Çankaya University Department of Mechatronics Engineering Master Course Catalog

MECE 508 Introduction to Optics (3 0 3) 7.5 ECTS
Introduction: Nature of Light, History of Optics, Particles and Photons, The electromagnetic Spectrum, Fundamentals of Geometrical Optics: Huygens' Principles; Fermat's Principle; Refraction and Reflection, Optical spaces; Gaussian Optics, Newtonian Equations, Longitudinal Magnification, Nodal Points, Gaussian Reductions, Fundamentals of Geometrical Optics: Thick and Thin Lenses, Vertex Distances, Thin Lens Imaging, Object Image Conjugates, Afocal Systems, Paraxial Optics, Paraxial Ray trace, Stops and Pupils, Marginal and Chief Rays, Field of View, Numerical Aperture and F-Number, Telecentricity, Depth of Focus and Depth of Field, Optical Systems: Parity and Plane Mirrors, Prism Systems, Objectives, Zoom Lenses, Keplerian Telescope, Field Lenses, Eye pieces, Relays, Microscopes, Illumination Systems, Aberration Theory: Chromatic Effects; Dispersion, Chromatic Aberration, Monochromatic Aberrations; Rays and Wave Fronts, Aberration Theory: Tilt and Defocus, Spherical Aberration and Defocus, Coma, Astigmatism, Distortion, Wave Equations: One Dimensional Wave Equation, Harmonic Waves, Plane Waves, Harmonic Waves as Complex Functions, Spherical Waves, Electromagnetic Waves, Polarization of Light, Interference of Light: Two Beam Interference, Young's Double Slit Experiment, Newton's Rings, Diffraction: Fresnel Diffraction, Fersnel-Kirchoff Diffraction Integral, Fresnel Diffraction from Circular Aperture, The Fresnel Zone Plate, Diffraction: Fraunhofer Diffraction, Rectangular and Circular Apertures, Resolution, Holography: Hologram Properties, White Light Holograms, Other Applications of Holography, Modulation of Light: The Nonlinear Medium, Second Harmonic Generation, Electro-optic Effects, The Faraday Effect, Optical Phase Conjugation, Modulation of Light: Spatial Light Modulators(SLM), Other Applications of SLMs, Fourier Optics.

MECE 512 Laser Machining (3 0 3) 7.5 ECTS
Understand the basic principles of light sources; LED and LASERS and identification of various uses of lasers in manufacturing, Laser safety and its implication in the workplace, Laser Types; working principles of CO2 lasers and applications in machinery, Laser Types; working principles of YAG lasers and applications in machinery, Laser Types; working principles of Excimer lasers and applications in machinery, Laser Types; working principles of Femtosecond lasers and applications in machinery, Applications of laser machinery; welding, drilling, cutting, Applications of laser machinery; hardening, cladding and consolidation, Laser micromachining; Laser material interaction (plasma formation, etc.), Laser micromachining; Active and passive photonic devices and laser written waveguides, Laser micromachining;Ultrafast laser writing, welding and joining, Laser micromachining ; Spatial and temporal adaptive beam engineering, Laser beam shaping technics on machinery, Understand the various issues on operations of laser systems in machining (cost, regulations, safety, etc.)

MECE 522 Contemporary Techniques for Small Mechatronic Parts (3 0 3) 7.5 ECTS
Introduction, Die Casting, Die Casting, Investment Casting, Powder Metallurgy, Sheet Metal Working; Piercing/blanking, Bending, Deep drawing for small size parts, Machine Tool Applications: Turning, Drilling, Milling for small parts, Abrasive Water Jet Cutting, Chemical Machining, Electric Discharge Machining (EDM), Electric Discharge Machining (EDM), Wire EDM, Laser Beam Machining, Ion Beam Machining, Nonconventional Welding Techniques: Ultrasonic Welding, Laser Welding, Additive Manufacturing.

MECE 523 Experimental Stress Analysis (3 0 3) 7.5 ECTS
Review of basic concepts of elasticity, Strain measurement methods, Electrical Resistance Strain Gages, Strain Gage Circuits, Transducer Design, sources of error, Force, torque and pressure measurements, Special-purpose gauges, rosette analysis, Photoelastic Measurement, Industrial applications, Project presentation.

