Course code	Course	Concentration Areas	Course syllabuses
EMC410038	**Acoustics I**	Vibration and Acoustics	Review of basic concepts. Conservation equations for mass, momentum, and energy. Wave equation and solution. Speed of sound. Sound intensity. Dissipation in the medium. Acoustic impedance. Propagation in ducts. Acoustic filters. Cut-off frequency. Variable section ducts.
EMC410073	**Acoustics II**	Vibration and Acoustics	Review of basic concepts of acoustics. Acoustic fields in rectangular, cylindrical and spherical cavities. Diffuse acoustic field. Sound radiation from spherical and cylindrical surfaces. Rayleigh integral. Radiation of flat plates. Piston radiation. Integral formulation of sound radiation. Transmission of sound through walls.
EMC410152	**Additive Manufacturing (3D Printing)**	Fabrication	History and evolutionary framework of additive manufacturing or 3D printing. Basic principle of manufacturing by adding layers. Classification of additive manufacturing technologies. Description of the main additive manufacturing processes nowadays, based on open source and dedicated systems concepts. Basic fundamentals of additive manufacturing techniques (material types, software, process parameters, etc). Correlation between process parameters and quality of the parts manufactured by additive manufacturing equipment. Recent advances and challenges in additive manufacturing.
EMC410205	**Analysis of Roughness and Integrity of Machined Surfaces I**	Fabrication	Aspects related to the concept of texture (topography) and the integrity of machined surfaces. The surface of solid bodies (technical bodies). Influence of the machining processes on the topography (texture) of machined surfaces. Characterization and classification of surfaces. Methods and technologies for analysis and measurement of surface geometry (topography/texture). Surfaces obtained by machining processes with defined geometry tools; surfaces obtained with tools with non-defined geometry; surfaces obtained by EDM; surfaces obtained by chemical material removal processes.
EMC410206	**Analysis of Roughness and Integrity of Machined Surfaces II**	Fabrication	Contextualization of the discipline. Influence of machining processes on the integrity of machined surfaces. Integrity of surfaces obtained by machining processes with defined geometry tools; integrity of surfaces obtained with tools with non-defined geometry; integrity of surfaces obtained by electrical discharge machining; integrity of surfaces obtained by chemical processes of material removal. Methods and technologies for characterization and analysis of machined surface integrity. Aspects related to the concept of texture (topography) and the integrity of machined surfaces.
EMC410067	**Applications of Computer Vision in Metrology**	Metrology and Instrumentation	Applications of computer vision in metrology, including: study of projective geometry and its applications, various techniques and principles for measuring 3D shapes, representation of surfaces using point clouds and meshes, notions of digital fringe processing, techniques for measuring displacements, deformations and curvature.
EMC410115	**Applications of Interferometry**	Metrology and Instrumentation	Interferograms and digital processing. Coherent light interferometers. Incoherent light interferometers. Speckle and shear interferometry. Interferometric and digital holography. Laser interferometry, laser tracker and laser tracer. Laser vibrometry. Fiber optic sensors. Interferometry in hostile environments.
EMC410128	**Artificial Intelligence Applied to Industrial Instrumentation**	Metrology and Instrumentation	Artificial Intelligence. AI tools: artificial neural networks, fuzzy logic, Bayesian networks and hybrid systems. Characterization and development of applications employing AI tools. Applications of AI techniques in instrumentation. Deepening in the application of artificial neural networks. Aspects of metrological reliability of AI-based tools.

EMC410040	**Automatic Systems in Hydraulics and Pneumatics**	Design of Mechanical Systems	Introduction to system modeling: Fundamentals of system modeling, Models used in industrial automation, Mechatronic systems. Pneumatic industrial automation: Introduction to pneumatics, Fundamentals of Boolean algebra, Main components of pneumatic controls, Programmable logic controllers, Combinatorial control design, Sequential control design. Automatic systems design: Conceptualization and modeling of automatic systems. Methods for automatic systems design. Channel/Agency Petri Net, Methods of analysis and synthesis using C/A Net.
EMC410084	**Boiling and Condensation: Fundamentals and Applications**	Thermal Sciences and Engineering	General introduction. The phenomena of boiling, condensation, and cavitation. Industrial applications. The boiling curve. Stephan's criterion for the stability of boiling regimes. Homogeneous nucleation and heterogeneous nucleation. Notions of thermodynamics-Van Der Waals equation and metastable states. Clausius-Clapeyron and Laplace equations. Concept of surface tension. Laplace-Kelvin equation. Nucleation in microcavities and stability. Bubble dynamics. Rayleigh-Plesset equation. Plesset-Zwick model. Bubble cycle. Nucleated boiling: main models and correlations. Boiling crisis phenomenon: Zuber model. Taylor and Helmholtz instability. Kutateladze correlation. Influence of contact angle on critical heat flow. Confined boiling. Introduction to condensation. Types of condensation. Wettability. Nusselt model. Condensation in film on plates and tubes. Condensation in the presence of non-condensable gases.
EMC410197	**Chemical Kinetics of Combustion**	Thermal Sciences and Engineering	Introduction, numerical approach to a combustion process. Global and detailed kinetic mechanisms, thermodynamic databases available in the literature Simulations of Chemical Equilibrium and Adiabatic Flame Properties Simulations of Chemical Kinetics: PSR Reactors, Laminar Flat Flame, Coke Tubes, Fast Compression Machine Analysis of detailed inetic mechanisms: First-order logarithmic coefficient analysis first order logarithmic coefficient analysis, brute force sensitivity analysis.
EMC410185	**Compact Heat Exchangers**	Thermal Sciences and Engineering	Analysis, selection and sizing of compact heat exchangers. LMTD method. E-Nut method. Pressure drop and pumping power. Global heat transfer coefficient calculation. Performance evaluation. Webb's methods. Method of minimum entropy generation. Entropy prediction. Condensate, ice and frost formation. Numerical and experimental methods for analysis of compact heat exchangers.
EMC410164	**Computational Methods in Plasticity I**	Mechanical Analysis and Design	Plasticity Theory. Phenomenology. One-dimensional problem. Strain decomposition. Plastic Flow Criterion. Plastic flow rule. Hardening rule. General plasticity model. Tresca, vonMises, Mohr-Coulomb and Drucker-Prager criteria. Associative and non associative rules. Isotropic and kinematic hardening. Finite Elements review. Finite Element Method in nonlinear problems. Incremental constitutive problem. Predictor-corrector algorithms. Implementation in Finite Elements. Linearization and consistent tangent matrix. Viscoplasticity. One-dimensional problem and general formulation.
