Course Descriptions

Numerical Code

For the engineering and technology courses, the following numerical codes are used.

- The first digit indicates the level of difficulty.
- The second digit indicates the course groups.

For the common courses, the above codes are not applied.

The numbers after each course (e.g., 3(3-0-6)) represent the credits, lecture hours, laboratory hours, and self study hours, respectively.

Prerequisite / Corequisite Requirements

It is the responsibility of the student to meet all prerequisite and corequisite requirements. Students may not be allowed to take a course if its prerequisites have not been satisfactorily passed. A corequisite course must be taken concurrently or must have been previously passed.

CES 201 Engineering Materials 3(3-0-6)
Prerequisite: None
Metals, plastics, asphalt, wood, cementitious materials, and concrete as engineering materials. Phase equilibrium diagrams and their interpretation. Testing and meaning of properties. Study of macro and microstructures in relationship with properties of engineering materials. Production processes for products using engineering materials. Deterioration and corrosion of engineering materials.

CES 215 Applied Mathematics in Civil Engineering 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
Ordinary differential equations of the first order. Linear ordinary differential equations of higher order. General ordinary differential equations. Boundary-value problems. Introduction to weak formulations. Initial-value problems. Eigen-value problems and their applications. Introduction to probability and statistics.

CES 302 Engineering Hydrology 3(3-0-6)
Prerequisite: None
Hydrologic cycle. Atmospheric water. Subsurface water. Groundwater. Surface water. Unit hydrograph. Flood routing. Hydrologic statistics. Frequency analysis.

CES 303 Civil Engineering Training 0(0-0-0)
Prerequisite: Junior standing
Students are provided with on-the-job training at selected governmental organizations, state enterprises or private companies. The purposes of the course are to provide the students opportunities to experience civil engineering works other than what learned in the class. The training period must not be less than 240 hours. Student must submit a report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on student's performance, quality of the report, and supervisor's comments.

CES 304 Engineering Geology 3(3-0-6)
Prerequisite: None
The earth and the universe. Scope of engineering geology. Geological processes and plate tectonics. Minerals and rocks, weathering and erosion. Earthquakes and the earth's interior. Deformation and mountain building: problems of dip and strike, joints, folds and faults. Mass wasting and landslides. Landforms: action of river, groundwater, glacier, wind and ocean. Maps: topographic and geological maps. Geology of reservoirs and dams.

CES 305 Urban Hydrology 3(3-0-6)
Prerequisite: None
Hydrologic cycle. Atmospheric water. Surface water. Unit hydrograph. Hydrologic statistics. Frequency analysis. Design storms. Design flows. Drainage design.

CES 311 Theory of Structures 3(3-0-6)
Prerequisite: CES 371 or consent of Head of School
Introduction to structural analysis. Reactions, shears and moments in statically determinate structures. Influence lines. Analysis of stresses in trusses. Graphic statics. Structures subjected to moving loads. Deflections of beams and frames by methods of virtual work and strain energy. Williot-Mohr diagrams. Analysis of statically indeterminate structures by the method of consistent deformation.

CES 312 Structural Analysis 3(3-0-6)
Prerequisite: CES 311 or consent of Head of School
Analysis of indeterminate structures. Elastic load methods. Strain energy method. Slope-deflection and moment distribution methods. Influence line for continuous beams and frames. Introduction to plastic analysis. Approximate analysis of building frames. Introduction to the matrix method of structural analysis.

CES 315 Computational Methods in Civil Engineering 3(3-0-6)
Prerequisite: MAS 215 or CES 215 or consent of Head of School
Use of computers. Programming concepts and techniques. Modern programming languages and tools for engineering problems. Numerical methods as applied to civil engineering problems. Introduction to finite element methods.

CES 321 Timber and Steel Design 3(3-1-5)
Prerequisite: CES 312 or consent of Head of School
Design of timber and steel structures. Tension and compression members. Beams. Beam-columns. Built-up members. Plate girders. Connection. Design practice. Tutorial design workshops.

CES 322 Reinforced Concrete Design 3(3-1-5)
Prerequisite: (CES 311 and CES 351) or consent of Head of School
Material properties of concrete and reinforcing bars. Fundamental behavior in thrust, flexure, shear, torsion, bond and interaction among these forces. Design of reinforced concrete structural components, i.e., beams, columns, slabs, stairs, footings, and retaining walls by working stress and strength design concepts. Reinforcement detailing. Tutorial design workshops.

CES 323 Advanced Structural Concrete Design 3(3-0-6)
Prerequisite: CES 322 or consent of Head of School
Analysis and design of T-beams, continuous beams, deep beams, long columns, combined footings, mat footings, pile caps and composite beams. Shear friction behavior and design. Strut and tie models. Design of one or two-storey houses. Introduction to prestressed concrete design.

CES 324 Structural Systems 3(3-0-6)
Prerequisite: None
Introduction to the physical principles that govern classical statics and mechanics of materials through the design of structural components of architectural structures.

CES 331 Soil Mechanics 3(3-0-6)
Prerequisite: CES 371 or consent of Head of School
Classification of soils. Soils and soil formation. Soil constituents and their properties. Physical properties of soils. Basic engineering properties of soils. Effective stress and pore pressure. Permeability of soils. Stresses and strains in a continuous body. Consolidation: one-dimensional consolidation. Shear strength and failure of soils. Stability analysis: plastic equilibrium, upper and lower bound solutions. Retaining wall.

CES 332 Foundation Engineering 3(3-0-6)
Prerequisite: CES 331 or consent of Head of School
Subsurface exploration. Soil/ground improvement: compaction, vibroflotation, precompression, sand drains, mechanical and chemical stabilization. Stability of slopes: infinite slopes, mass procedure and method of slices. Ultimate bearing capacity and Terzaghi's bearing capacity theory. Shallow foundation. Mat foundation. Pile foundation: types of piles, pile capacity, pile driving formula, and group piles. Elastic settlement of both shallow and deep foundations. Sheet piles: cantilever sheet piles and anchored sheet piles.

CES 333 Soil Mechanics Laboratory 1(0-3-0)
Corequisite: CES 331 or consent of Head of School
Soil exploration. Index properties of soils. Permeability. Compaction: CBR. Stress-strain behavior of soils. Shear strength and one dimensional consolidation.

CES 341 Transportation Engineering and Planning 3(3-0-6)
Prerequisite: None
Characteristics of transportation supply and demand. Measuring and estimating demand. Social and environmental impacts. Planning of transportation systems. Characteristics of transportation modes. Interaction between modes. Mode interfaces. Transportation technology, economics, public policy, implementation and management.

CES 343 Highway Engineering 3(3-0-6)
Prerequisite: CES 341 or CES 450 or consent of Head of School
Historical development of highways. Highway administration. Principles of highway planning. Traffic analysis. Geometric design and operations. Highway finance and economics. Highway materials. Flexible and rigid pavement design. Highway construction and maintenance. Problem-based studies.

CES 344 Logistics System Engineering 3(3-0-6)
Prerequisite: None
Roles of infrastructure systems and logistics. Basic concepts and case studies in international, regional, and urban logistics. Theory of commodity flows. Inventory management. Transportation costs. Intermodal logistics. Logistics distribution centers. Geographic Information System (GIS) for logistics routing and scheduling. Logistics optimization, decision making, and strategic planning. Information technologies in logistics.

CES 351 Concrete Technology 3(3-0-6)
Prerequisite: SCS 139 or consent of Head of School
Background of concrete. Cement: production, raw materials, types of cement, chemical and physical properties of cement, and hydration of cement. Aggregates: absorption, moisture content, specific gravity, solid volume and void ratio, gradation, and mechanical properties. Admixtures: mineral and chemical admixtures, and special admixtures. Properties of concrete in fresh state: workability, deformability, and segregation. Properties of concrete in plastic state. Properties of concrete in early age state. Properties of concrete in hardened state: mechanical properties and durability. Concrete practices.

CES 352 Material Testing 1(0-3-0)
Prerequisite: (CES 311 and CES 351) or consent of Head of School
Tests on properties of cement, properties of aggregates, properties of fresh cement paste, properties of fresh mortar, and properties of fresh concrete. Strength test of hardened concrete. Tensile test of reinforcing steel. Test on flexural reinforced concrete members.

CES 353 Construction Engineering and Management 3(3-0-6)
Prerequisite: None
Project delivery systems. Project organization. Site layout. Project planning. Critical path method. Resource management. Progress measurement. Construction safety. Quality systems. Contracts and tendering. Construction laws and regulations. Construction methods and equipment. Cost estimation.

CES 354 Civil Engineering Project Appraisal 3(3-0-6)
Prerequisite: None
Fundamentals of project appraisal and feasibility study. Planning of civil engineering projects. Economic analysis of civil engineering projects. Introduction to environmental impact assessment and social impact assessment. Case studies on civil engineering project appraisal.

CES 355 Construction Estimating and Tendering 3(3-0-6)
Prerequisite: CES 353 or consent of Head of School
Principles of construction cost estimating. Quantity takeoff. Methods of detailed cost estimating. Analysis of labor and equipment costs. Construction tendering process. Bidding and contracting systems for construction projects. Laws and regulations related to the construction industry.

CES 356 Introduction to the Construction Industry 3(3-0-6)
Prerequisite: None
Characteristics of the construction industry. Types of construction companies. Contracts. People involved in a project, their responsibilities and interrelationships. Evolution of a project. Interpreting working drawings. Construction bonds. Contract documents.

CES 361 Surveying 3(2-3-4)
Prerequisite: None
Introduction to surveying work. Basic field works: leveling. Principles and applications of theodolite. Angle measurement. Distance measurement. Errors in surveying: acceptable error, data correction, and triangulation. Precise determination of azimuth. Precise traverse plane coordinate system. Precise leveling. Route survey. Topographic survey. Map plotting. Introduction to photogrammetry and remote sensing.

