BSc in Electrotechnical Engineering

1st year: Industrial Automation Branch / Energy Branch

MATHEMATICAL ANALYSIS I
Preliminaries. Real functions of a real variable: definitions; function classes; properties. Limits and continuity: definitions; theorems. Differential calculus: definition of derivative and geometric interpretation; differentiability and continuity; derivation rules; Bolzano's, Weierstrass's, Rolle's, Lagrange's and Cauchy´s theorems; Cauchy's and L'Hôpital's rules; derivative applications; increments and differentials. Integral calculus: antiderivatives; techniques of integration; definite integral; applications: areas and volumes; improper integrals.
Digital Systems
Analysis of essential concepts of digital logic: numerical coding systems; digital arithmetic. Understanding basic logic gates and using them in the project of combinatory circuits. Analysis and understanding of function tables, operation characteristics, and pin-out of integrated circuits based in combinatory logic, such as: adders, comparators, multiplexers, demultiplexers, decoders, priority coders, etc. Study of logic families associated to the several integrated circuits. Study of basic synchronous and asynchronous memory cells, which are used in the synthesis and analysis of sequential circuits. Designing and analyzing counters and shift registers.
ALGEBRA
Complex numbers. Matrices and systems of linear equations. Vector spaces: subspaces, linear spanning; linear independence; basis and dimension; applications. Determinants and their application to the solution of linear systems and computation of the inverse of a square matrix. Analytic geometry: dot, vectorial and mixed product of vectors; applications; representation of straight lines and planes in the Euclidean space; application to distancies. Eigenvalues and eigenvectors of square matrices: application to matrix diagonalization.
Programming and Algorithms
Introduction to computers and languages; Data manipulation: data types, constants, variables, operators and expressions; Control of execution flow: if, switch, do, while and for; Top-down problem decomposition: division of programs, functions and parameters, recursion; Pointers: address, value and dynamic memory; Compositive data types: arrays, strings and structs; basic I/O: files, streams and devices.
Physics
Matemathical Tools in Physics: vector, graphical addition of vectors, unit vectors and vector component, vector addition by analytical

method, differentiation and integration; Motion in One Dimension: position vector and displacement, velocity and speed, motion with constant velocity, acceleration, motion with constant acceleration, free-fall, varying acceleration; Motion in two Dimensions: position, velocity and acceleration, constant acceleration-projectile motion, uniform circular motion, air resistance; Newtons Laws of Motion: force and mass, Newton's first law, Newton's second law, Newton's third law, weight and graviticional force by the earth; Applications of Newton's Laws of Motion: Contact forces – the normal force and frictional force, dynamics of uniform circular motion; Work and Energy: work done by constant force, work done by variable force, the work-energy theorem and kinetic energy, power; Conservation of Energy: one –dimensional conservative systems, graphical analysis of conservative systems, conservative forces and potencial energy, conservation of mechanical energy, nonconservative forces and internal energy, the law of conservation of energy; Momentum and the Motion of Systems: center of mass, motion of center of mass, momentum, impulse, conservation of momentum, collisions in one dimension, collisions in two dimensions.
MATHEMATICAL ANALYSIS II
Numerical and function series: definitions; tests for convergence; power series; Taylor and Maclaurin series; applications of power series. Real functions of several real variables: definitions; limits and continuity; partial derivatives; differentiability; increments and differentials; directional derivatives; extreme values and saddle points; optimization problems with constraints. Multiple integrals: definition and properties of double and triple integrals; geometric interpretation of double integral; double integrals in polar coordinates ; triple integrals in cylindrical and spherical coordinates; applications of double and triple integrals.
Electromagnetism
Study of alternate current and three-phase systems. Electric field: *Coulomb*'s law, *Gauss*'s law, dielectrics and capacity. Magnetic field: *Lorentz*'s force, *Bio-Savart*'s law, *Ampère*'s law. Electromagnetic induction: *Faraday*'s law, *Lenz*'s law, mutual inductance, self-inductance and magnetic energy. Specific applications of these theoretical concepts in the electrical engineering industry.
Object Oriented programming
Object Oriented Programming: abstraction, encapsulation, inheritance, static and dynamic members; Class Hierarchy: Abstract classes, Polymorphism, dynamic objects, casting; Basic data structures; Generic programming.
Circuit Analysis
Circuit variables and electrical circuit elements. Simple circuits solutions, based on straight examination; Experimental laws and techniques for circuits analysis: Mesh-Current Method; Node-Voltage Method, Thévenin and Norton Equivalents; Maximum Power

