Nanotechnology in Energy Systems

Course Information

Course Number: ENGS 3P44/ PHYS 3P44/ CHEM 3P44/ PHYS 5V84
Term/Year/Duration: Fall 2025 (D2)
Course Title: Nanotechnology in Energy Systems

Instructor Information

Instructor Name: Prof. Jasneet Kaur
Email: jkaur2@brocku.ca
Office Location: MCE 220
Contact: 905 688 5570 X 3997

Times and Locations:

Lecture schedule:

Monday: 9:30 – 11:00 AM in WH303

Thursday: 9:00 – 10:30 AM in WH303

Office hours: Wednesday, 1-2 pm at MC E220.
If you cannot make it, please email me to set up remote/in-person appointment.

Course Calendar Description:

Exploration of the intersection of nanotechnology and energy, focusing on how nanoscale materials and technologies are revolutionizing the energy sector. Principles of nanotechnology, nanofabrication and characterization techniques, and applications of nanotechnology in various energy systems, including renewable energy sources, energy storage, and energy efficiency. Topics may include unique properties of nanomaterials, synthesis and characterization of nanostructures, and nanomaterials for solar cells, fuel cells, batteries, supercapacitors, and energy-efficient devices.

Topics to be covered include:

1. Introduction to nanotechnology and basic principles.
2. Nanofabrication and some scalable synthesis techniques of nanomaterials.
3. Advanced microscopic and spectroscopic characterization techniques for nanomaterials characterization.
4. Basics of electrochemical energy systems and role of nanomaterials.
5. Advanced materials for energy generation and storage technologies, such as batteries, supercapacitors, fuel cells, electrolysers and photovoltaics for electric vehicles and electric grids with examples from peer-reviewed research articles.

Learning Outcomes:

- Understanding on fundamental principles of nanotechnology, including nanoscale phenomena and their distinctions from bulk material properties.
- Describe and compare key nanofabrication and characterization techniques relevant to energy applications.
- Understand working mechanisms of energy storage and conversion systems, such as batteries, supercapacitors, solar cells, fuel cells and electrolysers.
- Analyze the role of nanomaterials in energy conversion, storage, and efficiency across multiple systems, mentioned above.
- Apply critical thinking and problem-solving skills to interpret case studies and contemporary research findings in nanotechnology for energy systems.
- Communicate effectively, both orally and in writing, on concepts, applications, and implications of nanotechnology in the energy sector.

Course Communications:

All the announcements and course updates will be provided through the course Brightspace. For course related queries, reach out to me at jkaur2@brocku.ca. Please use your Brock email only for communication purposes.

There is an anonymous feedback form available throughout the term that your instructor will check on weekly basis. Please share any thoughts/comments/feedback (even compliments) that may be helpful for improving the course offering. The survey is available at: https://forms.office.com/r/QkvEEkJGHF

When the university is officially closed for inclement weather, University Communications will notify everyone via email.

Assessment Components:

Assessment Component	Grade Weight	Due Date
Quizzes	30%	Schedule posted below
Presentation and Research report	40%	Schedule posted below
Final Exam	30%	Schedule posted below
Total	100%	

The assessment components include the following:

1. **Quizzes**: 3 quizzes will be conducted during the term, each contributing 10% to the final grade. In case you are not able to attend the quiz due to some medical situation or emergency, please email your instructor to schedule a makeup quiz. This is approved once per term only.

2. **Seminar and Research report**: Every student will do research on a specific topic, share their learnings with the class using a presentation and will submit a research report which will be evaluated for their final grade. The presentation and the research report, each is worth 20% of the final grade. The research topics will be selected in discussion with the instructor from the list below. 3P44 students are expected to present for 12-15 mins with 5 mins of Q & A and 5V84 students are expected to present for 20-25 mins with 5-10 mins of Q & A. Reports for 3P44 students are expected to be 8-10 pages long and for 5V84 students, the report should be 12-15 pages long. You can also earn a bonus of 5% grade, if the reports are submitted in *Overleaf* format.

3. **Final exam:** The final exam will be of 90 mins which will include multiple choice questions, short answer and long answer questions based on the topics covered in the lectures. The final exam is worth 30% of the final grade and will be held during the last week of the lectures.

Late Submission Policy

The penalties for late submission of assigned coursework are 20% per day to a maximum of 5 days late, unless accompanied by medical documentation. See Medical Exemption Policy and the medical health certificate at the Registrar's Website (Forms).