EMC410104	**Computational Vibroacoustics**	Vibration and Acoustics	Review of Lagrangian Mechanics. Energy equations for bar, beam and thin plate elements. Rayleigh-Ritz method applied to beam bending. Finite Element Method applied to beam bending and plate bending. Extraction of eigenvalues and eigenvectors. Direct and modal methods for solution of harmonic response. Finite Element Method applied to the acoustic behavior of ducts and cavities. Analysis of fluid-structure interaction problems using the Finite Element Method. Review of sound radiation from irregular geometry bodies. Boundary Element

			Method applied to acoustical problems. Analysis of fluid-structure interaction problems using Finite Element Method and Boundary Element Method. Overview of other numerical methods applied to acoustics and vibrations.
EMC410193	**Computer-Aided Machining of Complex Geometric Shapes - Cax Systems Application**	Fabrication	Classification of complex geometric shapes (freeform); applications and manufacturing processes. Machining centers with up to 5 degrees of freedom and CNC for milling complex shapes. Concepts of CAD/CAM/CAx computer tools for modeling and manufacturing parts containing complex shapes. Methods and mathematical resources (parametric equations Sp//ne - Bézier curves) used to calculate tool paths by CAM systems. Milling operations of these geometries and the implications of tool-workpiece contact changes on the manufactured surface. Use of CAD/CAM systems for CNC programming and simulation of the machining of complex geometric shapes.
EMC410004	**Conceptual Mechanism Design**	Design of Mechanical Systems	Conceptual Design of Mechanisms. Review of mechanism concepts; number synthesis; type synthesis; dimensional synthesis; coupling design (self-aligning).
EMC6605000	**Conceptual Project**	Design of Mechanical Systems	Introduction: basic concepts and terminology; evolution of design research and training. Structures of the design process. Simultaneous engineering. Quality function deployment. Design requirements. Preparation and evaluation of the development proposal. Creativity: Intuitive and systematic methods of generating alternative designs; design theories and principles; synthesis function method; value analysis and design support computer systems. Industrial property. Human and industrial design factors in product design. Design for economic viability. Design selection methods. Systematic review of the design process.
EMC410189	**Control technology and evaluation of electrical parameters of hybrid arc welding processes**	Fabrication	
EMC410033	**Convection**	Thermal Sciences and Engineering	1 - Introduction. 2 - Fundamental concepts of Boundary Layer - Flat Plate Boundary Layer. 3 - Flow inside ducts 4 - External Natural Convection 3 - Flow inside ducts. 4 - External Natural Convection. 5 - Internal Natural Convection (Cavities) 6 - Notions of Convection in Porous Media. 7 - Notions of Turbulence.
EMC410132	**Convective Boiling and Condensation**	Thermal Sciences and Engineering	Introduction to two-phase flow. Flow pattern maps. General definitions. Homogeneous model. Separate phases model. Pressure drop. Two-phase multipliers. Lockhart-Martinelli correlation. Boiling in Forced Convection. Boiling onset. Chen correlation and other correlations and semi-empirical models. Critical Heat Flow (CHF). Heat flow of drying (dryout). Convective boiling in microchannels. Scale effects. Forces acting on the flow of a liquid subject to boiling in microchannels. Different forces on two-phase flow in microchannels. Condensation in microchannels. Scale effects. Forces acting on a flow with condensation. Pressure drop during condensation.
EMC410051	**Conversion and Rational Use of Energy I - Power Cycles**	Thermal Sciences and Engineering	Renewable and non-renewable energy sources. Centralized, distributed and isolated generation. Thermodynamics applied to power cycles. Rankine, Brayton, Otto and combined cycles. New technologies for power generation: ICM, turbines, recovery boilers (HRSG), fuel cells, organic Rankine Cycles (ORC), thermosolar and hybrid generation, and cofiring combustion systems. Cogeneration associated with drying processes, steam and hot water production. Review of the fundamentals of exergy. Irreversibilities and destroyed exergy. Exergy

			analysis applied to thermal cycles. Exergy analysis models. Optimization models. Exergy cost theory and exergy-environmental analysis models. Life cycle analysis (LCA), environmental impact and policies for sustainable development. Simulation of thermal cycles and real plants using existing computational resources.
EMC410139	**Damage Mechanics**	Mechanical Analysis and Design	(i) Introduction - phenomenological aspects of damage; (ii) Thermodynamics of irreversible processes; (iii) Thermal dissipation; (iv) Elastoplasticity with isotropic damage. (v) Discretization: incremental Finite Element Analysis. (vi) Viscoplasticity of materials
EMC6610000	**Design for Reliability and Maintainability**	Design of Mechanical Systems	Introduction to Reliability: Basic Concepts; Reliability in the Product Life Cycle; Reliability Measures and System Reliability. Design for Reliability: Reliability Requirements; Subsystem Level Reliability Allocation; Component Selection and Application; Component Utilization Rate; Redundant Systems. Reliability Test Planning and Assessment. Reliability Review. Maintainability; basic concepts; measures of maintainability; design principles for maintainability. Prediction, evaluation and testing of maintainability. Preventive and corrective maintenance analysis and planning. Maintenance review. Design for logistical support of the product or system. Planning and evaluation of logistical support.
EMC410107	**Digital Signal Processing for Metrology I**	Metrology and Instrumentation	Linear signals and systems. Time and frequency response of linear time invariant dynamical systems. Fourier transform. Data acquisition. Digital signal processing software.
EMC410148	**Dynamic Material Feeding in Welding Processes**	Fabrication	Metal transfer in the MIG/MAG process and principles of new technologies. MIG/MAG process with additional wire. Material feeding for permanent electrode processes (hot wire and cold wire). Types of wire pullers. Aspects of wire melting and incorporation into the melt pool. Behavior of the molten puddle and strand formation.
EMC410036	**Electricity and Electronics for Instrumentation**	Metrology and Instrumentation	Electricity for instrumentation: direct and alternating current electrical circuits; characterization of the main parameters of the components, in the time and frequency domains. The concepts of reactance and impedance. Power and power factor calculation. Safety aspects: electric shock; forms of protection. Thévenin model applied to electronic instrumentation. Basic instrumentation for electricity and electronics: sources, function generators, multimeters, counters and frequency meters, oscilloscopes. Structure of electronic systems of measurement and actuation. Notions of electronic processing of measurement signals: bridge circuits with DC and AC power; amplification; filtering; fundamental instruments. Introduction to electronics: characterization of analog and digital electronics. Basic electronic components: diodes, transistors, operational amplifiers; typical applications in instrumentation. Overview of the availability of electronic components for instrumentation applications.
