

**Western University  
Faculty of Engineering  
Mechatronic Systems Engineering Program**

**MSE 2214A—Thermodynamics**

**Course Outline 2018–19**

**Description:** This course covers the fundamental laws of thermodynamics, evaluation of properties of pure substances (e.g. water, steam, ideal gases), and the application of these concepts to the study of thermodynamic systems such as pumps, turbines, compressors and their use in energy conversion systems.

**Instructor:** Dr. Christopher T. DeGroot, P.Eng.  
SEB 3096, 519-661-2111 ext. 84455, [cdegroo5@uwo.ca](mailto:cdegroo5@uwo.ca)  
Consultation hours: By appointment.

**Academic Calendar Copy:** Properties of a pure substance, first law of thermodynamics, processes in open and closed systems, second law of thermodynamics; ideal gases, compressors and energy conversion systems.

**Contact Hours:** 3 lecture hours, 0.5 laboratory hours, 2 tutorial hours, 0.5 course.

**Antirequisite:** CBE 2214A/B, MME 2204A/B.

**Prerequisites:** Applied Mathematics 1413.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, 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 in the event that you are dropped from a course for failing to have the necessary prerequisites.

**CEAB Academic Units:** Engineering Science 60%, Science 40%

**Required Textbook:** “Thermodynamics, An Engineering Approach”, 9th Edition. Yunus A. Cengel, Michael A. Boles; McGraw-Hill.

**Required Software:** None.

**Recommended References:** “Fundamentals of Engineering Thermodynamics,” 6th Edition, Copyright 2008; Michael J. Moran & Howard N. Shapiro, John Wiley & Sons Inc.

**General Learning Objectives (CEAB Graduate Attributes):**

Knowledge Base	D	Use of Engineering Tools		Impact on Society and the Environment	
Problem Analysis	D	Individual and Team Work		Ethics and Equity	
Investigation	I	Communication Skills		Economics and Project Management	

Design		Professionalism		Life-Long Learning	
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Notation:  $x$  represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

## Topics and Specific Learning Objectives:

### 1. Introduction and definitions

At the end of this section, students will be able to:

- a. Understand and apply the definitions of work, energy, and heat
- b. Understand the concept of a thermodynamic system, be able to classify a system as closed, isolated, or open, and identify transfers of energy via work and heat

### 2. Properties of a pure substance

At the end of this section, students will be able to:

- a. Understand the concepts of thermodynamic state, equilibrium, simple compressible substances, and the state postulate
- b. Evaluate the thermodynamic properties of a pure substance in any phase, or combination of phases, using thermodynamic tables

### 3. First law of thermodynamics

At the end of this section, students will be able to:

- a. Apply first law of thermodynamics to closed and open systems and represent processes using property diagrams
- b. Derive simplified forms of the first law, starting from the general form, for common thermodynamic systems including pumps, compressors, turbines, etc.

### 4. Power and refrigeration cycles

At the end of this section, students will be able to:

- a. Analyze the operation of steam power cycles and refrigeration cycles
- b. Calculate the thermodynamic efficiencies of devices operating in a cycle and determine the maximum possible efficiency in the reversible limit

### 4. Second law of thermodynamics

At the end of this section, students will be able to:

- a. Understand the Clausius and Kelvin-Planck statements of the second law, and demonstrate their equivalency
- b. Understand the concepts of entropy, reversible processes, irreversibilities, and disorder in systems

### 5. Entropy changes of closed, open, reversible, and irreversible systems

At the end of this section, students will be able to:

- a. Evaluate the entropy change within closed, open, reversible, and irreversible systems undergoing a thermodynamic process
- b. Identify the entropy transfer associated with work and heat transfer

### 6. First and second law relationships and the universal principle of entropy increase

At the end of this section, students will be able to:

- a. Apply the first and second law to solve thermodynamics problems
- b. Understand the concept of entropy increase and its application to thermodynamic systems
- c. Determine whether or not processes are theoretically possible, based on second law analysis

**Evaluation:**

Course Component	Weight
Weekly tutorial exercises and iClicker queries	10%
Laboratory	10%
Midterm test #1	10%
Midterm test #2	20%
Final Examination	50%

**Homework Assignments:** Ungraded homework assignments containing suggested practice problems will be assigned on a weekly basis. Solutions will be provided the following week and will be discussed in tutorial.

**Tutorial Exercises and iClicker Queries:** Exercises will be assigned in most tutorial sessions for grading. Students may work in small groups and will have full access to their notes, textbooks, calculators, etc. A maximum of one hour will be given to complete the exercise. A maximum of 10 exercises will be assigned and a maximum of 7 will be counted towards the final grade. The instructor may ask students to respond to queries in the lecture period using iClickers, and these responses may be used as a portion of a student's grade.

**Laboratory:** There will be two lab exercises assigned. All lab data and calculations must be submitted by the end of the laboratory period for grading.

**Midterm Tests:** There will be two midterm tests, scheduled during the tutorial period. Midterms will be closed book. An equation aid and thermodynamics tables will be provided. Non-programmable calculators are permitted. The first midterm will be held on Oct. 15, 2018 from 10:30am-12:30pm in EC 2168A/B and EC 2130. The second midterm will be held on Nov. 12, 2018 from 10:30am-12:30pm in EC 2168A/B and EC 2130.

