ENVE4200/5200: Climate Change and Engineering

Course Syllabus, Winter 2021

Instructor: Dr. Thomas W. Walker
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Office Hours: By appointment

Course Description (Calendar):

Survey of the physical science of climate change, impacts on the built environment, and climate adaptation in engineering. Greenhouse gases, global warming, paleoclimatology, and Earth system responses. Climate change impacts on structural, water, transportation, and energy systems. Climate vulnerability assessment, case studies of design adaptation. Geoengineering methods.

Student Learning Outcomes:

At the end of this course, students will be able to:

- explain the physical science of climate change and describe impacts on the natural world including feedbacks and assessments of climate in the past;
- describe the potential impacts of changes in climate on built systems, including structural, water, transportation, and energy systems;
- assess a design plan for risks related to changing climate variables and propose alterations to mitigate these risks;
- describe policy tools used in climate mitigation and understand the interaction of public policy with engineering and design; and,
- compare and contrast different methods of geo-engineering and assess their strengths and weaknesses.

Course Week-by-Week Outline (subject to change):

Weeks 1-2: Physical science of climate change

Defining climate and weather, Earth?s energy balance, natural and anthropogenic forcings, paleoclimate and modern observations, greenhouse gas sources and sinks, global warming potential, climate sensitivity.

Week 3: Impacts on the Earth system

Feedbacks (albedo, water vapour, clouds), air temperature rise, sea level rise, ocean acidification and ocean temperature rise, glacier, permafrost, and sea ice loss, precipitation changes (frequency and intensity), changes in weather extremes.

Week 4: Mitigation and adaptation

Climate models, prediction, and uncertainty. Global carbon budget, committed warming, emissions mitigation strategies. Risk, vulnerability, and adaptation capacity.

Week 5: Interactions with energy and transportation systems

Role of energy and transportation sectors and mitigation. Changes in energy supply: hydroelectricity, thermal plant efficiency, and renewable sources. Changes in energy demand: heating vs cooling. Adaptation of existing road and rail under increased temperatures and inundation. Winter road networks and shifting foundations under permafrost. Heat stress on roads and maintenance.

Week 6: Impacts on water systems

Sea level rise, inundation, erosion, and coastal infrastructure. Freshwater availability, water resources management, changes to run-off and streamflow. Water quality, sediment and pollutant loads.

Week 7: Impacts on structures and land use

Changes to domestic and commercial occupancy, passive design options. Built heritage and the Venice declaration. Urban drainage, ecosystem services, green roofs. Transition from the sanitary city to the sustainable city.

Week 8: Impacts on public health

Direct changes in temperature, precipitation, and extremes (heat waves, droughts). Air quality co-benefits and short-lived climate forcers. Spread of disease vector ranges, including insect-, food-, and water-borne diseases. Heat warning systems and disease surveillance. Population displacement and migration.

Weeks 9-10: Climate vulnerability assessment

Risk assessment, probability and severity and the risk matrix, disaster risk reduction methods, PIEVC protocol, triple bottom line accounting (social, environmental, financial), case studies.

Week 11: Interactions of engineering with environmental policy

Existing international protocols (Paris, Kyoto), economic instruments (command-and-control, carbon pricing, cap-and-trade). Canadian policy context: national engineering guidelines, Pan-Canadian Framework on Clean Growth and Climate Change.

Week 12: Geo-engineering

Solar radiation management, carbon removal, carbon capture and storage, risks, policy discussions.

(Non-Exhaustive) Reading List:

This course does not draw from a single textbook, but from a broad set of sources including textbooks, reports, policies, and peer-reviewed research articles. Students are encouraged to read widely on the subjects covered in lectures. For the student desiring a starting point for their reading, the following set of sources will prove useful:

- Archer, D. (2012). *Global Warming: Understanding the Forecast.* 2nd edition. Wiley, Hoboken, NJ, USA.
- Bosher, L. and Chmutina, K. (2017). *Disaster Risk Reduction for the Built Environment.* Wiley Blackwell, West Sussex, UK.
- IPCC (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- IPCC (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Environment and Climate Change Canada (2016). *Pan-Canadian Framework on Clean Growth and Climate Change: Canada's plan to address climate change and grow the economy*. Gatineau, PQ, Canada.
- Environment and Climate Change Canada (2017). *Pan-Canadian Framework on Clean Growth and Climate Change: First Annual Synthesis Report on the Status of Implementation – December 2017*. Gatineau, PQ, Canada.

Assessment:

The final grade for the course will comprise work during tutorial sessions, take-home assignments, one project with a written report, and a final exam. Details on the individual graded components will be released at a later time. Weightings are as follows:

Component	Weight
Assignments	15
Tutorials	15
Project	30
Final Exam	40

Graduate students may be required to answer additional questions in assessments.

Course Policies:

Course Delivery

All the course activities including lectures, tutorials, and exams are offered online.

- Lectures will be delivered synchronously (i.e. at the scheduled time) through web conference and recorded for student review;
- Tutorial activities will be initiated synchronously; and,
- Details of the exam format and schedule will be released at a later time.

Communications

Course materials will be distributed through the course?s cuLearn page. Students are responsible for ensuring they are correctly registered through cuLearn, and for checking the cuLearn course management site regularly. Lecture slides will be made available before class; however, material will be presented in class that is not accessible through the slides alone. All electronic communications with the instructor must be through official Carleton email accounts. Effort will be made to respond to inquiries as quickly as possible, but please expect delays of up to 48 hours for a response. Complex technical questions should be addressed during office hours or by appointment.

Lateness

A geometrically-scaled penalty will be deducted from assignments and reports passed in after the deadline. The first day will deduct 10% of the possible grade for that assignment, the second will deduct 20%, the third 40%, and so on. Accommodation may be made for valid reasons, requirements for which are outlined below.

Final Exam

The final exam is for evaluation purposes only and exam papers will not be returned to the student. A minimum mark of 40% on the final exam is required to pass the course.

Appeals

All grade appeals in this course must be made within one week of the posting date.

Course Material Copyright

Classroom teaching and learning activities, including lectures, discussions, presentations are copy protected and remain the intellectual property of the author. All course materials, including Powerpoint presentations, outlines, and other materials are also protected by copyright and remain the intellectual property of the author. Students registered in the course may take notes and make copies of course material for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s). Students are not permitted to upload these copyrighted materials to any online repositories.

Academic Integrity:

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensure that a degree from Carleton University is a strong signal of each student?s individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. Carleton University?s Policy on Academic Integrity (http://www.carleton.ca/registrar/academic-integrity) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. It is your responsibility to be familiar with these policies. Any students who do not act with academic integrity will face severe consequences including immediate referral to Associate Dean of Student Affairs.

Academic Accommodation:

Students with diverse learning styles and needs are welcome in this course. You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows. For more information, please consult: http://students.carleton.ca/course-outline

Pregnancy Obligation

Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please consult: http://students.carleton.ca/course-outline

Religious Obligation

Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is

known to exist. For more details, please consult: http://students.carleton.ca/course-outline

Accommodations for Students with Disabilities

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your **Letter of Accommodation** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (http://www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Survivors of Sexual Violence

As a community, Carleton University is committed to maintaining a positive learning, working, and living environment where sexual violence will not be tolerated, and survivors are supported through academic accommodations as per Carleton?s Sexual Violence Policy. For more information about the services available and to obtain information about sexual violence and/or support, please visit: http://www.carleton.ca/sexual-violence-support

Accommodation for Student Activities

Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more information, please consult: http://students.carleton.ca/course-outline