CES 362 Introduction to Photogrammetry and Remote Sensing 3(2-3-4)
Prerequisite: CES 361 or consent of Head of School
Basic concepts of photogrammetry. Cameras and photography. Mathematical and geometric principles relevant to photography. Rectification and orientation. Orthophotography. Mosaic. Applications of photogrammetry. Basic concepts of remote sensing. Sensor and platform. Digital imagery. Image enhancement. Rectification and classification.

CES 363 Land Development 3(3-0-6)
Prerequisite: None
Methods and practices of land development. Market research. Financial feasibility. Land use regulations. Legal documentation. Site analysis and design. Case studies.

CES 370 Mechanics of Materials 3(3-0-6)
(For non-civil engineering students)
Prerequisite: SCS 138 or consent of Head of School
Forces, stresses, and equilibrium. Strains. Stress-strain relationships. Elastic and plastic behavior of materials. Linear elasticity. Plane stress and plane strain problems. Uniaxial problems. Bending of beams. Torsional problems.

CES 371 Mechanics of Solids I 3(3-1-5)
Prerequisite: SCS 138 or consent of Head of School
Forces and stresses. Stress and strain relationships. Stresses in beams. Shear and bending moment diagrams. Deflection of beams. Torsion. Buckling of columns. Mohr's circle and combined stresses. Failure criterion.

CES 372 Mechanics of Solids II 3(3-0-6)
Prerequisite: CES 371 or consent of Head of School
Torsion. Shear stress and shear center. Composite beams and reinforce concrete beams. Buckling of columns. Unsymmetrical bending. Impact and repetitive loading. Failure criteria.

CES 381 Hydraulics 3(3-0-6)
Prerequisite: MAS 215 or CES 215 or consent of Head of School
Properties of fluids, viscosity. Fluid statics. Conservation of mass, momentum, and energy. Viscous flow in pipes. Open channel flow. Fluid flow measurements. Dimensional analysis and similarity.

CES 382 Hydraulics Laboratory 1(0-3-0)
Corequisite: CES 381 or consent of Head of School
Experimental measurement of viscosity. Fluid pressure. Principles of fluid flow through orifices and weirs. Measurement of flow in pipes, flow in open channels, and unsteady flow.

CES 391 Special Topics in Civil Engineering I 3(3-0-6)
Prerequisite: Senior standing
New topics or areas of study not offered in other civil engineering courses. Topics may vary from semester to semester, but are different from CES 392.

CES 392 Special Topics in Civil Engineering II 3(3-0-6)
Prerequisite: Senior standing
New topics or areas of study not offered in other civil engineering courses. Topics may vary from semester to semester, but are different from CES 391.

CES 403 Seminar 1(0-3-0)
Prerequisite: Senior standing or consent of Head of School
A group seminar on one or more topics of interest in the field of civil engineering as approved by the seminar advisor.

CES 404 Civil Engineering Project 3(0-9-0)
Prerequisite: CES 403
An individual project on an interesting topic of current research and/or practical problem in the field of civil engineering as approved by the project advisor must be completed. At the end of the course, the completed project must be presented orally and a report of the project must be submitted.

CES 405 Special Study in Civil Engineering I 3(3-0-6)
Prerequisite: Consent of Advisor and Head of School
An in-depth study of a topic in the field of civil engineering that is different from CES 406.

CES 406 Special Study in Civil Engineering II 3(3-0-6)
Prerequisite: Consent of Advisor and Head of School
An in-depth study of a topic in the field of civil engineering that is different from CES 405.

CES 407 Senior Project 6(0-18-0)
Prerequisite: CES 403
An in-depth study on a topic of interest in the field of civil engineering as approved by the project advisor.

CES 408 Extended Civil Engineering Training 6(0-40-0)
Prerequisite: Senior standing
Extensive on-the-job training of at least 17 weeks at a selected organization that provides civil engineering services—an individual comprehensive research or practical project related to the training must be intensively conducted under close supervision of faculty members and supervisors assigned by the training organization. At the end of the training, the student must submit a report of the project and also give a presentation.

CES 414 Finite Element Methods in Engineering 3(3-0-6)
Prerequisite: None
Fundamentals of finite element methods. Boundary-value problems. Variational principles. Approximate methods. Development of standard elements. Finite element procedures. Solution techniques and computer implementation. Problem-based studies.

CES 423 Building Design 3(3-0-6)
Prerequisite: CES 322 or consent of Head of School
Design concepts of various types of buildings. Analysis and design of components of buildings including foundations, frames, shear walls, slabs, walls and others, in which emphasis is placed on reinforced concrete buildings.

CES 424 Bridge Engineering 3(3-0-6)
Prerequisite: CES 322 or consent of Head of School
Planning of bridge projects. Design, analysis and construction of various types of bridges including reinforced and prestressed concrete bridges, steel bridges, composite bridges, and cable-supported bridges.

CES 425 Construction Methods and Technologies 3(3-0-6)
Prerequisite: CES 351 or consent of Head of School
Construction of foundations: pile foundations, mat foundations. Erection of formworks and shoring. Concrete work in practice: storage of materials, batching mixing, transporting, placing, consolidating, surface finishing, curing, etc. Construction of mass concrete. Construction of bridges. Construction of tunnels. Construction of highways. Construction of dams. Underground construction.

CES 426 Durability of Concrete Structures 3(3-0-6)
Prerequisite: CES 351 or consent of Head of School
Introduction on durability problems in concrete structures. Bleeding. Plastic shrinkage and plastic settlement. Autogenous shrinkage. Thermal properties and thermal cracking. Effect of extreme temperature. Carbonation. Drying shrinkage. Alkali-aggregate reactions. Acid and sulfate attacks. Freezing and thawing. Chloride-induced steel corrosion. Abrasion and erosion. Biological degradation. Concept of durability and service life design for concrete structures. Case studies on durability problems in real structures.

CES 427 Infrastructure Maintenance 3(3-0-6)
Prerequisite: None
Concepts of maintenance of civil engineering infrastructures. Deterioration of materials for constructing infrastructures. Life cycle evaluation. Inspection: visual inspection, non-destructive tests, and partially destructive tests. Load tests. Evaluation of types and levels of damages. Materials and methods for protection. Materials and methods for repair. Materials and methods for strengthening. Evaluation after repair. Maintenance planning.

CES 433 Soil Modeling 3(3-0-6)
Prerequisite: CES 332 or consent of Head of School
Basic continuum theory in soil mechanics. Virtual work principles. Linear elasticity. Nonlinear elasticity. Failure criteria for soils. Flow of soils in the plasticity theory with hardening and softening. Introduction to the cam-clay model and the cap model.

CES 434 Earth Structures 3(3-0-6)
Prerequisite: CES 332 or consent of Head of School
Earth pressure theories. Arching theories. Soil structure interaction and its effects on earth-retaining structures. Soil pressures and related ground movements of earth-retaining structures. Rigid and flexible conduits. Design of earth and rock-fill dam. Soil ground tunneling.

CES 444 Hydraulic Engineering 3(3-0-6)
Prerequisite: CES 381 or consent of Head of School
Engineering economy in water resources planning. Reservoirs. Design of gravity dams, arch dams, buttress dams and earth dams. Spillways. Open channel flow and design. Piping systems, water hammer. Pumps and turbines. Design of drainage systems.

CES 445 Structural Dynamics 3(3-0-6)
Prerequisite: CES 312 or consent of Head of School
Essential characteristics of dynamic problems. Dynamics of simple structures: single-degree-of-freedom systems. Governing laws of motion. Free vibration responses. Responses to periodic forces. Analysis of responses to arbitrary dynamic loadings by the Duhamel integral. Dynamics of complex structures: multi-degree-of-freedom systems. Formulation of matrix equations of motion by the energy approach. Modal analysis: concept of principal coordinates. Introduction to structural responses to wind and earthquake. Introduction to vibration control techniques.

CES 446 Port and Airport Engineering 3(3-0-6)
Prerequisite: CES 341 or CES 450 or consent of Head of School
Planning and design of seaports and harbors. Planning of container terminal and cargo handling systems. Airport master planning. Air traffic control. Design of airport facilities.

CES 447 Land Transportation Engineering 3(3-0-6)
Prerequisite: CES 343 or consent of Head of School
Principles of highway and railway planning, design, and operations. Design of location and route layout, sections and intersections, drainage and earthwork, and pavements. Land transportation finance, economics, construction, and maintenance.

CES 448 River Engineering 3(3-0-6)
Prerequisite: (CES 381 and CES 444) or consent of Head of School
Classifications of rivers. Data collection methods. Velocity and flow rate measurement. Design of hydraulic structures: dike, spillway, dam, gate, pumping station, and sheet pile. Countermeasure on sediment control: corrosion, deposition, and scour. Bill of quantity and cost estimation. Operation and maintenance.

CES 449 Tunneling and Underground Excavations 3(3-0-6)
Prerequisite: (CES 304 and CES 331) or consent of Head of School
Tunneling and excavations in hard rock: basic rock mechanics, shape, size and orientation of an opening, elastic deformation and the Kirsch solution, rockmass classification, support design and ground reaction curve, drill and blast method, NATM tunneling method. Tunneling in soft ground: problems of urban tunneling, deformation and surface settlement, load on liners, face stability, methods of soft ground tunneling including EPB and slurry shield methods.

CES 450 Urban Engineering 3(3-0-6)
Prerequisite: None
Urban land use planning. Population dynamics. Urban transportation planning. Mass transit systems. Welfare economics. Economics of public goods. Public infrastructure financing. Urban environmental issues.

