Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Applied Mechanics and Technologies for Energy Efficiency
Course code	45531
Scientific sector	ING-IND/16 and ING-IND/13
Degree	Master Energy Engineering
Semester	I
Year	2
Academic year	2024/25
Credits	12
Modular	Yes

Total lecturing hours	Module 1 - 36 hours + Module 2 - 32 hours
Total lab hours	0
Total exercise hours	Module 1 - 24 hours + Module 2 - 24 hours
Attendance	Strongly recommended
Prerequisites	Module 1: students should be familiar with the basic knowledge of manufacturing engineering. Module 2: Some knowledge of electrical machines is preferred, e.g. the content of the course "Electric Power Conversion Equipment"
Course page	https://www.unibz.it/en/faculties/engineering/master-energy-engineering/course-offering/?academicYear=2024

Specific educational objectives	The course aims at teaching both scientific foundations and practical methods and helps to develop specific professional skills. Module 1 (Technologies and Production Processes for Energy Engineering) provides students the basics for designing sustainable and energy efficient manufacturing processes, machines, factories and production networks. Further the course allows students to learn and practice methods and software systems for applying lifecycle assessment (LCA) and energy audits. Module 2 (Functional Mechanical Design for Energy Efficiency): The course aims at giving the guidelines for the functional design of automatic machines, in particular taking into account mechanical efficiency. Criteria and methods to analyze and choose mechanical devices, design motion laws and to evaluate the best system to minimize the energy dissipation in electromechanical systems will be addressed.

Module 1	**Technologies and Production Processes for Energy Engineering**
Lecturer	Prof. Erwin Rauch Professor for Sustainable Manufacturing Faculty of Engineering erwin.rauch@unibz.it Dr. Marwa Benali Post-Doc at Sustainable Manufacturing Lab NOI Techpark Bruneck marwa.benaliepbelarbi@unibz.it MSc. Davide Don Senior Scientist Fraunhofer Italia Research davide.don@unibz.it
Scientific sector of the lecturer	Ing-Ind/16 Manufacturing Technology and Systems
Teaching language	English
Office hours	By appointment
Teaching assistant *(if any)*	MSc. Michaela Golser Research Fellow at Sustainable Manufacturing Lab NOI Techpark Bruneck michaela.golser@unibz.it
Office hours	18
List of topics covered	The course covers the following topics going from an overview of general manufacturing technologies, to sustainable and energy efficient manufacturing towards the analysis and measurement of engineering solutions for improving sustainability and energy efficiency in manufacturing: Lecture: Theory Part: 1) Introduction in sustainable manufacturing 2) Overview of general manufacturing technologies 3) Green manufacturing technologies and systems 4) Resources: Materials, Circular Economy, Zero Waste Management in Production 5) Energy: Energy types and Energy Efficiency in Manufacturing Industry 6) Standards, Sustainability reporting, KPIs in manufacturing and data-based monitoring 7) Theory to Lifecycle Assessment (LCA) 8) Theory to Energy Audit according to ISO 50001 Practical Part (2 assignments): 1) Assignment 1: Lifecycle Assessment (LCA) using

	OpenLCA software. Data collection at a case study company and assignment work in small groups 2) Assignment 2: Energy Audit according ISO 50001. Data collection at a second case study company and assignment work in small groups
Teaching format	Frontal lectures Excursion to companies Guest lectures from practitioners Exercises/assignments with computational software tools The professor can be contacted by students for questions and clarifications by appointment.

Learning outcomes	**Knowledge and understanding:** Students will 1. acquire a knowledge about some important production processes used for the fabrication of the main mechanical assemblies and components in the energy industry; 2. be able to identify the advantages and limitations of these industrial production processes; 3. acquire a basic knowledge of a production process **Applying Knowledge and understanding:** 4. Students will be able to select some manufacturing processes to be used in manufacturing and energy industry. 5. Students will have the ability to apply their knowledge to identify which are the main systems and issues of a production process. 6. The exercises in the classroom, progress tests, conversations with the teacher, and the performance of specific tasks would allow to assess and evaluate the students ability to apply his knowledge and understanding of the topics covered during the course. **Making judgments:** Students will acquire an autonomy of judgment that will allow him 7. to select proper manufacturing processes for the fabrication of some mechanical assemblies and components in the energy engineering field; 8. to examine objectively the results obtained from analytical processing and LCA software systems; 9. to make use of technical and scientific literature. **Communication skills:** 10. Students will have the ability to structure and prepare scientific and technical documentations inherent to the adoption of manufacturing processes used in the energy engineering field; 11. students will have the ability to present,

