

# MIE517H1 S

## Fuel Cell Systems

### Winter 2025 Syllabus

#### Course Meetings

##### MIE517H1 S

Section	Day & Time	Delivery Mode & Location
LEC0101	Monday, 3:00 PM - 4:00 PM	In Person: GB 221
	Thursday, 12:00 PM - 2:00 PM	In Person: BA 2185
TUT0101	Tuesday, 11:00 AM - 12:00 PM	In Person: BA 2165

Refer to ACORN for the most up-to-date information about the location of the course meetings.

#### Course Contacts

**Instructor:** Professor Olivera Kesler

**Email:** [kesler@mie.utoronto.ca](mailto:kesler@mie.utoronto.ca)

**Phone:** 416 978 3835

**Office Hours and Location:** after class or on zoom by appointment.

**Additional Notes:** Please use "MIE 517" as subject line for any emails sent regarding the course.

**Teaching Assistant:** Siyu Sun

**Email:** [siyu.sun@mail.utoronto.ca](mailto:siyu.sun@mail.utoronto.ca)

**Office Hours and Location:** By appointment

#### Course Overview

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation, including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

Electrolysis and hydrogen production will also be discussed.

#### Course Learning Outcomes

1. Identify major issues/benefits/challenges associated with use of hydrogen as an energy carrier.

2. Understand half-cell and overall reactions, ions, and side of the cells where water is produced for the five major fuel cell types using hydrogen, and where applicable, hydrocarbon or alcohol fuels.
3. Understand the relationship between current and reaction rate and calculate each using the other.
4. Determine enthalpy change, gibbs free energy change, and entropy change of important fuel cell and fuel cell processing reactions at various temperatures.
5. Relate gibbs free energy change to equilibrium standard voltage difference.
6. Calculate non-standard equilibrium voltage difference for fuel cell reactions for each fuel cell type.
7. Understand and quantify ohmic, kinetic, and mass transport losses.
8. Understand and interpret impedance spectroscopy data to separate ohmic resistance from polarization resistance.
9. Understand simple equivalent circuit and transmission line equivalent circuit models of fuel cells.
10. Determine enthalpy change of fuel processing reactions for steam reforming, partial oxidation reforming, and autothermal reforming.
11. Identify major degradation modes application to all fuel cell types and also specific degradation modes affecting each type, and some diagnostic markers of each.
12. Identify some major areas of remaining challenges and current development work for each major fuel cell type.

**Credit Value:** 0.5

**Graduate Attributes:**

- 11A. Economics and Project Management: Demonstrate ability to estimate the life-cycle economic and financial costs and benefits for relevant engineering activities. [Developed]
- 11B. Economics and Project Management: Demonstrate ability to evaluate the economic and financial performance of an engineering activity and compare alternative proposals on the basis of these measures. [Developed]
- 12A. Life-Long Learning: Demonstrate the ability to independently summarize, analyze, synthesize and evaluate information from a wide variety of sources (learning independently). [Introduced]
- 12B. Life-Long Learning: Demonstrate the ability to develop a strategy to identify and address gaps in knowledge (becoming a self-directed learner). [Introduced]
- 3C. Investigation: Demonstrate the ability to use critical analysis to reach valid conclusions supported by the results of the plan. [Introduced]
- 4C. Design: Demonstrate ability to select candidate engineering design solutions for further development. [Applied]
- 4D. Design: Demonstrate ability to advance an engineering design to a defined end state. [Introduced]
- 7A. Communication Skills: Demonstrate the ability to identify and credibly communicate engineering knowledge. [Introduced]
- 7B. Communication Skills: Demonstrate the ability to use different modes of communication. [Applied]

- 8A. Professionalism: Demonstrate the ability to describe engineering roles in a broader context, e.g. as pertains to the environment, health, safety, and public welfare. [Developed]
- 8B. Professionalism: Demonstrate the ability to recognize the impacts of engineering within a global society (the broader public interest). [Developed]
- 9A. Impact of Engineering on Society and the Environment: Demonstrate understanding of the relationships among technology and the social, cultural, economic and environmental conditions of society, locally and globally, in both the short-and long-term. [Applied]
- 9B. Impact of Engineering on Society and the Environment: Demonstrate the ability to identify and choose alternative ways to mitigate or prevent adverse social, environmental, human health and safety impacts. [Introduced]
- 9C. Impact of Engineering on Society and the Environment: Demonstrate awareness of legal issues relevant to an engineering activity. [Introduced]
- 10A. Ethics and Equity: Demonstrate the ability to recognize ethical and equity based dilemma. [Introduced]