CES 451 Site Investigation 3(3-0-6)
Prerequisite: None
Surface/Subsurface exploration. Concept of land use mapping and terrain evaluation. Site location and site investigation for roadways and tunnels. Groundwater exploration. Dam and reservoir site investigation. Waste disposal site location and geotechnical aspect of landfill sites.

CES 491 Probabilistic Methods in Structural Engineering 3(3-0-6)
Prerequisite: None
Analysis and specification of structural performance using probabilistic and statistical methodology. Material properties' variability. Uncertainty in live, earthquake or wind loadings and responses. Reliability of structural systems. Applications of computer simulation. New code formulas with a probabilistic basis.

CES 493 Pavement Design 3(3-0-6)
Prerequisite: (CES 322, CES 332 and CES 343) or consent of Head of School
Characteristics of pavement loads. Stress analysis in pavements. Design practices. Construction, rehabilitation and maintenance. Optimization of the design of rigid and flexible pavements systems. Empirical and mechanistic stochastic structural subsystems. Utility theory. Serviceability concept. Cost studies. Traffic delay. Environmental deterioration. Rehabilitation and maintenance optimization systems.

CES 494 Coastal Engineering 3(3-0-6)
Prerequisite: CES 381 or consent of Head of School
Linear wave theory. Transformation of regular waves. Analysis of irregular waves. Transformation of irregular waves. Nearshore currents. Sediment transport. Beach deformation. Design of breakwaters, seawalls, groins and jetties.

CES 495 Hydraulics Structures 3(3-0-6)
Prerequisite: CES 381 or consent of Head of School
Hydraulics aspect of the theory and design of hydraulic structures: storage dams, spillway, outlet works, diversion works, drop structures, stone structures, conveyance and control structures, flow measurement and culverts.

CES 498 Water Supply and Sanitary Engineering 3(3-0-6)
Prerequisite: CES 381 or consent of Head of School
Sources of water supply: drinking water standards, quality requirement, groundwater collecting. Water transmission and distribution. Cold water systems. Waste and vent systems. Water treatment techniques: screening, coagulation and flocculation, sedimentation, filtration, disinfection, softening removal, and taste and odor removal.

CHS 211 Organic Chemistry for Engineers 3(3-0-6)
Prerequisite: SCS 126 or consent of Head of School
A study of all aspects of fundamental organic chemistry, including nomenclature, chemical and physical properties, reactions and syntheses of the major classes of organic compounds.

CHS 212 Physical Chemistry for Engineers 3(3-0-6)
Prerequisite: SCS 126 or SCS 139 or consent of Head of School
Quantum theory, spectroscopy, statistical mechanics, thermodynamics, kinetic theory, reaction kinetics, and electrochemistry.

CHS 213 Applied Mathematics in Chemical Engineering 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
Treatment and interpretation of engineering data. Ordinary differential equations of the first order and higher order. Laplace transformation. Fourier analysis – Fourier series. Integrals and transforms. Partial differential equations. Nonlinear equations, approximation and interpolation, numerical differentiations and integration. Numerical solution of differential equations. Emphasis on solving chemical engineering problems.

CHS 241 Material and Energy Balance 3(3-0-6)
Prerequisite: SCS 126 or consent of Head of School
Introduction to chemical engineering calculation: stoichiometry and material balance calculation, recycling, bypassing and purging, use of chemical and phase equilibrium data, and energy balance.

CHS 242 Chemical Engineering Thermodynamics I 3(3-0-6)
Prerequisite: None
Definitions and basic concepts. SI units. Properties of pure substances and ideal gases. Heat and work. First and second laws of thermodynamics and their applications. Concept of entropy. Power and refrigeration cycles, equipment including gas turbines and internal combustion engines.

CHS 251 Unit Operations I 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Physical properties of fluids, fluid static and applications, characteristics of fluid flow and momentum transfer including applications, design of unit operations for solid-fluid separations.

CHS 301 Chemical Engineering Training 0(0-0-0)
Prerequisite: Junior standing or consent of Head of School
Students are provided with on-the-job training at selected modern industrial or service facilities. The purpose of the course is to allow the students

opportunities to observe how industrial engineers function, to learn how to collaborate with co-workers, and to develop self-responsibility. The training period must not be less than 240 hours. Students must submit a report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on student's performance, quality of the report, and supervisor's comments.

CHS 316 Statistics for Chemical Engineering 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
Course covers applications of statistics to chemical engineering. Topics include probability, descriptive statistics, estimation, hypothesis testing, regression, and experimental design.

CHS 321 Cell Biology for Chemical Engineers 3(3-0-6)
Prerequisite: SCS 126 or consent of Head of School
Cells and cell structure, introduction to microbiology, microbial ecology, metabolic diversity in microorganisms, microbial biotechnology.

CHS 327 Bio-Chemical Technology 3(3-0-6)
Prerequisite: SCS 126 or consent of Head of School
Introduction to Bio-Chemical technology, general concepts of enzyme catalysis. Applications of chemical engineering concepts in Bio-Chemical technology and Bio-Chemical processes.

CHS 328 Pharmaceutical Industry and Technology 3(3-0-6)
Prerequisite: None
Survey of basic principles of biochemistry and molecular biology with emphasis on broad understanding of chemical events in pharmaceutical products in the industry in terms of metabolism and structure-function relationships of biological molecules. Introduction to pharmaceutical production systems including separation and purification processes.

CHS 331 Chemical Reaction Kinetics and Reactor Design 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Application of thermodynamic and kinetic fundamentals to the analysis and design of chemical reactors, types of reactors: single reactor and multiple reactor systems, isothermal and non-isothermal operations of reactors, homogeneous reactors, and introduction to heterogeneous reactors.

CHS 343 Chemical Engineering Thermodynamics II 3(3-0-6)
Prerequisite: CHS 242 or consent of Head of School
Thermodynamics of multi-component systems and applications for phase equilibrium and chemical reaction equilibrium.

CHS 352 Unit Operations II 3(3-0-6)
Prerequisite: CHS 251 or consent of Head of School
Basic principles and mechanisms for heat transfer, conceptual design for heat transfer equipment.

CHS 353 Unit Operations III 3(3-0-6)
Prerequisite: CHS 352 or consent of Head of School
Basic principles and mechanisms for mass transfer, conceptual design of mass transfer and simultaneous heat-mass transfer equipment.

CHS 358 Chemical Process Laboratory 1(0-3-0)
Prerequisite: CHS 241 or consent of Head of School
Fundamentals, instrumentation, and techniques with emphasis on quantitative chemical analysis, including spectroscopic methods, volumetric analysis, redox and acid-base titrations, gravimetric analysis as well as some preparative techniques used in organic and inorganic synthesis.

CHS 359 Computer Application for Chemical Engineering 3(2-3-4)
Prerequisite: None
Problem-based course: Computer applications for chemical engineering calculation, development of mathematical models and computer solution, process simulation and process analysis using software packages.

CHS 362 Chemical Engineering Laboratory I 1(0-3-0)
Corequisite: CHS 352 or consent of Head of School
Laboratory practice and experimental studies on topics covered in momentum and heat transfer.

CHS 363 Chemical Engineering Laboratory II 1(0-3-0)
Corequisite: CHS 353 or consent of Head of School
Laboratory practice and experimental studies on topics covered in simultaneous heat and mass transfer.

CHS 371 Petroleum and Petrochemical Technology 3(3-0-6)
Prerequisite: CHS 211 or consent of Head of School
Introduction to petroleum and petrochemical products, natural gas and their uses. Study chemical and physical properties of some important petrochemical products. Applications of chemical engineering fundamentals to the design of processes in the petrochemical industry including refinery and production plants.

CHS 372 Polymer Science and Development 3(3-0-6)
Prerequisite: CHS 211 or consent of Head of School
Principles of polymer synthesis, characterization, and structure/property relationship. Polymer synthesis covering fundamental kinetics and mechanisms of polymerization reactions. Principles and applications of polymer characterization techniques including spectroscopy, thermal property measurements, crystal structures, nano and micro-structures of polymers.

CHS 373 Polymer Processing 3(3-0-6)
Prerequisite: CHS 211 or consent of Head of School
Basic understanding of mechanical behaviors of polymer and polymer processing methods. Mechanical properties covered in this class: fluid mechanics, viscoelasticity, creep and stress relaxation, rheology, macroscopic and microscopic aspects of deformation and fracture, hardening mechanisms, high temperature deformation, and fracture mechanisms.

CHS 402 Chemical Engineering Seminar 1(0-2-1)
Prerequisite: Senior standing
Students are required to present reports on current developments of chemical engineering technology to their classmates and faculty members. The reports may lead to senior projects later on. The reports have to be submitted for grading.

CHS 414 Computational Chemistry 3(3-0-6)
Prerequisite: SCS 126 or SCS 139 or consent of Head of School
Numerical analysis focusing on methods used in mathematical models in chemistry: molecular mechanics and molecular dynamics of small and large molecules, potential energy surfaces, force fields, energy minimization by numerical methods, and quantum mechanical approaches.

CHS 415 Environmental Chemical Engineering 3(3-0-6)
Prerequisite: SCS 126 or consent of Head of School
Impacts of environmental pollution, environmental quality standards, sources and characteristics of industrial wastes and treatment methods, and hazardous wastes and disposal methods.

CHS 417 Safety in Chemical Operations 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Principles of safety and loss prevention control, hazard identification and handling including risk assessment, principles of safety management, and legislation and safety laws.

CHS 424 Engineering Properties of Biomaterial 3(3-0-6)
Prerequisite: None
Concept of biomaterials, metallic implant materials, bioceramics, biopolymers and composite implant materials, tissue response to implants, medical devices and evaluation, soft and hard tissue replacement, and introduction to tissue engineering.