	communicate, discuss and argue the topics covered in the course. **Learning skills:** 12. The students will develop learning skills through the individual study of the topics dealt in the lecturing and exercise hours. In addition, the analysis of different problems relative to the fabrication of mechanical components will also be addressed by group discussions and case studies. 13. The students will have the opportunity to extent the knowledge of the topics of the course by consulting scientific literature, specialized texts, technical standards and international standards that the professor will provide during the course.
Assessment	Knowledge and understanding: written exam Applying knowledge and understanding: assignments in exercise part Making judgements: assignments in exercise part Communication skills: presentation of results of exercises (case study) Learning skills: lab exercises, written exam **Written exam** means exam with review questions and exercises (Duration 3h) **50% weight** **Assignments** in lab exercises means: case study work, group work in small groups and subsequent presentation of the results. **25% weight for Assignment 1** **25% weight for Assignment 2**
Assessment language	English
Evaluation criteria and criteria for awarding marks	Module 1: The grade is calculated 50% from the results of the written exam and 50% from the results of the project work performed in assignments. Criteria for the evaluation of the written examination: completeness and correctness of the answers. Criteria for the evaluation of the project work / case study: accuracy and completeness as well as creativity in structuring of the proposed solution, the quality of the results and quality of presentation. **Final Mark of the Course "Applied Mechanics and Technologies for energy Efficiency"** Mathematical average of the marks obtained in the Module 1 and 2.

Required readings	There is no single textbook that covers the entire course. A collection of suggested readings from various sources will be announced during the course.
Supplementary readings	Additional textbooks, lecture notes, research papers and readings may be provided by the professor. • Schebek, L., Herrmann, C., & Cerdas, F. (Eds.). (2019). Progress in Life Cycle Assessment (Sustainable Production, Life Cycle Engineering and Management). Cham, Switzerland: Springer International Publishing. • Thiede, S., & Herrmann, C. (Eds.). (2019). Eco-factories of the Future. Springer International Publishing. • David A. Dornfeld, Editor. Green Manufacturing - Fundamentals and Applications. Springer (2013). ISBN 978-1-4419-6015-3.

Module 2	**Functional Mechanical Design for Energy Efficiency**
Module code	45531B
Scientific sector	ING-IND/13
Degree	Master Energy Engineering
Semester	I (winter semester)
Year	II (second year of master)
Academic year	2024/25
Credits	6

Total lecturing hours	32
Total lab hours	0
Total exercise hours	24
Attendance	Strongly recommended
Prerequisites	None, though some knowledge of electrical machines will be of assistance. E.g. the content of the course "Electric Power Conversion Equipment"
Course page	https://www.unibz.it/en/faculties/engineering/master-energy-engineering/course-offering/?academicYear=2024

Specific objectives	The course aims at giving the guidelines for the functional design of automatic machines, in particular taking into account mechanical efficiency. Criteria and methods to analyze and choose mechanical devices, design motion laws and to evaluate the best system to minimize the energy dissipation in electromechanical systems will be addressed.

Lecturer	Dr. Roberto Belotti
Scientific sector of the	ING-IND/13

lecturer	
Teaching language	English
Office hours	See timetable online: www.unibz.it/en/timetable/ and by appointment
Teaching assistant *(if any)*	N.A.
Office hours of teaching assistant	N.A.
List of topics covered	• Introduction to functional design, classification of the mechanisms and motion systems. • Basic concepts and definitions. Mechanical efficiency, performance, energy efficiency and energy savings in automatic machines. Direct/reverse energy flow and motor–load systems. • Mechanical components for transferring and transforming energy. Classification based on function, working principle as well as performance and efficiency. • Optimization aimed at improving the quality of motion and efficiency. • Energy storage systems and energy recovery. Classification (working principle and scope of use). • Classification of motion laws implemented in automatic machines. Analysis of the main requirements in the design of a motion law and its optimization.
Teaching format	Frontal lectures, hand-calculation exercises, computer-assisted exercises

Learning outcomes	**1. Knowledge and Understanding** • Identify the main components of transmission systems and sources of inefficiency • Understand the basic principles of energy storage, recovery and redistribution systems; **2. Applying knowledge and understanding** • Evaluate and select the proper transmission system considering mechanical and energy efficiency; **3. Making judgments** • Select and design an effective motion law under different working conditions and targets; • Choose suitable combination of mechanical and electric components for energy transformation and transfer **4. Communication skills** • Ability to structure and prepare scientific and technical documentation **5. Learning skills** • Ability to independently build upon the knowledge acquired during the study course by reading and

understanding scientific and technical documentation.

Assessment

Formative assessment

Form	**Details**	**Learning outcomes assessed**
In-class exercises	Continuously in exercise courses	1, 2, 3, 4, 5

Summative assessment

Form	**Duration**	**Learning outcomes assessed**
Written exam	3 h	1, 2, 3, 4, 5

Assessment language	English

Evaluation criteria and criteria for awarding marks

The written examination will include both theoretical questions and numerical exercises to show ability to solve problems handled in this course.

Form	Evaluation criteria and weight
Written examination	Theoretical knowledge (35%) Correctness of methods (30%) Correctness in solution (30%) Appropriate use of units (5%)

Required readings

Slides provided to the students after each lecture and notes taken by students during lecture

Supplementary readings

A collection of suggested readings from various sources will be announced during the course. Such sources will be papers, manuals, technical notes, and excerpts from textbooks, including

- Biagiotti, Luigi, and Claudio Melchiorri. *Trajectory planning for automatic machines and robots*. Springer Science & Business Media, 2008.
- Norton, Robert L. *Kinematics and dynamics of machinery*. Mcgraw hill higher education, 2009.
- Filizadeh, S. *Electric Machines and Drives: Principles, control, modelling and simulation*. CRC Press, 2013.