

CARLETON UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
ACSE3209A/CIVE3209A – BUILDING SCIENCE
WINTER 2024

Instructor: Brodie W. Hobson, MAsC, EIT

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Office hour: Wednesdays 10:30 am to 11:30 am in CB 4207 and/or by appointment (email)

Teaching Assistants:

TBA

1) Course schedule

The class meets Mondays from 6:05 pm to 8:55 pm in Azrieli Theatre 302. All tutorials/problem analysis/labs are in Canal Building 5301 unless otherwise announced in class.

2) Course description

Building envelope design and analysis; applied heat transfer and moisture transport; solar radiation; hygrothermal modelling; control of rain, air, vapour, and heat; materials for wall, window, curtain wall, roof, and foundation systems; building envelope retrofit case studies; building code; envelope construction.

3) Prerequisites

MAAE2400 and third-year status in B.Eng. Architectural Conservation and Sustainability Engineering or third-year status in B.Eng. Civil Engineering.

4) Learning Outcomes

- Understand fundamentals of heat, air, and moisture transfer in buildings.
- Apply principles of building envelope design in a cold climate.
- Understand and apply design strategies to control heat, air, and moisture transfer in buildings.
- Understand fundamental concepts in relevant building codes and standards.
- Understand basic functionalities of hygrothermal simulation tools.
- Perform hygrothermal analysis for envelope assemblies.
- Understand analysis and testing methods for air infiltration.
- Understand analysis and testing methods for thermal conductance.
- Understand and apply design strategies to mitigate moisture damage in buildings.
- Understand psychrometric processes in buildings.

- Understand thermal performance metrics in buildings.
- Understand and apply thermal mass utilization strategies for energy efficiency and resilience

5) Graduate Attributes

Engineering programs are accredited by the Canadian Engineering Accreditation Board (CEAB). As part of this process, we collect GA data to assess how effectively we are teaching or conveying the GAs with a goal to continually improve our programs. The GA data are aggregate data for a course and are NOT linked to student names or student numbers. The GAs assessed in this course include the following:

GA - Indicator	Assessment Tool
GA 2.1 – Problem definition	Questions in the midterm
GA 2.2 – Approach to the problem	Questions in the assignments
GA 2.3 – Use of assumptions	Questions in the assignments
GA 2.4 – Interpreting the solution – validity of results	Questions in the midterm and final

For information on GAs and continual curriculum improvement, visit the [Accreditation section of Engineers Canada website](#).

6) Accreditation Units

Math	Natural Science	Complementary Studies	Engineering Science	Engineering Design
-	-	-	75%	25%

7) Textbook(s)/Software

Required: All required software is available through the Civil & Environmental Engineering desktop on [cuDesktop](#). LBNL THERM and WINDOW can be installed on your own personal computer.

- LBNL THERM
- LBNL WINDOW
- WUFI

Supplementary: For your interest only. Will not be used directly during the course.

- *Building Science for a Cold Climate* by Hutcheon and Handegord
- *Building Physics – Heat, Air, and Moisture: Fundamentals of Engineering Methods with Examples* by Hens
- *Building Science for Building Enclosures* by Straube and Burnett

8) Topics and Tentative Plan

All dates provided are tentative and subject to change. In the case of a disagreement between announcements and this document, the announcements will govern.

Week of Jan 8:

Lecture 1 – Background

- Definition and importance of building science
- A brief history of building science

No tutorials held.

Week of Jan 15:

Lecture 2 – Weather and Climate

- Climate data for building performance analysis
- Heating and cooling degree-days
- Solar geometry and radiation

Assignment 1 posted Jan 15

Week of Jan 22:

Lecture 3 – Online Asynchronous: Heat Transfer and Storage in Buildings (Part I)

- Thermal transmittance
- Methods to compute thermal transmittance for wood- and steel-frame assemblies

Tutorial 1a – Software Demo: LBNL WINDOW and THERM

Tutorial 1b – Lab: Solar geometry demonstration using heliodon

Week of Jan 29:

Lecture 4 – Heat Transfer and Storage in Buildings (Part II)

- Boundary conditions (film coefficients, sol-air temperature, SHGC)
 - Thermal mass
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Week of Feb 5:

Lecture 5 – Heat Transfer and Storage in Buildings (Part III)

- Thermal properties of envelope materials and windows
- Thermal analysis and design of walls, ceilings, attics, and roofs
- Measuring thermal properties

Tutorial 2a – Problem Analysis: Heat transfer, weather, and climate

Tutorial 2b – Lab: Infrared thermography and measuring heat flux

Assignment 1 due Feb 9 @ 11:59 pm

Week of Feb 12:

Lecture 6 – Properties of Air

- Psychrometric analysis
- Mixing, heating, cooling, dehumidifying and humidifying air

Assignment 2 posted Feb 12

Week of Feb 19:

Reading week. No in-person lectures or tutorials held.