CHS 425 General Food Science 3(3-0-6)
Prerequisite: None
Studies of the physical, chemical, and microbiological aspects of food, the function of and changes in components during preparation and processing of food.

CHS 426 Genetic Engineering 3(3-0-6)
Prerequisite: None
Basic principles of classical and molecular genetics, structure and functions of nucleic acids, replication and regulation with emphasis on genetic diseases, mutations, and genetic engineering and its applications.

CHS 429 Bio-Chemical Technology Laboratory 1(0-3-0)
Prerequisite: CHS 327 or consent of Head of School
Laboratory practice and experimental studies on topics covered in Bio-Chemical technology.

CHS 455 Chemical Engineering Process Design 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Problem-based course: Applications of chemical engineering fundamentals to the design of a multi-unit process. Emphasis on use of process simulators.

CHS 457 Chemical Engineering Plant Design 3(3-0-6)
Prerequisite: CHS 455 or consent of Head of School
Problem-based course: Conceptual design of chemical plants, general design considerations and selection, process design projects of a chemical plant.

CHS 461 Process Dynamics and Control 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Mathematical modeling of chemical engineering systems, solution techniques and dynamics of these systems, introduction to automatic control, feedback control concepts, stability analysis, frequency response and control system designs, introduction to measurement, and control instrument characteristics.

CHS 462 Biosensor and Bio-instrumentation 3(3-0-6)
Prerequisite: None
Principles of biologically based sensing elements and interfacing techniques. Design and analysis methods of biosensing and transducing components in bioinstrumentation. Applications of biosensors and bioinstrumentation in bioprocessing, bioenvironmental, biomechanical and biomedical engineering.

CHS 463 Energy Technology and Management 3(3-0-6)
Prerequisite: CHS 241 or consent of Head of School
Electric power generation and distribution, heat exchangers, pinch analysis, fuels and combustion, heat engines and steam boilers, principles of energy management in industry, energy auditing, cleaner technology, and tools and methods to enhance the efficiency of industrial energy systems.

CHS 474 Polymer Composite and Biopolymers 3(3-0-6)
Prerequisite: CHS 211 or consent of Head of School
This course focuses on synthesis, characterization, polymer composites and their applications. Topics include: polymer synthesis and functionalization, thermodynamics of polymer solutions, polymer blends, crystallization, microphase separation in block copolymers, biological applications of polymeric materials and characterization of polymer blends employing FTIR spectroscopy.

CHS 481 Special Topics in Chemical Engineering I 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other chemical engineering courses. Topics may vary from semester to semester. Topic covered is different from CHS 482 and CHS 483.

CHS 482 Special Topics in Chemical Engineering II 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other chemical engineering courses. Topics may vary from semester to semester. Topic covered is different from CHS 481 and CHS 483.

CHS 483 Special Topics in Chemical Engineering III 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other chemical engineering courses. Topics may vary from semester to semester. Topic covered is different from CHS 481 and CHS 482.

CHS 484 Senior Project 6(0-18-0)
Prerequisite: Senior standing
A student team will be given a problem, for which they must determine appropriate approaches and actions to

obtain feasible solutions. This involves establishment of initial contacts, project proposal development, preliminary data collection, data analysis, verification of the results, and practical implementation. A presentation of the project and the submission of a comprehensive report are due at the end of the semester.

CHS 485 Special Study in Chemical Engineering I 3(3-0-6)
Prerequisite: Consent of Advisor and Head of School
An in-depth study of a topic in the field of chemical engineering.

CHS 486 Special Study in Chemical Engineering II 3(3-0-6)
Prerequisite: Consent of Advisor and Head of School
An in-depth study of a topic in the field of chemical engineering. Topic covered is different from CHS 485.

CHS 487 Chemical Engineering Extended Training 6(0-40-0)
Prerequisite: Senior standing
Students are provided with on-the-job training at selected modern industrial or service facilities for an extended period of at least 17 weeks. The purpose of the course is to allow the students opportunities to observe how industrial engineers function, to learn how to collaborate with co-workers, and to develop self-responsibility. Students must submit a report at the end of the training period.

CSS 221 Computer Graphics and Applications 3(2-3-4)
Prerequisite: None
Representation and manipulation of graphic data. Representation and transformations of two-dimensional space, three-dimensional space. Illumination and shading modes. Visualizing and analyzing numerical data associated with scientific, business, and/or entertainment applications. Methods of creating, storing, manipulating, presenting and animating two and three dimensional graphical objects. Elements of image processing. Programming computer graphics with OpenGL or similar library.

CSS 223 Principles of Programming Languages 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Style of conventional programming languages. Language evaluation criteria. Influences on language design. Lexical analysis. Syntax analysis. Semantic considerations. Study the concepts of conventional programming language, e.g., Pascal, Fortran, Cobol, Lisp, C.

CSS 224 Computer Architectures 3(3-0-6)
Prerequisite: ECS 371 or consent of Head of School
Computer evolution. Conventional computer architectures. CPU and ALU structures and design. Instruction sets. Hardwired and microprogrammed control. Pipelining. Array and vector processors. Multiprocessor systems. Memory organizations. Cache memory. I/O organizations.

CSS 225 Operating System 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Basic concepts of operating systems. Processes. Interprocess communication and synchronization. Input-output. File systems. Memory management.

CSS 300 Computer Science Training 0(0-0-0)
Prerequisite: Junior standing or
consent of Head of School
Practical training in private sectors or governmental departments in the field of computer science not less than 240 hours during summer vacation of the third year. Students must submit a report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on student's performance, quality of the report, and supervisor's comments.

CSS 321 Theory of Computation 3(3-0-6)
Prerequisite: None
Automata, computability, and complexity, emphasizing computability and computational complexity theory. Regular and context-free languages. Decidable and undecidable problems, reducibility, completeness theory, recursive function theory. Finite automata and regular languages. Push-down automata and context-free languages. Turing machines and decidable (recursive) languages.

CSS 322 Security and Cryptography 3(3-0-6)
Prerequisite: None
Principles of number theory and the practice of network security and cryptographic algorithms. Topics include primes, random numbers, modular arithmetic and discrete logarithms, conventional or symmetric encryption, and public key or asymmetric encryption, key management, hash functions, digital signatures, certificates and authentication protocols, electronic mail security, web security and protocols for secure electronic commerce, some applications, such as smart cards, electronic voting, and some programming topics, e.g., provable security.

CSS 323 Compiler Design 3(3-0-6)
Prerequisite: CSS 223 or consent of Head of School
Introduction to the compilation of programming languages. Principles and practice of lexical and syntactic analysis. Error analysis.

CSS 400 Project Development 1(0-3-0)
Prerequisite: Senior standing or
consent of Head of School
Practical projects or problems in Computer Science for individual students or groups of students under supervision of faculty members. Students are required to submit and present the project proposal to their project committee appointed by the school.

CSS 403 Senior Project 6(0-18-0)
Prerequisite: Senior standing or
consent of Head of School
Practical projects or problems in computer science for individual student or group of students under supervision of faculty members. Students are required to submit and present the project report to their project committee appointed by the school.

CSS 411 Software Process and Quality Assurance 3(3-0-6)
Prerequisite: None
Process concepts, including themes and terminology, process infrastructure (e.g. personnel, tools, training), modelling and specification of software processes, measurement and analysis of software processes, software engineering process improvement, quality

analysis and control (e.g. defect prevention, quality metrics, root cause analysis). Process implementation, including life cycle models (e.g. waterfall, incremental, spiral), life cycle process models and standards (e.g. IEEE, ISO), individual software process and team software process. Software quality concepts and culture. Software quality standards. Software quality processes. Process assurance and product assurance.

CSS 412 Software Architecture 3(3-0-6)
Prerequisite: None
Introduction to software design with emphasis on architectural design. Concepts and activities for software architecture design. Notations, models, and specification languages for software architecture design, Techniques, methods, tools for designing, building analysing, and evaluating software architecture. Object-oriented approach for software architecture design. Macro-level software system architectures with an emphasis on approaches to interconnection and distribution of system components. Models of software architecture. Architecture styles and patterns, including explicit, event-driven, client-server, and middleware architectures. Decomposition and composition of architectural components and interactions. Use of non-functional requirements for trade-off analysis. Micro-level architecture including patterns, frameworks, and component-based software engineering. Management of software architecture design. Reuse of software architecture design.

CSS 413 Software Verification and Validation 3(3-0-6)
Prerequisite: None
Theory and practice of software testing. Topics include V&V terminology and Foundations, including metrics and measurement (e.g. reliability, usability, performance). Methods for evaluating software for correctness, and reliability including code inspections, program proofs and testing methodologies. Formal and informal proofs of correctness. Code inspections and their role in software verification. Unit and system testing techniques. Coverage analysis (e.g. statement, branch, basis path, multi-condition, dataflow). Black-box functional testing techniques, integration testing. Developing testing cases based on use cases or customer stories. Operational profile-base testing. System and acceptance testing. Testing across quality attributes (e.g. usability, security, compatibility, accessibility).

CSS 414 Software Project Management 3(3-0-6)
Prerequisite: None
Fundamental issues in the management and economics of a software engineering project in the context of the software development lifecycle. Topics: techniques for project planning (cost estimation; budgeting and scheduling), controlling (including quality assurance and configuration management), risk analysis and risk management, organizing, staffing, and directing a software project (leadership and motivation), capability maturity model (CMM), and contemporary issues in management.

CSS 421 Pattern Recognition 3(3-0-6)
Prerequisite: None
Introduction to statistical decision theory, adaptive classifiers, and supervised and unsupervised learning. Different types of pattern recognition systems are introduced, including transducers, feature extraction, and decision units. Techniques for optical character recognition, speech processing, and remote sensing.

