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. Geo-engineering 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 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.


Weeks 9-10: Climate vulnerability assessment: risk assessment, probability and severity and the risk matrix, disaster risk reduction methods, triple bottom line accounting (social, environmental, financial), case studies.


Week 12: Geo-engineering: Solar radiation management, carbon removal, carbon capture and storage, risks, costs, and 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, beginning with the references contained in each set of lecture slides. For students seeking further reading, the following set of materials will prove useful:

Assessment:

Carleton University uses the twelve-point system for letter grades as follows:

<table>
<thead>
<tr>
<th>Grade Range</th>
<th>Grade</th>
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<tbody>
<tr>
<td>90 – 100 %</td>
<td>A+</td>
</tr>
<tr>
<td>85 – 89 %</td>
<td>A</td>
</tr>
<tr>
<td>80 – 84 %</td>
<td>A-</td>
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<tr>
<td>77 – 79 %</td>
<td>B+</td>
</tr>
<tr>
<td>73 – 76 %</td>
<td>B</td>
</tr>
<tr>
<td>67 – 69 %</td>
<td>C+</td>
</tr>
<tr>
<td>60 – 62 %</td>
<td>B-</td>
</tr>
<tr>
<td>57 – 59 %</td>
<td>C</td>
</tr>
<tr>
<td>53 – 56 %</td>
<td>D</td>
</tr>
<tr>
<td>50 – 52 %</td>
<td>D-</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
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<tbody>
<tr>
<td>Assignments</td>
<td>15</td>
</tr>
<tr>
<td>Tutorials</td>
<td>15</td>
</tr>
<tr>
<td>Project</td>
<td>30</td>
</tr>
<tr>
<td>Final Exam</td>
<td>40</td>
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</tbody>
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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 delivered in person.

Communications

Course materials including assessments will be distributed through the course’s Brightspace page. Students are responsible for ensuring they are correctly registered through Brightspace, and for checking the Brightspace 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 penalty of 10% per day will be deducted from assignments and reports submitted after the stated deadline. 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 instructor. All course materials, including Powerpoint presentations, outlines, and other materials are also protected by copyright and remain the intellectual property of the instructor. 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

Special Information for Pandemic Measures

It is important to remember that COVID-19 is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you’re sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton’s symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: Further, while proof of vaccination is no longer required as of May 1, 2022 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in cuScreen as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton’s COVID-19 response and health and safety requirements please see the University’s COVID-19 website (http://carleton.ca/covid19) and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

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.
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).

Carleton University has launched a new academic accommodation management system, Ventus. With Ventus, course instructors can view up-to-date information on their student’s academic accommodation requirements, and submit and manage exam booking requests with the McIntyre Exam Centre. Ventus provides students with more control over their accommodations on a per-course and per-test basis, and creates an improved user experience for students and faculty with real-time data in one shared web location. Students can request and manage their academic accommodations via the Ventus Student Portal (http://ventus.carleton.ca/student). More information on using Ventus, with overviews of the student and faculty portals, can be found on VentusHelp.

**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