Transfer; Superposition. Reactive circuit components. Source-free RL, RC and RLC circuits; Sinusoidal steady-state analysis; Frequency response.
Computer Architecture and Operating Systems
Fundamentals of computer architecture and factors influencing the design of hardware and software elements of computer systems. Organization, architecture and instruction set of the most representative modern processors (CISC vs. RISC). Arithmetic and logic processing, memory, “datapath”, pipelining and I/O system. Fundamental concepts of operating systems design; process management and communication; processor scheduling; memory management; and file systems.

2nd year: Industrial Automation Branch / Energy Branch

Data Bases
Objectives and functions of Database Management Systems (DBMS). Hierarchical model. Network model. Relational model. Relationships. Instances and schemes. Data dictionary . Keys. Primary key, foreign key and indices. Integrity and rules. Functional dependencies and normalization. First normal form (1FN), second normal form (2FN), third normal form (3FN) and Boyce-Codd normal form. Entity-relationship method. Extended entity-relationship method.SQL. SQL’s DDL commands. SQL’s DML commands.
APPLIED MATHEMATICS TO ELECTRICAL ENGINEERING
Part I: Complex variable functions. Analytical and elementary complex functions. Complex integration: contour integral, integration of analytical functions. Series representation of complex variable functions: Taylor and Laurent Series. Zeros and Singularities. Residual Theorem. Fourier and Laplace Transforms. Part II: Review on Probability, Random Variables and Normal distribution. Sampling Distributions. Estimation using a single sample of the mean, variance and proportion. Hypothesis testing using a single sample about the mean, variance and proportion, Hypothesis Tests using the p-value. Simple Linear Regression and Correlation.
Electronics I
Circuits and electric units. Semiconductor basics. Diodes and diode circuits. Bipolar transistors. MOS and JFET transistors. Basic circuits with transistors and diodes. Single stage amplifiers. Current sources and voltage sources, band-gap. Circuits with operational amplifiers. Digital circuits. Linear power supplies.
ELECTRICAL INSTALLATIONS
- IEC Standards for electrical installations - Overvue on low voltage equipment, namely circuit breakers and fuses. Installation and dimensioning of cables based on current carrying capacity, voltage drop and Joule effect losses.Protection of cables and electrical equipment against overload and short circuit. - Protection of human beings: effects of current on human beings. Protection against both direct and indirect contact. Systems TT, TN,

IT - maximum protect lenght for the protection of human beings. - Lightning and Telecommucations distribuition on buildings: General aspects of technical and oficial rules. Transformer MV/LV: Dimensioning and designing of equipment and swichboards.
Project Planning and Managent
Linear programming: Optimization with and without constraints; Graphical solution of linear programming problems; Simplex algorithm; Sensitivity analysis and duality. Forecasting models: Moving-average; Exponential smoothing with trend and with seasonality. Linear regression and fitting nonlinear relationships; Project management: Gantt chart; Critical path method with a single time estimate and with three activity time estimates; Economical evaluation of investment projects: The balance sheet and Income statements; Cash-flow; Discount rate; Total time of a project; Net present value (NPV); internal rate of return (IRR); Pay-back time; Sensitivity and risk analyses; Simulation.
Electronics II
Circuits with the differential pair. Analogue multipliers. Output stages in A, B, C and D class. Audio power amplifiers. Frequency response of electronic circuits. Study of the operational amplifier 741. Feedback and stability. Sinusoidal oscillators. Analog and switched capacitor filters. Digital circuits.
Systems Theory
Signals and systems classification. Analysis of continuous LIT systems in time domain. Analysis of LIT systems in frequency domain: Laplace transform; transfer function; stability; transient response and steady state response, frequency response of 1st and 2nd order systems. Block diagram representation. Mathematical modelling of systems. Servomechanisms. Basic Systems Identification. Transient and steady state analysis of higher-order systems. State-space systems representation.
Instrumentation Electronics
Basic measurement theory. Errors, Accuracy and precision. Deflection meter movements. Types of analogue meters. Voltage, current, power and energy measurement methods. Bridge circuits. Electronics multimeters. Oscilloscope. Probes and connectors. Signal generators. Data converters. Handling signals, sensors and instrumentation. Spectrum analysers. Signal conversion and interfaces.