Important dates for Fall 2025 (D2)

The most recent listing of Important Dates for all durations is at Full Listing of Important Dates – Important dates

First day of classes: 3 September

Last day of lectures: 2 December

Reading Week: 13-17 October

Deadline for withdrawal without academic penalty: 4 November

Relationship between attendance and grades:

Students are expected to attend all the classes and must participate in all the components of the course, including quizzes, final exam, in-class presentation, and research report and must achieve at least 50% grade in all the components of the course in order to pass the course.

Academic Policies

Academic Integrity

Statement for undergraduate courses

Academic misconduct is a serious offence. The principle of academic integrity, particularly of doing one's own work, documenting properly (including use of quotation marks, appropriate paraphrasing and referencing/citation), collaborating appropriately, and avoiding misrepresentation, is a core principle in university study. Students should consult Section VII, "Academic Misconduct", in the "Academic Regulations and University Policies" entry in the Undergraduate Calendar to view a fuller description of prohibited actions, and the procedures and penalties. Information on what constitutes academic integrity is available at Brock University Academic Integrity Website.

Penalties for Academic Misconduct in the Faculty of Mathematics and Science

The following are minimum penalties usually imposed in academic misconduct cases in FMS. Please be aware that Associate Dean, Undergraduate Programs, may assign different penalties than those listed here, depending on the details of individual cases. Also note that cheating on exams carries significantly higher penalties.

First offence: Zero grade on assignment, additional penalty of 100% of the weight of the assignment to be subtracted from the final grade, mandatory completion of the AZLS Academic Integrity workshop.

Second offence: Zero grade on assignment, additional penalty of 200% of the weight of the assignment to be subtracted from the final grade, 4-month suspension.

Third or additional offence: Zero grade in course, 1-year suspension, permanent removal from major program.

Cheating on exams: Zero grade in course, including for first offenses.

Intellectual Property Notice

All slides, presentations, quizzes, exams, and other course materials created by the instructor in this course are the intellectual property of the instructor. A student who publicly posts or sells an instructor's work, without the instructor's express consent, may be charged with misconduct under Brock's Academic Integrity Policy and/or Code of Conduct, and may also face adverse legal consequences for infringement of intellectual property rights.

Use of Generative AI (Gen AI)

- In the age of GenAI (*e.g.*, ChatGPT), the expectation of you remains to present original academic work for report and slides, following the instructions of the assignment determined by the instructor for this course for requirements, expectations, and parameters for completion and submission of your work for grading.
- Therefore, the use of GenAI tools and GenAI-generated content is not allowed (unless explicitly requested/instructed) as a resource or source for answers and discussion in submitted work.
- Unauthorized use of GenAI will be treated as an academic misconduct.

Accommodations

The University is committed to fostering an inclusive and supportive environment for all students and will adhere to the Human Rights principles that ensure respect for dignity, individualized accommodation, inclusion and full participation. The University provides a wide range of resources to assist students, as follows:

a) If you require academic accommodation because of a disability or an ongoing health or mental health condition, please contact Student Accessibility Services at askSAS@brocku.ca or 905 688 5550 ext. 3240.
b) If you require support with challenges related o health, well-being, and academic success, please feel free to visit Brock's Care and Connect webpage or contact studentaffairs@brocku.ca.

c) Medical Self-Declaration Forms (brief absence up to 72 hours)

In the case of a short-term medical circumstance, if a student wishes to seek an academic consideration, please use the Medical Self-Declaration Form. The request is to be made in good faith by the student requesting the academic consideration due to a short-term condition that impacts their academic activities (e.g., participation in academic classes, delay in assignments, etc.).

The period of this short-term medical condition for academic consideration must fall within a 72-hour (3 day) period. The form must be submitted to the instructor either during your brief absence or if you are too unwell, within 24 hours of the end of your 3-day brief absence.

Medical Verification Form (extended duration)

In cases where a student requests academic consideration due to a medical circumstance that exceeds 72 hours (three days) and will impact their academic activities (e.g., participation in academic classes, delay in

assignments, etc.), or in the case of a final exam deferral, the medical verification form must be signed by the student and the health professional as per process set out in the Faculty Handbook III:9.4.1.

d) If you are experiencing mental health concerns, contact the Student Wellness and Accessibility Centre. *Good2Talk* is a service specifically for post-secondary students, available 24/7, 365 days a year, and provides anonymous assistance: Good 2 Talk or call **1-866-925-5454**. For information on wellness, coping and resiliency, visit: Brock University (Mental Health)

e) If you require academic accommodation on religious grounds, you should make a formal, written request to your instructor(s) for alternative dates and/or means of satisfying requirements. Such requests should be made during the first two weeks of any given academic term, or as soon as possible after a need for accommodation is known to exist.

