Instructor

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Course Delivery

online instruction. Class lectures will be delivered via the course MS TEAMS channel ARCH 4212.03 Building Systems Integration Winter 2023.

Availability Outside of Class Hours

Please email AP to arrange a virtual meeting time on the course MS TEAMS channel ARCH 4212.03 Building Systems Integration Winter 2023.

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 Brightspace 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.

[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/.

We, the faculty, are working to address issues of historic normalization of oppressive politics, segregation, and community disempowerment, which continues within our disciplines today.

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

This course studies performance standards related to human activities in buildings, and the systems and configurations required to support those activities. Building systems are considered in relation to climate, urban situation, and the natural environment. Principles of systems thinking, as well as the use of physical and computational modeling methods are applied to the Comprehensive Design of a building to achieve defined performance standards and to consider issues of sustainability regarding energy balance, water conservation and component materials.

This term, the course will focus on HVAC systems and is integrated with ARCH 4005: Design and its project for a Museum of Halifax Art and Culture. HVAC is an acronym for Heating, Ventilation and Air Conditioning. The purpose of a building's HVAC system is to provide the building's occupants with year-round climatic (indoor environment) comfort. It does this through the control of heat and moisture. The HVAC system is part of the mechanical package in a building's design other parts of the mechanical package include plumbing, sprinklers and elevators. The HVAC systems discussed in this course are ones that depend on electricity and fossil fuels to operate. In other words, active systems which depend on mechanically induced airflow as opposed to passive systems which do not depend on mechanically induced airflow to function.

Topics covered in the lectures when describing HVAC include all air, all water and air + water HVAC systems, loads and schedules, controls, zoning, heating, and cooling plants, ventilation systems, distribution systems and terminal units. Consider the above topics collectively referred to in the course schedule as HVAC a required introduction to your understanding of HVAC systems.

As an architect, your role in the design process is not to design the HVAC system per se but ensure the design can fit into the building and it works well with the other building systems - structure, envelope and architecture (i.e., space) from both occupant requirements and an environmental impact perspective. To this end, the second part of the course will look at HVAC systems as an architectural solution. This part of the course is called Comprehensive Design in the course schedule. The content covered in the lectures identifies and suggests architectural strategies one can use to mitigate the HVAC system's environmental impacts and resolve spatial issues through building system integration design choices.

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 understanding of HVAC system terminology and operation;

2. an understanding of several environmental impacts associated with the life cycle of HVAC equipment; and

3. an ability to resolve spatial conflicts between HVAC system components and the building proper.

Course Brightspace site & Course Resources

On the course Brightspace site - https://dal.brightspace.com/d2l/home/248484 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.

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 on Tuesday & Thursday morning from 10:00am to 11:30am. The lectures will be delivered on the course MS TEAMS channel **ARCH 4212.03 Building Systems Integration Winter 2023**. All lectures will be recorded and posted on the course Brightspace site.

Note: lectures titles may change

lecture schedule

week & date		**Tuesday (T)**	**Thursday (TH)**	**assignment introduction & due dates**
1	(T) January 10 & January 12	HVAC: the carbon question - a question of consumption	HVAC: comfort requirements as a function of building type (museum - artifacts + people)	
2	Professional Practice Week - No Class			
3	(T) January 24 & (TH) January 26	HVAC: sizing - loads and schedules, controls, zones	HVAC: plants - creating comfort, water vs. air, heating & ventilation systems, DOAS	
4	(T) January 31 & (Th) February 2	HVAC: plants - cooling systems 1, refrigerant cycle and refrigerants, AC units vs. heat pumps, air, water and geothermal heat pumps	HVAC: plants - cooling systems 2, air & water systems, distribution systems, cooling towers & chillers distribution systems and terminal units, chill beams	
5	(T) February 7 & (Th) February 9	*assignment 1 introduction: understanding a mechanical room* Comprehensive Design: competing for space: -plants & mechanical rooms,	class exercise: understanding a mechanical room	*assignment 1 introduced*
6	(T) February 14 & (Th) February 16	*penultimate review assignment 1: understanding a mechanical room*	*assignment 1 hand-in & review* Comprehensive Design: reducing consumption and smart creation - Combined Heating & Power	*assignment 1 hand-in (Th) February 16,*
7	Winter Break - No Class			
8	(T) February 28& (Th) March 2	Comprehensive Design: competing for space: the third dimension - the plenum	Comprehensive Design: schematic design, examples, zones in practice - your museum	
9	(T) March 7 & (Th) March 9	*assignment 2 introduction: laying out the whole building's HVAC system* Comprehensive Design: identifying & linking the parts	class exercise: laying out your museum's HVAC system	*assignment 2 introduced*
10	(T) March 14 & (Th) March 16	digital crits: laying out the whole building's HVAC system	*penultimate review assignment 2: laying out the whole building's HVAC system*	
11	(T) March 21	*assignment 2 hand-in & review* SLEQ		*assignment 2 hand-in (T) March 21*

SLEQ: The Student Learning Experience Questionnaire (SLEQ) will be completed in week 11.

Course Assignments

There are two course assignments: **understanding a mechanical room** & **laying out the whole building's HVAC system**. Each assignment is to be done individually and each assignment is worth 50% of your course grade. 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.

