Instructor

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Course Delivery

online instruction. Class lectures will be delivered via the course MS TEAMS channel ARCH 4212.03 Winter 2025 B5 BSI

Availability Outside of Class Hours

Please email AP to arrange a virtual meeting time on the course MS TEAMS channel.

University Policies, Learning and Support Resources

This course is governed by the academic rules and regulations set forth in the University Calendar and the Senate: https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog
See the School's "Academic Regulations" page (tinyurl.com/dal-arch-regulations) for links to university policies and resources:

- Academic Integrity
- Accessibility
- Code of Student Conduct
- Diversity and Inclusion – Culture of Respect
- Student Declaration of Absence - go to https://tinyurl.com/dal-sda-form
- Territorial Acknowledgement: Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.[1]
- Work Safety
- Fair Dealing policy
- Important Dates in the Academic Year (including add/drop dates): http://www.dal.ca/academics/important_dates.html
- Dalhousie Grading Practices Policy: https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Learning and Support Resources

- General Academic Support – Advising: https://www.dal.ca/campus_life/academic-support/advising.html

Additional Academic Support

Content and software support are available from the BSI teaching group. Software support for TEAMS and TEAMS is available through the Dalhousie ITS site https://www.dal.ca/dept/its/current.html as well as the School of Architecture's Computer Help Desk. The links to the library and copyright office are below.

- Dalhousie Libraries: http://libraries.dal.ca
- Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Faculty Policy on Equity, Diversity and Inclusion

The Faculty of Architecture and Planning is committed to recognizing and addressing racism, sexism, xenophobia and other forms of oppression within academia and the professions of architecture and planning. We, the faculty, are working to address issues of historic normalization of oppressive politics, segregation, and community disempowerment, which continues within our disciplines today.

[1] For more information about the purpose of territorial acknowledgements, or information about alternative territorial acknowledgements if your class is offered outside of Nova Scotia, please visit https://native-land.ca/.

Calendar Description

This course emphasizes environmental controls in buildings with a complex program. It examines how passive and active control systems can achieve climatic comfort with low lifetime environmental impacts. It also studies guide for environmental performance, including configurational approaches, quantitative assessments, and associated standards and regulations.

Additional Course Description

The course content includes performance and comfort standards related to human activities in buildings, active(non-passive) mechanical systems (a.k.a. HVAC - Heating, Ventilation and Air Conditioning), global warming and carbon, bioclimatic design (shaded buildings), passive cooling and heating strategies and whole building systems integration (see **Pedagogy & Competency + Learning Objectives** and **Lecture Schedule** below).

Given this range of topics covered over the term. the course will provide you with an overview understanding of the above topics, and in a couple of instances, through a focus brought about by the two course assignments, an ability of the carbon consequences of refrigerants and comprehensive architectural; design thinking as it applies to whole building hybrid HVAC systems

Pedagogy & Competency + Learning Objectives

The course takes a problem-based learning approach where the course's learning objectives are found in the course assignments. The course lectures support the assignments in that the lectures will provide you with an understanding of what is being asked of you for each assignment along with an ability to complete them.

The course's **learning objectives** include:
1. an awareness of HVAC system terminology, components, systems and operation;

2. an awareness of bioclimatic design and passive, low energy cooling strategies;

3. an awareness of global warming, climate modeling, Global Warming Potential of the Greenhouse gases, and carbon dioxide equivalence;

4. an understanding the Global Warming Potential of refrigerants;

5. an understanding of what is and how to complete a comprehensive architectural design;

6. an understanding of building systems integration theory; and

6. an ability to design a whole building hybrid HVAC system

Course TEAMS site & Course Resources

On the course TEAMS site - you will find the course outline, course resource materials, the assignments and where you are expected to submit assignments. There is no required textbook, software or equipment required to take this course. You should have received an invite to the TEAMS site and on-line lectures.

Time Spent on the Course

For this three-credit-hour course, you are expected to spend an average of *9 hours per week throughout the term on all course-related activities, including classes, for a total of about 108 hours*. If you find you are spending substantially more time on the course, please notify AP.

