# UNIVERSITÀ DEGLI STUDI DI PALERMO

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| **DEPARTMENT** | Ingegneria |
| **ACADEMIC YEAR** | 2021/2022 |
| **BACHELOR'S DEGREE (BSC)** | ELECTRICAL ENGINEERING FOR THE E-MOBILITY |
| **SUBJECT** | MOTOR VEHICLE SYSTEMS |
| **TYPE OF EDUCATIONAL ACTIVITY** | B |
| **AMBIT** | 50298-Ingegneria elettrica |
| **CODE** | 21267 |
| **SCIENTIFIC SECTOR(S)** | ING-IND/33 |
| **HEAD PROFESSOR(S)** | TELARETTI ENRICO Ricercatore a tempo determinato Univ. di PALERMO |
| **OTHER PROFESSOR(S)** | |
| **CREDITS** | 6 |
| **INDIVIDUAL STUDY (Hrs)** | 96 |
| **COURSE ACTIVITY (Hrs)** | 54 |
| **PROPAEDEUTICAL SUBJECTS** | |
| **MUTUALIZATION** | |
| **YEAR** | 3 |
| **TERM (SEMESTER)** | 1° semester |
| **ATTENDANCE** | Not mandatory |
| **EVALUATION** | Out of 30 |
| **TEACHER OFFICE HOURS** | **TELARETTI ENRICO**<br>Tuesday 11:00 12:00 Qualunque giorno e orario compatibile con gli impegni istituzionali, previo appuntamento telefonico o via mail. LUOGO: Edificio 9, II piano. Edificio 9, 2nd floor. Appointment is needed by telephone or e-mail |

**DOCENTE:** Prof. ENRICO TELARETTI

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| **PREREQUISITES** | Basic concepts on mathematics, physics, applied physics, electrical engineering, electrical machines and electric drives, power electronics, automotive control systems, electrochemical storage systems. |
| **LEARNING OUTCOMES** | KNOWLEDGE AND UNDERSTANDING<br>The student, at the end of the course, will have acquired knowledge and understanding regarding management, sizing and testing of electrical infrastructures for mobility (distribution networks, distributed generation, smart grids, charging infrastructures).<br>Knowledge and understanding skills are achieved through front lessons, exercises and private study. The verification of these objectives is expected within the final exam.<br><br>APPLYING KNOWLEDGE AND UNDERSTANDING<br>The student, at the end of the course, will be able to apply his knowledge and understanding to size and manage distribution networks and electrical infrastructures for mobility.<br>Knowledge and understanding skills are acquired through study of practical applications presented during lessons and through practical exercises.<br>The verification of these objectives is expected within the final exam.<br><br>MAKING JUDGMENTS<br>The student, at the end of the course, will have acquired the ability to gather all the data necessary for the study and analysis of distribution networks and electricity infrastructures for mobility, with particolar reference to their sizing and management.<br>On the basis of collected data and theoretical knowledge acquired, the student will be able to formulate independent judgments on effectiveness and strenght of different design concepts.<br><br>COMMUNICATION SKILLS<br>The student, at the end of the course, will have acquired language and communication skills to express issues concernig the subject of the course. He will be able to hold conversations on distribution systems and electricity infrastructures for mobility, including the various components, characteristics and functioning.The target will be achived through front lessons, exercises and discussions on case studies. The verification of these objectives will be expected within the written and oral examination.<br><br>LEARNING ABILITY<br>The student, at the end of the course, will have acquired knowledge and skills on issues related to the subject of the course, but he will also be able to operate, in any case, a continuous selfstudy, because of the constant changes in regulation and legislation and of the technical and technological progress.<br>He will also be able to continue his engineering studies with greater autonomy, awareness and discernment, recognizing that independent learning will characterize his entire professional life. The verification of these objectives will be implemented through discussion and classroom debate, involving students directly. |
| **ASSESSMENT METHODS** | EXAMINATION METHODS<br>The final assessment is performed based on two different exams: a first written test at the end of the first module, and an oral exam at the end of the course, lasting about 45 minutes. The oral exam will consist of open-ended questions, focused on the entire program.<br>The oral examination is aimed at verifying skills and disciplinary knowledge in all of the main topics described in the program and their applications. During the oral examination will also be evaluated language properties, clarity of presentation and the correct use of the technical language.<br><br>The final assessment is on a 30 basis, according to the following criteria:<br><br>- 28-30/30 cum laude<br>The student demonstrates a very good / excellent knowledge and understanding of the course contents, which declines in absence of errors and with selfcorrection of some inaccuracies; the answers to the questions posed are organized with a rigorous approach by providing complete solutions and demonstrating good / excellent application capabilities with a high degree of autonomy. The ability to communicate is characterized by very good / excellent clearness, fluency and use of language and articulated arguments which show a full ability to rielaborate and make judgments both in the same discipline and in interdisciplinary fields.<br><br>- 24-27<br>The student demonstrates a satisfactory / good knowledge and understanding of the course contents, which declines with few minor errors or omissions partially |

