

## MIE1745 Surface Engineering

### Instructor

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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.

### Course Format

- Lecture Times: Tuesdays 10:00 – 11:30AM in BA 2135  
Thursdays 10:00 – 11:30AM in HS 100
- Learning Management System: Quercus: <https://q.utoronto.ca/courses/356512>

### Course Overview, Content, and Objectives

One materials-related topic that is important for many different fields of engineering is the interactions between solids and liquids. Why do some materials absorb water when others do not? How do adhesives work? How do non-stick pans achieve their properties? Why is the build plate adhesion of 3D printers so important? What properties of molten plastics are important for additive manufacturing? How do disparate materials adhere together and how do they fracture apart?

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.

### 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 engineering phenomenon

### Composition of Final Marks (COFM)

- Assignments: 10%
- Proposal: 40 - 50%
- Term Test: 40 - 50%

#### Assignments (10%)

Biweekly assignments will be posted to Quercus. Practicing assignments helps students understand course materials and develop analytical and problem-solving skills. Five assignments are given throughout the term, and each is collected for marks (2% per assignment for a total of 10%). Assignments are assigned via Quercus at the beginning of the week, are worked on over the following two weeks, and are submitted electronically on Quercus by the deadline. Late assignments can receive a maximum of 1% (each) of the course mark but may be turned in at any time before the final day of class.

#### Proposal (40 - 50%)

Students will be responsible for proposing a research topic / new idea that demonstrates their mastery of the course content. A separate file contains all the details/requirements of the proposal. This file may be found on the course Quercus site. Inappropriate use of AI technologies such as ChatGPT will result in an automatic failure in the course.

#### Term Test (40 - 50%)

The term test will be a cumulative and open notes/books assessment of your knowledge/understanding of the course content. The term test is worth 90% - P, where P is the percentage allocated to the proposal. The value of P will be selected to maximize the final grade. Style and date TBD.

### Required Readings

- In-class notes

### Recommended Readings (all available on the U of T Library Website)

- 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)
- Law, K.-Y., Zhao, H. *Surface Wetting. Characterization, Contact Angle, and Fundamentals*. (Springer, 2016)
- Journal papers given or mentioned throughout the course

### Course Schedule

The following course schedule gives a general description of topics covered and the corresponding chapters in textbooks by de Gennes, Butt, and Law. Supplemental information will be provided in the form of journal articles or other sources of information.

Topics	de Gennes	Butt	Law
Surface energy	Ch1	Ch1, 8	Ch7
Surface tension	Ch1	Ch2, 3	Ch7
Laplace Pressure	Ch1	Ch1	-
Contact angles	Ch2	Ch7.1	Ch3.1, 3.2
Contact angle hysteresis	Ch3	Ch7.3	Ch3.3-3.4, 5.4
Pressure, thermodynamics, and $\zeta$ isotherms	-	Ch3.4, 9	-
Measuring contact angles and surface tension	Ch2.6	Ch2.4, 7.3	Ch2
Surface roughness / Wenzel	Ch7, Ch9.2	Ch7.3	Ch4.1, 4.2
The Cassie-Baxter model	Ch9.2.2	Ch7.2	Ch4.3
Oil repellency	Ch9.2.2	-	Ch6.3
Surface chemistry	-	Ch10	-
Surface modification	-	Ch10	-
Surface Analysis Techniques	Ch9.4.2.2	Ch6.4, 8.6-8.8	Ch8.3.1
Adhesion	-	Ch11.1	Parts of Ch5

### 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 postsecondary 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/>

### 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](http://uoft.me/petitions) 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.

### 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