Lecture Schedule

This is an online course. There are two one and half hour lectures per week, Tuesday from 11:00am to 12:30pm and Thursday from 2:00pm to 3:30pm. The lectures will be delivered on the course MS TEAMS channel **ARCH 4212.03 Building Systems Integration Winter 2025**. All lectures will be recorded and posted on the course TEAMS site.

lecture schedule

week & date		**Tuesday (T)**	**Thursday (TH)**	**assignment introduction & due dates**
1	(T) January 7 & January 9	Lecture 1: course introduction, **HVAC**: anatomy & comfort	Lecture 2a: **HVAC**: fans, ventilation & heating, systems Lecture 2b: **HVAC**: cooling systems - the vapour compression cycle	
2	**Professional Practice Week - No Class**			
3	(T) January 21 & (TH) January 23	Lecture 3: **HVAC** loads & sizing	Lecture 4a: **HVAC** greenhouse effect, greenhouse gases, refrigerants, GWP and CO_2e Lecture 4b: **HVAC** assignment 1 introduction	***assignment 1 introduced (TH) January 23***
4	(T) January 28 & (Th) January 30	Lecture 5: **HVAC**: distribution systems & terminal units	Lecture 6: **HVAC + Comprehensive Design**: mechanical rooms *Q& A assignment 1*	
5	(T) February 4 & (Th) February 6	Lecture 7: **HVAC**: *penultimate review assignment 1: understanding a mechanical room*	Lecture 8a: **Comprehensive Design**: the what and how of comprehensive design *assignment 1 hand-in & review.* Lecture 8b: **Comprehensive Design** assignment 2 introduction	***assignment 1 hand-in + assignment 2 introduction (Th) February 6***
6	(T) February 11 & (Th) February 13	Lecture 9a: **Comprehensive Design**: change - how the climate will change over your building's operational life span Lecture 9b: **Comprehensive Design**: life cycle - whole building carbon & energy, circularity, planetary boundaries	Lecture 10: **Comprehensive Design**: building systems integration theory,	
7	**Winter Break - No Class**			
8	(T) February 25& (Th) February 27	Lecture 11: **Comprehensive Design:** solar shading systems - *systems integration*: envelope + interior	Lecture 12: **Comprehensive Design:** solar shading examples - Brazil	
9	(T) March 4 & (Th) March 6	Lecture 13: **Comprehensive Design: Design** thermal mass - *system integration* structure + envelope: material selection for time and place	Lecture 14: **Comprehensive** passive HVAC -cooling (ventilation) - biomimicry, Mithraeums, heating (ventilation)- trombe walls, sections - *system integration*: structure+ mechanical + envelope + interior	
10	(T) March 11 & (Th) March 13	Lecture 15: **Comprehensive Design**: *Q&A assignment 2*	Lecture 16: **Comprehensive Design**: *penultimate review assignment 2, Q&A*	
11	(T) March 18	Lecture 17: **Comprehensive Design**: *assignment 2 hand-in & review* SLEQ		***assignment 2 hand-in (T) March 18***

Course Assignments

There are two course assignments: **1) understanding a mechanical room** & **2) a comprehensive architectural design - a whole building hybrid HVAC system**. Each assignment is to be done individually. Assignment one is 30% of your term grade, assignment 2 is 70%. Please see **Course Grade Scale & Grading Rubric** section below to learn who and how the assignments will be marked along with the late assignment policy. The expectation is that assignment one should take you 16 hrs and assignment 2 68 hours. Adding the 24 hours of in-class lecture to the two assignment hours, the term course total is 108 hours.

Assignment 1: understanding a mechanical room (30%):to be done individually, due 11:00 am Thursday, February 6, 2025

The central mechanical room is where "all the big pieces live" - the heating equipment, cooling equipment and central ventilation equipment which together creates a comfortable year-round indoor environment for the building occupants. This comfort comes at a cost. Aside from the dollars, this equipment can be a major source of a building's life cycle Global Warming Potential (GWP) and ozone depleting substances.

Points

Several points to consider before we proceed with the assignment.

1) The mechanical room contains a lot more than the" mechanical components" i.e., the equipment mentioned above. It also includes the building's electrical panels, the point where the plumbing systems go from inside to the outside and visa versa, the building control system panels and the building sprinkler pump.

2) The mechanical room is noisy. Noise control is something which will not be addressed directly in this assignment. However, you should be aware that mechanical room noise is an issue and locate it accordingly.

3) Be aware that your building will have a fresh air (a.k.a. make-up air) requirement and the mechanical room has to have access to outdoor air.

4) Your buildings will be around for a long time, at least several generations. It is reasonable to expect that over the operational life span of your building, HVAC technology will improve in terms of energy efficiency and environmental emissions. This being the case, expect the possibility that HVAC equipment could be switched out and/or more or less equipment will be added to the mechanical room. For this to happen, your layout has to have a degree of spatial flexibility.