**Final Examination:** The final examination will be take place during the regular examination period and will be 3 hours in duration. The final exam will be closed book. An equation aid and thermodynamics tables will be provided. Non-programmable calculators are permitted.

**Course Policies:** The following course-specific policies will be enforced throughout the course:

Tutorial exercises: All tutorial exercises must be handed in by the end of the designated writing period. No late submissions will be accepted. There are no make-up options regardless of the reason for which the exercise was missed. Of the maximum of 10 exercises, a maximum of 7 will be counted towards the student's grade.

Laboratory sessions: Attendance to laboratory sessions is mandatory. All pre-lab exercises must be completed prior to attending the lab in order to receive full grades. All lab data and calculations must be handed in by the end of the laboratory period for grading. Should a student miss a lab without legitimate reason, a grade of zero will be given and no opportunity to complete the lab at a later date will be provided.

**Midterm tests:** No make-up midterm options will be offered, regardless of the circumstances for which the midterm test was missed. If a student misses a midterm test, the student must follow the Instructions for Students Unable to Write Tests and provide documentation to Undergraduate Services within 24 hours of the missed test. If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam. Missing a midterm test with academic consideration will automatically shift the weight of the missed midterm test to the final exam. If no reasonable justification for missing a midterm test is provided, then the student will receive a grade of zero for the test.

**Final examination:** To obtain a passing grade in the course, a mark of 60% or more must be achieved on the final examination. A final examination mark < 60% will result in a final course grade of 48% or less. If the above conditions are not met, your final grade cannot be greater than 48%. Students who have failed this course (i.e., final average < 50%) must repeat all components of the course.

**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 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:** All classes, laboratories, and tutorials are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the program, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

**Absence Due to Illness or Other Circumstances:** Students should immediately consult with the instructor or program Director if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or program Director regarding how best to deal with the problem. Failure to notify the instructor or program Director immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_medical.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf)

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_religious.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

**Cheating and 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. University policy states that cheating, including plagiarism, 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.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

**Use of Electronic Devices:** Turn off all sound for pagers and cell phones. Students may use laptops, tablet computers, or smart phones *only* to access the course OWL site during lectures and tutorials. Use of *nonprogrammable* calculators *only* is permitted during quizzes and examinations. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

**Use of Personal Response Devices (“Clickers”):** Students may be asked to respond to queries in lectures using “clickers”. It is the student’s responsibility to ensure that the device is activated and functional, and to seek assistance from the instructor if they are having any difficulties using the device. Students must only use their own clicker. The use of another student’s clicker for an in-class response constitutes a scholastic offence. The possession of a clicker belonging to another student will be interpreted as an attempt to commit a scholastic offence.

**Policy on Repeating All Components of a Course:** Students who are required to repeat an Engineering course 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 by the student for grading in subsequent years.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course. If the student fails to act on information that has been posted on these sites and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

**Accessibility:** 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 Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

**Support Services:** Office of the Registrar, <http://www.registrar.uwo.ca/>

Student Development Centre, <http://www.sdc.uwo.ca/>  
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>  
USC Student Support Services, <http://westernusc.ca/services/>

Students who are in emotional/mental distress should refer to Mental Health @ Western, [http://www.health.uwo.ca/mental\\_health/](http://www.health.uwo.ca/mental_health/), for a complete list of options about how to obtain help.

**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, SEB 2097, for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.
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 TESTS**

1. If you are in first year and you are unable to write a 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 term test, inform your instructor PRIOR to the scheduled date of the test. 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, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.
3. Be prepared to provide supporting documentation to the Department Chair and/or the Undergraduate Services Office (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. **N.B.** The approval of the Chair or the Undergraduate Services Office is required when rescheduling 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 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, 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 sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. 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 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 may want 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 2018 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

Absences Due to Illness:

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_12](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_12)

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=#Page\\_75](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=#Page_75)

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/forms/smc.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 14, 2018
Full courses and full-year half course (i.e. “E”, “Y” or no suffix)	September 14, 2018
Second term half course (i.e. “B” or “G”)	January 15, 2019

**Drop Deadlines:**

First term half course (i.e. “A” or “F”)	November 12, 2018
Full courses and full-year half courses (i.e. “E”, “Y” or no suffix)	November 30, 2018
Second term half or second term full course (i.e. “B” or “G”)	March 7, 2019

**Contact Information:**

Undergraduate Services Office:	SEB 2097	Telephone: (519) 661-2130	E-mail: <a href="mailto:engugrad@uwo.ca">engugrad@uwo.ca</a>
Dept. of Chemical and Biochemical Engineering & Green Process Engineering:	TEB 477	Telephone: (519) 661-2131	E-mail: <a href="mailto:cbeugrad@uwo.ca">cbeugrad@uwo.ca</a>
Dept. of Civil and Environmental Engineering:	SEB 3005	Telephone: (519) 661-2139	E-mail: <a href="mailto:civil@uwo.ca">civil@uwo.ca</a>
Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering:	TEB 279	Telephone: (519) 661-3758	Email: <a href="mailto:eeugrad@uwo.ca">eeugrad@uwo.ca</a>
Dept. of Mechanical and Materials Engineering:	SEB 3002	Telephone: (519) 661-4122	E-mail: <a href="mailto:mmeundergraduate@uwo.ca">mmeundergraduate@uwo.ca</a>