CSS 422 Knowledge Management and Discovery 3(3-0-6)
Prerequisite: None
Introduction to knowledge and knowledge management concepts, knowledge modelling in order to effectively deploy organization practices, processes, and technology to increase the return on knowledge capital. Knowledge capital includes everything from new drugs designed from research into the human genome to better processes for responding to customer service complaints. Introduction to information retrieval, information retrieval models, retrieval evaluation. Data mining: principles and applications. Data mining techniques: characterization, association, classification and clustering.

CSS 423 Bioinformatics 3(3-0-6)
Prerequisite: None
The intersection of biology, mathematics, and computer science to address biological and medical research problems. Introduction to bioinformatics, which includes a survey of existing public databases and strategies for applying bioinformatics techniques to a variety of biological research problems, such as genomic analysis, DNA microarray analysis, phylogenetic, three-dimensional structure prediction, and proteomics.

CSS 424 Multimedia Processing 3(3-0-6)
Prerequisite: None
Multimedia processing in computer applications. Basic signal and image processing and the manipulation of audio, images, and video content. Methods to acquire, process, and organize multimedia information in various forms, such as speech, images, characters and so on. This will include the use of tools and packages as well as creating programs to access and process multimedia data. Some artistic and perceptual/cognitive principles relevant to presentation of multimedia information in order to realize a "human-friendly" man-machine interface.

CSS 425 Advanced Programming Languages 3(3-0-6)
Prerequisite: CSS 223 or consent of Head of School
Formal grammars. Context-free languages. The theory of programming language compilers.

CSS 495 Special Topics in Computer Science I 3(3-0-6)
Prerequisite: None
Special study on current topics related to computer science and computer engineering.

CSS 496 Special Topics in Computer Science II 3(3-0-6)
Prerequisite: None
Special study on current topics related to computer science and computer engineering.

CSS 499 Extended Computer Science Training 6(0-40-0)
Prerequisite: Senior standing or
consent of Head of School
Extensive on-the-job training of at least 17 weeks at a selected organization that provides computer science

services — an individual comprehensive research or practical project related to the training must be intensively conducted under close supervision of faculty members and supervisors assigned by the training organization. At the end of the training, the student must submit a report of the project and also give a presentation.

EC 210 Introductory Economics 3(3-1-5)
Prerequisite: None
A study of the principles of micro and macro economics with applications in basic economic problems; factors that influence supply and demand of products; consumer behavior; important features of perfect and imperfect competitive markets; analysis of Gross National Product, determination of National Income, fiscal and monetary policies; importance of international trade and finance on balance of payment and national income.

ECS 201 Basic Circuit Analysis 3(3-1-5)
(For non-major students)
Prerequisite: None
Current and voltage. Circuit elements. Kirchhoff's laws. Resistive circuits. Circuit analysis techniques such as node analysis, mesh analysis, superposition, and Thevenin's and Norton's equivalent circuits. Inductance and capacitance. First-order circuits and their responses. Second-order circuits and their responses. Sinusoidal steady-state analysis. Three-phase circuits. Mutual inductance and ideal transformers. Network responses: natural frequencies, network functions, frequency responses, resonance. Fourier series and applications to network analysis. Introduction to computer-aided circuit analysis and design.

ECS 202 Basic Electronic Circuits 3(3-1-5)
(For non-major students)
Prerequisite: ECS 201 or ECS 203 or
consent of Head of School
Introduction to voltage amplifiers, Bode plots. Operational amplifiers (Op-amp) as voltage amplifiers and 1st-order filters, inverting and non-inverting amplifiers summing and difference amplifiers, integrators, and low-pass filters. Semiconductors, PN junction, diodes and Zener diodes, half-wave, full-wave and bridge rectifiers, voltage regulators and power supplies. Bipolar junction transistors (BJTs), DC and AC analysis of common emitter amplifiers. Class A, B, AB power amplifiers. Feedback and control. Power electronic circuits, thyristors and phase-control rectifiers.

ECS 203 Basic Electrical Engineering 3(3-1-5)
(For non-major students)
Prerequisite: None
A service course covering electrical engineering principles and technology for students with major outside electronics and communication engineering. Topics include electrical signals, basic circuit theory, DC and AC circuit analysis, Kirchhoff's law, Thevenin theorem, three-phase circuits, basic electronic devices and circuits, fundamental of operational amplifiers, feedback and control, fundamentals of power systems, DC and AC motors and generators, transformers, loss and efficiency of DC/AC machinery, household/industry wiring and preview of electrical communication systems.

ECS 204 Basic Electrical Engineering Laboratory 1(0-3-0)
(For non-major students)
Corequisite: ECS 201 or ECS 203 or
consent of Head of School
A service course for students with major outside electronics and communication engineering. Laboratory practice and experimental studies on topics covered in ECS 201 or ECS 203.

ECS 205 Basic Electrical Engineering with Applications 3(2-2-5)
(For non-major students)
Prerequisite: None
A course for students with majors outside electronics and communication engineering. The course covers electrical engineering principles and technology, as well as laboratory practice and experimental studies. Topics included are basic circuit theory, DC and AC circuit analysis, DC and AC measurements, electronic devices and circuits, operational amplifiers, and feedback control systems.

ECS 210 Basic Electrical Engineering Laboratory 1(0-3-0)
Prerequisite: ECS 216 or consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 216.

ECS 213 Electrical Engineering Mathematics 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
First-order and higher-order ordinary differential equations (ODE's); series solution of ODE's; system of ODE's; partial differential equations; boundary value problems; vector spaces; basis and dimensions; Cayley-Hamilton theorem; functions of matrices; state-space representation; difference equations; computer-aided software for computation.

ECS 216 Circuit Analysis 3(3-1-5)
Prerequisite: None
Current and voltage; circuit elements; Kirchhoff's laws; resistive circuits; circuit analysis techniques such as node analysis, mesh analysis, superposition, and Thevenin's and Norton's equivalent circuits; inductance and capacitance; first-order circuits and their responses; second-order circuits and their responses; sinusoidal steady-state analysis; phasor diagram; three-phase circuits; computer-aided software for circuit analysis.

ECS 217 Computer Tools in Electrical Engineering 1(0-3-0)
Prerequisite: None
Basic descriptive geometry: points, lines, planes and their relationships and basic developed views; computer graphics: methods of creating, storing, manipulating, presenting and animating two and three dimensional objects; familiarization with graphical softwares; softwares and tools for electrical engineering: MATLAB, PSPICE, LaTeX, etc.

ECS 218 Data Structures, Algorithms, and Object Oriented Programming 3(2-2-5)
Prerequisite: ITS 100 or consent of Head of School
Problem-based learning; Concepts of data structures; basic data structures; stacks, queues, linked lists, trees, etc. recursion, hash tables, sorting and searching algorithms; Concepts of Object-oriented Programming;

class, inheritance and message passing; Practice on C++ and JAVA programming languages.

ECS 231 Electronic Circuits I 3(3-0-6)
Prerequisite: ECS 216 or consent of Head of School
Semiconductors and their characteristics. p-n Junction. Diodes and diode circuits. Bipolar junction transistors. Field-effect transistors. Transistor biasing and circuits. Analysis of transistor circuits. Transistor amplifier circuits. Frequency response of amplifiers.

ECS 233 Electromagnetics 3(3-0-6)
Prerequisite: MAS 117 and SCS 139 or
consent of Head of School
Static electric fields. Conductors and dielectrics. Capacitance. Convection and conduction currents. Static magnetic fields. Inductance. Magnetic materials and magnetic circuits. Time-varying electric and magnetic fields. Maxwell's equations. Electromagnetic waves and transmission lines. Introduction to waveguides and antennas.

ECS 261 Electrical Measurement and Instrumentation 3(3-0-6)
Prerequisite: ECS 201 or ECS 216 or
consent of Head of School
Units. Measurement standards. Errors in measurements. Basic instruments and their operation principles: ammeters, voltmeters, ohmmeters, wattmeters, oscilloscopes, signal generators, and signal analyzers. Instrument calibrations. Impedance measurements. Transducers and their applications. Digital techniques in measurements. Noise in measurements.

ECS 281 Signals and Systems 3(3-0-6)
Prerequisite: ECS 213 or MAS 215 or
consent of Head of School
Continuous-time and discrete-time signals and systems. Linear systems and their properties. Fourier analysis of continuous-time and discrete-time signals and systems. Sampling and Convolution, reconstruction of signals. Laplace transform and its applications to continuous-time system analysis. Z-transform and its applications to discrete-time system analysis.

ECS 300 Electronics and Communication Engineering Training 0(0-0-0)
Prerequisite: Junior standing or
consent of Head of School
Practical training in a private sector or governmental departments in related fields of electronics and communication engineering for not less than 240 hours during summer vacation of the third year. Students must submit a report at the end of the training period. A satisfactory (S) grade or an unsatisfactory (U) grade will be given based on the student's performance, quality of the report, and supervisor's comments.

ECS 306 Basic Electrical Machines and Power Systems 3(3-0-6)
Prerequisite: ECS 201 or ECS 203 or ECS 216 or
consent of Head of School
Basic concepts in power system analysis such as phasors, complex power, power factor improvement, three-phase circuit. Voltage, current and power calculations in single phase and three phase systems. Introduction to Magnetic Circuits and Transformers. Basic concept of DC and AC Rotating Machines. Induction motor and synchronous generator: principles, characteristic, operations and applications.

ECS 307 Basic Electromechanical Energy Conversion Laboratory 1(0-3-0)
Prerequisite: ECS 306 or ECS 308 or
consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 306 or ECS 308.