The intent of assignment 1) is to provide you with

- an ability to fit heating, cooling and ventilating equipment in a defined space; and
- an understanding of the mechanical room not only as the location of the above equipment but as one source of the building's environmental impacts.

a set of plans and a chart

The assignment asks you to complete two connected exercises. The first exercise is a game of spatial chess and the second exercise is a puzzle. The end goal is to select a set of heating, cooling and ventilating equipment that meets a portion of your building's conditioning load and 1) fits into a mechanical room of your design and 2) on paper in the service of meeting the required building conditioning loads, produces a minimal, ideally the minimum, environmental impact (Global Warming Potential) in terms of life cycle emissions.

In short, if a selected piece of equipment meets the design conditioning load but doesn't fit in the room then you will need to select another piece of equipment. Also, if a piece of equipment meets the design conditioning load and fits into the room, but has a higher environmental impact, then another piece of equipment of similar specifications, then you will have to choose again. As you can see, this assignment is a tiered two step exercise with an objective of selecting a set of equipment that meets climate load, fits into the mechanical room and produces the least environmental impact. This is the general assignment workflow. The next few paragraphs will fill in the specific pieces you need to complete the assignment.

Mechanical room layout (20%)
For the purposes of this assignment, you are asked to layout a mechanical room which will meet the conditioning loads for the whole building highlighted in B5 Design 4005 2025 - Center for Sustainability 2025. The conditioning loads are as follows: x heating (BTU/hr), y cooling (tons), z ventilation (cfm) (see Lecture 4b). You will note in the B5 Design Studio program for the Center for Sustainability that the mechanical room has been sized at 5000 square feet. This is a guide and it is not intended to restrict you in terms of your mechanical room design. Your mechanical room ultimate size will be "what it is" once you have met the assignment's equipment criteria.

To meet these loads, your mechanical engineer has told you to design the room's layout so it can contain *two natural gas boilers, two chillers,* an Air Handling Unit (AHU) complete with a coil/filter bank and associated piping and ductwork such that all equipment is operational. The engineer also told you the ventilation system will include 20% outdoor (makeup) air. The room is to be designed so that the machinery is accessible for installation, maintenance, repair & replacement (think circularity).

One note for future reference: You could have been asked to install a heat recovery ventilator (HRV) in the mechanical room. You are not being asked to install one in this assignment. But, given an interest in life cycle thinking, you could give some thought to how you could install an HRV into the mechanical room during one of the building's future refits. If asked, you would want to (presently) design the mechanical room so that the HRV installation would be a minimal intervention.

From a manufacturer's list of equipment (Carrier, Johnson Controls & Trane) you will select a boiler, chiller and AHU that has been sized to meet the comfort loads for an institutional building located in Halifax. Studying the equipment's data sheets will show each piece of equipment's physical dimensions.

GWP & the environmental impact chart (10%)
Building on what you learned in class about the environmental impacts from air conditioning equipment, calculate the Global Warming Potential (GWP) and carbon dioxide equivalence for *each* air conditioning plant included in your design. When considering the environmental impacts, assume your building has an operational life span of 80 years.

Complete the tiered exercise for two cooling plants either for two different designs from one manufacturer or a similar design from two different manufacturers. Once done, make a design recommendation of the one you would choose, please provide your reasons why you selected this unit.

Note: It is up to you, in consulting with your design tutor, to determine your mechanical room's physical dimensions and location given the above-mentioned requirements and issues.

note for best case examples for pdfs 1) & 2) go to ARCH4212.03 Winter 2025 B5BSI>General>Files>Class Materials>2024 assignment 1 best case examples

Deliverables
1) a plan and two sections of the mechanical room showing the plant and ductwork/piping mentioned above on two 11 x 17 sheets. Please submit the two sheets as a .pdf file to the course TEAMS site - name, ARCH 4212.03 2025, assignment 1 - plan and sections.
2) a table listing the projected amounts of cooling plant's carbon dioxide equivalence over (your) building's operational life cycle for two cooling plant options. Also, please identify your selected equipment for each plant on your table. Please submit the table as a pdf file to the course TEAMS site - name, ARCH 4212.03 2025, assignment 1 - table

- ***Note you are asked to calculate carbon dioxide equivalence, not GWP. GWP is given and needed along with the life cycle refrigerant leakage total to calculate each chiller refrigerant carbon dioxide equivalence ($kgCO_2e$ or $MTCO_2e$).***

Assignment 2: a comprehensive architectural design - a whole building hybrid HVAC system (75%), to be done individually, due 11:00 am Tuesday, March 18, 2025
The following description is based on four parts: Guides, Points, Learning Objectives and Deliverables.