MECE 524 Control Methods in Intelligent Control Systems (3 0 3) 7.5 ECTS
Introduction to intelligent control systems, historical background, review of fundamental control concepts, System Modeling and State-Space Representation, Lyapunov stability theory, types of system stability, and applications, Adaptive Control – Fundamental Principles
Model Reference Adaptive Control (MRAC), MRAC structure, adaptation laws, example applications, Self-Tuning Regulators, Parameter estimation, regression models, predictor-based control, Introduction to Predictive Control, Basics of Model Predictive Control (MPC), core principles, example applications, Predictive Control with Time Constraints, Cost functions in MPC, control horizon, constrained system control, Introduction to Fuzzy Control, Basics of classical fuzzy logic, structure of fuzzy control systems, Fuzzy Control – Design and Implementation, Fuzzy control rules, membership functions, application examples, Robust Control – Fundamental Concepts, Uncertainty modeling, system sensitivity, introduction to H-infinity control, Robust Control – H_infinity and LMI-Based Methods, H_infinity control design, Linear Matrix Inequality (LMI) approach, sample case studies
Performance Analysis and Method Comparison, Comparative performance analysis of all control methods via simulations, Project Presentations and General Review, Student project presentations, course wrap-up, discussion, and feedback

MECE 531 Elastic-Plastic Stress Analysis (3 0 3) 7.5 ECTS
Stress-strain relations, Yield criteria and the general behaviour of materials beyond proportional limit, Approximate theories on the theory of plastic flow, Bending, torsion, plane strain and plane stress, Plasticity for materials with isotropic hardening, Kinematic hardening and time dependence, Theories based on crystal slip, Solutions of various plane stress problems; rotating shafts, Solutions of various plane stress problems; rotating disks, Solutions of various plane stress problems; pressure vessels, Solutions of various plane stress problems; shrink fits, Solutions of various plane stress problems; rotating tubes, Term Project presentation

MECE 543 Computer Integrated Manufacturing Systems (3 0 3) 7.5 ECTS
Scope of Computer Integrated Manufacturing (product manufacturing phases), Computer technology, computer-manufacturing process interface/connection (communication with the microprocessor and manufacturing system), Computer-aided process planning (manual and computer-aided planning, variant and generative process planning approaches), Group technology (coding, flow analysis), Flexible manufacturing systems and flexible manufacturing cells (structure and communication), Information flow in manufacturing, regional network systems (LAN), Planning of manufacturing systems (machine tool requirements planning, simulation approach)

MECE 544 Pattern Recognition (3 0 3) 7.5 ECTS
Introduction to Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant

Sufficient Statistics, Coping with Missing or Noisy Features, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, K-Nearest-Neighbor Classification, Support Vector Machines, Mixture Modeling, Expectation-Maximization, Unsupervised Learning, Clustering, Vector Quantization, K-means

MECE 566 Artificial Intelligence for Mechatronics Engineers (3 0 3) 7.5 ECTS
Introduction: What Is AI? Agents and Environments, The Nature of Environments, The Structure of Agents: Agent programs, Simple reflex agents, Model-based reflex agents, Goal-based agents, Utility-based agents, Learning agents, Solving Problems by Searching, Searching for Solutions, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Knowledge-Based Agents, Reasoning, Advanced Search Strategies, First-Order Logic, Making Simple Decisions, Learning, Learning: Supervised Learning, Unsupervised Learning, Reinforcement Learning, Reinforcement Learning, Definition of Optimization, Fundamental Optimization methods, Neural Networks, Genetic Algorithms, Genetic Programming, Fuzzy Logic

MECE 584 Robot Vision (3 0 3) 7.5 ECTS
Introduction to Computer Vision: Human visual system, comparison with a machine vision system, Computer Vision, Industrial Machine Vision vs. Image understanding, components of machine vision system in context of a manufacturing environment, Illumination and sensors: Control of illumination and light levels, Image formation- elementary objects, camera sensors- CCD, CMOS, characteristics of camera sensors.
Image Acquisition: Sampling and quantization, Inter pixel distances, adjacency conventions. Image acquisition hardware, speed considerations, Digital image processing: Basics of digital image, Point operations- contrast stretching, thresholding, noise suppression by image addition, background subtraction. Neighborhood operations- convolution, noise suppression, Image Segmentation : An overview of edge detection techniques: Gradient and difference based Operators-Roberts estimate operators, template matching, edge fitting, assessment of edge detection, Image Analysis: Introduction- inspection, location and identification, image analysis techniques template matching, components of statistical pattern recognition process, Houghs transform technique, Robot programming and robot vision: Brief review of robot programming methodologies, homogeneous transformations, robotic programming language- RCL: data types and variable declarations, arithmetic expression statements, frame expression statements, Vision algorithms: Vision algorithms for identifying end wires- binary vision algorithm, grey scale vision algorithm, active ranging using structured light technique in industrial vision, Machine vision in manufacturing: Types of tasks- code recognition, object recognition, position recognition, completeness check, shape and dimension check, surface inspection. Types of production, types of evaluation, Value- Adding machine vision, Case Studies: Machine vision applications to industries: Condition monitoring, metrology and gauging, OCR and OCV, Augmented reality, Surveillance.

