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MIE1745 Surface Engineering

Contact Information

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Academic Calendar Entry

MIE1745 Surface Engineering
Surface energy and surface tension, contact angles, superhydrophobic surfaces, adhesion, roughness and texture, surface chemistry, solid/liquid interactions.
Prerequisites: 4th Year standing

Course Format

- Lecture Times: TBD
- Learning Management System: Quercus
- Office Hours: TBD

Course Overview, Content, and Objectives

One materials-related topic that is important for mechanical, civil engineers is the interactions between solids and liquids. Why do some materials absorb water when others do not? How does broccoli remain dry after washing it? How to non-stick pans work? Why is the build plate adhesion of 3D printers so important? What properties of the molten plastics are important for additive manufacturing?

This course will discuss how liquids interact with solids, and how these interactions are affected by the chemical, physical, and mechanical properties of the solid, in addition to the viscosity, surface tension, and chemical structure of the liquid. The objective is for students to gain a deep understanding about how liquids and solids interact at interfaces. Examples will be drawn from all fields of engineering and the course is not tilted towards any one discipline in particular.

Learning Outcomes

After completing this course, students should be able to:

- Understand what the concepts of surface tension and surface energy physically mean
- Justify why surface properties are different from the bulk properties of materials
- Explain various models of wettability
- Argue how wettability relates to adhesion
- Compare and contrast the different properties of a surface and a liquid that control their interactions
- Apply the fundamentals learned in class to a real-world scenario to explain a common engineering phenomenon

Engineering Accreditation

The Canadian Engineering Accreditation Board requires students to have achieved competency in a twelve main areas by graduation. To ensure that our program provides sufficient instruction in these 12 graduate attributes, course learning outcomes have been mapped to the graduate attributes for each course. The relevant graduate attributes for this course are identified below.

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Course Learning Outcomes	Graduate Attributes (as defined below)											
	1	2	3	4	5	6	7	8	9	10	11	12
• Understand what the concepts of surface tension and surface energy physically mean	A											
• Justify why surface properties are different from the bulk properties of materials		A	A									
• Explain various models of wettability		A										
• Argue how surface energies relate to adhesion			A	A								
• Compare and contrast the different properties of a surface and a liquid that control their interactions				A		A						
• Apply the fundamentals learned in class to a real-world scenario to explain a common engineering phenomenon				A			A					A

CEAB Graduate Attributes

1. **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
3. **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
4. **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.
5. **Use of engineering tools:** 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.
6. **Individual and team work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
7. **Communication skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
8. **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
9. **Impact of engineering on society and the environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
10. **Ethics and equity:** An ability to apply professional ethics, accountability, and equity.
11. **Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.
12. **Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

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Evaluation Criteria and Grading

- Assignments: 10%
- Presentation: 25%
- Midterm Exam: 25%
- Final Exam: 40%

Assignments (10%)

Biweekly assignments will be posted to Canvas. Practicing assignments helps students understand course materials and develop analytical and problem-solving skills. Five assignments are given through the term and each is collected for marks (2% per assignment for a total of 10%). Assignments are assigned via Canvas at the beginning of the week, are worked on over the following two weeks, and are submitted electronically on Canvas by the deadline. NOTE: No marks for late assignments will be given. NO EXCEPTIONS.

Presentation (25%)

Students in groups of 3-4 (ideally all from different disciplines) will be responsible for presenting on a topic learned in the course, and applying that knowledge to a real-life scenario from each of their disciplines. All topics must be pre-approved by Dr. Golovin. A presentation outline (5%), actual presentation and visuals (15%), and question answers after the presentation (5%) make up the 20% course mark. A zero-sum team member assessment must be completed by all team members in order for the Presentation mark to count towards the final grade. Students will rank all team members including themselves on a -1, 0, +1 scale, with their net score requiring a sum of zero. An individual's overall Presentation score may be scaled based on the total peer assessment given by all team members. The schedule of deliverables (all uploaded to Canvas) is shown in the table below.

Midterm Exam (25%)

A take-home midterm exam will be given out during the week of Feb. 24th. The exam is open book / notes and group discussion is encouraged. You will be given time in-class during the 24th and the 26th to complete the exam with eachother. However, **all students must submit a unique exam and copying will not be tolerated. Any students submitting identical answers will receive zero credit for the exam.**

Final Exam (45%)

The final exam will be a 3-hour written examination held during the examination period. The final exam is cumulative and open notes/books/internet. No conversing with others.