1) Guides
information you may find helpful
Sustainability - a.k.a. sustainable development " Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." https://www.iisd.org/mission-and-goals/sustainable-development

Comprehensive Design "focuses on the concept of design thinking – It is a fundamental process of problem-solving that addresses social challenges and the tangible needs of users." https://careerexploration.indiana.edu/majors/comprehensive-design

"**Comprehensive Architectural Design** focuses on the comprehensive design of a single building, integrating material selection, mechanical, acoustical, structural, lighting, and two- and three-dimensional studies". https://design.lsu.edu/architecture_work/arch-5001-comprehensive-architectural-design/

your design's time and place: You are designing your building during a period of rapid change. The environmental conditions your building will experience when it is first built, will be different than the ones it will experience at its end. One aspect of the design that will not change are the user's requirements. Irrespective of the climate and weather, building users want to be comfortable, safe and if required, productive.

Climate change and user consistency - the want to be comfortable irrespective of what is happening outside - requires a design response. It can be one where your design can be changed over time i.e., the ability to be refurbished as required "the circularity response". It can be a design for the "worst case climate scenario". It can be a fixed design with a narrow performance matrix which includes a deliberate end of life point whose materials and systems emphasis deconstruction and re-build -"a fixed point in time". This is a design problem, there is more than one right answer. Your challenge is to justify your response. These performance choices also represent different visual and physical system integration.

2) Points
(hybrid HVAC system design points to follow)
Point 1: Climate change in Halifax 2099 will be one where the summer time day and night air temperatures will be hotter than today and more consistently hot over the season. Climate change will turn our present summer climate from a set of discrete "heat" blocks to one large "heat" block from May through September as compared to today (2016 (2025)). Please note, there will still be a temperature difference between day and night - something you can take advantage of in your design.

Point 2: A hybrid HVAC whole building design includes *both an active and passive* heating, cooling and

Point 3: keep the active air distribution system (ductwork) separate from the passive air distribution system (architecture).

Point 4: The passive cooling system can be used May - September.

Point 5: Use PMV comfort criteria for the active system and Adaptive comfort criteria for the passive system.

Point 6: apply zone control + schedule for both the active and passive HVAC systems.

Point 7: As part of the passive system design, which also applies to the active system design, incorporate the principles of continuity identify systems integration+ thermal mass into your design solution.

Point 8: Identify the performance and visual system integration aspects of your passive design solutions.

Point 9: Given user requirements and environmental challenges over the building's operating life span, your work should take a minimal approach to the consumption of energy, materials and the "emissions of development" which include carbon.

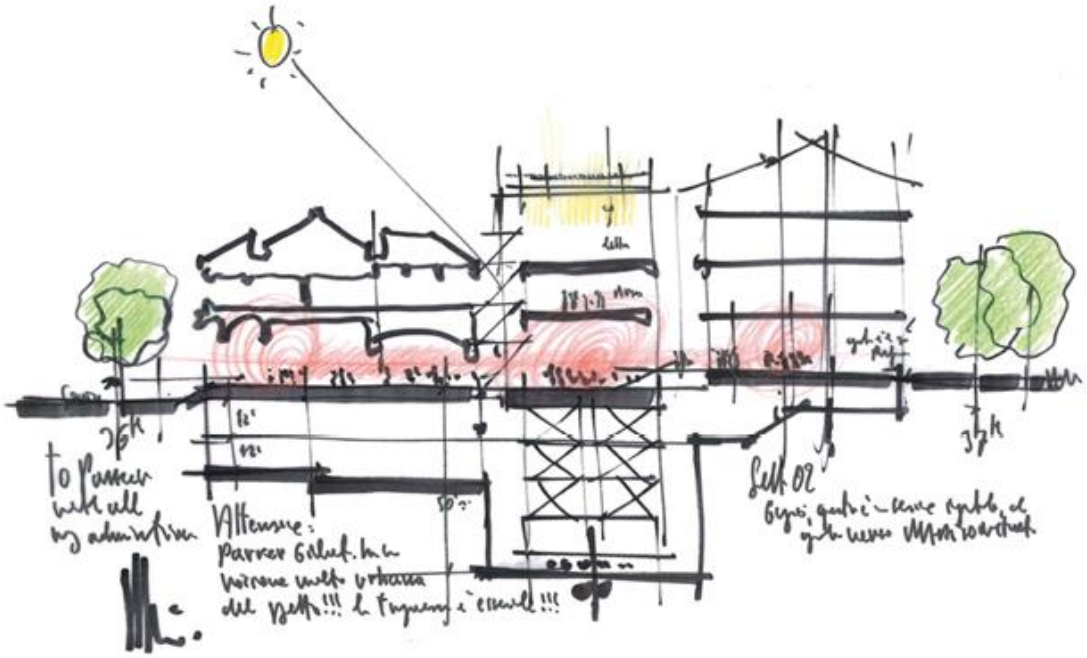
Point 10: Illustrate the integration and materials of the structural, mechanical and lighting systems to meet both the comfort and lighting needs of the building users along with addressing several social challenges around the issue of sustainability

