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	2023/24
Credits	12
Modular	Yes

Total lecturing hours	36 + 32
Total lab hours	0
Total exercise hours	24 + 24
Attendance	Strongly recommended
Prerequisites	Module 1: students should be familiar with the basic knowledge of energy performance assessment and energy management of buildings. 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/

Module 1	**Technologies and Production Processes for Energy Engineering**
Lecturer	***Dr. Gabriele Pasetti Monizza*** Faculty of Engineering Mail:
Scientific sector of the lecturer	Ing-Ind/16 Manufacturing Technology and Systems
Teaching language	English
Office hours	By appointment
Teaching assistant *(if any)*	-
Office hours	18
List of topics covered	The course covers the following topics going from a general overview of energy uses towards methods for mapping, measuring and for improving sustainability and energy efficiency in manufacturing processes. Lecture:

	Part A) MODELING AND MEASURING ENERGY USES IN FACTORIES 1. Energy in factories 2. Manufacturing processes 3. Energy and environmental assessment 4. Monitoring and data gathering 5. From Digital Shadow towards Digital Twin Part B) MODELING AND MEASURING MANUFACTURING PROCESSES FOR ENERGY EFFICIENCY 1. Types of industries 2. Lean, Agile, Resilient and Green (LARG) performance assessment framework 3. Mapping and representing processes through the Value Stream Mapping (VSM) method 4. Strategies and methods for optimizing resources demand Practical part: • Smart Mini Factory Lab Demonstrations (2h): Visit to the lab for understanding and experiencing manufacturing machineries, assembly processes and logistics. • Excursion with practice guest lecture (4h): Excursion to a manufacturing company including a visit and guest lecture regarding practical experiences with activities in energy auditing and monitoring. Exercise: The manufacturing company of the excursion will become a case study for processes and resource demand analysis. The students will work in group (max. 5 people) developing the case study: • Represent the overall manufacturing processes including an energy demand analysis • Map and represent the whole processes or a detailed task through the Value Stream Mapping method • Identify possible problems, goals and scopes of optimization measures • Define recommendations and measures for optimizing energy demand
Teaching format	Frontal lectures Excursions to companies Guest lecture from practitioners (during excursions) Exercises through classroom and laboratory activities

Learning outcomes	**Knowledge and understanding:** The student understands the basics of energy management in manufacturing process and knows advanced methods for monitoring, mapping and optimizing energy demand. **Applying Knowledge and understanding:** The student applies and practices theoretical contents through exercises, case studies and project work. Theory contents are practiced through exercises using practical examples. In Module 1 the student applies independently methods for mapping and optimizing energy demand. He defines recommendations and measures for optimizing resources demand. **Making judgments:** The student identifies the appropriate strategy and engineering solutions for optimizing energy demand in manufacturing. He is able to judge and interpret results of mapping and monitoring of a manufacturing process and to use them to derivate measures. **Communication skills:** Ability to structure, prepare and present scientific and technical documentation describing project activities and to discuss them with decision-makers. The student can make professional discussions and is able to structure, present and argue professional content through analog (flipchart) and digital (PowerPoint, software) media. The students are encouraged to present, discuss and support their results through power point presentations. **Learning skills:** The student learns both by frontal teaching (theory part) as well as by exercises in the classroom and in the laboratory (practical exercises). The student is able to enlarge the knowledge through self-study and consultation of scientific and technical texts. Ability to autonomously extend the knowledge acquired during the study course by reading and understanding scientific and technical documentation.
Assessment	*Formative assessment* In class discussion about the topics covered during the course (ILOS assessed 1,2,3,6,12). *Summative assessment* The assessment of the course is: • Oral exam (ILOS assessed 4,5,7,8,11) The oral exam consists in 2 or 3 open-end questions to assess the knowledge and understanding of the topics of the course and the ability of the student to present, communicate, discuss and argue the methods for monitoring, mapping and optimizing energy demand in factories.

Assessment language	English
Evaluation criteria and criteria for awarding marks	The grade is calculated 60% from the results of the oral exam and 40% from the results of the project work performed during class exercises. Criteria for the evaluation of the oral examination: completeness and correctness of the answers. Criteria for the evaluation of the project work during class exercises: 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.

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	2022/23
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" (LM-30)
Course page	https://www.unibz.it/en/faculties/engineering/master-energy-engineering/course-offering/

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 evaluate the best system

	to minimize the energy dissipation in electromechanical systems will be addressed.

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

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<tr><td></td><td>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.</td></tr>
<tr><td>Assessment</td><td>Formative assessment<table><tr><th>Form</th><th>Details</th><th>Learning outcomes assessed</th></tr><tr><td>In-class exercises</td><td>Continuously in exercise courses</td><td>1, 2, 3, 4, 5</td></tr></table>Summative assessment<table><tr><th>Form</th><th>Duration</th><th>Learning outcomes assessed</th></tr><tr><td>Written exam</td><td>3 h</td><td>1, 2, 3, 4, 5</td></tr></table></td></tr>
<tr><td>Assessment language</td><td>English</td></tr>
<tr><td>Evaluation criteria and criteria for awarding marks</td><td>The written examination will include both theoretical questions and numerical exercises to show ability to solve problems handled in this course.<table><tr><th>Form</th><th>Evaluation criteria and weight</th></tr><tr><td>Written examination</td><td>Theoretical knowledge (35%)
Correctness of methods (30%)
Correctness in solution (30%)
Appropriate use of units (5%)</td></tr></table></td></tr>
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<tr><td>Required readings</td><td>Slides provided to the students after each lecture and notes taken by students during lecture</td></tr>
<tr><td>Supplementary readings</td><td>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,</td></tr>
</table>

	2009. • Hughes, Austin, and Bill Drury. *Electric motors and drives: fundamentals, types and applications*. Newnes, 2019.