EMC410173	**Engineering Risk Analysis and Management**	Design of Mechanical Systems	Basic concepts of risk in technical systems. Product life cycle. Accident mechanisms and risk management. Risk probability assessment (RAP). Risk management and the life cycle of technical systems. Key techniques for risk analysis and risk management. Human reliability: general aspects and correlations with the risk of technical systems.
EMC410100	**Environmental Acoustics**	Vibration and Acoustics	Assessment of noise in communities. Types of environmental noise sources. Measurement of environmental noise. Subjective evaluation of noise nuisance. Assessment of noise indoors.

EMC410181	**Experimental Characterization in Solid Mechanics**	Mechanical Analysis and Design	Structure and deformation of materials - types of atomic bonds in metals and polymers, internal structure, elastic deformation, inelastic deformation; 2. Stress-strain relationships and mechanical behavior; 3. Experimental characterization techniques - uniaxial compression, uniaxial tension, tension in EPD, simple shear, impact, dynamic-mechanical analysis (DMA), hardness and indentation, bending, torsion, creep and fatigue; 4. Surface characterization techniques - optical microscopy, scanning electron microscopy, atomic force microscopy; 5. Mechanical strain measurement - straingages, digital imagecorrelation (DIC); 6. Mechanical tests for validation of material models (small punch, V-notchshear, cyclic stress-strain curve); 7. Determination of material parameters from experimental data - identification processes, characteristic tests, schematic representation of the actual behavior, error functions, algorithms for parameter extraction; 8. Statistical analysis of experimental data - statistical distributions, confidence intervals, comparison of means, regression, error propagation; 9. Applications.
EMC410153	**Experimental Stress Analysis I**	Metrology and Instrumentation	Metrology and solid mechanics review. Topics in: extensometry, moiré, holography, photoelasticity, residual stresses, hybrid methods.
EMC410163	**Experimental Stress Analysis II**	Metrology and Instrumentation	Experiment in extensometry, experiment in photoelasticity, experiment in holography/moire, practical work applied to a mechanical problem.
EMC410138	**Experimental Techniques in Acoustics and Vibrations**	Vibration and Acoustics	Basic Instrumentation in Vibrations and Acoustics. Sound power measurement of sources. Sound absorption measurement of materials. Acoustic Filters. Sound transmission loss and radiation efficiency measurement. Frequency response measurement of structural components. Measurement of structural damping.
EMC6607000	**Expert Systems Applied to Engineering**	Design of Mechanical Systems	Background on SE. Advantages and disadvantages of an ES. Components and life cycle of an ES. Aspects related to the definition of the knowledge domain. Techniques for knowledge acquisition and representation. SE validation and verification. Prototype implementation using SHELL tools.
EMC410055	**Fatigue**	Mechanical Analysis and Design	Analysis of the phenomenon of fatigue and response of materials to cyclic loading. Types of tests and test machines. Material curves, fatigue life regimes. Fatigue curves estimation. Stress concentration in elastic and elasto-plastic regime. Effect of mean stresses, importance of residual stress for fatigue. Crack propagation, Paris law, propagation life.
EMC410096	**Finite Element Method A**	Mechanical Analysis and Design	FEM in 1D problems: bar problem. Weighted residuals, PTV, Principle of least total potential energy. Overlap. Processes of applying boundary conditions. 2D/3D FEM in scalar field: Heat conduction problem. Strong and weak formulation. Global and elementary basis. Inhomogeneous Dirichlet boundary conditions. Convergence curves. FEM for linear elasticity. Strong and weak formulation. FEM for plane strain, stress and axisymmetric states. Volumetric elements. Isoparametric elements. Mapping. Jacobian. Numerical integration. Applications and convergence evaluations. Basic mathematical properties of FEM. Linear and bilinear 1D forms. Equivalence between variational and minimum problems. Uniqueness of solution. A-priori error estimates in 1D FEM. FEM of homogeneous plates. Kinematic Mindlin-Reissner model. Pathologies: "bending locking
EMC410113	**Finite Element Method B**	Mechanical Analysis and Design	FEM in structural dynamics. Discrete systems. D'Alembert's principle. PTV in bars. Mass and stiffness matrix of bar, beam, elastic solids. Lagrange equations of motion. Modal analysis. Guyan reduction. Harmonic response analysis. Direct integration methods: central difference, diagonalization of the mass matrix. Implicit methods.

			Stability and accuracy. 1D plasticity. Frictional model. Integration algorithms for rate independent plasticity. Finite elements for 1-D elasto-plasticity. Classical 3-D plasticity. Classical J2 theory, isotropic kinematic hardening. Integration algorithms. Basic algorithm. Associative plasticity. J2 plasticity. Nonlinear isotropic/kinematic hardening. Radial feedback method.
EMC410154	**Flow, Heat Transfer and Geomechanics in Porous Media**	Thermal Sciences and Engineering	1 - Single-phase flow with heat transfer: Conservation equations; Forced and natural external and internal convection. 2 - Single-phase flow coupled with geomechanics (poroelasticity): Conservation equations for the flow and for the poroelastic problem. Terzaghi and Mandell problems; Notions on the numerical solution strategy. 3 - Single-phase flow with inactive tracer. 4 - Two-phase flow in porous media: Formulation in saturations and mass fractions; Application in petroleum reservoir simulation.
EMC410034	**Fracture Mechanics**	Mechanical Analysis and Design	Mechanical properties of materials, failure criteria, stress concentration concept, plastic analysis, linear elastic fracture mechanics, elasto-plastic fracture mechanics, property characterization in fracture mechanics. Standards.
EMC410032	**Fundamentals and Practice of Welding, Brazing and Thermal Cutting**	Fabrication	Concept of welding and brazing. Classification of welding processes. The various types of energy used: flame, arc, resistive heating, LASER, electron beam, pressure and friction. Oxy-fuel and plasma cutting practice. Welding practice with coated electrodes: deposition on plate, root welding in flat and vertical positions. MIG/MAG welding practice: system set-up (torch assembly, electrical connections, gas connections, peripherals, and fundamental adjustments), plate deposition and root welding of thick carbon steel plates in flat and vertical positions. Practical TIG welding of carbon steel: system set-up (torch assembly, electrical connections, gas connections, peripherals and basic adjustments), welding of thin plates in flat butt and angle positions Stainless steel TIG welding practice: welding thin plates in flat butt and angle position. Same in vertical position. Electric Resistance Welding practice. Fast Stud Welding practice Brazing practice. Plasma Welding practice Safety Notions in Welding and Cutting.