3) Learning Objectives

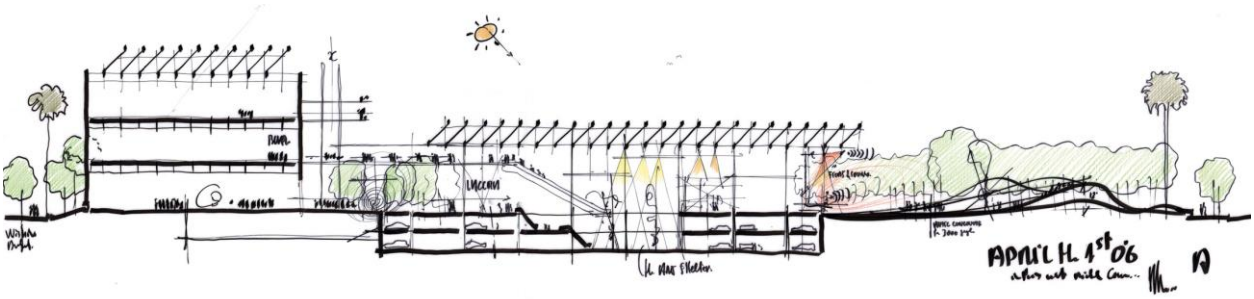
The intent of assignment 2 is to provide you an ability to design at the schematic level of detail:

- a whole building hybrid HVAC system;
- a fixed solar (direct sunlight) shading solution for any building orientation and location;
- a passive, controlled air-cooling system which includes inlets, intramural pathways and outlets;
- a passive controlled air-heating system which includes inlets, intramural pathways and outlets;
- an active, controlled cooling system which includes cooling coils, chiller, cooling tower and associated piping.
- an active, controlled heating system which includes heating coils, boiler, makeup air, and chimney
- a duct distribution system from the AHU to the various rooms. The distribution system is to include ductwork, diffusers and grills. Control points are to be zone thermostats. The distribution system is to also include an 80/20 make up air system.
- 2D, sections, elevations, plans, schematics of the various proposed solutions;
- four system physical and visual integration in your drawings;
- 2D drawing a building's relationship to site and occupant use; and
- the different materials used in the building's construction.

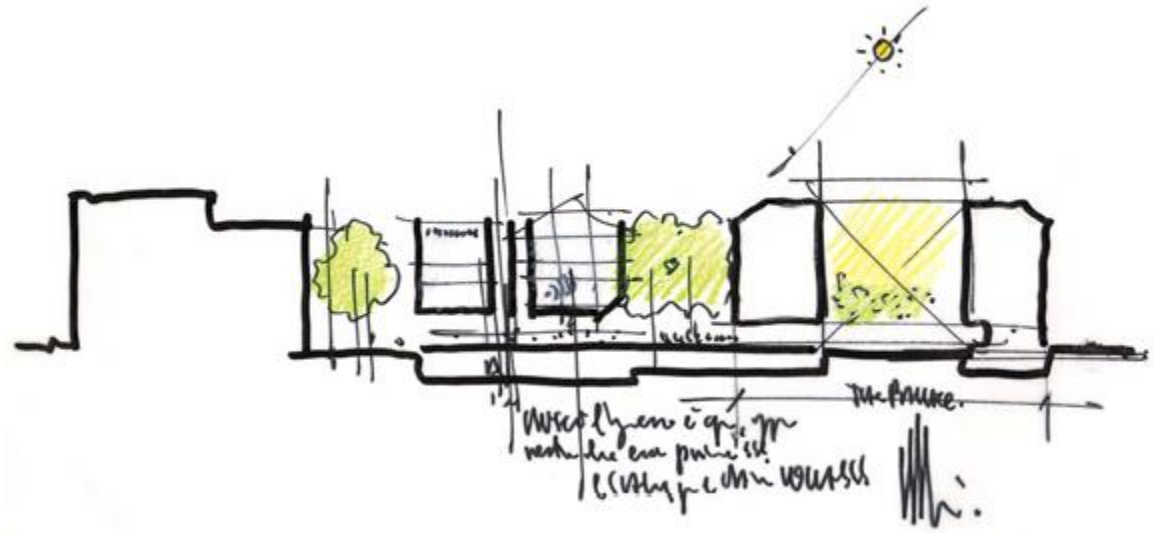
A picture is worth 1000 words. For this assignment, a schematic design level of detail is one captured by the following three Renzo Piano sketches. Detail drawings or calculations (e.g., duct or pipe sizes) are not required.