2nd year: Industrial Automation Branch

Fundamentals of Telecommunications
Introduction to Telecommunications systems. Transform and Fourier Series of continuous signals. Signal transmission and analysis. Sampling and PCM. Physical Mediums of transmission. Modulation techniques with continuous carrier. Digital transmission

principles. Emergent technologies of digital communication systems.
Power systems fundaments
Basic electric machines principles, related physic laws. Transformers: ideal and real, efficiency, equivalent scheme, autotransformer. Induction machines, short circuit and wounded, equivalent scheme, starting methods. Directional current machines: types and characteristics. Introduction to synchronous machines. Determination of equivalent parameters of different machines, constructive variants, monophasic and polyphasic systems. Introduction to electric power systems.

2nd year: Energy Branch

Materials and Energy Conversion
Proprieties of materials that are good electricity conductors, insulators, semiconductors, superconductors or magnetic. Protection techniques for materials. The energy conversion approach to produce force or torque. Steady-state of transformers and DC machines: circuit models and laboratory tests, losses and efficiency. Different types of excitation, characteristic curves, starting and speed-control methods of DC motors. Vector diagrams, voltage-load variation and parallel with 2 three-phase transformers.
ELECRICAL INSTALLATIONS THEORY AND LEGAL REGULATIONS
- Legal regulations - Power suply networks: development and execution - Project licensing organization - Works follow-up tests and simulations

3rd year: Industrial Automation Branch / Energy Branch

Control Theory
Control systems introduction. Time domain analysis, in open and closed loop: transient response, steady state error analysis, stability. Controller design, analysis and specification of control systems based on root locus, frequency design, Bode Diagram. Stability criterion. PID control: methods of Ziegler-Nichols, pole-placement, etc. Basic techniques of project and compensation. Systems analysis in presence of disturbances, delays and several feedback loops. Digital PID design by emulation method.
Idustrial Automation
Automation in industry. Components of an automatic system. Pneumatic, hydraulic and thermo actuators. Visualization interfaces. Sensors. Sensors classification. Static and dynamic parameters. Programmable Logic Controllers (PLC). PLC architecture. PLC's languages. Ladder diagram (LADDER), Instruction list (STL) and Structured Control Language (SCL). Grafcet. Discrete event

systems. Petri nets. Industrial networks. Fieldbus. Profibus and CANBus.
Maintenance
Reliability; Diagnostic and testing methods for Electrical Systems, Mechanical Systems and Electromechanical Systems; Maintenance of Electrical, Mechanical and Electromechanical Systems; Industrial Instrumentation Maintenance; Maintenance objectives and strategies; Maintenance service structure; Maintenance contracts; Maintenance information circuits and documents; maintenance management and organization