EMC410102	**Fundamentals of Aeroacoustics**	Vibration and Acoustics	Review of the basic equations of fluid dynamics and linear acoustics. Green's function for the non-homogeneous wave equation. Elementary sound sources: monopoles, dipoles and quadrupoles. Acoustic analogies, Lighthill theory and Curle's formulation for the Lighthill analogy; Influence of rigid bodies in the vicinity of the aerodynamic source and Ffowcs Williams-Hawkings equation. Compact Green's functions and confined flows, effect of discontinuities at low Reynolds numbers. Aeroacoustics of an open duct: Whistling, Howe's Energy Corollary.
EMC410035	**Fundamentals of Computer Vision**	Metrology and Instrumentation	Fundamentals of optics applied to computer vision, including: study of light and light sources; the laws of light propagation; the fundamentals of geometric optics and image formation; study of the major optical systems and the study of digital images and notions of their processing.
EMC410029	**Fundamentals of Fluid Mechanics**	Thermal Sciences and Engineering	Review of vector calculus; Notions of tensor calculus; Kinematics and dynamics of deformable media; Energy equation; Constitutive equations; Flow of Newtonian fluids; Flow of perfect fluids.
EMC410106	**Fundamentals of Interferometry**	Metrology and Instrumentation	Fundamentals of geometric optics: lenses, mirrors and image formation. Wave motion. Mathematics of wave superposition. Light, light sources and coherence. Polarization. Interference and conditions for interference. Diffraction. Subjective and objective speckle.

EMC410105	**Fundamentals of Metrology**	Metrology and Instrumentation	Measure. Units of measurement and the international system. The error of measurement. The measurement system. Calibration and traceability. Results of direct measurements. Indirect measurement results. Guide for the expression of uncertainty in measurements. Uncertainty propagation through modules. Monte Carlo Method. Quality Control. Selection of measurement systems.
EMC410103	**Fundamentals of Modal Analysis**	Vibration and Acoustics	Technical concepts are presented, as well as measurement techniques applied to the study of vibrations. The goal is to obtain modal parameters of structures from their vibration responses.
EMC410144	**Fundamentals of Solid Mechanics A**	Mechanical Analysis and Design	First part of the study of the fundamentals of continuum mechanics theory, with emphasis on solid mechanics. Development of an appropriate philosophical approach to the study and analysis of mathematical models in their relationship with the associated physical models and phenomena. Rigorous detailing of concepts, models and theorems concerning: the various types of stress measurements, strains and rates, general principles of continuum mechanics, elements of constitutive relations and thermodynamics of solids.
EMC410057	**Fundamentals of Solid Mechanics B**	Mechanical Analysis and Design	Second part of the study of the fundamentals of continuum mechanics theory, with emphasis on solid mechanics. Development of an appropriate philosophical stance in the study and analysis of mathematical models in their relation to the associated physical models and phenomena. Rigorous detailing of concepts, models and theorems concerning: the general principles of continuum mechanics, the elements of constitutive relations, and the thermodynamics of solids.
EMC410028	**Fundamentals of Thermodynamics**	Thermal Sciences and Engineering	Reversibility x Irreversibility. The first law of thermodynamics. The first law of thermodynamics for open systems. The second law of thermodynamics. The second law of thermodynamics for open systems. Thermodynamic equilibrium. Differential relations involving state variables. Equilibrium and homogeneity: Euler relation, Gibbs-Duhem equation. Thermodynamic potentials. Maxwell relations. Phase transitions.
EMC410136	**Geometric Metrology**	Metrology and Instrumentation	Fundamentals of geometric metrology. Causes of measurement errors and typical errors in geometric metrology. Geometric specification of products. Three-dimensional measurement by contact coordinates. Three-dimensional measurement by non-contact coordinates. Industrial computed tomography. Micro and Nano-metrology. Lectures and practical classes in laboratory.
EMC410182	**Geometry of complex spatial parallel robots**	Design of Mechanical Systems	Characterization of mechanisms and space parallel robots with complex kinematic chain; Position and differential, direct and inverse kinematics for complex parallel mechanisms and robots; Identification of work volume and volumetric ratio for space parallel robots of mobility 3 and 4; Statics and kinetostatics for complex parallel robots; Analysis of dimensional errors in the design phase of parallel robots; Stiffness.
EMC410052	**Heat and Mass Diffusion**	Thermal Sciences and Engineering	Basics of thermodynamics and phase equilibrium; Equations for conservation of mass and energy in diffusive systems; Analytical solutions of problems involving heat and mass diffusion (permanent, transient and moving-boundary regime).
EMC410077	**Heat Transfer and Computational Fluid Mechanics I**	Thermal Sciences and Engineering	The fundamental objective of the course is to convey to the student the basic concepts of the finite volume method applied to problems involving Fluid Mechanics and Heat and Mass Transfer. At the end of the course it is intended that the student, besides knowing the numerical methodology in depth, has the ability and theoretical foundation to advance their studies in the numerical area, write their own programs and be prepared to understand the numerical technology existing in commercial programs available.

EMC410109	**Heat Transfer and Computational Fluid Mechanics II**	Thermal Sciences and Engineering	INTRODUCTION: Brief History, Structured and unstructured meshes, Elements, Creation of control volumes. COORDINATE TRANSFORMATION: Global transformation, Lengths and areas, Base vectors, Vector representation, Local transformation. FORMULATIONS USING STRUCTURED MESHS: The nature of transformation, Types of mappings, Generation of the system, Curvilinear coordinate, Transformation of the conservation equations, Obtaining the approximate equations (moving meshes). FORMULATIONS USING UNSTRUCTURED MESHES:
EMC410126	**Helicoid Theory**	Design of Mechanical Systems	Vector spaces, heligars and heliforces. Reciprocal spaces and helicoid systems. Heligiros and heliforces in parallel manipulators. Type synthesis of parallel manipulators using helicoid theory. Velocity kinematics and Jacobian analysis. Modeling of elastic mechanical systems. Dynamics of mechanical systems.
EMC410095	**Hydraulic and Pneumatic Circuits and Components**	Design of Mechanical Systems	Fundamentals of hydraulic system modeling: Structure of hydraulic systems, Principles of fluid mechanics applied to hydraulic component modeling, Dynamic component modeling. Characterization and modeling of components: Pumps and motors, cylinders, discrete and continuous control valves (proportional, servoproportional and servovalve). Circuit modeling and analysis: Open circuits for industrial and mobile applications, Closed circuits employing hydrostatic drive, Theoretical-experimental circuit analysis. Modeling of pneumatic components and circuits: Compressible flow for pneumatics, Modeling and sizing of valves and actuators. Theoretical and experimental analysis of circuits.