f) If you have been affected by sexual violence, the Human Rights & Equity Office offers support, information, reasonable accommodations, and resources through the Sexual Violence Support & Education Coordinator. For information on sexual violence, visit Brock's Sexual Assault and Harassment Policy or contact the Sexual Violence Support & Response Coordinator at humanrights@brocku.ca or 905 688 5550 ext. 4387.

g) If you have experienced discrimination or harassment on any of the above grounds, including racial, gender or other forms of discrimination, contact the Human Rights and Equity Office at humanrights@brocku.ca.

Sequence and Dates of Topics and Readings

Below is a list of dates of topics with associated readings and other relevant information. This is a tentative list and is subject to change based on class discussions at the discretion of the instructor.

Table 1 Sequence of Dates of Topics and Readings

Lectures	Focus/topic	Reading references, other information
Lecture 1 September 4, 2025	Introduction + Course syllabus Introduction to nanoscale and nanomaterials	Reading references: Lecture materials posted on Brightspace 1. F. J. Owens, C. P. Poole Jr. (2008) The Physics and Chemistry of Nanosolids, Wiley 2. G. L. Hornyak, J. Dutta, H. F. Tibbals, A. K. Rao (2008) Introduction to Nanoscience 3. K. E. Drexler (2006) Engines of Creation 2.0, The Coming Era of Nanotechnology
Lecture 2, 3 Sept 8-12	Nanofabrication and Synthesis techniques	Lecture materials posted on Brightspace F. J. Owens, C. P. Poole Jr. (2008) The Physics and Chemistry of Nanosolids, Wiley
Lecture 4 Sept 15	**Quiz 1**	**Quiz #1 based on lectures 1-3**
Lecture 5 Sept 18	Nano fabrication and Characterization	Lecture materials posted on Brightspace F. J. Owens, C. P. Poole Jr. The Physics and Chemistry of Nanosolids, Wiley
Lecture 6,7 Sept 22-26	Nano characterization techniques (XRD, SEM, TEM)	Lecture materials posted on Brightspace F. J. Owens, C. P. Poole Jr. (2008) The Physics and Chemistry of Nanosolids, Wiley
Lecture 8 Sept 29	Nano characterization	Lab visit and demonstration – depending on lab availability or lecture on Nano characterization
Lecture 9 Oct 2	**Quiz 2**	**Quiz #2 based on lectures 5-8**
Lecture 10 Oct 6	Characterization techniques (AFM, Raman, IR spectroscopy)	Lecture materials posted on Brightspace F. J. Owens, C. P. Poole Jr. (2008) The Physics and Chemistry of Nanosolids, Wiley
Lecture 11 Oct 9	Electrochemistry principles	Lecture materials posted on Brightspace. Electrochemical Engineering, Harb and Fuller, 2018 (available online through Brock Omni)
Oct 13-17	**Reading week**	**No lectures**
Lecture 12, 13 Oct 20-24	Electrochemical devices using advanced materials	**Student presentations**
Lecture 14, 15 Oct 27-31	Electrochemical devices using advanced materials	**Student presentations**
Lecture 16 Nov 3	**Quiz 3**	**Quiz #3 based on lectures 10-15**

Lecture 17 Nov 6	Electrochemical Energy systems	Harb, J.N. and Fuller, T. (2018) Electrochemical Engineering
Lectures 18,19 Nov 10-14	Electrochemical Energy systems	Harb and Fuller, Electrochemical Engineering
Lectures 20,21 Nov 17-21	Sustainable energy systems Battery, Supercapacitor, Water Electrolyser	Reading references: Lecture materials posted on Brightspace
Lecture 22 Nov 24	Sustainable energy systems: Key research articles from the field	Reading references: Lecture materials posted on Brightspace Research paper discussion on two-dimensional materials for energy storage and conversion systems
Lecture 23 Nov 27	Review	Revision of topics
Lecture 24 December 1	**Final exam**	**90 mins exam in classroom**

Topics for pedagogical lesson/ student presentations:

1. Batteries: Li/ Na/ K-ion batteries
2. Water electrolyser for green hydrogen generation
3. Supercapacitors
4. Solar cells
5. Fuel cells
6. Magnetic properties of quantum materials
7. Layered materials and their energy applications
8. Energy harvesting: Triboelectric and piezoelectric nanogenerators
9. Other relevant topics