3rd year: Industrial Automation

Data Networks
Introduction to data networks. Standard organizations. Network architectures. OSI model; Data transmission: transparency; Data link layer: error detection and flow control methods. Medium access control of local area networks (Ethernet and Wi-Fi); Switching: 802.1d, 802.1Q, STP, 802.1w, 802.1s. TCP/IP basics. ICMP and ARP Protocols. MainRouting Protocols. VRRP. Multicast. Ethernet LAN design.
Electromechanical Drives
Constitution of an electromechanic system; Modelation of the stationary and dynamic behavior of industrial mechanic components; Electric vehicles characteristics; Actuator systems with three-phase asynchronous machines; Actuator systems with synchronous machines; Applications of control systems on electromechanic actuators; Energy sources for electric traction systems: batteries and fuel cells.
Industrial Networks
Fieldbuses. OSI model. Fieldbuses architectures. Data link layer. MMS (Manufacturing Message Specification). Protocol solutions commercially available. Master/Slave with token. CSMA/CD(CR, DCR). Producer, distributor and consumer. Industrial networks. Topologies, services and profiles. Examples: Field – Profibus DP; Control – Profibus FMS; Command – ProfiNET. Monitoring and supervisory. HMI systems. SCADA systems. Architecture, components, functions, methodologies and management systems integration.
Embedded Systems
Understanding the fundamental concepts related to: processor architecture; programming languages; instructions; addressing modes; basic programming structures and their interaction. Implementation of mechanisms related to several data communication processes, and understanding of the different control communication modes between the processor and the outside world. Study and analysis of control and operating modes of: SPI, I2C, USART, and ADC. Understanding the basic concepts of scheduling: scheduling of periodic

tasks; and processing of sporadic tasks. Access to shared resources.
Industrial Robotics
Study of the following essential concepts: translations, rotations, transformations, and transformation arithmetic. Understand the geometry of manipulators. Understand the manipulator kinematics and dynamic models. Study of trajectory generation applied to manipulation robotics. Programming of manipulation robots. Be acquainted of the main types of industrial mobile robots, and there main characteristics.
Project
This course is carried out under the supervision of at least one teacher. Each Group of students (up to three students) are required to develop a project on the following areas: electromechanical systems, industrial automation, manipulation robotics, mobile robotics, control applications, electronic and automation applications, energy management, industrial electric installations, service and household electric installations, maintenance, quality control, etc.

3rd year: Energy Branch

Power Electronics
Applications of power electronics. Power electronics semiconductors. Basic DC/DC switching converters. Isolated DC/DC switching converters. Inverters. Controlled and non controlled rectifiers. Power supplies. Magnetic design. EMI.
Electric Machines
Steady-state of three-phase asynchronous and synchronous machines: circuit models and laboratory tests, vector diagrams, losses and efficiency. Air gap magnetic field, current diagram, torque-speed characteristic and starting and speed-control methods of three-phase asynchronous motors. Three-phase asynchronous generators. Asynchronous single-phase motor. Voltage regulation, parallel operation with the grid, power and V-curves of three-phase synchronous machines. The salient rotor synchronous machine. Special motors.
Energy quality and Management
Terms, definitions, parameters, normalization and standards related to Power Quality and Management; Power quality auditing and monitoring; Sources, analysis and principles of protection from power quality problems. International and national energy resources. Power markets models: European, Iberia and Portuguese markets of electricity; Review of European most significant directives, normalization and regulation regarding energy management. Electricity rate types. Portuguese electricity rates and bill calculations. Electric energy loads and loads typical profiles; Energy conservation and electrical energy rational use in buildings and plants; Cogeneration and tri-generation; Economic analysis of capital investments aiming energy rational use. Financing programs.
Distribution and Microgeneration
Energy Power Systems Study. Overhead and underground transmission networks. Electrical stations in the distribution network. Short-

circuit currents in the distribution network and their protection systems. Distributed generation and microgeneration systems. Technical issues of independent power production interconnection with the grid.
Electromechanic Drives Control
Constitution of an electromechanic system; Modelation of the stationary and dynamic behavior of industrial mechanic components; Electric vehicles characteristics; Actuator systems with three-phase asynchronous machines; Actuator systems with synchronous machines; Applications of control systems on electromechanic actuators; Energy sources for electric traction systems: batteries and fuel cells.
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