Western University
Faculty of Engineering

CBE 4428 – Introduction to Nanoengineering / MME 4428 – Fundamentals of Nanoengineering Science

COURSE OUTLINE – 2025-2026

CALENDAR DESCRIPTION:

An introduction to fundamental concepts in nanoengineering, emphasizing limitations of macroscale models and presenting alternative molecular approaches to the engineering of nanoscale systems.

COURSE INFORMATION:

Instructor: Dr. Michael Boutilier, P.Eng.
Office: TEB 437
Phone: 519-661-2111, ext. 84361
email: michael.boutilier@uwo.ca

Classes:
Tu 8:30 am – 9:30 am
W 10:30 am – 11:30 am
Th 3:30 pm – 5:30 pm

Office hour: Email for an appointment until a regular time is scheduled.

PREREQUISITE:

AM 2277 or AM 2276
CBE 2214 or MME 2204

ANTIREQUISITE:

You can receive credit for either CBE 4428 or MME 4428, but not for both.

EVALUATION:

The final mark will be calculated as follows:

Test 1 (Thu. Oct. 9, 3:30-5:30 pm)	33%
Test 2† (Thu. Nov. 13, 3:30-5:30 pm)	33%
Final exam (during exam period)	34%

The tests and final exam are **open book / open notes**. Indicated test dates are tentative and may be changed with advanced notice.

†Designated assessment: supporting documentation is always required to receive academic consideration for Test 2 in this course.

COURSE DELIVERY:

This course is planned for in-person delivery. Each week, students will attend 3 hours of lectures and a 1 hour tutorial. Lecture slides will be posted on the OWL website, but most of the lecture notes will be written on the board during class. Problem sets will be posted for practice but will not be collected. Tutorial and lecture times may be interchanged without notice.

TOPICS:

1. Introduction to nanotechnology
   - Overview of current and emerging applications of nanotechnology.
   - Unique properties of nanomaterials.
   - Common tools for nanostructure fabrication and characterization.
2. Molecular viewpoint
   - Characteristic magnitudes encountered in nanoscale systems.
   - Models for interatomic forces and energy.
3. Statistical thermodynamics
   - The molecular origins of thermodynamic properties and the second law of thermodynamics.
   - Applications predicting phase change, thermodynamic properties, and reaction rates.
4. Molecular simulations
   - Overview of available simulation tools for nanoscale systems.
   - Case studies calculating diffusion coefficients, molecular structure, and activation energy.
5. Quantum mechanics
   - The implications of quantization and the wave nature of matter for small systems.
   - Examples in thermal radiation, gas properties, and microscopy.
6. Nanofluidics
   - Fluid flow at the nanoscale and the collapse of continuum fluid mechanics.
   - Molecular origins of transport coefficients.
   - Applications in nanopore flow and separation processes.

LEARNING OUTCOMES:

At the end of this course, students should:

- Recognize the limitations of macroscale descriptions in analyzing nanoscale systems and the conditions under which molecular approaches are needed.
- Be familiar with the order of magnitude of engineering parameters at the nanoscale.
- Understand the molecular origins of thermophysical properties and transport phenomena.
- Appreciate classical property models and the second law of thermodynamics as large system limits, and entropy as a measure of disorder.
- Be able to analyze small thermodynamic systems.
- Have knowledge of various molecular simulation methods, their underlying modeling approximations, and the essential details of their implementation.
  - Note: this learning objective aligns with and is selected for the assessment of the graduate attribute “use of engineering tools” (ET1 and/or ET2, LEVEL: applied): An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
- Be able to choose appropriate simulation tools to resolve the important details of nanoscale systems and to carry out such calculations.

- Realize the implications of quantization and wave properties on system behavior, formulate quantum mechanical models, and glean insight into real system response through the analysis of simple systems.
- Be able to choose appropriate models for nanoscale fluid flow and predict flow rates through nanoscale geometries.
  - Note: this learning objective aligns with and is selected for the assessment of the graduate attribute "problem analysis" (PA1, PA2, and/or PA3, LEVEL: applied): An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

EXPECTATIONS / KEYS TO SUCCESS:

- Solve problem sets the week they are assigned.
  - Attempt problems independently first.
  - Review in-class examples and tutorial problems then discuss with classmates if you get stuck.
  - Bring your work to office hours or email a photo of your work to the instructor for further guidance.
- Attend all lectures and tutorials and take notes.
  - Arrive to class on time.
  - Routinely review class notes.
  - Ask questions during class, at office hours, or by email.
  - In the rare case that you miss class, get the notes from a classmate and study the material that you missed. Note that lecture slides are intended to be visual aids but are not a complete set of notes.
- Complete all work on time.