Assignment 1: understanding a mechanical room (50% of course grade):to be done individually
Description: The central mechanical room is where "all the big pieces live" - the heating equipment, cooling equipment and central ventilation equipment which 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.

Several points to consider before we proceed with the assignment.
1) The mechanical room contains a lot more than the" mechanical component" 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 that HVAC equipment will 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 this assignment 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 museum'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 (30%)
For the purposes of this assignment, you are asked to layout a mechanical room which will meet the conditioning loads for the three rooms highlighted in B5 Design 4005 2023 Assignment 1 PROGRAM & SITE Exercise 1 - THE ROOMS 1:5 - 1:20. In THE ROOMS assignment, you are asked to design 3 rooms - the Gallery,

Exhibition Room & Event Hall. From the brief, the conditioning loads are as follows: heating (kW), cooling (tons), ventilation. 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 and an Air Handling Unit (AHU) complete with a coil/filter bank. 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 maintenance, repair & replacement.

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 a museum located in Halifax. Studying the equipment's data sheets will show each piece of equipment's physical dimensions. You will also determine fan and pump sizes and their corresponding power ratings to determine environmental impact.

Environmental impact chart (20%)
Building on what you learned in class about the environmental impacts from conditioning equipment, calculate the Global Warming Potential (GWP) and note how the manufacturer has dealt with the issue of ozone depletion for the selected equipment. When considering the environmental impacts, assume your museum has an operational life span of 80 years.

Complete the tiered exercise for three sets of climate conditioning equipment (heating + cooling + ventilation) either from different manufacturers or different models from one manufacturer. Select the one set that fits and has the minimal environmental impacts.

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.

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 Brightspace site.
2) a chart listing the projected amounts of GWP over the museum's operational life cycle. Please submit the table as a .pdf file to the course Brightspace site.

Assignment 2: laying out the whole building's HVAC system (50% of course grade): to be done individually
Description: The mechanical room is one part of a building's HVAC system. The other parts are other pieces of equipment used to heat, cool and ventilate the building not located in the mechanical room, the distribution systems - ductwork in the case of air and pipes in the case of water, terminal units - radiators, diffusers and grills and controls. These parts also require space both by floor and between floors.

To make the HVAC system work, these different parts need to be connected into one integrated whole. There are three types of integration, physical, visual and performance. Physical integration demands the components have to fit into the space. The distribution systems share space and volume and needs to weave through the structure and interior architecture either in plenums or within walls as well as connecting ductwork and piping between floors through vertical chases. Visual integration creates the image. This image of the HVAC system should be consistent with your design's overall visual idea down to the room and component. What you are trying to achieve with visual integration is visual harmony. Performance integration is how each system has been designed to accommodate other. The design between the envelope and HVAC is one example of a shared function. Another example is structure and HVAC where vertical chases also take lateral loads and are part of the building's circulation system.

The intent of this assignment is to provide you with
- an understanding of the various components of your building's HVAC system; and
- an ability to create a schematic layout of these components for each floor as well as between floors and in the case of the cooling equipment, either identifying the roof top units which include the evaporator & condenser or the linkage between chiller and cooling tower through details or plans & sections.

a set of plans & sections
The present ask is for you to illustrate through a set of plans and sections your museum's HVAC system and climate zoning. This will be accomplished via a set of three drawing packages described below.

drawing set 1 - whole building HVAC system schematic (25%)
The first drawing set is a series of 1:50 plans and sections in a sheet size of your choosing which shows a central mechanical room or local mechanical rooms depending on the type of system you are using, ductwork, piping, terminal units, louvers and roof top units/cooling towers. The drawings which show how the interior structure/space accommodates the HVAC system in plan and section. The plan drawings should also include room layouts as well as locating plenums where they exist. The section drawings should highlight specific points in the plan drawings showing plenums, exposed duct, terminal units, and local mechanical rooms if they are part of the HVAC system design.

drawing set 2 - cooling & heating equipment selected layout (15%)
The second set of drawings are 1:20 plans and section in a sheet size of your choosing of either:
1) if you are using an air-to-air system - roof top units connected to a representative cooling coil;
2) if you are using a water-to-water system - chiller/cooling tower system connected to a cooling coil in the AHU or terminal unit; and
3) if you are using an air-to-water system chiller/cooling tower system connected to a cooling coil in the AHU or terminal unit.

As well, respective of the selected cooling option, please include in drawing set 2 a 1:20 drawing in plan & section of the boiler connected to a representative radiator or heating coil in the AHU or terminal unit.

Please reference the locations of drawing set 2 in drawing set 1.

drawing set 3 - zones (10%)
A set of drawings at 1:50 scale of the building's floor plates that differentiate the HVAC zones by color. Within each zone show the control strategy (i.e., thermostat locations).

Deliverables
1) All plans and sections included in drawing sets 1-3 are to be submitted as pdfs to the course Brightspace site.

Course Grade Scale & Grading Rubric
The assignments are due before class 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
Deductions for late submissions encourage time management and maintain fairness among students.

	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 16	yes	3%	Tuesday 21	receives 0% and no comments
Assignment 2	(T) March 21	no		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).
- With a Student Declaration of Absence (maximum two per course), an assignment may be submitted up to three weekdays late without penalty. An SDA cannot be used for the final assignment.
- 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, 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 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 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 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 to distinguish + through - work and are intended to complement but not replace the University's terminology.
AP
December 8, 2022