CIVIL-450

# Thermodynamics of comfort in buildings

Khovalyg Dolaana

| Cursus | Sem. | Type |
|---|---|---|
| Civil Engineering | MA2, MA4 | Opt. |
| Minor in Integrated Design, Architecture and Sustainability | E | Obl. |

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| Language of teaching | English |
| Credits | 3 |
| Session | Summer |
| Semester | Spring |
| Exam | During the semester |
| Workload | 90h |
| Weeks | 14 |
| **Hours** | **3 weekly** |
| Courses | 2 weekly |
| Exercises | 1 weekly |
| **Number of positions** | |


## Summary

This course provides an integrated approach to analyze thermal performance of buildings by examining thermodynamics of heat flows in buildings and correlation between human thermoregulation, thermal sensation of occupants, dynamic indoor and outdoor environment, performance of the building envelope


## Content

- Ergonomics of the thermal environment, subjective and objective assessment of the indoor thermal environment
- Dynamic thermal performance of the building envelope and its effect on energy required for conditioning indoors
- Space heating and cooling generation and emission systems, personalized comfort systems (PCSs)
- Thermodynamic analysis of the intricate relationship between human body, indoor and outdoor environment, building envelope, and mechanical conditioning systems.
- Practical evaluation of the thermal sensation and comfort of occupants in an office building prototype, analysis of the dynamic behavior of the building and energy expense to maintain indoor comfort.

## Keywords

Indoor thermal environment, dynamic building performance, heating/cooling, energy use

## Learning Prerequisites

### Required courses

- Building energetics (ENG-445)

### Recommended courses

- Thermodynamics and energetics (ME-251)
- Comfort and architecture: sustainable strategies (AR-442)
- Building physics (PHYS-118)

### Important concepts to start the course

- Indoor environmental quality (IEQ), thermal comfort

- Thermal conditioning needs in buildings
- Thermal transmittance of the building envelope

## Learning Outcomes

By the end of the course, the student must be able to:

- Characterize performance of the building envelope, know the basic principles of integrated HVAC equipment and efficiency metrics, critically evaluate the dynamic performance of the heating/cooling systemelope
- Assess / Evaluate energy expenditure to provide indoor comfort
- Carry out measurements of indoor comfort and energy performance using diagnostic instumentation
- Take into consideration energy performance of indoor comfort and energy performance using diagnostic instrumentation
- Perform data analysis and presentation

## Transversal skills

- Write a scientific or technical report.
- Make an oral presentation.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Demonstrate the capacity for critical thinking

## Teaching methods

- Lectures and exercises on theoretical introduction to the search of the equilibrium between personal sensation, indoor thermal environment, performance of the building envelope and mechanical thermal conditioning systems
- Laboratory activities to enrich understanding of students on dynamic indoor environment and the associated energy expense to maintain comfortable conditions. Students will perform measurements in an office room and analyze heat flow and energy consumption of the integrated HVAC system. The test facility is a small building prototype located on the Smart Living Lab (www.smartlivinglab.ch) site in Fribourg

## Expected student activities

Participate in lectures, work on exercises, work in groups on measurements in the building prototype, analyze results, prepare a presentation, and write a technical report

## Assessment methods

Three mini-tests: 45% (3 x 15%)
Laboratory report and presentation: 55%

## Supervision

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| Office hours | Yes |
| Assistants | Yes |
| Forum | No |

## Resources

### Bibliography

- Y. A. Çengel; A. J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill Education, 5th edition.
- M. Moran, H. N. Shapiro, D. D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamcis,

John Wiley & Sons, 7th edition.

• 2017 ASHRAE Hanbook – Fundamentals

• C.-E. Hagentoft, Introduction to Building Physics, Studenlitteratur, 2001

• P. O. Fanger, Thermal Comfort, Danish Technical Press, 1970

• M. Humphreys, F. Nicol, S. Roaf, Adaptive Thermal Comfort – Foundations and Analysis, Taylor and Francis Group, 2016

### Ressources en bibliothèque

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• 2017 ASHRAE Hanbook - Fundamentals

### Prerequisite for

**"Le contenu de cette fiche de cours est susceptible d'être modifié en raison du covid-19"**