REFERENCE TEXTBOOK:

Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience, 2nd edition. K. A. Dill & S. Bromberg. Garland Science, 2010.

CONSULTATION HOURS:

Students are encouraged to ask questions during lectures and tutorials. Weekly office hours will be scheduled for students to meet with the instructor. Other individual consultation can be arranged by appointment with the instructor.

COURSE POLICIES:

The following course-specific policies will be strictly enforced throughout the course:

Emergency Contingency Plans

- Course policies, class delivery method, and the number/format of assessments may change at any time in response to difficulties that emerge as a result of pandemics or other emergencies.
- If circumstances prevent in-person instruction from continuing as planned, some or all of the remaining course content will be delivered entirely online, synchronously (i.e., at the times indicated in the timetable) and/or asynchronously (e.g., posted on OWL for students to view at their convenience). Any remaining assessments will also be conducted online at the discretion of the course instructor.

Examinations

- The tests and final exam are open book / open notes.
- The tests and final examination will be 2 hours.

- If you are unable to write a test for medical or compassionate reasons, you must provide the appropriate documentation. Failure to provide adequate documentation will result in a mark of zero. Make up tests will be scheduled later in the term. Students who miss a make up test for any reason, whether approved for academic consideration or not, will be assigned a grade of zero on the test.
- Students must request academic consideration as soon as possible and no later than 48 hours after the missed assessment.
- Supporting documentation is always required to receive academic consideration for Test 2, the designated assessment. Students are not eligible to use an undocumented absence to request academic consideration for Test 2.
- In the event of changes to the course delivery method due to a pandemic or other emergency, the tests and exam may need to be administered online. By enrolling in this course, you are consenting to the use of online proctoring software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded.

Absences from Final Examinations

- If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a make-up Final Exam).
- You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation."
- **Note:** missed work can only be excused through one of the mechanisms above. Being asked not to attend an in-person course requirement due to potential COVID-19 symptoms is not sufficient on its own.

Use of artificial intelligence (AI) tools

- Any use of artificial intelligence (AI; e.g., ChatGPT) to produce course work that is submitted for grading is considered cheating and/or plagiarism and is not permitted. This applies to work including, but not limited to test and exam problem solutions.

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 provided by the Faculty of Engineering. You should understand that academic relief will not be granted automatically on request. You must demonstrate to 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.

For further information, please consult the University's medical illness policy at:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf.

The Student Medical Certificate is available at:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

UNITS: SI units will be the primary units used in lectures and tutorials. However, other units, such as Å and eV, will be encountered regularly.

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.

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.

ACCESSIBILITY: Please contact the course instructor if you require material in an alternative format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education (formerly SSD) at 661-2111 x82147 for any specific questions regarding an accommodation.

ILLNESS AND OTHER PROBLEMS: Students should immediately consult with the instructor or Associate Chair (Undergraduate) if they have problems that could affect their performance in the course. The student should seek advice from the Instructor or Associate Chair (Undergraduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Undergraduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

NOTICES: At least once each day, students are required to check their Western email and notices posted on the OWL course site.

EMAIL POLICY: Students wishing to communicate with the instructor by email should include "CBE4428" or "MME4428" at the start of the subject line. Email responses should not be expected in less than 2 business days.

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, projects, and laboratories cannot be resubmitted by the student for grading in subsequent years.

GRADUATE ATTRIBUTE ASSESSMENT FOR ACCREDITATION BY THE CANADIAN ENGINEERING ACCREDITATION BOARD:

Graduate Attribute	Indicator	Assessment tool	Assessment Level
Problem Analysis	PA2: Demonstrate ability to formulate a strategy to solve an engineering problem.	Tests/Exam	A: Applied
Engineering Tools	ET2: Demonstrates ability to apply appropriate engineering tool(s) and resources	Tests/Exam	A: Applied

ACCREDITATION (AU) BREAKDOWN

Natural Science = 50%
Engineering Science = 50%