

CIVIL-450

Thermodynamics of comfort in buildings

Khovalyq Dolaana

Cursus	Sem.	Type
Civil Engineering	MA2, MA4	Opt.

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 indoor thermal comfort by examining thermodynamics of heat flows in buildings and correlation between indoor thermal environment, performance of the building envelope and thermal conditioning systems (HVAC).

Content

Energy, entropy and exergy concepts; their application to analyze technical services of buildings.
 Indoor thermal comfort and ventilation requirements, indoor environmental standards
 Thermal conditioning, heat/cold generation and distribution systems, loads calculation
 Exergy analysis of various systems used for thermal management and ventilation of buildings
 Practical evaluation of indoor comfort, energy, and exergy of air conditioning in building prototype

Keywords

Thermal comfort, thermal conditioning, HVAC, thermodynamics, energy efficiency, energy analysis.

Learning Prerequisites**Required courses**

N/A

Recommended courses

Thermodynamics and energetics (ME-251)
 Building energetics (ENG-445)
 Comfort and architecture: sustainable strategies (AR-442)

Important concepts to start the course

Energy, entropy and exergy
 Indoor environmental quality (IEQ), thermal comfort requirements
 Thermal conditioning needs in buildings

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 HVAC equipment and efficiency parameters, critically evaluate the dynamic performance of the ventilation and heating/cooling

- Use the concept of exergy as a measure to evaluate sustainability of heating/cooling services and ventilation in buildings
- Assess / Evaluate energy and exergy expenditure to provide indoor comfort
- Carry out measurements of indoor comfort and energy performance using diagnostic instrumentation
- Take into consideration energy performance and requirements of IEQ standards
- Perform data analysis and presentation
- Specify Indoor comfort requirements

Transversal skills

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

Teaching methods

- Lectures and exercises for theoretical introduction to the search of the equilibrium between thermal comfort, performance of the building envelope and mechanical systems; comparative analysis of energy and exergy performance of thermal conditioning systems in buildings
- Laboratory activity to enrich understanding of students on indoor comfort and the associated energy expense. Students will perform measurements of the indoor thermal comfort in an office room and analyze exergy flow and energy consumption of the integrated HVAC system. The test facility is a small building prototype located on the smart living lab site in **Fribourg**

Expected student activities

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

Assessment methods

Mid-term exam: 20%
Laboratory report: 50%
Final exam: 30%

Supervision

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 Thermodynamics**, John Wiley & Sons, 7th edition.
- **2017 ASHRAE Handbook – Fundamentals**
- C.-E. Hagentoft, **Introduction to Building Physics**, Studienlitteratur, 2001
- M. Pinteri#, **Building Physics: from Physical Principles to International Standards**, Springer, 2017
- M. Shukuya, **Exergy - Theory and Applications in the Built Environment**, Springer, New York, 2013

- 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

- 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 Thermodynamics*, John Wiley & Sons, 8th edition.
- 2017 ASHRAE Handbook - Fundamentals
- C.-E. Hagentoft, *Introduction to Building Physics*, Studenlitteratur, 2001
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- P. O. Fanger, *Thermal Comfort*, Danish Technical Press, 1970
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Websites

- [http://- www.lowex.net](http://www.lowex.net)
- [http://- www.annex69.org](http://www.annex69.org)

Prerequisite for

Master Project