EMC410069	**Hydraulic and Pneumatic Control Systems**	Design of Mechanical Systems	Introduction: Typical configurations, characteristics and applications of hydraulic and pneumatic positioning systems, Servovalves, proportional valves and fast switching valves, Pneumatic control systems: Flow and continuity equation in pneumatic systems, Modeling and simulation of pneumatic positioners. Hydraulic Control Systems: Linear and nonlinear modeling of valves and actuators, Modeling of hydraulic positioners, Design method of hydraulic positioners. Controllers: Synthesis of linear and nonlinear controllers. Compensation of typical nonlinearities. Theoretical and experimental analysis of positioners.
EMC410161	**Instrumentation for Acoustics and Vibration**	Vibration and Acoustics	Microphones; Accelerometers; Sound Intensity Probe; Measurement uncertainties; Extensometry; Acoustic Holography; Laser Vibrometry; Flow, rotation and temperature measurement methods.
EMC410116	**Instrumentation for the Oil and Gas Industry**	Metrology and Instrumentation	Measure. Units of measurement and the international system. The error of measurement. The measurement system. Calibration and traceability. Results of direct measurements. Indirect measurement results. Guide for the expression of uncertainty in measurements. Uncertainty propagation through modules. Monte Carlo Method. Quality Control. Selection of measurement systems.
EMC410111	**Introduction to Combustion**	Thermal Sciences and Engineering	Introduction, Fuels and oxidants, Stoichiometry, Conservation of mass and composition of multicomponent mixtures; Thermodynamic properties of mixtures, First law of thermodynamics; Chemical equilibrium, properties of adiabatic flames; Chemical kinetics, Elementary reaction rates and heterogeneous reactions; Detailed mechanisms for hydrocarbons, Mechanisms of pollutant formation; Conservation equations and reactive flows with negligible diffusive transport; Detonations and deflagrations, Chapman-Jouguet detonations; Diffusive mass and heat transport; Premixed flames, Schvab-Zeldovich formulation; Propagation of spherical flames and stabilized flames; Flames in non-premixed jets, Combustion of sprays.

EMC6623000	**Introduction to Mechanical Systems Controller Project**	Design of Mechanical Systems	Dynamic models of mechanical and electromechanical systems. Dynamic response: transfer function, block diagrams, poles and zeros. Fundamental principles of feedback: types of feedback, stability. Root locus design: tracing the root locus. Frequency response design: Bode diagrams, Nyquist stability, gain margin and phase margin. Design in state space: description, poles, zeros and eigenvalues.
EMC6630000	**Introduction to Robotics**	Design of Mechanical Systems	Fundamental concepts, manipulator types and configurations. Kinematics/Geometry. Kinematics/Differential Motion. Statics. Dynamics. Trajectory Planning. Manipulator Control. Manipulator Simulation. Manipulator Programming.
EMC410091	**Introduction to Sustainable Manufacturing - Part A**	Fabrication	Definition of Sustainable Manufacturing and Industrial Ecology. Technological Changes and Increased Risks. Resource Status. Environmental Legislation. Design of Products and Processes for the Environment. Materials Selection Considering Environmental Aspects. Impacts of Extraction and Processing of Materials. Eco-Auditing Primary and Intermediate Processing Industries Analysis of Energy Use, and Approaches to Minimizing Energy Use Environmental Interactions during Product Use. End-of-life design. Life-Cycle Assessment (LCA). ISO 14040 Standard. LCA applications: Automobiles, Thermoplastic Materials, Paper, Aluminum, Machining Fluids. LCA Summary (SLCA). Applications of SLCA.
EMC410070	**Kinematics and Statics of Mechanisms and Robots**	Design of Mechanical Systems	Kinematics of mechanisms. Statics of mechanisms. Notions of Dynamics of mechanisms. Graphical analysis of mechanisms. Applications in mechanisms and robots (manipulator robots, vehicular dynamics, surgical devices, etc.).
EMC410190	**Lattice Boltzmann Method in Acoustics**	Vibration and Acoustics	Historical aspects and review of the paradigm of computational methods in aeroacoustics; Introduction to the particle dynamics-based method; Kinetic gas theory; Introduction to the Lattice Boltzmann method; Solid and annelike boundary conditions; Unaligned and shifting boundary conditions; Axisymmetric schemes for LBM; Association of LBM with the finite difference method; Multiple relaxation time methods in LBM; High order schemes.
EMC410183	**Lean in Products and Processes**	Fabrication	Introduction to Lean: Philosophy, Approach, Methodology. Lean in products and processes. Waste in Products and Processes. Lean Product and Process Development System. Lean concepts, methods and tools in products and processes. Value Stream Mapping in product and process development Lean implementation in products and processes. Toyota Kata. Lean in the context of Industry 4.0.
EMC410179	**Lean Systems**	Fabrication	Introduction to Lean Systems and Lean Approach; Lean as a transformation method; The Principles of Lean Approach; Value and Waste; Process Modeling; Value Stream Mapping; Lean Manufacturing Systems; Pull Systems; Toyota Kata Approach.
EMC410155	**Lubrication Theory**	Thermal Sciences and Engineering	The objective of the course is to introduce the student to the fundamentals of hydrodynamic lubrication theory, while also familiarizing him with recent problems involving particular aspects of lubrication. During the course the student will prepare a computational program so that at the end he will have a tool that will allow him to analyze general problems involving static and dynamic bearing loads.
EMC410142	**Machining Technology I - Part A**	Fabrication	Introduction to manufacturing processes. Basic metrology concepts needed for machining manufacturing, causes of errors, types of geometric errors. Fundamentals of machining processes with defined geometry tools. Thermal

			and mechanical stresses in machining. Study of chip formation mechanisms and wear mechanisms and forms. End-of-life criteria. Introduction to cutting tool materials. Types, properties and applications of tool materials.
EMC410059	**Machining Technology I - Part B**	Fabrication	Study of lubricant-refrigerant media employed in machining processes. Criteria criteria, influence factors on machinability and analysis of machinability of different of different materials. Economic determination of machining conditions. Optimization of machining operations.
EMC410146	**Machining Technology II A**	Fabrication	Technological background for machining processes employing cutting tools with wedges of undefined geometry. Empirical study of chip formation mechanisms, wear mechanisms, presentation of tool materials, manufacturing of bonded abrasives. Application of aids.