ECS 308 Basic Electromechanical Energy Conversion 3(3-1-5)
Prerequisite: ECS 201 or ECS 203 or ECS 216 or
consent of Head of School
Introduction to magnetic circuits. Basic principles of transformers, efficiency, and connections. Basic concepts of DC and AC rotating machines. Characteristics of DC generators, motors, speed control, and applications. Synchronous and induction machines: principles, characteristics, operations and applications. Three phase and single phase induction motors. Methods of starting single-phase induction motors.

ECS 315 Probability and Random Processes 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
Random experiments, events, probability, discrete and continuous random variables, probability density functions, cumulative distribution functions, functions of random variables, expectations; central limit theorem, law of large numbers, central limit theorem; introduction to random processes, random noise, Gaussian random process, autocorrelation and power spectral density.

ECS 320 Electronic Circuits Laboratory 1(0-3-0)
Prerequisite: ECS 231 or ECS 324 or
consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 231 or ECS 324.

ECS 322 Electronic Circuits II 3(3-0-6)
Prerequisite: ECS 231 or consent of Head of School
Problem-based learning; Introduction to differential amplifiers and current mirrors. Operational Amplifiers-741 op-amp circuits, feedback amplifiers, frequency responses, Bode plots, stability, phase compensation. Comparators. Waveform generators and waveshaping. Active filters. Switched-capacitor filters. Power electronic circuits: Regulated power supplies, regulators, and power amplifiers.

ECS 323 Physical Electronics 3(3-0-6)
Prerequisite: ECS 231 or ECS 324 or
consent of Head of School
Quantum mechanical principles. Atomic structure. Crystal structure. Energy band theory. Energy bands and charge carriers in semiconductors and metals. Equilibrium and transport properties of semiconductors. p-n Junction and diode equation. Diodes, bipolar and field-effect transistors. Physical principles of other semiconductor devices of current interest.

ECS 324 Electronic Devices and Basic Circuits 3(3-0-6)
Prerequisite: ECS 216 or consent of Head of School
Introduction to four types of amplifiers, voltage amplifiers, current amplifiers, transconductors, transresistors. Bode plots. Operational amplifiers (Op-

amp) as voltage amplifiers and 1st-order analogue filters, i.e. inverting and non-inverting amplifiers, voltage followers, summing and difference amplifiers, integrators, differentiators, low-pass filters, high-pass filters and all-pass filters. Non-ideal Op amps, CMRR, slew rate and offset voltage. Semiconductors, PN junction, diodes and Zener diodes, half-wave, full-wave and bridge rectifiers, voltage regulators, power supplies, clippers and clampers. Bipolar junction transistors (BJTs), DC and AC analysis of common emitters, common base and common collector amplifiers. Field-effect transistors (MOS and CMOS), DC and AC analysis of common sources, common gate and common drain amplifiers.

ECS 325 Analog Circuits 3(3-0-6)
Prerequisite: ECS 231 or ECS 324 or
consent of Head of School
Differential amplifiers and current mirrors. Frequency response, 2nd-order analogue filters using transistors and op-amps, i.e. low-pass filters, high-pass filters, band-pass filter, biquad filters and all-pass filters. Negative feedback, stability and phase compensation techniques. Positive feedback, linear and non-linear oscillators, quadrature oscillators, bistable, astable and monostable multivibrators.

ECS 332 Principles of Communications 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Corequisite: (ECS 315 or IES 302) or
consent of Head of School
Signal analysis and processing in communication systems. Principles of amplitude, angular, and pulse modulations. Digital modulation techniques. Noise in communication systems and its effects. Data transmission. Introduction to telecommunications.

ECS 341 Mobile Application Programming 3(2-2-5)
Prerequisite: ITS 100 or consent of Head of School
Problem-based learning; principles of mobile application development; programming languages, for mobile devices, such as Linux, JAVA, .NET, C/C++, Mac; syntax and library usage; hand-on practice on a suitable software development kit (SDK); current and future trends of mobile applications.

ECS 350 Communication Laboratory 1(0-3-0)
Prerequisite: ECS 332 or consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 332.

ECS 351 Communication Networks and Transmission Lines 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
End-to-end requirements. Network theorems. Analysis and design of equivalent one-port and two-port, series and parallel resonance. Wave filters Impedance transformation and matching. Network approach to theory of transmission lines. Utilization of transmission lines for impedance matching. Telephone lines. Switching systems. ISDN. Modem. LAN.

ECS 352 Telecommunications 3(3-0-6)
Prerequisite: ECS 332 or consent of Head of School
The structures and principles of telecommunication systems. Signal transmission in telecommunication systems. Telecommunication networks. Circuit switching and packet switching. Performance estimation. Congestion control.

ECS 353 Data Communications 3(3-0-6)
Prerequisite: ECS 332 or consent of Head of School
Data communication concepts. Theory and techniques in data communications: transmission, encoding, decoding, error detection, error correction, link control, networking, and standards. Data communication hardware and software.

ECS 362 Electronic Instrumentation 3(3-0-6)
Prerequisite: ECS 201 or ECS 216 or
consent of Head of School
Measurement standards. Errors in measurements. Measurement principles. Analysis, characteristics, and applications of instruments used in electrical engineering such as current, voltage, power, impedance measurement, signal generator, signal analyzer, etc. Introduction to industrial sensors, transducers, actuators, etc. Process measurement terminology and definitions (refer to ISA standards). Measurement of process variables: temperature, pressure, flow level, displacement, velocity, etc. Programmable Logic Control (PLC). Data monitoring and data acquisition systems.

ECS 363 Mechatronic Instrumentation 3(3-0-6)
Prerequisite: (ECS 203 or ECS 216) and (MES 211 or MES 310 or MES 311) or consent of Head of School
Analysis, characteristics and applications of instruments used in engineering mechatronics including transducers, sensors, actuators, etc. Measurement principles. Integrated sensors actuators. Programmable Logic Control (PLC) Data Acquisition Systems.

ECS 364 Introduction to Mechatronics 3(3-0-6)
Prerequisite: None
Introduction to integration of mechanical, electrical, and computer systems for information processing and control of machines and devices. Basic electronics, signal processing, micro-controller and microprocessor, sensors and actuators. Control architecture in mechatronic systems. Overview of electro-mechanical design and embedded systems in topics of current interest in mechatronics.

ECS 370 Digital Circuit Laboratory 1(0-3-0)
Corequisite: ECS 371 or consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 371.

ECS 371 Digital Circuits 3(3-0-6)
Prerequisite: None
Number systems and codes. Logic signals and gates. Electronic circuits of logic gates. Logic gate families. Logic gate characteristics. Arithmetic circuits. Combinational logic circuits. Sequential logic circuits. Programmable logic devices. Introduction to A/D and D/A conversions. Introduction to digital integrated circuits.

ECS 380 Feedback Control Laboratory 1(0-3-0)
Prerequisite: ECS 381 or consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 381.

ECS 381 Feedback Control Systems 3(3-0-6)
Prerequisite: ECS 201 or ECS 216 or
consent of Head of School
System representation. Mathematical models of systems. Closed-loop and open-loop control systems. Transfer functions. Signal flow graphs. Stability of linear control systems. Stability analysis techniques. Time-domain analysis and frequency-domain analysis of control systems. Time-domain design and frequency-domain design of control systems. Compensations. Introduction to computer-aided control analysis and design. Although MAS 215 is not a required course, the knowledge gained from this would be of great benefit to students of ECS 381 and is therefore recommended.

ECS 382 Microprocessors 3(3-0-6)
Prerequisite: ECS 371 or consent of Head of School
Microprocessor architecture, instruction sets assembly language programming, microprocessor interfacing, applications, introduction to DSP processors, practical projects and assignments.

ECS 384 Microcontroller and Computer Interfacing 3(3-0-6)
Prerequisite: ECS 371 or consent of Head of School
Microprocessor architecture. Assembly language programming. Microprocessor interfacing descriptions of the microprocessor-based system components: electronics, functions, and interfaces. System bus. Interrupts. DMA and I/O. Practical projects and assignments.

ECS 385 Computer Interfacing 3(3-0-6)
Prerequisite: ECS 382 or consent of Head of School
Architectural view of microprocessor-based systems. Components of microprocessor-based systems. Detailed descriptions of the components: electronics, functions, and interfaces. System bus. Interrupts, DMA and I/O. Interfacing techniques.

ECS 386 Introduction to Embedded System 3(3-0-6)
Prerequisite: ECS 370 or consent of Head of School
Concepts of timing and clocks; task-modeling and real-time operating system; processors; signal digitization and conditioning; memory; interfacing; state-machine and concurrent processes; encoding and flow control; formal verification.

ECS 396 Project Development 1(0-3-0)
Prerequisite: Senior standing or
consent of Head of School
Practical projects or problems in communications for individual students or groups of students under supervision of faculty members. Students are required to submit and present the project proposal to their project committee appointed by the program.

ECS 398 Senior Project 6(0-18-0)
Prerequisite: ECS 396 or consent of Head of School
The continuation of ECS 396 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee.

ECS 421 Semiconductor Device Theory 3(3-0-6)
Prerequisite: ECS 323 or consent of Head of School
Quantum mechanics. Crystalline solids. Energy band theory. Intrinsic and extrinsic semiconductors. Electrons and holes in semiconductors. Transport, generation, and recombination of excess carriers. Current flow in p-n junctions. Semiconductor devices.

ECS 422 Analog Filter Design 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or
consent of Head of School
Reviews of 1st and 2nd order analog filters, i.e. bilinear transfer functions and frequency responses, cascade design with 1st-order filters, and biquad circuits. Butterworth low-pass filters. Butterworth band-pass filters. The Chebyshev response. Sensitivity. Delay filters. Frequency transformations. Ladder design with simulated elements. Switched-capacitor filters.

