UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	ELECTRICAL ENGINEERING
SUBJECT	ELECTRICAL SAFETY TECHNIQUE
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50363-Ingegneria elettrica
CODE	07186
SCIENTIFIC SECTOR(S)	ING-IND/33
HEAD PROFESSOR(S)	FAVUZZA SALVATORE Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**FAVUZZA SALVATORE** Monday 12:00 13:30 Studio proprio sito al terzo piano del DEIM (ex DIEET) - edificio 9 Wednesday 14:00 15:00 Polo decentrato di Caltanissetta

DOCENTE: Prof. SALVATORE FAVUZZA

PREREQUISITES	The following knowledge are requested in order to understand the topics of the course: - methodologies for the analysis of electric circuits and networks; - structure, features and components of electrical transmission, distribution and utilization systems; - main components and devices for operation and protection of electrical distribution networks.
LEARNING OUTCOMES	KNOWLEDGE AND UNDERSTANDING On completion of the course, students will have acquired specific knowledge and understanding on the risk of electrocution related to use of the electrical energy due to direct and indirect contacts and, more generally, on the electricity dangers and its associated phenomena, as well as on the protection measures to be employed in each case to prevent human hazards or property damage in accordance with safety rules. In particular, students will be able to understand and correctly apply requirements of standards and laws dealing with electrical safety on design, realization and verification of electrical systems and installations, both in civil and industrial field, and to prepare and draft the necessary technical documentation certifying their compliance with standards and laws. To achieve these objectives, the course will include lectures, discussion of case studies and guided exercises. The verification of these objectives is expected within the final oral exam. APPLYING KNOWLEDGE AND UNDERSTANDING The student will have gained adequate knowledge and skills to analyze and solve problems related to electrical safety independently and methodically in the design and management of electrical systems and installations in compliance with safety standards and laws. In addition, he will be able to arrange the necessary tests and measurements on electrical systems in order to check their compliance with safety regulations, as well as to provide the necessary adjustment measures, where required, to ensure an efficient and safety system; furthermore he will able to approach the design a HV earthing system. To achieve these objectives, the course will include lectures, discussion of case studies, classroom and autonomous or in team exercises, use of softwares and of commercial catalogs, development of a project. The verification of these objectives is expected within the final oral examination, including the discussion of the project that each student presents. MAKING JUDGMENTS The student at the end of the course will have acquired the ability to gather and interpret all the data necessary for the identification and analysis of the main issues related to the electrical safety. On the basis of the collected data and theoretical knowledge and acquired practices, he will be able to make independent judgments about the effectiveness of different design solutions applicable to the examined case. To achieve these objectives, the course will include lectures, discussion of case studies, classroom and autonomous exercises, use of specialized softwares and of commercial catalogs, development of a project. The verification of these objectives is expected within the final oral examination, including the discussion of the project that each student presents. COMMUNICATION SKILLS The student will be able to expose with competence and property of language the different electrical safety problems existing in electrical systems and installations even complex, as well as to draw up a reasoned and detailed report justifying the choices and solutions adopted at the designing stage, or to be taken in the phase of verification, in order to achieve the level of safety required by technical regulations and laws. To achieve these objectives, the course will include lectures, discussion of case studies, development of a project in team. The verification of these objectives is expected within the final oral examination, including the discussion of the project that each student presents. LEARNING ABILITY The student at the end of the course will have acquired knowledge and skills not only on issues related to electrical safety, but also about on the need to work always and in any case a continuous self- study, because of the constant changes in regulations and legislation and the technical and technological progress. He will be able, therefore, to continue his engineering studies with greater autonomy, awareness and discernment, recognizing that independent learning will characterize throughout his professional life. To achieve these objectives, the course will include lectures, discussion of case studies, tutorials, development of a project. The verification of these objectives is expected within the final oral examination, including the discussion of the project that each student presents.