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| | corrected or integrated by means the professor guide; the answers to the questions posed are basically correct, showing a satisfactory / good ability of independent analysis. The ability to communicate is characterized by a satisfactory / good consistency in connecting the concepts both in the same discipline and in interdisciplinary fields; adequate clearness and substantially correct use of language.<br><br>- 18-23<br>The student demonstrates a sufficient/decent knowledge and understanding of discipline contents, which declines with no several and critical errors and/or omissions; the answers, even if adequate, are characterized by a limited level of autonomy and effectiveness. The ability to communicate is of acceptable level of clearness, fluency and use of language, but with some limitations of concepts reinterpretation and connection in disciplinary context.<br><br>- below 18<br>The student shows to have not reached the minimum level of learning outcomes. Insufficient knowledge, with many several and siginificant errors or inaccuracies; insufficient capacity in the analysis and resolution of the problems, lack of autonomy in the methodological approach, inability to orient in an autonomous way or to conduct disciplinary and interdisciplinary links; deficient presentation skills and argumentation, unclear and inadequate use of language. |
| **EDUCATIONAL OBJECTIVES** | The course aims to give students the basic knowledge on electrical infrastructures for mobility (distribution networks, distributed generation, smart grids, charging infrastructures), with particular reference to the design aspects and management issues.<br>A further objective is to give awareness about the need to operate a continuous study throughout the professional activity, because of the constant changes of the regulation and technical context, in order to identify the better solutions to secure the proper operation of electrical systems for mobility. |
| **TEACHING METHODS** | Front lessons, exercises, case studies development, analysis and classroom discussion. |
| **SUGGESTED BIBLIOGRAPHY** | Dispense  e altro materiale didattico forniti dal docente<br>Teaching material provided by the teacher on specific topics |

## SYLLABUS

| Hrs | Frontal teaching |
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| 6 | Preliminary concepts: Transition towards sustainable mobility, history of the electric vehicle, definition and difference among electric vehicles, electric vehicle configurations, vehicle dynamics principles, basic concept on electric traction motors. |
| 4 | Hybrid vehicles: Hybrid vehicle classification, coupling modes, hybrid series/parallel/series-parallel configurations, gear transmissions. Hydrogen and fuel cell vehicles. |
| 6 | Electric storage devices for mobility: Electrochemical storages, operating principles, characteristic parameters, Peukert's law, automotive battery requirements, lead-acid battery, nickel based battery, lithium-ion battery, charging infrastructures. Mathematical model, battery charging level estimation, charge equalization, active and passive equalization schemes. High power density energy storages: supercapacitors, flywheels. General characteristics and performances, models, employment issues. |
| 12 | Charging infrastructures for electric vehicles Legislative and regulatory frameworks in mobility sector. Technical specifications for the development of electrical infrastructures (charging stations, connectors, sockets for electric mobility). Electric vehicle charging systems: safety requirements, construction requirements, charging modes, connectors, fixed sockets, mobile and fixed connectors, plugs, communication and control devices between vehicles and charging stations, protection against overcurrents, earthing systems, protection against contacts, impact on the distribution network, design criteria. |
| 6 | Vehicle to Grid (V2G), Vehicle to Home (V2H), Vehicle to everything (V2X). Microgrid: integration between V2G/ V2H e renewable generation. Impact of electric vehicles on power distribution networks. |
| 6 | Grid services by electric vehicles: frequency and voltage regulation, power quality, spinning reserve, renewable integration, peak-shaving, distribution upgrade deferral, network congestion, arbitrage, communication protocols, V2G control schemes, economic aspects. |
| 2 | End-of-life options for electric vehicle batteries: reuse, second life, practical examples, economic aspects |

| Hrs | Practice |
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| 12 | Exercises and case study analysis on sizing, planning and management of charging infrastructures for mobility |