



**Carleton  
University**

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**CIVE 5210 Advanced Computational  
Modeling Strategies of Historic  
Buildings**  
(Winter – 2025)

### **Course Info:**

**Meeting Times and Location: Wednesday 5:35–8.25 pm,**

#### **Reference Books:**

[B1] Roca, P., Lourenço, P.B., & Gaetani, A. (2019). Historic Construction and Conservation: Materials, Systems and Damage (1st ed.). Routledge (Cost: \$75).

[B2] Heyman, J. (1997). The stone skeleton: Structural engineering of masonry architecture. Cambridge University Press (Cost: \$80).

**Course Webpage:** The course materials will be available on [BrightSpace](#). Please follow the course web page for announcements, posted lectures, grades, etc.

### **Class Description:**

Introduction to conservation engineering; commonly used construction materials in historic buildings and their constitutive laws; Graphical and numerical methods to analyze masonry arches; Theory and application of discrete element method and its applications to simulate the mechanics of unreinforced masonry buildings.

**Prerequisites:** N/A

### **Tentative Lecture Schedule:**

**Week 1:** Introduction, course motivation, and essential background information regarding computational modeling, continuum and discontinuum-based analysis, conservation engineering, and masonry structures.

**Week 2-4:** Implementation and application of the finite-difference method (FDM), Implicit and explicit solution procedures, Cundall's local damping formulation, and the concept of dynamic relaxation.

**Week 5-7:** Introduction to Discrete Element Method (DEM); Contact Mechanics; Fundamental concepts of DEM (boundary conditions, loading, and computational procedure).

**Week 7-10:** Limit equilibrium analysis (lower and upper bound theorems) and their coupled use with DEM.

**Week 11-12:** Collapse and damage mechanisms of masonry buildings, structural analysis via classical approaches, and DEM-based simulations

## **Course Objectives and Learning Outcomes**

- To learn the essential structural elements (such as arches, vaults, and walls) used in historic buildings.
- To learn the material properties of brick and stone masonry and related binding materials (e.g., lime- or cement-based mortar).
- To learn limit analysis lower and upper bound theorems to analyze masonry arch and arch-pier systems.
- To learn the discrete element method and perform linear and non-linear analysis using DEM for various conservation engineering problems.

## **Assignments and Marking Scheme:**

**Assignment-I:** FDM and Local Damping

**Assignment II:** Solving various rigid-body mechanics problems using DEM

**Assignment-III:** Macro-Block analysis vs. DEM predictions – Structural analysis of masonry arches and walls.

**Assignment-IV:** Large-scale discrete block simulation of an unreinforced masonry building.

\* All late assignments will be subject to a 20% penalty / per day after the deadline.

**Assignments (40%):** 4 assignments.

**Final Research Report (50%):** The final project will be delivered as a **minimum of 20** pages of report. The template and other details regarding the report will be shared by the instructor.

**Final Presentation (10%)**

## **Copyright**

The materials (including the course outline, slides, posted notes, videos, labs, projects, assignments, quizzes, exams, and solutions) created for this course are intended for personal use only. They may not be reproduced, redistributed, or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without written permission from the author, both during and after the semester.

## **Learning and Working Environment**

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](#) at [equity@carleton.ca](mailto:equity@carleton.ca)

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

## **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](mailto: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. Please consult the [PMC website](#) for the deadline to request accommodations for the formally-scheduled exam (if applicable).

**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](#).

## **Engineering Academic Advising**

[The Engineering Academic Support Service](#) assists undergraduate engineering students with course selection, registration, and learning support from first-year through to graduation.

Academic Advisors Contact can be found here: <https://carleton.ca/engineering-design/current-students/undergrad-academic-support/undergraduate-advisors/>.

## **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 [orCEEUGChair@cunet.carleton.ca](mailto:orCEEUGChair@cunet.carleton.ca).

ACSE: Prof. Elie Azar

Email: [Elie.Azar@carleton.ca](mailto:Elie.Azar@carleton.ca), Office: 3432 Mackenzie

CIVE: Prof. Heng Khoo

Email: [heng.khoo@carleton.ca](mailto:heng.khoo@carleton.ca), Office: 3364 Mackenzie

ENVE: Prof. Shoeleh Shams

Email: [shoelehshams@cunet.Carleton.ca](mailto:shoelehshams@cunet.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! <https://wellness.carleton.ca/mental-health/wellness-desk/>
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. <https://carleton.ca/health/>
3. **Residence Counselling and Wellness Service:** Counselling services specifically for students in residence. <https://carleton.ca/health/residence-counselling/>
4. **Therapy Dogs:** Carleton's therapy dogs are around campus with their owners (who are Carleton University staff and faculty) to comfort and provide support to help you thrive as a university student. <https://carleton.ca/wellness/dogs/>
5. [Emergencies and Crisis](#) and [Emergency Numbers](#)
6. **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, 24/7/36 <https://good2talk.ca/>
7. **Empower Me:** Undergraduate students have access to free counselling services in the community through Empower Me, either in person, by telephone, video-counselling or e-counselling. **This free service is accessible 24/7, 365 days per year. Call 1-844-741-6389 (toll free) to make an**

appointment with a counsellor in the community. More information is available <https://students.carleton.ca/services/empower-me-counselling-services/>

8. **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. More information can be found at: <https://walkincounselling.com/>
9. **Distress Centre of Ottawa and Region:** Available 10am-11pm, 7 days/week, 365 days/year. **Distress Line:** 613-238-3311, **Crisis Line:** 613-722-6914 or 1-866-996-0991, **Text:** 343-306-5550. <https://www.dcottawa.on.ca/>
10. **Distress and Crisis Ontario, Available for chat 2 pm – 2 am EST.** <https://www.dcontario.org/>
11. **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. <https://bouncebackontario.ca/>.