ECS 423 Operational Amplifier Design 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or
consent of Head of School
Fundamentals of operational amplifiers. Linear op amp circuits. Active filter design using op amps. Practical op amp limitations. Stability and frequency compensation. Nonlinear circuit applications.

ECS 424 Analog Integrated Circuits 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or
consent of Head of School
Output stages and power amplifiers. BJT and MOS circuits of operational amplifiers. Advanced current mirrors and op-amps. Comparators. Voltage references. Data conversion, sample and holds, Nyquist-rate digital-to-analog converter circuits, Nyquist-rate analog-to-digital converter circuits, Oversampling converters. Translinear principles. Analog multipliers and dividers. Phase-locked loops (PLL). Precision rectification.

ECS 425 Digital Integrated Circuits 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or
consent of Head of School
Design principles of digital integrated circuits. NMOS inverters, pseudo NMOS, pass transistors, CMOS inverters, transmission gates. Logic families and their characteristics. Sources of propagation delay. Noise margins. Dynamic loads. Crosstalk. Transmission line effects. Advanced design concepts, Programmable gate arrays (PLAs).

ECS 426 Integrated Circuit Fabrication 3(3-0-6)
Prerequisite: ECS 323 or consent of Head of School
Fabrication technology and processes of integrated circuits. Theory and practice of diffusion, oxidation, ion implantation, photolithography, and etching, Layer deposition, Bipolar, NMOS, CMOS Technologies. Yield and reliability considerations. Statistical process control.

ECS 427 Introduction to VLSI Design 3(3-0-6)
Prerequisite: ECS 371, ECS 322 or ECS 325 or
consent of Head of School
Introduction to design and fabrication of very large scale integrated systems using NMOS and CMOS technologies. CAD tools and computer-aided design. Use of state-of-the-art design methodologies and tools. Testing and design for testability. Modularity, parallelism, local communications, fault tolerance.

ECS 428 Current-Mode Analog Integrated Circuits 3(3-0-6)
Prerequisite: ECS 424 or consent of Head of School
Current conveyors. Current-mode amplifiers. Transconductors. Continuous-time transconductance-C filters. Dynamic current mirrors. Switched-current filters. Current-mode analog-to-digital and digital-to-analog converters. Analog interface circuits for VLSI.

ECS 429 Noise Reduction Techniques 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or consent of Head of School
Basic principles of noise reduction. Grounding. Signal grounding techniques. Diagnosis of noise problems. Grounding and shielding. Filtering conducted noise. Inductive and capacitive shielding. Reducing electromagnetic coupling. Selecting right cable. Circuit board layout. Signal routing and least impedance. Transmission line effects. Noise coupling mechanisms. Circuit board grounding issues. Filtering conducted noise. DC power distribution and decoupling. Component placement and layer stackup. Chassis, cable and system issues.

ECS 431 Industrial Electronics 3(3-0-6)
Prerequisite: ECS 231 or ECS 324 or consent of Head of School
Thyristors. Industrial control devices. DC motors and control circuits. AC motors and variable-frequency drives. Operational amplifiers and linear ICs. Digital electronics. Analog and digital transducers. Industrial process control. Microprocessors and communication systems. Programmable logic controllers.

ECS 441 Communication Electronics 3(3-0-6)
Prerequisite: ECS 322 or ECS 325 or consent of Head of School
RF and power amplifiers, oscillators, phase-locked loops, filters, carrier modulators and demodulators, analog-to-digital and digital-to-analog converters, examples of commercially available integrated circuits for communication systems.

ECS 442 Microwave Principles 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
Problem-based learning; Maxwell's equations and boundary conditions, transmission-line theory, s-parameters, using Smith charts, impedance matching, microwave transmission line and waveguides, microwave resonators and filters, microwave network analysis, power dividers and directional couplers, microwave measurement and applications.

ECS 450 Signal Processing and Communication Laboratory 1(0-3-0)
Prerequisite: ECS 281 or consent of Head of School
Sampling and reconstruction of signals, digital filter design and hardware implementation, real-time filtering, AM-FM modulation/demodulation, basic digital communication technique, spectrum analysis, power measurement, DSP system simulation.

ECS 451 Data Communications and Networks 3(3-0-6)
Prerequisite: None
Network models, OSI layers and protocols, TCP/IP, VOIP, wide-area and local-area networks, routing algorithms and switching techniques, networking equipment, such as ATM, router, and bridge.

ECS 452 Digital Communication Systems 3(3-0-6)
Prerequisite: ECS 332 or consent of Head of School
Fundamental digital transmission concepts. Sampling Theorems. Random and nonrandom signals, low pass random signals. Baseband and carrier digital transmission systems. Quantization. Source coding. Pulse code modulation, delta modulation. Bandpass digital modulation techniques: principles of ASK, PSK, FSK, performance comparisons, and spectral analysis. Channel Coding methods for error detection and correction. Synchronization subsystems. Time-division multiple-access systems.

ECS 453 Satellite Communication Systems 3(3-0-6)
Prerequisite: ECS 332 or consent of Head of School
Introduction to space communications and frequency used. Satellite orbits and their effect on communication systems design. Communication satellites and their principal subsystems. Multiple access. Earth stations. Satellite networks. Techniques in satellite communications.

ECS 454 Fiber Optics 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
Cylindrical dielectric waveguide and propagating conditions, optical cable types, link budget and evaluation, optical transmission parameters, laser principles, laser modulation techniques by feeding baseband IF or RF, optical detections, regenerative repeater, application of optical components: optical divider and combiner, coupler, and lens, optical fiber production and process. Fiber optic communication systems. Coding, multiplexing and demultiplexing.

ECS 455 Mobile Communications 3(3-0-6)
Prerequisite: ECS 332 or consent of Head of School
Principles of cellular radio, mobile radio propagation and channel modeling, multiple access methods, physical and logical channels, digital mobile communication systems: TDMA, GSM, CDMA, WCDMA, multi-carrier and OFDM systems.

ECS 456 Optical Communications 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
Problem-based learning; Characteristics of lightwave propagation in optical fibers. Types of optical fibers. Optical transmitters and receivers. Optical filters and amplifiers. Optical components: optical divider and combiner, coupler, lens switches. Optical communication systems. Coding, multiplexing, demultiplexing, switching, and wavelength conversion. Optical network architectures.

ECS 461 Electromagnetic Wave Propagation 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
Basic principles and analytical techniques of electromagnetic wave propagation. Transmission lines. Waveguides and resonators. Basic microwave networks. Scattering. Radiation. Basic antenna theory.

ECS 462 Antennas 3(3-0-6)
Prerequisite: ECS 233 or consent of Head of School
Problem-based learning; Basic definitions and theorems, formulation of the radiation problems, isotropic point source, power and field patterns, directivity and gain, radiation impedance, wave polarization, radiation from current elements. Analysis and design of linear wire antenna, linear array antenna, Uda-Yagi antenna, log-

periodic antenna, aperture antenna. Antenna measurement techniques.

ECS 464 Computer Interfacing and Instrumentation 3(3-0-6)
Prerequisite: ECS 382 or consent of Head of School
Overviews of general-purpose microprocessor, digital signal processor (DSP), and specialized processor architectures. Tradeoff analysis: algorithm complexity, software-hardware tradeoffs, etc. Basic hardware and software computing elements: basic components such as functions, buses, interconnections, buffers, etc. Interrupts, DMA, and I/O. Instruction sets and programming. Interfacing Techniques. System design method and tools: hardware design, software design, example of system design, etc.

ECS 465 Biomedical Instrumentation 3(3-0-6)
Prerequisite: ECS 261 or ECS 362 or consent of Head of School
Overviews of human body. Electrodes and biotransducers. Bioelectric amplifiers. Instrumentation for heart and brain parameters. Magnetic resonance imaging. Medical laboratory instrumentation. Medical ultrasound. Bioelectric and biomagnetic measurement. Biochemical measurement. Chemical transducers: electrochemical, optical, and biosensor based chemical transducers, etc. Continuous measurement of chemical qualities. Computers in biomedical equipment. Optical based chemical equipment for environment monitoring.

ECS 466 Optical Metrology 3(3-0-6)
Prerequisite: ECS 261 or ECS 362 or consent of Head of School
Optic Reviews: light sources, photodetectors, and fiber optics. Principles and applications of optical sensors, transducers, and equipment in industrial and biomedical areas. Example of sensor system design. Optical based chemical analysis equipment for environmental monitoring: air and water pollution. Continuous Emission Monitoring Systems (CEMs) Optical instrumentation: spectrophotometer, spectroscopy, non-dispersive infrared (NDIR), etc.

ECS 467 Introduction to Industry Automation 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Introduction to computer controlled system in industry. Hardware and software tools for measurement and controlling systems: LabView, Real-time Workshop (RTW), etc. Data transmission and network protocols used in industry. Process control terminology and definitions (refer to ISA standards). State control. State diagrams. Logic control. LADDER programming. PETRINET. Distributed control systems (DCS). Automated measuring systems: IEEE488 standard bus. Automated inspection systems. Their functional characteristics and computerized controls are covered. Automated visual inspection: machine visions and color sensors, etc. Current topics of interest from the literature.

ECS 471 Switching Theory 3(3-0-6)
Prerequisite: ECS 371 or consent of Head of School
Models for sequential circuits: state tables and state diagrams, clock and pulse modes, and Mealy and Moore models. Analysis of synchronous sequential circuits (SSC): completely and incompletely specified circuits, state assignment, equivalent states, state reduction, circuit realization, and synthesis of SSC. Analysis of asynchronous sequential circuits (ASC): races, cycles, hazards, and synthesis of ASC. Introduction to fault diagnosis, Sequential circuits and regular expressions.