Morgan Library



LACMA Expansion



Gardner Museum

4) Deliverables
A set of four pdfs (see below) to the course TEAMS site - name, ARCH 4212.03 2025, assignment 2
Recognizing this assignment is due before your final ARCH 4005 design, the expectation is you will answer the above based on an earlier version of your design. You will not be penalized for your design development. *Please note that you are designing for a changing climate during the building's operational life span ((2030 - 2099).*

The 4 pdf''s grade weight:

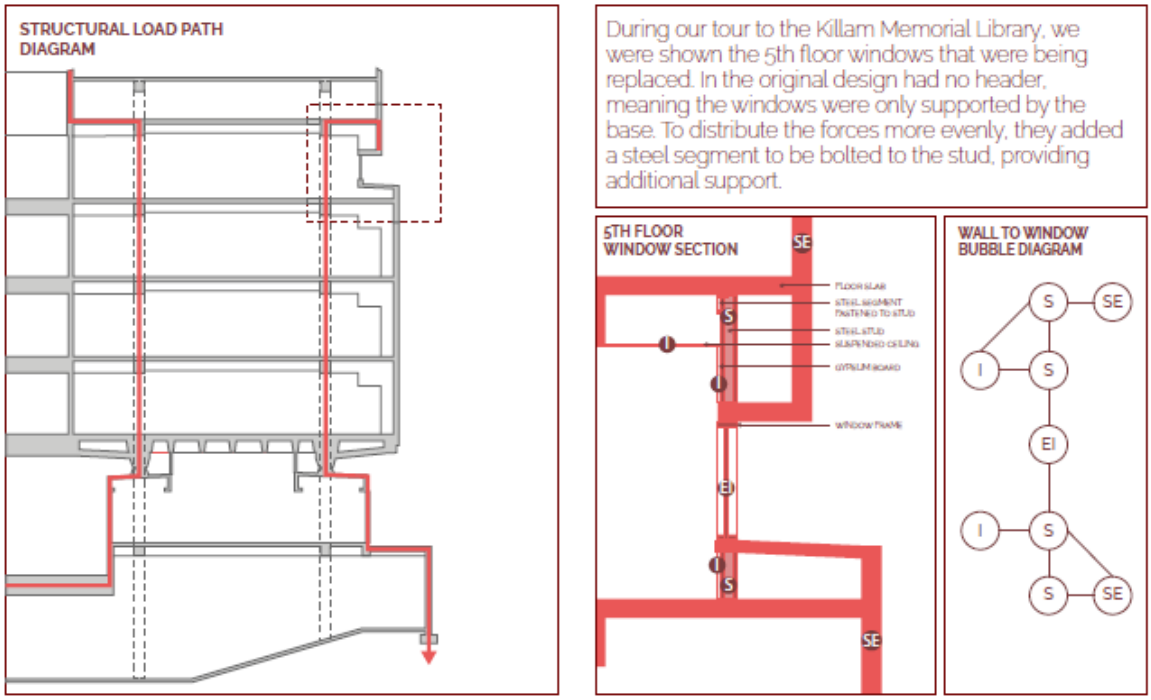
pdf 1) 2D whole building zone control drawing 5%

pdf 2) 2D active HVAC system schematic which would include a critical plan and critical section along with locations of louvres, grills, dampers, mechanical room + equipment, cooling towers, piping, ductwork represented as color coded lines highlighting insulation where required. terminal units, a note about your

