

**Faculty of Science Course Syllabus (Section A)
Department of Physics and Atmospheric Science**

PHYC/ENVS 2310

Energy and the Environment

Winter 2023

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

Instructor:	<i>Michael Metzger</i> <i>(E-Mail: michael.metzger@dal.ca)</i>
Lectures:	<i>Monday, Wednesday, Friday 13.35-14.25 (credit hours: 3)</i>
Office hours:	<i>Monday, Wednesday, Friday 14.30-15.00, Dunn building, Room 329</i>
Laboratories:	-
Tutorials:	-
Course delivery:	<i>In-person, Studly Campus, Sir James Dunn Building, Room 101</i>

Course Description

This course covers the physical principles and limitations of renewable energy resource utilization and the fundamentals of energy conversion. It provides a quantitative introduction to electricity generation from fossil, nuclear and renewable resources, e.g., solar, wind and hydroelectricity. It also introduces important energy storage technologies, e.g., batteries and hydrogen. The impact of various energy technologies on the global climate and environment will be discussed.

Course Prerequisites

PHYC 1190.03/1290.03 (or PHYC 1310/1320), CHEM 1011.03/1012.03, and MATH 1000.03 (or MATH 1215.03), or permission of the instructor.

Course Exclusion

Students who have previously taken PHYC 3330 cannot take PHYC 2310.

Learning Objectives

Students should develop a general understanding of the global energy demand, conventional methods of electricity production, our rate of fossil fuel resource utilization, renewable energy sources and the need for energy conversion and storage. They should learn the fundamental physical laws governing energy conversion and storage as well as be able to perform quantitative analyzes of energy resources.

Course Materials and Delivery

- Required textbook: “Sustainable Energy” by Richard A. Dunlap, 2nd US Edition, 2019 Cengage Learning, Inc. ISBN: 978-1-337-55166-3. The Dalhousie bookstore has copies of this textbook. Students should purchase either new or used copies (2nd Edition only) of the textbook.
- Brightspace page: **ENVS2310 & PHYC2310 - Energy and the Environment (Sec 1) - 2023 Winter**.
- Slides: We will use slide decks for each chapter (see below) to discuss the relevant contents. PDFs of all slides shown in the course will be made available on the Brightspace page.
- Examples: During the course, examples of quantitative analyses will be given by the instructor on a document camera to illustrate and reinforce the learning of scientific concepts. It is expected that the students write down these examples in their notebooks for later reference.
- Assignments: The problem sets in the course assignments will be very close to the examples provided during the lectures. Assignment problems will be posted on the Brightspace page. Students will need access to a computer to upload problem solutions to the Brightspace page.

Course Assessment

Assessment	Weight (% of final grade)	Date
Assignments		
#A	10	<u>Start: January 16, 2023 / Due: January 30, 2023</u>
#B	10	<u>Start: January 30, 2023 / Due: February 13, 2023</u>
#C	10	<u>Start: February 13, 2023 / Due: February 27, 2023</u>
#D	10	<u>Start: February 27, 2023 / Due: March 13, 2023</u>
#E	10	<u>Start: March 13, 2023 / Due: March 27, 2023</u>
#F	10	<u>Start: March 27, 2023 / Due: April 10, 2023</u>
Tests/quizzes		
-	-	-
Final exam		
Final	40	<u>Scheduled exam period: April 13-25, 2023</u>

Other course requirements

-

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (<50)
A- (80-84)	B- (70-72)	C- (55-59)	

Course Policies on Missed or Late Academic Requirements

- Students are expected to use the Student Declaration of Absence form for late or missed assignments. The form may be used 2 times in this course.
- If problem solutions to assignments are handed in up to 1 week late, they will count half (5% of final grade).
- If no problem solutions to assignments are handed in more than 1 week after due date, they will count zero.

Course Policies related to Academic Integrity

It is expected that students discuss assignment problems as a group. However, it is an academic offense to copy the solution of someone else. Allegations will be submitted to an Academic Integrity Officer of the Faculty of Science for evaluation and possible sanction. The minimum sanction is zero on the assignment.

Course Content

During the term, we will attempt to cover the most important contents of the “Sustainable Energy” textbook as well as supplementary material grouped in the below chapters. Grey/cursive text applies to bonus topics that might be skipped in the interest of time. If appropriate and available, industry experts will be invited to give guest lectures. The class material requires simple calculus and diligent reading.

Tentative schedule

January 9, 2023 – April 11, 2023

Holidays/Break: Munro Day (February 3, 2023), Heritage Day (February 20, 2023), Winter Study Break (February 20-24, 2023), Good Friday (April 7, 2023)

Total sessions: 35

Chapter 1: Energy Fundamentals -- [Sessions 1-4]

- 1.1. Motivation
- 1.2. Forms of Energy
- 1.3. The Laws of Thermodynamics
- 1.4. The Use of Heat and Electricity
- 1.4. World Energy Usage

Chapter 2: Energy from Fossil Fuels -- [Sessions 5-10]

- 2.1. Traditional Energy Sources
 - 2.1.1. Oil
 - 2.1.2. Natural Gas
- 2.2. Resource Availability
- 2.3. Environmental Consequences
- 2.4. Climate Change
- 2.5. Fighting Climate Change