MECE 547 Linear System Theory I (3 0 3) 7.5 ECTS
Linear spaces: fields, linear independence, Basis, direct sum decomposition, normed linear spaces, convergence concepts, Banach spaces. Linear transformations: null and range spaces, matrix representation, Inner product spaces, Hilbert spaces, concept of orthogonality, Projection theorem, direct sum decomposition, Projection theorem, Hermitian matrices, Systems of linear algebraic equations, Fourier series, Linear transformations defined by a

square matrix characteristic and minimal polynomials, Block diagonal form, Jordan canonical form, Functions of a square matrix

MECE 548 Linear System Theory II (3 0 3) 7.5 ECTS
Differential equations: existence and uniqueness, Linear differential equations, stability of solutions, Variational equation, periodically time-varying differential equations, Difference equations, Dynamical system representations: Equivalence, linearity, time-invariance, Differential system representations: Impulse response, system function, Stability (Lypunov stability, bounded input bounded state stability, bounded input bounded output stability), Algebraic equivalence, duality, Controllability, observability,
Realization, Kalman Decomposition (decomposition of controllable and observable parts), Transform techniques.

MECE 587 Optimization (3 0 3) 7.5 ECTS
Methods of proof and some notation. Vector spaces and matrices, Transformations: Linear transformations, Eigenvalues and Eigenvectors, Orthogonal Projections, Quadratic Forms and Matrix Forms, Concepts from Geometry: Linear Segments, Hyperplanes and Linear Varieties, Convex sets, Neighborhoods, Polytopes and Polyhedra, Elements of Calculus Sequences and Limits, Differentiability, Derivative Matrix, Differentiation Rules, Gradients and Tayler Series, One Dimensional Search Methods: Golden Section Search, Fibonacci Search, Newton's Methods, Secant Method, Line Search Methods, Gradient Methods: Method of Steepest Descent, Analysis of Gradient Methods, Newton's Methods: Levenberg-Marguardt Modification
Conjugate Direction Methods: Conjugate Direction and Gradient Algorithms, Quasi-Newton Methods: Approximating the inverse Hessian, The Rank One Correction Formula, DFP and BFGS algorithms, Kaczmarz's algorithm. Solving Ax=b in general.
Genetic Algorithm: Chromosomes and Representation Schemes, Selection and Evolution, Introduction to Linear programming, Simplex Methods and Duality

MECE 588 Power Electronics and Electrical Drives (3 0 3) 7.5 ECTS
Basics of power electronics and electrical drives, Power electronics elements and their characteristics, AC-DC converters-Single phase rectifiers, Three phase rectifiers, DC-DC converters-Buck regulator, Boost and Buck-Boost regulators and their operation characteristics, DC-AC converters (Inverters)-Single phase inverters, Three-phase inverters and PWM control techniques, Basics of electric machines and their operation principles, DC machine control – different configurations, AC machine control- different configurations, Control methodes in electric machine drives, Simulation studies using Matlab-Simulink

MECE 590 Seminar (0 0 0) 7.5 ECTS
Introduction to the course and selection of seminar topics, Literature review and analysis, Drafting the seminar report, Supervisor's evaluation of the draft report, Revisions based on feedback, Discussion on presentation techniques, Preparation of the seminar, Practice sessions for the oral examination, Delivery of the seminar presentation, Incorporation of feedback and submission of the final report.

MECE 592 Projects (0 0 0) 15 ECTS
What is a scientific project?, Definitions of basic concepts, Scientific research methods, Finding a project idea, Examining TUBITAK projects and BAP projects, Preparing the problem definition section, Preparing the purpose of the study section, Preparation of research question and/or hypothesis section, Preparation of the method and methods section used in the project,

Preparation of project time plan, Summary and conclusion writing, Information about TUBITAK, industrial projects and BAP projects, Project assignment presentation

MECE 599 Thesis (0 0 0) 60 ECTS
Orientation and overview of the thesis process, Defining the research problem and aim, Formulating research questions and/or hypotheses, Building the theoretical and conceptual framework, Literature review techniques and reference management, Research design and methodology selection, Development of data collection tools, Ethical review and preparation for fieldwork, Data collection process, Data analysis techniques, Presentation and interpretation of findings, Writing the discussion and conclusion sections, Academic writing, referencing, and formatting, Thesis defense preparation and presentation practice.