ASSESSMENT METHODS	The exam is oral. It consists on a discussion during which the student must answer to at least five open questions on the entire program of the course; moreover each student presents a project - developed during the course autonomously or in team - of an HV earthing system, consisting of technical documentation (report, plans). The project is also subject of discussion in the examination. Oral exam looks at: - the degree of knowledge and understanding of course program; - the ability to apply the knowledge gained with competence, consistency, efficiency and independence of judgment, to solve problems or applications related to course and/or related contexts; - the ability to reprocess the knowledge and skills acquired by identifying disciplinary and interdisciplinary links; - the clearness capacity and correct use of language. The evaluation is done at the end of the exam depending of the overall results achieved according to what follows: - 28-30/30 cum laude The student demonstrates a very good / excellent knowledge and understanding of the course contents, which declines in absence of errors and with self-correction 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. - 24-27 The student demonstrates a satisfactory / good knowledge and understanding of the course contents, which declines with few minor errors or omissions partially 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. - 18-23 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 characterize 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. - below 18 The student shows to have not reached the minimum level of learning outcomes. Insufficient knowledge, with many several and significant 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	Teaching goal is to allow that the student acquires the knowledge and skills needed to study and solve danger problems related with the use of electricity and with its associated phenomena and to provide useful elements for achieving acceptable level of safety in the design, execution and operation of electrical systems, also in accordance with regulatory constraints. A further objective is to gain awareness about the need to make a continuous selfstudy during the whole of the future professional activity, because of the constant changes in regulations and legislation and the technical and technological progress, in order to identify the most appropriate solutions to ensure the proper functioning of the electrical installations in safe conditions.
TEACHING METHODS	Lectures, exercises, projects/case studies analysis and classroom discussion, use of softwares and catalogs. Teaching activities are organized to help the achievement learning outcomes and educational objectives. The course is characterized by theoretical contents and practical aspects; it is done in order to stimulate the participation of students by providing interactive lectures, in which priority is given not only to the connections among topics of the same course, but even those interdisciplinary; during exercises and discussion of case studies, the student is encouraged to critically analyze the issues proposed by developing their skills of analysis, of independent evaluation, communication, argumentation and of use of language, being called to deal with the professor and other students. Special attention is devoted to the application in order to provide tools and their correct methods of use, since these are the elements that will characterize the professional activities of an engineer.
SUGGESTED BIBLIOGRAPHY	

	-V.ito Carrescia: Fondamenti di Sicurezza Elettrica - Edizioni TNE, Torino - ISBN 9788894847260 -Dispensa curata dal docente

SYLLABUS

Hrs	Frontal teaching
5	LEGISLATION AND STANDARDS REFERENCES L. 186/68, D.M. 37/08, D.P.R. 462/01. CEI, IEC and CENELEC Standards. CEE Directives and CE marking. Compliance with Standards of electrical materials; IMQ and CEI marks.
2	GENERAL SAFETY PRINCIPLES Definitions of safety, failure rate and risk.Series and shunt protection systems. Reliability and safety. Force majeure or fortuitous events circumstances. Acceptable level of safety.
4	ELECTRICAL CURRENT AND HUMAN BODY Basic concepts of electrophysiology; cellular resting and action potential, excitability curve. Pathophysiological effects of electric current on the human body; muscle tetanization, breathing stop, ventricular fibrillation and path factor, burns. Time-current diagrams. Electrical resistance of the human body. Dangerousness of the electric current path.
4	DISPERSION OF THE ELECTRIC CURRENT IN THE GROUND Soil behavior as an electrical conductor, ground resistance of a ground electrode, equivalent hemispherical, electrical potentials in the soil, shunt ground electrodes.
2	GENERAL REMARKS ON THE PROTECTION AGAIN DIRECT AND INDIRECT CONTACTS Functional, basic and supplementary insulation, direct and indirect contact, exposed-conductive-part of an equipment. Classification of electrical equipments in relation to protection measures against indirect contacts. Safety curve for the allowable voltages. Definition of extraneous-conductive-part. Classification of electrical distribution systems. Classification of equipment in relation to their mobility.
5	PROTECTION AGAINST INDIRECT CONTACTS IN THE TT SYSTEMS Equivalent fault circuit and voltage assumed by exposed-conductive-parts. Protection by means of automatic circuit-breakers with thermomagnetic release; coordination between earth resistance and protection device and protection limits. Protection by means of residual current devices (RCDs), selectivity horizontal and vertical , selective and delayed RCDs, toroidal devices. Main equipotential connection. Considerations on the neutral conductor.
5	PROTECTION AGAINST INDIRECT CONTACTS IN THE TN SYSTEMS Equivalent fault circuit, fault loop and voltage assumed by exposed-conductive-parts. Safety requirements. Distribution and terminal circuits. Transferred voltages and supplementary equipotential connections. Voltages on the neutral under abnormal operating conditions of the circuit. TN system in public low-voltage distribution networks. Comparison between TN and TT systems.
3	PROTECTION AGAINST INDIRECT CONTACTS IN THE IT SYSTEMS Features of an IT system, double fault to earth, insulation monitoring devices. Safety requirements in case of distributed and undistributed neutral. Overvoltages due to a resistive or inductive fault to earth.
3	PPROTECTION AGAINST INDIRECT CONTACTS WITHOUT AUTOMATIC DISCONNECTION OF THE CIRCUIT Protection by double or reinforced insulation; tracking phenomenon and safety requirements. Protection by circuits electrical separation; insulation transformer. Protection by non-conducting locations. Protection by earth-free local equipotential bonding.
2	REALIZATION OF THE EARTHING SYSTEM Intentional ground electrodes and ground electrodes of fact; corrosion of ground electrodes. minimum size of dispersing elements. Earthing collectors, earthing conductors, protection and equipotential conductors.
11	PROTECTION AGAINST INDIRECT CONTACTS IN HIGH VOLTAGE SYSTEM Potential distribution on the soil surface; hemispherical electrode, deep spherical electrode and method of images, straight cylindrical electrode, meshed ground grids. Step and touch voltages. Safety curve for the permissible touch voltages and safety requirements. Global earthing system. General study methodology for complex ground-electrodes; equivalent sources method and Maxwell subareas method. Characteristics performances of ground grids in homogeneous soil; evaluation of the characteristic quantities by means of abacus or approximate analytic expressions in order to the design. Drainage of the ground fault current through the overhead ground wires and cable metal sheaths. Conductive interference between buried electrodes and transferred potentials; general study methodology, application examples and safety measures. Human simulation for the evaluation of actual touch and step voltages; calculation matrix method and method of global equations.
2	SAFETY PROBLEMS IN THE INTERFACE OF HIGH/LOW VOLTAGE SYSTEMS Grounding of exposed-conductive-parts of high voltage and low voltage equipments and of neutral point of low voltage system.
4	PROTECTION AGAINST DIRECT CONTACTS Total protection measurements; basic insulation, enclosures and barriers; degrees of protection of enclosures and barriers. Partial protection measures. Protection by limitation of the electric charge and the current. Protection by means of residual current devices; protective limits intrinsic to the tripping characteristic and to special circuit conditions. Behavior of the residual current devices in case of continuous components of the earth current.
2	EXTRA LOW VOLTAGE SYSTEMS Protection against direct and indirect contacts by means of safety extra-low voltage systems (SELV) and protective extra-low voltage systems (PELV); safety transformer, Class III equipments and safety requirements. Functional extra-low voltage systems (FELV).