EMC410147	**Machining Technology II B**	Fabrication	Technology of machining processes employing cutting tools with wedges of undefined geometry. Study of the grinding, honing, lapping and blasting processes.
EMC410156	**Machining Technology III A**	Fabrication	Technology of the processes of thermal removal by electrical discharge, chemical removal, thermo-chemical removal, electro-chemical removal, ultrasonic removal, electron-beam removal, and water-jet removal. The main process parameters, auxiliary media, and potential applications are presented, showing practical examples for the processes in question.
EMC410118	**Machining Technology IV**	Fabrication	Laser process technology; the nature of light; refractive index, polarization and brightness; interference; laser light; atoms, molecules and energy levels; energy distribution and laser action; laser resonators; resonance modes; bandwidth reduction; laser quality enhancement; cavity damping; nonlinear optics; semiconductor lasers; solid-state lasers; disk lasers and fiber lasers; gas lasers; eximer lasers; tunable lasedrs.
EMC410172	**Machining Technology V (Applications LASER processes)**	Fabrication	Fundamentals of laser materials processing; Laser sources; Surface treatment; Forming; Rapid prototyping; Bonding of materials; Ablation; Drilling; Cutting; Systems technology; Measuring technologies.
EMC410031	**Manufacturing Integration - Part A**	Fabrication	Introduction to Manufacturing. Background on Manufacturing Systems. Elements that constitute a manufacturing system. Layouts of Manufacturing Systems: Functional (Job Shop), by Product (Flow Shop), Positional, Continuous Processes, Cells. Production Planning and Control. Manufacturing Resource Planning. Master Production Plan. Material Requirements Planning. Capacity resource planning. Determination of manufacturing time for a product. Sequencing rules. Economic lot size. Reorder point. ABC stock. Balancing activities. Use of Computers in a Manufacturing System. Computer Aided Design (CAD) and its role in manufacturing. CAD/CAM interfaces (IGES; STEP; STEP-NC). Simultaneous Engineering. Design for Manufacture and Assembly (DFMA). Product modularity. Transport systems and material handling.
EMC410060	**Manufacturing Integration - Part B**	Fabrication	Introduction to Lean Manufacturing. Definition of waste. Types of waste. Little's Law. The ten steps to implement Integrated Manufacturing Systems. Formation of Manufacturing Cells. Reduction of Setup Time. Continuous Improvement (Kaizen). Theory of Constraints. Integrated Quality Control. Jidoka. Preventive Maintenance. Total Productive Maintenance. Leveling and Balancing (Heijunka). Interconnection of Cells via Kanban, CONWIP and POLCA. Inventory Control Integration. Suppliers Inclusion. Automation and Robotization for Problem Solving. Overall Equipment Effectiveness (OEE). Design of products with lean characteristics.

EMC410037	**Mathematical Concepts in Vibrations and Acoustics**	Vibration and Acoustics	Real vector spaces and linear transformations. General theory of linear differential equations. Differential equations with constant coefficients. Laplace transform. Euclidean spaces. Convergence in Euclidean spaces. Fourier series. Boundary problems for ordinary differential equations. Boundary problems for partial differential equations; wave and heat equations.
EMC410078	**Mathematical Methods for Solving Ordinary Differential Equations**	Thermal Sciences and Engineering	- Ordinary differential equations of the first order - Method of separation of variables: Solution of exact equations; Solution of linear equations. - Second-order ordinary differential equations - Homogeneous: Constant coefficients; Euler-Cauchy equation
EMC410050	**Mathematical Methods for Solving Partial Differential Equations**	Thermal Sciences and Engineering	Sturn-Liouville Problems, Fourier Series, Fourier Integrals, Fourier Transform. Parabolic, Hyperbolic and Elliptic Partial Differential Equations, Wave problem, Heat problem, Membrane problem, Laplace equation, Solution by Laplace transform, Solution by Fourier transform, Special methods for solution of PDEs, Duhamel's method, Expansion by eigenfunctions, Integral method, Green's function-impulse-response, d'Alembert's method, Conformal maps, Variational method (Ritz method), Perturbation methods - Galerkin methods, Integral transform and Inverse problems.
EMC410108	**Measurement Automation I**	Metrology and Instrumentation	Automated measurement and control systems: general structure, typical modules and market availability. Test automation benches. Digital signal processing in metrology: softwares with typical application in metrology and automation. Virtual instruments: characterization and application. Development of software for application in metrology and automation of measurement. Development of software for application in metrology and automation of measurement. Practical work involving details of structuring, development, debugging and documentation of programs using graphic language.
EMC410127	**Measurement Automation II**	Metrology and Instrumentation	Signal acquisition systems: modules; general characteristics. Signal multiplexing: metrological and operational aspects. A/D and D/A converters: types, specifications and characteristic applications. Sample-hold circuits. Reconstitution of digitized information: aliasing problem. Measurement automation systems architecture. Computerized instruments: design, advantages, applications. Buses and data transmission: interfaces and protocols. Automation of test benches. Uncertainty analysis applied to automated systems
EMC410039	**Mechanism and Robot Analysis**	Design of Mechanical Systems	Principles of mechanism and robot analysis. Kinematics of mechanisms and robots. Mechanisms and robots statics. Dynamics of mechanisms and robots. Topological analysis of mechanisms and robots. Graphical analysis of mechanisms and robots. Specific applications (manipulator robots, vehicle dynamics, etc.). Topological synthesis of mechanisms. Topological synthesis of robots.
EMC410094	**Mechanism and Robot Dynamics**	Design of Mechanical Systems	Generalized coordinates; Equations of motion; Conservation theorems; Lagrangian mechanics; Rigid body motion; Inertial geometry; Dynamics applied to robot control.
EMC6606000	**Modeling and Simulation of Mechanical Systems**	Design of Mechanical Systems	Modeling and templates. Types of models. Mathematical models. Iconic models; applications; design; materials used and construction. Analog models: similarities; projects; materials; construction and tests. Computer modeling. Analysis of the parameters of the design space; sensitivity, compatibility and stability analysis. Design optimization formulation. Main optimization methods for linear and non-linear problems.

EMC410133	**Monitoring, Automation, Control and Non-Destructive Testing for Welding Processes**	Fabrication	Welding Automation Systems: manipulators, robots, positioners, devices, welding cells, orbital heads. Hybrid Processes and Modern Variants of Classical Processes. Sensing: sensor types, functionality, applications. Modern techniques for monitoring and analyzing welding processes and automation systems: conventional filming, high-speed filming, motion measurement, thermographic filming, electrical data acquisition. Inspection techniques for welded joints and coatings through Non-Destructive Testing: visual inspection, ultrasound (phased array), ultrasonic thickness measurement, liquid penetrant testing, magnetic particle and radiographic testing.