Required Readings

- In-class notes

Recommended Readings

- de Gennes, P. G., Brochard-Wyart, F. & Quere, D. *Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves*. (Springer, 2004)
- Butt, H.-J., Graf, K, & Kappl, M. *Physics and Chemistry of Interfaces*. (Wiley, 2003)

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Course Schedule

The following course schedule gives a general description of topics covered and the corresponding chapters in textbooks by de Gennes and Butt. Supplemental information will be provided on Canvas.

Week of	Deliverable
Sept 9	
Sept 13	
Sept 20	Assignment 1 due (Friday)
Sept 27	
Oct 4	Assignment 2 due (Friday)
Oct 11	
Oct 18	Assignment 3 due (Friday)
Oct 25	**MIDTERM**
Nov 1	**Presentation outlines due**
Nov 8 (Reading Week)	
Nov 15	Assignment 4 due (Friday)
Nov 22	
Nov 29	**Presentations due**
Dec 6	**Presentation questions due** Assignment 5 due (Friday)

Confirmed Topics	de Gennes	Butt
Surface energy	Ch1	Ch1,8
Surface tension	Ch1	Ch2,3
Laplace Pressure / Kelvin	Ch1	Ch1
Contact angles	Ch2	Ch7.1
Contact angle hysteresis	Ch3	Ch7.3
Measuring contact angles and surface tension	Ch2.6	Ch2.4,7.3
Surface roughness / Wenzel	Ch7,Ch9.2	Ch7.3
The Cassie-Baxter model	Ch9.2.2	Ch7.2
Oil repellency	Ch9.2.2	-
Surface chemistry	-	Ch10
Chemical surface modification	-	Ch10
Physical surface modification	-	Ch10.4
Adhesion	-	Ch11.1

Accessibility and Well-Being

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability or health consideration that may require accommodations, please feel free to approach the course instructor and/or the Accessibility Services Office (http://www.studentlife.utoronto.ca/as) as soon as possible. The Accessibility Services staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let them and your instructor know your needs, the quicker they can assist you in achieving your learning goals in this course.

Diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. The source of symptoms might be strictly related to your course work; if so, please speak with the instructor. However, problems with relationships, family worries, loss, or a personal struggle or crisis can also contribute to decreased academic performance.

The University of Toronto provides mental health services to support the academic success of students. In addition to counselling services, the university offers programming on personal development including individual resilience, coping skills, peer support, and healthy habits. More information can be found at http://www.healthyuoft.ca/ and at the health and wellness centre, https://www.studentlife.utoronto.ca/hwc . Additionally, help is available through Good2Talk (1-866-925-5454), a free, confidential helpline providing professional counselling and information and referrals for mental health, addictions and well-being to post-secondary students in Ontario, 24/7/365.
Other resources available to Engineering Students can also be found at:
https://undergrad.engineering.utoronto.ca/undergrad-resources/resources-for-u-of-t-engineering-students/

Turnitin

Normally, students will be required to submit their course assignments to Turnitin.com for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their assignments to be included as source documents in the Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site.

Petitions

A petition is your formal request for an exception to a Faculty or University rule, regulation or deadline. The University of Toronto acknowledges that students sometimes encounter unforeseen or uncontrollable circumstances that can severely interfere with their ability to fulfill their academic obligations. Some examples of reasons you may consider submitting a petition:

- severe personal illness
- illness or death of a close family member
- personal or family crisis
- other extenuating circumstances

Engineering undergraduate students are required to submit term-work petitions. More information about petitions can be found at the Office of the Registrar at http://uoft.me/petitions.

Additionally, you are highly encouraged to let your instructor know if you file a petition. This will allow him/her to track the progress of your petition and take steps to expedite the process if it gets delayed.

Late Submission Policy

Any late submissions would **cost you 10% daily**, meaning that 0-24 hours late submission, your assignment will be mark out of 90%, 25-48 hours late submission, your assignment will be marked out of 80% and finally 49 to 72 hours late submission, your assignment will be marked out of 70%. After 3 days, late submissions are not being accepted for **any main deliverables**.

No late submission is accepted for all **in-class assignments/quizzes**!

No late submission is accepted for **Term Tests**!

Social Media Policy

Social media are powerful tools for communication, community-building, and networking. The use of social media is not required for MIE315. Although members of the teaching team may respond to messages on social

media, we recommend that students communicate to the teaching team via official U of T email. We will not discuss grades or personal information on social media platforms.

Students may choose to keep in touch with members of the teaching team after the completion of the course, and social media are a great way to do so. However, we are also cognizant of the perceived student-teacher power dynamic. In light of this, we will not respond to connection requests until after the completion of the course.

Academic Integrity

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If students have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, they are expected to seek out additional information on academic integrity from their instructors or from other institutional resources