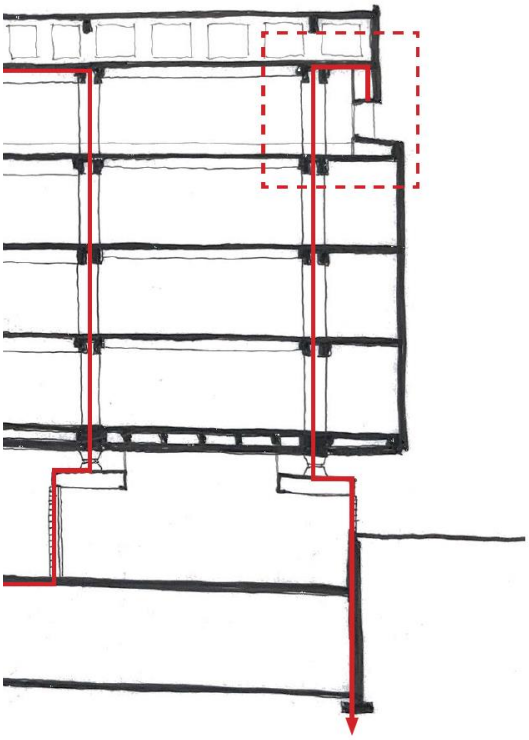
note for best case examples for pdfs 1) & 2) go to ARCH4212.03 Winter 2025 B5BSI>General>Files>Class Materials>2023-2024 assignment 2 best case examples

pdf 3) 2D isometric of the exterior window solar shade design for both the west and south facades which includes sun charts, solar block charts, plan and elevation for a south and west facing window system - window + exterior fixed shades 25%

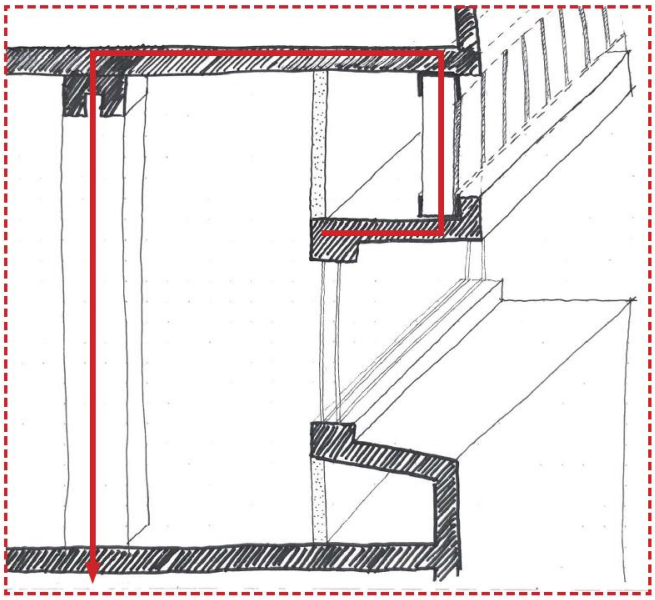
pdf 4) 2D <u>passive</u> HVAC system schematic which would include a critical plan and critical section along with the location of thermal mass materials and components, sketches of the passive HVAC system's visual + physical integration (see below), a note about your climate change strategy 25%



Molly Rainnie, ARCH 5220.03 2024



Melanie Roberts, ARCH 5220.03 2024



Retrofit of library included replacing windows. During construction, it was discovered that there was no header above the window to support the weight of the wall above it. To improve the structural integrity of the wall, a C-channel was installed; steel studs slide into the channel, which is attached directly to the concrete slab of the ceiling above. The load is then transferred to columns.

Course Grade Scale & Grading Rubric

The assignments are due @ 11:00 am on their respective hand-in date and will be graded by AP as per Dalhousie University's Undergraduate Grade Scale and Definitions found at: https://www.dal.ca/campus_life/academic-support/grades-and-student-records/grade-scale-and-definitions.html along with the grading rubric found below.

Due Dates and Late Submissions

see the chart below.

	Due date	Is a late assignment accepted?	If so, what is the deduction per weekday? *	Is there a final deadline for a late submission?	What happens after that?
Assignment 1	(Th) February 6	no			receives 0% and no comments
Assignment 2	(T) March 18	no			receives 0% and no comments

* For example, if an assignment is evaluated at 75% before applying a 3%-per-weekday deduction, it would receive 72% for being 1–24 hours late; 69% for 25–48 hours late; etc.