EMC410098	**Multiphase Flows: Fundamentals**	Thermal Sciences and Engineering	Multiphase flow: definition; applications; classification. Flow patterns in pipelines. Conservation laws for two-phase flow. Local instantaneous formulation. Equilibrium conditions at the interface. Average formulations. Two fluid, Drift Flux and Homogeneous models. 1D formulations and closure correlations.
EMC410157	**Optimization in Mechanical Design**	Mechanical Analysis and Design	The subject aims to study mathematical concepts and numerical optimization techniques for mechanical design, with emphasis on improving structural performance. Although this is the application focus, the conceptual tools are general enough to be understood and applied in other engineering areas. The course is divided into two parts. The first part is intended to present the minimum theoretical concepts necessary to solve practical cases and have a comprehensive view of the optimization problem. The second part completes this first vision with new theoretical concepts, algorithms and classic application cases.
EMC410063	**Physical Fundamentals and Technological Basis of Arc Welding Processes**	Fabrication	Fundamental electricity to understand arc welding: direct current, alternating current, single and polyphase system. Power calculation. Conventional and electronic welding power sources. Gases applied in arc welding processes. Technological aspects related to mechanization systems of welding and cutting. Fundamentals and physical properties of the welding arc and its requirements with respect to energy sources. Opening of the arc in the various welding processes. Basic study of metal transfer in the various processes.
EMC410149	**Product Development Management**	Design of Mechanical Systems	Introduction: project management in the context of industrial product development. Project management processes: initiation, planning, execution, control, and closure. Product development strategies. Project selection.Project goals and organization for product development.Managing integration, content, time, cost, quality, human resources, communications, and risk in product development.
EMC410097	**Project of Composite Materials Structures A**	Mechanical Analysis and Design	Types and properties of fibers, matrices and composites. Fabrication processes. Micromechanics of a blade. Macromechanics of a blade. Stress-strain relationship. Failure criteria. Analysis of the laminate. Initial failure analysis. General equations for first order models: kinematic and motion equations. Principle of virtual work. Strain energies. Particularizations for thin plates. Interlaminar stresses. Comparisons with analytical solution. Shear factor k for homogeneous and orthotropic laminated plates.
EMC410114	**Project of Composite Materials Structures B**	Mechanical Analysis and Design	1st order finite element formulations for laminated plates. Linear stiffness matrix, inertia matrix, force vector. Natural frequencies. Finite element programming. Analysis using ANSYS. Stability and buckling critical load. Adjacent equilibrium method. Buckling load analysis and Identification of interlaminar stresses in Ansys. Analysis of sandwich plates. Analytical solution of 3D elasticity for rectangular plate. Higher order theories.
EMC410162	**Psychoacoustics: Analysis and Modeling of Hearing Mechanisms**	Vibration and Acoustics	Introduction to psychophysics and definition of basic concepts, General laws of psychophysics, Psychometric methods; Introduction to the anatomy of the auditory system; Analysis and modeling of the mechanisms of hearing, Analysis and modeling of the outer ear physiology (HRTF, ILD, IID, boundary element modeling),

			Analysis and modeling of the middle ear physiology (system nonlinearity, middle ear FRF, active system, finite element modeling), Analysis and modeling of ear physiology (processes in the basilar membrane, discrete model of the basilar membrane, active and passive system, modeling by circuit models, auditory filters, critical band and the auditory sensations elicited by pure tones, masking; Auditory sensations: Description, measurement and modeling.
EMC410174	**Refrigeration Compressor Theory and Modeling**	Thermal Sciences and Engineering	Vapor compression refrigeration cycle; Reciprocating compressors; Compressor modeling; Valve systems; Experimental characterization of compressors; Other types of positive displacement compressors; Refrigerants; Bearings; Centrifugal compressors.
EMC410053	**Refrigeration Fundamentals I**	Thermal Sciences and Engineering	Historical and environmental aspects. Single-stage systems, Carnot refrigeration cycle, standard refrigeration cycle, cycles with subcooling and superheating, cycle with intermediate heat exchanger, cycle with carbon dioxide, heat transfer and pressure drop in components, effect of foreign substances in the circuit, methods of capacity control, calculation of thermodynamic properties. Reciprocating compressors, mean effective pressure, volumetric efficiency, indicated diagram, coefficient of performance, scale effects. Multi-stage systems, additional components, multi-component cycles, cascade cycles. Properties of mixtures, BrLi-H20 systems with single and double effects, capacity control, crystallization, NH3-H2O systems, elementary steady-state processes, rectification of binary mixtures, coefficient of performance, Platen-Munters system, ideal gases, constant pressure cycle, constant pressure cycle with internal heat exchanger, aircraft climate systems, Stirling cycle, vortex tubes. Refrigerants, history, ozone layer depletion, Montreal protocol, greenhouse effect, Kyoto protocol, properties of interest.
EMC410125	**Room Acoustics**	Vibration and Acoustics	Sound fields indoors. Room acoustics. Airborne sound insulation. Structural sound insulation.
EMC410088	**Scaling Methods Applied to Thermal Engineering**	Thermal Sciences and Engineering	The goal of this course is the use of scaling methods in the solution of various academic engineering problems. The course begins with a review of fundamental thermodynamic concepts, such as the Minimum Energy Principle, followed by entropic balance in open systems. Then, a series of examples (see "Topics to be Covered" table below), mostly focused on thermal engineering, are developed in order to obtain such solutions. The course also explores, whenever possible, the determination of optimal solutions of these examples as well as the similarity between the solutions obtained and natural systems with correlated functions (e.g., the irrigation system commonly found in tree leaves.) At the end of the course, it is desired that students feel more comfortable with scaling methods and, at the same time, able to rationalize natural occurrences, be they geometric, phenomenological, etc.
EMC410065	**Sensors and Transducers**	Metrology and Instrumentation	Characterization of the measurement process and the role played by transducers in the measurement chain. Strain measurement. Displacement measurement. Force measurement. Torque measurement. Pressure measurement. Flow measurement. Rotation measurement. Temperature measurement.