Tutorial 3 – Online Asynchronous: Midterm review

Week of Feb 26:

Lecture 7 – Infiltration

- Driving mechanisms
- Air pressure calculations
- Measuring air leakage
- Energy cost of infiltration
- Control of infiltration in buildings

Tutorial 4a – Problem Analysis: Properties of air

Tutorial 4b – Lab: Heating, cooling, and humidification explained using HVAC trainer

Week of Mar 4:

Lecture 8 – Ventilation

- Natural, mechanical, and mixed-mode ventilation
 - Mechanical ventilation configurations
 - Ventilation standards
 - Heat recovery and economizers
 - Psychrometric analysis of AHUs and VAV terminal zones
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Week of Mar 11:

Midterm held in-class.

Tutorial 5a – Problem Analysis: Infiltration and ventilation

Tutorial 5b – Lab: AHU mixing explained using HVAC trainer

Tutorial 5c – Lab: Capture hood and micro-manometer demonstration

Assignment 2 due Mar 15 @ 11:59 pm

Week of Mar 18:

Lecture 9 – Vapour Diffusion

- Definition and quantification of vapour diffusion
- Analysis of condensation potential
- 1D steady-state vapour transfer in materials and assemblies
- Condensation and drying rates

Assignment 3 posted Mar 18

Week of Mar 25:

Lecture 10 – Vapour Convection and Condensation Control

- Definition and quantification of vapour convection
- Design strategies for condensation control

Tutorial 6a – Online Asynchronous: Problem Analysis: Vapour transport

Tutorial 6b – Online Asynchronous: Software Demo: WUFI

Week of Apr 1:

Lecture 11 – Moisture and Rain Control

- Capillary action
- Moisture storage and deterioration mechanisms
- Strategies to mitigate moisture damage in cold climates
- Rain control

Week of Apr 8:

Lecture 12 – Final Exam Review

- Review course content

No tutorials held.

Assignment 3 due Apr 10 @ 11:59 pm

Final exam held in-person (location TBA)

9) Evaluation and Marking Scheme

Assignment 1	10%
Assignment 2	10%
Assignment 3	10%
Midterm	20%
Final	50%

a) Final Examination

- Final exams are for evaluation purpose and will not be returned to students.
- Students who are unable to write the final examination because of a serious illness/emergency or other circumstance beyond their control may apply for accommodation by contacting the Registrar's office. Consult the [Section 4.3 of the University Calendar](#).

b) Late Submission Policy

Assignments submitted after their due date without instructor permission will be docked 25% immediately and an additional 25% at every 24-hour interval that passes between assignment submission and the due date.

c) Missed Term Work

Students who claim medical or other extenuating circumstances beyond their control as a reason for missed term work (including the midterm) are held responsible for immediately informing the instructor concerned and for alternate arrangements with the instructor and in all cases, this must occur no later than three (3) days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. Consult [Section 4.4 of the University Calendar](#).

10) Academic dates

Students should be aware of the academic dates (e.g., last day for academic withdrawal) posted on the Registrar's office web site <https://carleton.ca/registrar/registration/dates/academic-dates/>

11) Academic Integrity and Plagiarism

- a) Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: <https://carleton.ca/engineering-design/current-students/fed-academic-integrity> Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.
- b) One of the main objectives of the Academic Integrity Policy is to ensure that the work you submit is your own. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as “presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.” This includes reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source.

Examples of violations of the policy include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using another’s data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one’s own; and
- failing to acknowledge sources of information through the use of proper citations when using another’s work and/or failing to use quotations marks.

