Fakultät für Ingenieurwesen
Facoltà di Ingegneria
Faculty of Engineering

COURSE DESCRIPTION – ACADEMIC YEAR 2024/2025

Course title	**Engineering Thermodynamics and Heat Transfer for Mechatronics**
Course code	42186
Scientific sector	IIND-07/B (Building Physics and Building Energy Systems) (ING-IND/11)
Degree	Bachelor in Industrial and Mechanical Engineering (L-9)
Semester	2
Year	2
Credits	6
Modular	No

Total lecturing hours	36
Total lab hours	24
Attendance	Not compulsory
Prerequisites	-
Course page	Microsoft Teams (2024/25 - Engineering Thermodynamics and Heat Transfer for Mechatronics - Giovanni Pernigotto - 42186 | General | Microsoft Teams)

Specific educational objectives	The course belongs to the type *"caratterizzanti"*. This course aims to introduce students to the fundamentals of engineering thermodynamics, to give an overview of the main thermodynamic processes and direct / indirect cycles, and to describe the main aspects of the different heat transfer mechanisms (conduction, convection, radiation), as well as their application to exchange and dissipate heat in mechanical and electrical systems. Students will learn theoretical concepts, acquire the ability to apply these concepts to some reference system calculations, using both analytical and advanced numerical simulation approaches.

Lecturer	Prof. Giovanni Pernigotto (https://www.unibz.it/en/faculties/engineering/academic-staff/person/30622-giovanni-pernigotto)
Contact	Office: Faculty of Engineering, B1 Building at the NOI Techpark, Office B1.4.15 E-mail: giovanni.pernigotto@unibz.it Phone: +39 0471 017632
Scientific sector of lecturer	IIND-07/B (Building Physics and Building Energy Systems)
Teaching language	English
Office hours	Friday 14:00 - 18:00, to be previously agreed by email
Lecturing Assistant (if any)	-
Contact LA	-
Office hours LA	-
List of topics	PART 1 Introduction, fundamentals, thermodynamic processes and cycles: • Introduction to measurement theory: measurement and units, systems of measurement units, uncertainty • Fundamentals of thermodynamics:

	○ Thermodynamic systems/processes (non-flow/flow) and quantities (state and path functions) ○ Work, heat, 0^{th} law ○ First law and applications ○ Second law and applications • Operating fluids: ideal gas and phase-change fluids • Reference cycles (direct and reversed): vapour and gas cycles <u>PART 2</u> <u>Heat transfer:</u> • Heat transfer mechanisms: ○ Conduction ○ Convection ○ Radiation • Global heat transfer ○ Mechanisms ○ Extended surfaces ○ Heat exchangers • Numerical methods for modelling heat transfer mechanisms
Teaching format	The course includes (1) classroom lectures introducing theoretical concepts and (2) exercise classes providing numerical examples of technical applications. Lectures format includes blackboard and PowerPoint presentations, as well as videorecording and video-tutorials. As part of the exercise classes, visits and experimental activities in the Building Physics Labs at the NOI Techpark will be also organized. Course standard and additional teaching material will be available for the students through the MS Teams group.

Learning outcomes	<u>Knowledge and understanding</u> 1. Fundamentals of technical systems' energy balance, thermodynamic processes and cycles. 2. Heat transfer mechanisms. <u>Applying knowledge and understanding</u> 3. Solution of energy balance problems, with quantification and assessment of exchanged mass and energy fluxes within and among physical systems. 4. Design and analysis of solutions to exchange heat and to dissipate heat generated in mechanical and electrical systems. 5. Use of analytical and numerical methods to solve heat transfer problems. <u>Making judgements</u> 6. Making judgments through the acquisition of the basics of the thermodynamic analysis of complex systems.

7. Comparison and selection of different solutions to exchange, transfer and dissipate heat in mechanical and electrical systems.

<u>Communication skills</u>

8. Correct use of technical terms and definitions, including the correct use and conversion of the units of measurement.

<u>Ability to learn</u>

9. Lifelong learning skills through the comparison of different sources, and engineering methods and the acquisition of a critical sense.

Assessment

The assessment is subdivided into three parts (two written parts + a numerical simulation report):

1. **(written) numerical exercise:** the first part deals with the solution of a numerical exercise related to the calculation of energy balance and exchanges of the technical systems considered in the course. Through this numerical exercise, I will assess the ability of the student of *applying the knowledge and understanding* of the analysis and solution techniques, and of *making judgment* and to correctly use the units of measurement.
2. **(written) theoretical exam:** the second part consists of some open questions dealing with theoretical aspects of each main topic of the course (engineering thermodynamics, heat transfer). Through the theoretical written exam, I will assess the *knowledge and understanding* of the fundamental topics, as well as the *communication* skills.
3. **Numerical simulation report:** a report on a numerical simulation on a heat transfer problem (PC simulations), which can be developed during the course and must be delivered before the exam date. Through this numerical simulation report, I will assess the ability of the student of *applying the knowledge*, his/her/their *communication* skills, as well as his/her/their *ability to learn*.

Formative assessment

Form	%	Length /duration	ILOs assessed
Numerical simulation report	25 %	During the course	(4), (5), (8), (9)

Summative assessment

Form	%	Length /duration	ILOs assessed
Numerical exercise	30 %	1 exercise (1 hour)	(3), (4), (5), (6), (7)
Theoretical exam	45 %	2 open-ended questions (1.5 hours)	(1), (2), (8)

Assessment language	English
Assessment Typology	Monocratic
Evaluation criteria and criteria for awarding marks	The first part (**numerical exercise**) consists of an exercise with six numerical questions. The answer is correct when the number provided is within a given tolerance with respect to the reference value. Each student works on the same problem but with personal starting data. The evaluation is based on the accuracy of the numerical result of each question. The starting mark is assigned considering 3 points per each correct answer (starting from 12). The score of this part contributes for 30 % to the final mark. In the second part (**theoretical written exam**), each of the two proposed questions concerns a different part of the program (applied thermodynamics and heat transfer). The evaluation is based on the completeness of the answer in terms of 1) definition of the subject 2) analytical description 3) graphical and mathematical representations 4) proof (if required). The score of this second part contributes for 45 % of the final mark. The third part (**numerical simulation report**) consists of a short report on numerical heat transfer simulations performed to solve a problem with advanced numerical methods which will be taught during the course. Instructions for numerical simulations and assignment on the heat transfer problem to solve will be given during the course. The report has to be delivered before the exam date. Its assessment will focus on (1) completeness of the adopted numerical assumptions, (2) clarity of the presented results, (3) correctness of units of measurements. The score of this third part contributes for 25 % of the final mark. Each part must be successfully passed (mark at least equal to 18).

Required readings	Lessons and slides of the course.
Supplementary readings	• G.F.C. Rogers, Yon Mayhew. *Engineering Thermodynamics: Work and Heat Transfer* (4th Editionor later) Pearson Education (1996) • F. Incropera, D. DeWitt. *Fundamentals of Heat and Mass Transfer* (5th Edition/or later), Wiley (2002) • S. V. Patankar. *Numerical Heat Transfer and Fluid Flow*, CRC Press (2009) • H.D. Baehr, K. Stephan. *Heat and Mass Transfer*, Springer (2006) Subject Librarian: David Gebhardi, David.Gebhardi@unibz.it and Ilaria Miceli, Ilaria.Miceli@unibz.it
Software used	ANSYS Mechanical APDL