EMC410074	**Signal Analysis for Vibrations and Acoustics**	Vibration and Acoustics	Introduction to signal analysis. Fourier series and integral. Linear systems theory, convolution and windowing. Time sampling and aliasing errors. Discrete Fourier transform and fast Fourier transform. Review of statistical concepts, probability density function and averaging. Stochastic processes. Correlation, autocorrelation and

			cross-correlation. Spectral density and cross spectral density. System identification, coherence function and frequency response functions.
EMC410066	**Signal Conditioning in Electronic Instrumentation**	Metrology and Instrumentation	
EMC410101	**Statistical Energy Analysis**	Vibration and Acoustics	Development of the basic equations and assumptions of SEA. Vibration energy. Modal density of components. Coupling factor. Damping. Radiation efficiency. Input power. Practical examples.
EMC410112	**Statistics for Experimentation**	Metrology and Instrumentation	Summary and data representation. Probability. Discrete random variables and probability distributions. Continuous random variables and probability distributions. Parameter Estimation. Statistical inference for one sample. Statistical inference for two samples. Curve fitting. Design and analysis of experiments with a single factor. Design and analysis of experiments with several factors. Notions on statistical quality control.
EMC410191	**Stochastic Process and Random Vibrations**	Vibration and Acoustics	Review of statistical concepts. Probability density function and averages. Second-order probability density function and ensemble means. Correlation, autocorrelation and cross-correlation. Spectral density. Narrowband and broadband processes. Cross spectral density. Response of 1GL system to random excitation. Two dimensional Fourier series. Response of continuous systems to point and distributed random excitation. Random vibrations in Finite Elements.
EMC410140	**Structural Reliability**	Mechanical Analysis and Design	Definition of reliability, concept of failure modes, failure rate. Main probabilistic distributions and their applications in reliability. Order statistics and probability plots. Numerical methods.
EMC410080	**Structure, Properties and Processing of Polymers**	Fabrication	Crystalline and amorphous structure of polymers, crystallization kinetics, transition temperatures and engineering use temperature, rheological and viscoelastic properties of polymers, polymer composites, main polymer characterization techniques, and fundamentals of manufacturing processes for elastomers and polymer composites.
EMC410166	**Subjective Acoustics**	Vibration and Acoustics	Sound quality of products. Subjective evaluation. Jury evaluation methods. Methods of analysis used in subjective evaluation.
EMC410134	**Submarine Acoustics**	Vibration and Acoustics	Introduction to underwater acoustics. Review of sound propagation theory. Reflection and transmission at an interface. Acoustic ray theory. Sources and receivers in underwater acoustics. Acoustic scattering by a body. Underwater acoustic signal processing. Sonar systems and seabed mapping.
EMC410196	**Synthesis of Mechanisms and Robots**	Design of Mechanical Systems	Number synthesis, type synthesis, dimensional synthesis, graph theory, group theory, matroid theory, helicoid theory, compliant mechanisms, origami mechanisms, self-aligning mechanisms, mechanisms for assistive technology, cable robots.
EMC410213	**Teaching Internship I**	-	Teaching in higher education involving teaching activities of preparation and application of theoretical, theoretical-practical and practical classes, participation in partial evaluation of programmatic content and the application of pedagogical methods or techniques (directed studies, seminars, among others).

EMC410214	**Teaching Internship II**	-	Teaching in higher education involving teaching activities of preparation and application of theoretical, theoretical-practical and practical classes, participation in partial evaluation of programmatic content and the application of pedagogical methods or techniques (directed studies, seminars, among others).
EMC410215	**Teaching Internship III**	-	Teaching in higher education involving teaching activities of preparation and application of theoretical, theoretical-practical and practical classes, participation in partial evaluation of programmatic content and the application of pedagogical methods or techniques (directed studies, seminars, among others).
EMC410041	**Thermal Radiation I**	Thermal Sciences and Engineering	Thermal radiation - Introduction, concepts. Blackbody. Properties of surfaces. Kirchhoff's law. Gray surface. Electromagnetic theory - Maxwell's equations. Shape factor. Monte Carlo method. Radiative exchange between surfaces - method of radiosities and Gebhart's method.
EMC410054	**Turbulent Flow Modeling**	Thermal Sciences and Engineering	General aspects of turbulence; Scales of turbulence; Basic mean flow theory; Direct and large-scale simulations; Turbulent viscosity models; Transport models for Reynolds' stresses; Flows with heat transfer; Flows with density variation; Transient flows.
EMC410023	**Vehicle Dynamics**	Design of Mechanical Systems	Tires, resistance to motion, transmission of forces to the ground and mechanics of braking, power balance, stability, steering, suspension, vehicle dynamics.
EMC410030	**Vibrations 1**	Vibration and Acoustics	Review of basic vibration concepts; Vibration response to any excitations - frequency response functions; Vibrating systems with multiple degrees of freedom; Continuous vibrating systems; Vibration analysis through energy concepts.
EMC410093	**Voltaic Arc Welding Processes I**	Fabrication	The conventional and pulsed MIG/MAG process with various principles and synergistic and adaptive control. Influence of electrode diameter, factors affecting weld geometry. Modern versions of the MIG/MAG welding process in short-circuit metal transfer (STT, CCC, CMT,...) and free-flying (RapidArc, PCS,..). Orbital MIG/MAG welding for root and filler passes. Open-chamber and closed-chamber orbital TIG welding.
EMC410119	**Voltaic Arc Welding Processes II**	Fabrication	The TIG process with cold and hot wire addition and push-pull techniques. The TIG process with constricted arc and comparisons with the plasma process. The multi-electrode TIG process. The TIG process versions with wire pulsation (TIP TIG) and with tangential injection of wire (TOP TIG).
EMC410110	**Welding Metallurgy**	Fabrication	Concept of weldability and influencing factors. Heat sources, welding thermal cycle and heat affected zone (HAZ). Weldability of non-alloy and low alloy steels: cold cracking, carbon equivalent, prediction of maximum hardness in the HAZ. Obtaining and applying TRC-S diagrams. Pre-heating and post-heating. Solidification of fusion welds: primary and secondary structure in steels, operational variables, microstructure and properties of the fused zone. Solidification cracks. Special weldability problems: reheat cracks, sensitization. Repair techniques by welding without subsequent heat treatment.
EMC410130	**Welding Stainless Steels**	Fabrication	Application of equilibrium diagrams in welding stainless steels. Primary and secondary crystallization in stainless weld metals. Precipitation reactions in the melt zone and heat affected zone. Mechanism of hot crack formation. Weldability of ferritic, martensitic and austenitic stainless steels. Procedures for welding the various types of stainless steels. Welding dissimilar joints and coatings with stainless steels.