Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Electric and Hybrid Mobility
Course code	45541
Scientific sector	ING-IND/32 (Module 1) "Electric powertrains and batteries" ING-IND/08 (Module 2) "Internal combustion engines for hybrid powertrains"
Degree	Master in Energy Engineering
Semester	2
Year	*OPT*
Academic year	2022/2023
Credits	6
Modular	Yes (3+3)
Total lecturing hours	18 + 18
Total lab and exercise hours	12 + 12
Attendance	Not mandatory but recommended
Recommended preliminary knowledge	"Power Production, CHP and District Heating Systems", "Electric Power Conversion Equipment"
Connections with other courses	The course "Electric and Hybrid Mobility" is primarily linked to the courses "Power Production, CHP and District Heating Systems" and "Electric Power Conversion Equipment". Other courses of the same area are "Electrical Systems Engineering", "Electrochemical energy storage and conversion".
Course page	Course Offering / Free University of Bozen-Bolzano (unibz.it)

Specific educational objectives	The course of Electric and Hybrid Mobility is an elective course in the Energy Engineering degree. The course consists of two modules: the first one is specifically focused on electric motors for the automotive industry, battery storage systems and related power converters; the second one is mainly focused on the use of internal combustion engines in the powertrains and their coupling with electric drives in Hybrid Electric Vehicles. The course aims to introduce students to the novel technologies used for powertrains in the automotive sector for light/heavy duty vehicles that are moving towards electrification, in order to meet the stringent requirements in terms of emissions and performance. Specific educational objectives: - Understand the characteristics and the advantages of electric and hybrid powertrains vs. their conventional

	counterparts - Define modern and promising future solutions for the internal combustion engines used in hydrid vehicles or as range extenders - Understand the advantages and disadvantages of different solutions for hybrid and electric powertrains - Understand the constraints in the sizing of electric motor(s), battery and combustion engine for hybrid and electric vehicles - Describe the principles of battery storage operation and the key performance parameters - Define the management criteria and control methods for hybrid powertrains

Module 1	**Electric powertrains and batteries**
Lecturer	Dr. Ludovico Ortombina
Scientific sector of the lecturer	ING-IND/32
Teaching language	English
Office hours	By appointment or after the lectures
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	The Electric powertrains and batteries module is intended to give the students an overview of the current and promising solutions for electric and hybrid vehicles, comprising aspects related to electro-mechanical power conversion, power converters and batteries. The course will cover the following topics: • Typical motors and drives used in electric cars, their requirements and figures of merit • Basics of electric power converters used in electric cars • Typology of batteries, their operation and performance in electric cars.
Professional applications of the covered topics	The knowledge acquired during this course can be applied in several public and private companies in the automotive and mobility sector.
Teaching format	The course consists of lectures in which the topics are presented by the teacher. There are also classes (exercises) that will give practical examples of the application of the theoretical topics. Course topics will be presented at the blackboard and using electronic slides. Teaching material and additional materials will be provided by the teacher during the semester.

Module 2	**Internal combustion engines for hybrid powertrains**
Lecturer	Prof. Fabio Orecchini
Scientific sector of the lecturer	ING-IND/08
Teaching language	English

Office hours	By appointment or after the lectures
Teaching assistant (if any)	-
Office hours	-
List of topics covered	The Internal combustion engines for hybrid powertrains module is intended to give the students an insight of the novel design solutions in traditional powertrains for the transport sector with a specific focus on the coupling of internal combustion engines to hybrid drives. The course will cover the following topics: • Vehicles and Powertrains • Combustion Engine Powertrains • Mild hybrid, series and parallel hybrid vehicles, Plug-in vehicles • Mechanisms for torque/power sharing in HEVs • Driving Cycles and Fuel Consumption.
Professional applications of the covered topics	The knowledge acquired during this course can be applied in several public and private companies in the automotive and mobility sectors.
Teaching format	The course consists of lectures in which the topics are presented by the professor. There are also classes (exercises) that will give practical examples of the application of the theoretical topics. Course topics will be presented at the blackboard and using electronic slides. Teaching material and additional materials will be provided by the Professor during the semester.

<table>
<tr><td>Learning outcomes</td><td>The learning outcomes referred to the Dublin Descriptors:

Knowledge and understanding
The course allows the students to acquire advanced knowledge on the main solutions for the powertrains in the transport sector with specific focus on hybrid and electric cars (1). The topics presented will provide the basis for a thorough understanding of the architectures, of the design approaches and of the modeling (2) of modern powertrains and battery systems used in the automotive sector.

Applying knowledge and understanding
The student will be able to apply the acquired knowledge during exercises, where the studied models will be used to assess specific practical problems (3). Students will also apply the theoretical contents by using calculation codes and numerical models of the studied powertrains, storage systems and battery management systems (4).

Making judgments
The student should acquire the ability to evaluate and compare different powertrain solutions, considering the overall architecture, the main components ad their management (5). The student should also be able to discuss and correlate the numerical results with the physical problem (6).

Communication skills
The student should acquire the proper technical language (7) and should be able to present design choices, the and numerical results with a critical approach (8).

Learning skills
The student should acquire lifelong learning skills through the possession of the tools to update knowledge (9) on the powertrains in the automotive sector and the battery systems. Moreover, the student should be able to get the required data and information from databases, technical and scientific papers (10).</td></tr>
<tr><td>Assessment</td><td>The final exam consists in an oral exam on the theoretical topics of the course.

Formative assessment
<table>
<tr><th>Form</th><th>Length /duration</th><th>ILOs assessed</th></tr>
<tr><td>In class</td><td>24 X 120 minutes</td><td>3, 4, 5, 6</td></tr>
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	exercises | | |

Summative assessment

Form	%	Length /duration	ILOs assessed
Oral exam – theory	100%	2 or 3 open-end questions (about 1 hour)	1, 2, 3, 5, 7, 8,

Assessment language	English
Evaluation criteria and criteria for awarding marks	The student must demonstrate to have acquired the fundamental principles and the theoretical basis required in the modern electrified powertrain sector; moreover, the student must show the ability to apply the knowledge in practical test cases. In order to get a positive final mark, the student must demonstrate understanding of all the basic knowledge presented in the course. The maximum evaluation is achieved by demonstrating in-depth knowledge. For the evaluation of the oral exam the following criteria will be taken into account: - Ability to describe the powertrain architectures and design solutions of internal combustion engines, electric drives and storage systems - Ability to model the single systems presented in the lectures and in the exercises - Ability to approach a basic design of a modern powertrain - Ability to provide examples/applications of the theoretical concepts - Proper use of the technical language

Required readings	The slides presented during the lectures will be available in the reserve collection. Any additional required material will be supplied during the lectures and made available in the reserve collection.
Supplementary readings	-