Note: The following University or School policies take precedence over course-specific policies:

- No late assignments are accepted after the last day of weekly classes (the Friday before review week).
- A Student Declaration of Absence (maximum two per course), cannot be used as a reason for an assignment extension.
- With a medical note submitted to the School office, a course assignment (including a final assignment) may be submitted more than three weekdays late without penalty. The number of weekdays depends on how long you were unable to work, as indicated in the medical note. If more than one course is affected, you should consult with the Undergraduate/Graduate Coordinator to set a new schedule of due dates.
- A student with an accessibility plan that allows for deadline extensions does not need to submit an SDA.

If you need to complete a Student Declaration of Absence form because you are missing a lecture, https://cdn.dal.ca/content/dam/dalhousie/pdf/campuslife/Health%20and%20wellness/FINAL%20Student%20Declaration%20of%20Absence%20Form.pdf please submit it to AP via email.

Grading rubric

A+: 90 - 100% (excellent)
The term's work is complete and correct in terms of the selection table and 2D schematics for assignment 1 and the plans and sections for assignments 2. The work is an *example of best practice*. There is considerable evidence of original thinking; outstanding grasp of subject matter; evidence of extensive knowledge base. It can be included in a publication others can use to teach or study from.

A: 85-89% (excellent - competent)
The term's work is complete and correct in terms of the selection table and 2D schematics for assignment 1 and the plans and sections for assignments 2. The work is an *industry ready document but not an example of best practice.* It would not be used in a publication others would use to study or teach from because it is derivative - imitative of the work found in other publications.

A-: 80-84% (excellent - conditionally competent)
The term's work is complete and correct in terms of the selection table and 2D schematics for assignment 1 and the plans and sections for assignments 2. One or more aspects of the work is either missing or not developed. The work is an *industry ready document with minor revisions.*

B+: 77-79% (good - understand)
The term's work shows evidence of a grasp of the subject matter; some evidence of critical capacity and analytical ability; reasonable understanding of relevant issues; evidence of familiarity with the subject. The work is not industry ready. It shows a *weakness* in one or more areas. The work can be completed with minor supervision.

B: 73-76% (good - aware)
The term's work shows evidence of a grasp of the subject matter; some evidence of critical capacity and analytical ability; reasonable understanding of relevant issues; evidence of familiarity with the subject. The work is not industry ready. It has *substantial weaknesses* in multiple areas. The work requires direct supervision to complete.

B-:70-72% (good - conditionally aware)
The term's work shows evidence of a grasp of the subject matter; some evidence of critical capacity and analytical ability; reasonable understanding of relevant issues; evidence of familiarity with the subject. The work is passable work. It shows a *minimal understanding* having considerable weakness and/or errors in one or more areas. The work requires direct supervision with explicit directions to complete.

C+:65–69%, C: 60–64%, C–: 55–59% (satisfactory)
Evidence of some understanding of the subject matter; ability to develop solutions to simple problems.

D: 50–54% (marginal pass)
Evidence of minimal familiarity with the subject matter; minimal analytical and critical skill.

F: <50% (fail)
The term's work does not meet the requirements of the course's deliverables and/or is absent.

Note the terms in the () are AP's terms and are intended to complement but not replace the University's terminology.

Course References

Climate Change

Climate Change World Weather File Generator for World-Wide Weather Data – CCWorldWeatherGen
"The climate change world weather file generator (CCWorldWeatherGen) allows you to generate climate change weather files for world-wide locations ready for use in building performance simulation programs."
https://energy.soton.ac.uk/ccworldweathergen/

Comprehensive Design

Bachman, Leonard. 2003. Integrated Buildings: The Systems Basis of Architecture. New York. John Wiley & Sons, Inc.

Barber, Daniel, A. 2020. Modern Architecture and Climate: Design before Air Conditioning. Princeton: Princeton University Press.

Climate Consultant 6. 2021. Robin Liggett and Murry Milne. UCLA Energy Design Tools Group
https://www.sbse.org/resources/climate-consultant
4212
Rush, Richard (editor). 1986. The Building Systems Integration Handbook. New York. John Wiley & Sons, Inc.

HVAC
Daniels, Klaus. 2003. Advanced Building Systems: A Technical Guide for Architects and Engineers. Berlin. Birkhauser.

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January 1, 2025