phone: 519-661-3758 E-mail: [eceugrad@uwo.ca](mailto:eceugrad@uwo.ca)  
Integrated Engineering ACEB 2410: Phone: 519-661-6725 E-mail: [engceli@uwo.ca](mailto:engceli@uwo.ca)  
Mechanical Engineering: SEB 3002 ; Phone: 519-661-4122 E-mail: [mmeundergraduate@uwo.ca](mailto:mmeundergraduate@uwo.ca)

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