## Marking Scheme

Assessment	Percent	Details	Due Date
<b>Mid-term exam</b>	35%	One aid sheet of 8.5" x 11" paper with only handwritten notes is permitted, and one non-graphing calculator is permitted. The exam will be held during class time.	2025-02-27
<b>Homework assignment 1</b>	5%		2025-01-31
<b>Homework assignment 2</b>	5%		2025-02-14
<b>Homework assignment 3</b>	5%		2025-03-20
<b>Homework assignment 4</b>	5%		2025-04-03
<b>Final Exam</b>	45%	The final exam covers all course material presented during the term. One aid sheet consisting of only handwritten notes on both sides of an 8.5"x11" sheet of paper will be permitted, as well as a non-graphing calculator.	Final Exam Period

### Late Assessment Submissions Policy

late assignments submitted only with prior approval

## Policies & Statements

### University Land Acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Learn more about Canada's relationship with Indigenous Peoples [here](#).

### Indigenous Students' Supports

If you are an Indigenous engineering student, you are invited to join a private Discord channel to meet other Indigenous students, professors, and staff, chat about scholarships, awards, work opportunities, Indigenous-related events, and receive mentorship. Email [Professor Bazylak](#) if you are interested.

Indigenous students at U of T are also invited to visit Nations House's (FNH) Indigenous Student Services for culturally relevant programs and services. If you want more information on how to apply for Indigenous specific funding opportunities, cultural programs, traditional medicines, academic support, monthly social events or receive the weekly newsletter, go to the FNH [website](#), [email](#) or follow FNH on social media: [Facebook](#), [Instagram](#), or [TikTok](#). A full event calendar is on the CLNX platform. Check CLNX often to see what new events are added!

### Wellness and Mental Health Support

Your personal wellness and mental health are important. The University of Toronto and the Faculty of Applied Science & Engineering offer a wide range of free and confidential services that can support your well-being.

As a U of T Engineering student, you have a Departmental [Undergraduate Advisor](#) or a Departmental [Graduate Administrator](#) who can support you by advising on personal matters that impact your academics. Other resources that you may find helpful are listed on the [U of T Engineering Mental Health & Wellness webpage](#), and a small selection are also included here:

- [U of T Engineering's Student & Community Wellness Coordinator](#)
- [Health & Wellness](#) and the [On-Location Engineering Wellness Counsellor](#)
- [Health & Wellness Peer Support Program](#)
- [Accessibility Services](#) & the [On-Location Advisor](#)
- [Graduate Engineering Council of Students' Mental Wellness Commission](#)
- [SKULE™ Mental Wellness](#)
- [U of T Engineering's Learning Strategist](#) and [Centre for Learning Strategy Support](#)
- [Registrar's Office](#) and [Scholarships & Financial Aid Office & Advisor](#)

We encourage you to access these resources as soon as you feel you need support; no issue is too small. You may reach out to the counsellors at [U of T Telus Health Student Support](#) for 24/7 free and confidential counselling support.

If you find yourself feeling distressed and in need of more immediate support visit [uoft.me/feelingdistressed](https://uoft.me/feelingdistressed) or U of T Engineering's [Urgent Support – Talk to Someone Right Now](#).

## **Accommodations**

The University of Toronto supports accommodations for students with diverse learning needs, which may be associated with mental health conditions, learning disabilities, autism spectrum, ADHD, mobility impairments, functional/fine motor impairments, concussion or head injury, visual impairments, chronic health conditions, addictions, D/deaf, deafened or hard of hearing, communication disorders and/or temporary disabilities, such as fractures and severe sprains, or recovery from an operation.

If you have a learning need requiring an accommodation the University of Toronto recommends that students [register with Accessibility Services](#) as soon as possible.