SYLLABUS

Hrs	Frontal teaching
2	PPLICATION OF PROTECTION MEASURES AGAINST DIRECT AND INDIRECT Considerations on the risk associated with direct and indirect contacts and the related limits of allowable voltages. Electrical Hazard Analysis upon certain environmental conditions. Places with high electrical risk; confined conductive spaces, bathrooms and shower rooms, swimming pools, building sites.
4	ELECTRICAL SAFETY IN HOSPITALS AND MEDICAL ENVIRONMENTS Patient with a direct electrical connection to the heart in surgery environments, microshock hazard and medical IT protection system. Classification of medical environments and safety requirements against indirect contacts. Medical electrical equipments. Symmetry to ground of medical equipments.
3	PLACES WITH DANGER OF EXPLOSION E/O AT HIGHER RISK IN CASE OF FIRE Definitions: explosive atmosphere, minimum ignition energy and ignition temperature, flammability limits and temperature of flammability. Classification of areas at risk of explosion. Hazardous areas for the presence of flammable gases or vapors. Hazardous areas for the presence of combustible dusts. Hazardous areas for the presence of explosive substances. Direttive Atex; classification of equipments intended for use in areas at risk of explosion. Electrical apparatus for explosive atmospheres; ways of protection and components Ex. Electrical plants in places at higher risk in case of fire; classification of cables in relation to fire.
7	PROTECTION AGAINST LIGHTING Thunderstorm physics and lightning. Lightning current wave shape and classification. Keraunic level. Damage caused by direct and indirect lightning strikes. Catchment area and catchment radius of a lightning protection system; protected volume. Positioning and installation of the external lightning protection system (LPS) of a structure; levels of the protection and effectiveness of the LPS in relation to the values assumed by lightning current parameters. Application of the standard CEI in order to protect a structure against the lightings; risk assessment and components of the risk of lightning, tolerable frequency of lightning to the structure, choice of the level of protection and features of external and internal LPS.

Hrs	Practice
9	Choice of the configuration and design of the ground grid of a primary station. IEEE Standard 80-2013.
1	Application of the standard CEI 81-10 in order to protect a structure against the lightings.

Hrs	Others
1	Presentation of course, objectives, exams outline, texts.