12) Copyright

The materials (including the course outline and any slides, posted notes, videos, labs, project, assignments, quizzes, exams and solutions) created for this course and posted on this web site are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

13) Inclusivity in the classroom

We will strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space (physical or virtual) which we work in will be safe for everyone. Please be considerate of everyone’s personal beliefs, choices, and opinions.

14) Addressing Human Rights Concerns

The University and all members of the University community share responsibility for ensuring that the University’s educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the [Department of Equity and Inclusive Communities](mailto:equity@carleton.ca) at equity@carleton.ca

15) Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Academic 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.

You should request your academic accommodations in the [Ventus Student Portal](#), for each course at the beginning of every term. For in-term tests or midterms, please request accommodations at least two (2) weeks before the first test or midterm. For final exams, the deadlines to request accommodations are published in the [University academic calendars](#) for both undergraduate and graduate students.

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 your 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, see the [Senate Policy on Accommodation for Student Activities \(PDF\)](#).

Pregnancy Obligation: Please contact your 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 review the [Student Guide to Academic Accommodation \(PDF\)](#).

Religious Obligation: Please contact your 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 review the [Student Guide to Academic Accommodation \(PDF\)](#).

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 where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit the [Sexual Violence Prevention & Survivor Support](#).

16) Student Mental Health and Wellness

As a university student you may experience a range of mental health challenges that can significantly impact your academic success and overall well-being. Carleton's [Wellness Services Navigator](#) is designed to help students connect with mental health and wellness resources.

If you need to talk to someone from the department for more information and support with connecting to resources, you can contact the following faculty members, depending on your program. Or contact the department at or CEEUGChair@cunet.carleton.ca.

ACSE: Prof. [Scott Bucking](#)

Email: scott.bucking@carleton.ca, Office: 5209 Canal Building

CIVE: Prof. [Heng Khoo](#)

Email: heng.khoo@carleton.ca, Office: 3364 Mackenzie

ENVE: Prof. [Shoeleh Shams](#)

Email: shoeleh.shams@Carleton.ca, Office: 4242 Mackenzie

Here is a list of on-campus and off-campus recourses:

1. [Carleton's Wellness Desk](#): Located at 204A MacOdrum Library, is a space for students to learn about resources, connect with our Wellness Coordinator, and decompress during stressful times of the year. You can pop into the Wellness Desk any time during its hours of operation – no appointments necessary!
2. Carleton's Health and Counselling Services: To book an appointment contact the main clinic by calling (613) 520-6674. If urgent, let the Patient Care Coordinator know or go in person to the main clinic (2500 Carleton Technology and Training Centre Building) and indicate that they are in crisis and need to speak to someone right away. For more information, please see <https://carleton.ca/health/>
3. [Emergencies and Crisis](#) and [Emergency Numbers](#)
4. [Good2Talk](#) (1-866-925-5454): Good2Talk is a free, confidential helpline providing professional counselling and information and referrals for mental health, addictions and well-being to post-secondary students in Ontario, 24/7, 365 days per year.
5. [Empower Me](#): Undergraduate students have access to free e-counselling services in the community through Empower Me. This free service is accessible 24/7, 365 days per year.
6. The Walk-In Counselling Clinic (off-campus community resource): The walk-in Counselling Clinic have offices in various locations across Ottawa and the greater Champlain region that are open 7 days a week. Individuals will be assisted, with no appointment, on a first-come, first-serve basis during the Walk-in Counselling Clinic hours. The Walk-in Counselling Clinic offers services in many languages and is free and confidential. For more information, please see <https://walkincounselling.com/>

7. Distress Centre of Ottawa and Region: Available 24/7, 365 days per year. Distress Line: 613-238-3311, Crisis Line: 613-722-6914 or 1-866-996-0991, Text: 343-306-5550. For more information, please see <https://www.dcottawa.on.ca/>
8. Distress and Crisis Ontario: Available for chat 2 pm – 2 am EST. For more information, please see <https://www.dcontario.org/>
9. BounceBack Ontario (Toll-Free: 1-866-345-0224) is a free skill-building program managed by the Canadian Mental Health Association (CMHA). It is designed to help adults and youth 15+ manage low mood, mild to moderate depression and anxiety, stress or worry. Delivered over the phone with a coach and through online videos, you will get access to tools that will support you on your path to mental wellness. For more information, please see <https://bouncebackontario.ca/>.