We know that many students may be hesitant to reach out to Accessibility Services for accommodations. The process of accommodation is private; we will not share details of your needs or condition with any instructor.

If you feel hesitant to register with us, we encourage you to reach out for further information and resources on how we can support. It may feel difficult to ask for help, but it can make all the difference during your time here.

Phone: 416-978-8060

Email: [accessibility.services@utoronto.ca](mailto:accessibility.services@utoronto.ca)

## **Quercus Information**

This course uses the University's learning management system, Quercus, to post information about the course. This includes posting readings and other materials required to complete class activities and course assignments, as well as sharing important announcements and updates. The site is dynamic and new information and resources will be posted regularly as we move through the term, so please make it a habit to log in to the site on a regular, even daily, basis. To access the course website, go to the U of T Quercus log-in page at <https://q.utoronto.ca>. Once you have logged in to Quercus using your UTORid and password, you should see the link or "card" for this course. You may need to scroll through other cards to find this. Click on this link to open our course area, view the latest announcements and access your course resources. There are Quercus help guides for students that you can access by clicking on the "?" icon in the left side column.

**SPECIAL NOTE ABOUT GRADES POSTED ONLINE:** Please also note that any grades posted are for your information only, so you can view and track your progress through the course. No grades are considered official, including any posted in Quercus at any point in the term, until they have been formally approved and posted on ACORN at the end of the course. Please contact me as soon as possible if you think there is an error in any grade posted on Quercus.

## Academic Integrity

All students, faculty and staff are expected to follow the University's guidelines and policies on academic integrity. For students, this means following the standards of academic honesty when writing assignments, collaborating with fellow students, and writing tests and exams. Ensure that the work you submit for grading represents your own honest efforts. Plagiarism—representing someone else's work as your own or submitting work that you have previously submitted for marks in another class or program—is a serious offence that can result in sanctions. Speak to me or your TA for advice on anything that you find unclear. To learn more about how to cite and use source material appropriately and for other writing support, see the [U of T writing support website](#). Consult the [Code of Behaviour on Academic Matters](#) for a complete outline of the University's policy and expectations. For more information, please see the [U of T Academic Integrity website](#).

## Video Recording and Sharing (Download and Re-use Prohibited)

This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. Do not download, copy, or share any course or student materials or videos without the explicit permission of the instructor.

For questions about the recording and use of videos in which you appear, please contact your instructor.

## Equity, Diversity and Inclusion

### Looking for community? Feeling isolated? Not being understood or heard?

**You are not alone.** You can talk to anyone in the Faculty that you feel comfortable approaching, anytime – professors, instructors, teaching assistants, [first-year](#) or [upper years](#) academic advisors, student leaders or the [Assistant Dean of Diversity, Inclusion and Professionalism](#).

**You belong here.** In this class, the participation and perspectives of everyone is invited and encouraged. The broad range of identities and the intersections of those identities are valued and create an inclusive team environment that will help you achieve academic success. You can read the evidence for this approach [here](#).

**You have rights.** The [University Code of Student Conduct](#) and the [Ontario Human Rights Code](#) protect you against all forms of harassment or discrimination, including but not limited to acts of racism, sexism, Islamophobia, antisemitism, homophobia, transphobia, ableism, classism and ageism. Engineering denounces unprofessionalism or intolerance in language, actions or interactions, in person or online, on- or off-campus. Engineering takes these concerns extremely seriously and you can confidentially disclose directly to the Assistant Dean for help [here](#).

Resource List:

- [Engineering Equity, Diversity & Inclusion Groups, Initiatives & Student Resources](#)
- [Engineering Positive Space Resources](#)
- Request a religious-based accommodation [here](#)
- Email Marisa Sterling, P.Eng, the Assistant Dean, Diversity, Inclusion & Professionalism [here](#)
- Make a confidential disclosure of harassment, discrimination or unprofessionalism [here](#) or email [engineering@utoronto.ca](mailto:engineering@utoronto.ca) or call 416.946.3986
- Email the Engineering Society Equity & Inclusivity Director [here](#)
- [U of T Equity Offices & First Nations House Resources](#)