Chapter 3: Nuclear Energy -- [Sessions 11-15]

- 3.1. Basic Nuclear Physics
- 3.2. Nuclear Fission
 - 3.2.1. The Fission of Uranium
 - 3.2.2. Nuclear Reactor Design
 - 3.2.3. Types of Thermal Neutron Reactors
- 3.3. Nuclear Safety
- 3.4. *Nuclear Fusion*

Chapter 4: Solar Energy -- [Sessions 16-21]

- 4.1. Fundamentals
 - 4.1.1. The Solar Constant
 - 4.1.2. Heat Transfer
- 4.2. Direct Use of Solar Energy
- 4.3. Solar Thermal Electricity Generation
- 4.4. Photovoltaics

Chapter 5: Wind Energy -- [Sessions 22-25]

- 5.1. Wind Turbine Design
- 5.2. Obtaining Energy from the Wind
- 5.3. Applications of Wind Power

Chapter 6: Energy from Water -- [Sessions 26-30]

- 6.1. Hydroelectricity
 - 6.1.1. Turbine Design
 - 6.1.2. High and Low Head Systems
 - 6.1.3. Utilization of Hydroelectricity
 - 6.1.4. Pumped Hydro
- 6.2. Energy from the Ocean
 - 6.2.1. Wave Energy
 - 6.2.2. Tidal Energy
 - 6.2.3. *Exploratory Ocean Energy*

Chapter 7: Geothermal Energy -- [Sessions 31-33]

- 7.1. Origins of Geothermal Energy
- 7.2. Uses of Geothermal Energy
 - 7.2.1. Heat Pumps
 - 7.2.2. Geothermal Electricity
- 7.3. Utilization of Geothermal Electricity
- 7.4. Geo(-thermal) Energy Storage
 - 7.4.1. Compressed Air Energy Storage
 - 7.4.2. Thermal Energy Storage



Chapter 8: Renewables Integration -- [Sessions 34-35]

8.1. Possible Energy Futures

8.2. Mitigation of Climate Change

8.2.1. The Cost of Renewables

8.2.2. Greenhouse Gas Emissions Reduction

Chapter 9: Electrochemical Energy Conversion and Storage

9.1. Fundamentals

9.2. Batteries

9.2.1. Primary Batteries

9.2.2. Lithium-ion Batteries

9.2.3. Beyond Lithium-ion Batteries

9.3. Hydrogen

9.3.1. Properties of Hydrogen

9.3.2. Hydrogen Production

9.3.3. Hydrogen Transport and Storage

9.3.4. Fuel Cells

9.4. Other Electrochemical Devices

9.4.1. Supercapacitors

9.4.2. Redox-Flow Batteries

Chapter 10: Transportation

10.1. Fundamentals

10.1.1. Energy in the Transportation Sector

10.1.2. The Need for Electrification

10.2. Internal Combustion Engine (ICE)

10.2.1. Fuel Efficiency

10.2.2. Hybrid Electric Vehicles (HEVs)

10.3. Battery Electric Vehicles (BEVs)

10.4. Hydrogen Vehicles

10.4.1. Hydrogen Internal Combustion Vehicles

10.4.2. Fuel Cell Electric Vehicles (FCEVs)

10.4.3. Hydrogen Refueling Infrastructure

10.5. Efficiency of Transportation Technologies

10.5.1. Wells-to-wheels Efficiency

10.5.2. Carbon Footprint Analysis

Faculty of Science Course Syllabus (Section B)*PHYC/ENVS 2310**Energy and the Environment**Winter 2023***University Policies and Statements**

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness

Statement: <http://www.dal.ca/cultureofrespect.html>

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)

<https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=117&chapterid=-1&topicgroupid=31821&loaduseredits=False>

University Grading Practices

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Faculty of Science Course Syllabus (Section C)*PHYC/ENVS 2310**Energy and the Environment**Winter 2023***Student Resources and Support****Advising****General Advising** https://www.dal.ca/campus_life/academic-support/advising.html**Science Program Advisors:** <https://www.dal.ca/faculty/science/current-students/undergrad-students/degree-planning.html>**Indigenous Student Centre:** https://www.dal.ca/campus_life/communities/indigenous.html**Black Students Advising Centre:** https://www.dal.ca/campus_life/communities/black-student-advising.html**International Centre:** https://www.dal.ca/campus_life/international-centre/current-students.html**Academic supports****Library:** <https://libraries.dal.ca/>**Writing Centre:** https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html**Studying for Success:** https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html**Copyright Office:** <https://libraries.dal.ca/services/copyright-office.html>**Fair Dealing Guidelines** <https://libraries.dal.ca/services/copyright-office/fair-dealing.html>**Other supports and services****Student Health & Wellness Centre:** https://www.dal.ca/campus_life/health-and-wellness.html**Student Advocacy:** <https://dsu.ca/dsas>**Ombudsperson:** https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html**Safety****Biosafety:** <https://www.dal.ca/dept/safety/programs-services/biosafety.html>**Chemical Safety:** <https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>**Radiation Safety:** <https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>**Scent-Free Program:** <https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>**Dalhousie COVID-19 information and updates:** <https://www.dal.ca/covid-19-information-and-updates.html>