ECS 472 Digital Signal Processing 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Discrete-time signals and systems. Linear time-invariant systems and their properties. Sampling of continuous-time signals and convolution. IIR and FIR filter designs. Effects of finite word length. The discrete Fourier transform. Fast Fourier transform algorithms. Relations between Fourier Transform (FT), Discrete-frequency FT (DFFT) or Fourier series, Discrete-time FT (DTFT), and Discrete FT (DFT: Discrete both time & frequency).

ECS 473 Digital Filter Design 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Analog filter fundamentals for the study of digital filters. Common analog filters: Butterworth, Chebyshev, elliptical, and Bessel filters. Fundamentals and design techniques of FIR and IIR filters. Finite word length effects and sensitivity analysis.

ECS 474 Digital Speech Processing 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Speech Quality & Intelligibility. Speech coding standards, Linear Predictive coding techniques, Frequency domain codes. Speech enhancement and noise reduction. Speech recognition.

ECS 475 Digital Image Processing 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Digital image fundamentals. Image transformations. Image enhancement. Image restoration. Image compression. Image segmentation. Representation schemes and descriptors.

ECS 476 Adaptive Filtering 3(3-0-6)
Prerequisite: ECS 281 or consent of Head of School
Fundamental concepts of adaptive filtering. Introduction to design and implementation of digital adaptive filters. Analysis and practical considerations of filtering algorithms and structures.

ECS 477 Signal Processing for Communication Systems 3(3-0-6)
Prerequisite: ECS 472 or consent of Head of School
Problem-based learning; Speech coding and decoding, image coding and decoding, transmultiplexers, filter banks, channel estimation, channel equalization, synchronization, array processing, power spectral estimation, adaptive filtering, ADC and DAC algorithms.

ECS 478 Introduction to Computer Vision and Pattern Recognition 3(3-0-6)
Prerequisite: None (ECS 475 Digital Image Processing is recommended.)
Optics and image acquisition. Image sequence processing. Stereo vision. Texture segmentation. Multivariate data analysis. Discriminant functions. Unsupervised learning and clustering. Self-organizing map (SOM). 3-D medical imaging (computed tomography), Range data and surface analysis. 3-D structure analysis.

ECS 480 Robotics Laboratory 1(0-3-0)
Prerequisite: ECS 481 or consent of Head of School
Laboratory practice and experimental studies on topics covered in ECS 481.

ECS 481 Introduction to Robotics 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Operation principles, analysis, and design of robots. Mechanical manipulators: kinematics, dynamics, trajectory planning, and control. Robotic vision and visual feedback. Robot programming languages. Control algorithm design. Current topics of interest from the literature.

ECS 482 Digital Control Systems 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Discrete-time systems. The z-transform. Sampling and reconstruction. State-space descriptions. Stability of digital control systems. Designs of digital control systems using transform techniques and state-space methods. Quantization effects. Introduction to discrete-time optimal control.

ECS 483 Linear System Theory 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Mathematical description of systems. State-space description of linear dynamical systems. Controllability and observability. Stability analysis. Stabilizability and detectability. State feedback and observers. Introduction to optimal control.

ECS 484 Nonlinear System Analysis 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Introduction to nonlinear systems. Nonlinear differential equations. Equilibrium points. Phase plane analysis. Stability concepts. Local and global stability. Linearization and local stability. Lyapunov theory. Describing function analysis. Introduction to nonlinear control.

ECS 485 Dynamic Systems and Control 3(3-0-6)
Prerequisite: MES 351 or consent of Head of School
Mathematical modeling of mechanical, electrical, pneumatic, hydraulic and combined physical systems using unified approach such as Bond graph technique. Introduction state-variables, system response, stability using laplace transform technique. System characteristics: controllability and observability. Open and closed loop responses of control systems. Solution to state equation by direct analysis and digital computer methods.

ECS 486 Embedded System Development Project 3(2-2-5)
Prerequisite: ECS 386 or consent of Head of School
Problem-based learning; hands-on experience on embedded system design; embedded programming using high-level programming language; applications of real-time operating system for embedded system; hardware and software co-design techniques and verification techniques; system testing.

ECS 487 Optimization Techniques 3(3-0-6)
Prerequisite: MAS 210 or consent of Head of School
Optimization concepts. Types of optimization problems. Calculus of variations. Lagrange multipliers. Gradient techniques. Linear programming. The simplex method. Nonlinear and dynamic programming.

ECS 488 Adaptive Control Systems 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Concepts and principles of adaptive control systems. Structures of adaptive control systems and related adaptive control algorithms. Stability, convergence, and robustness of adaptive controllers. Applications of adaptive control.

ECS 489 Stochastic Systems 3(3-0-6)
Prerequisite: (ECS 315 or IES 302) and ECS 381 or consent of Head of School
Stochastic processes. Fundamentals of stochastic systems. Stochastic control systems and their principles. Separation of estimation and control. Kalman filtering. Dynamic programming. System identification.

ECS 491 Electronics and Communication Engineering Seminar I 1(0-3-0)
Prerequisite: Senior standing or consent of Head of School
Presentation and discussion of recent advances and research in electronics and communication engineering by guest lecturers, faculty, and students. Topics may vary from semester to semester. S/U grading.

ECS 492 Electronics and Communication Engineering Seminar II 1(0-3-0)
Prerequisite: Senior standing or consent of Head of School
Presentation and discussion of recent advances and research in electronics and communication engineering by guest lecturers, faculty, and students. Topics may vary from semester to semester. S/U grading.

ECS 493 Topics in Electronics and Communication Engineering I 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other electronics and communication engineering courses. Topics may vary from semester to semester.

ECS 494 Special Problems in Electronics and Communication Engineering 3(0-9-0)
Prerequisite: Senior standing or consent of Head of School
Special problems in electronics and communication engineering assigned according to each student's needs, interests, and capabilities. Students are required to submit complete investigation reports and present investigation results to their committee appointed by the school.

ECS 495 Topics in Electronics and Communication Engineering II 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other electronics and communication engineering courses. Topics may vary from semester to semester. Topic covered is different from ECS 493.

ECS 496 Special Study in Electronics and Communication Engineering I 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students wish to participate in an exchange program. It is designed for topics related to current development and fundamental knowledge in electronics and communication engineering technologies, but not presently offered as either a required or technical elective.

ECS 497 Special Study in Electronics and Communication Engineering II 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students wish to participate in an exchange program. It is designed for topics related to current development and fundamental knowledge in electronics and communication engineering technologies, but not presently offered as either a required or technical elective.

ECS 499 Extended Electronics and Communication Engineering Training 6(0-40-0)
Prerequisite: Senior Standing or consent of Head of School
Full-time research or practical training under close supervision of faculty members and assigned supervisors from the Electronics and/or Communication Engineering-related company for at least 17 weeks. Evaluation based on the project achievement, project report and final oral presentation.

EL 070 English Course I 0(3-0-6)
Prerequisite: Depending on result from placement test
This is a remedial course specially designed as an English review to prepare first-year students to be able to study advanced courses.

EL 171 English Course II 3(3-1-5)
Prerequisite: Depending on result from placement test or passing EL 070
This intermediate course aims to develop the four English skills – listening, speaking, reading and writing. Students are given more practice in listening comprehension, reading various printed materials and writing short paragraphs.

EL 172 English Course III 3(3-1-5)
Prerequisite: Depending on result from placement test or passing EL 171
This advanced course aims to further develop students' English skills. Students practice listening to news and dialogues, reading more complex passages, and writing various types of paragraphs.

EL 210 English for Engineering I 3(3-1-5)
Prerequisite: EL 172
A course to practice English skills in engineering contexts with an emphasis on reading, writing, listening and speaking. Texts, selected passages and other materials of medium length on engineering are included.

EL 310 English for Engineering II 3(3-1-5)
Prerequisite: EL 210
A course to practice English skills in engineering contexts with an emphasis on reading longer printed materials as well as descriptive and explanatory writing. Listening and speaking tasks related to engineering are included.

GTS 101 Skills Development for Technical Studies 3(3-1-5)
Prerequisite: None
Development of techniques for effective study in college. Covers time management, motivation, taking notes from books and lectures, memory training, and reading strategies. Studying for and taking exams, using libraries, teaching/learning styles, and basic strategies for learning any new content.

GTS 111 Mathematical Analysis for Management Science 3(3-1-5)
Prerequisite: None
Elementary matrices – matrix addition, matrix multiplication, matrix inversion, applications in population dynamics; probability – sets and counting, Venn diagrams, permutation and combination; statistics – describing data, numerical measures, probability distributions, uniform probability distributions, conditional probabilities and tree diagrams, discrete probability distributions, binomial probability distributions, normal probability distributions and normal approximation to the binomial distribution.

GTS 112 Linear Algebra 3(3-1-5)
Prerequisite: GTS 111
Matrices and systems of linear equations; Hermitian matrices and unitary matrices; LU factorizations; determinant; Cramer's rule; vector spaces; linear independence; bases; dimensions; rank of matrices; orthogonality; eigenvalues and eigenvectors; reduction of matrices to diagonal forms.

GTS 116 Mathematics for Technologists I 3(3-1-5)
Prerequisite: None
Introductory calculus: a course on the differential and integral calculus of functions of one variable. Topics include limits and continuity of functions, origin and definition of the derivative, exponential and logarithmic forms, origin and definition of anti-derivative; integral calculus; indefinite integrals. Taylor's Theorem for a function of two variables; introduction to differential equations.

GTS 117 Mathematics for Technologists II 3(3-1-5)
Prerequisite: GTS 116 or consent of Head of School
Introduction to vectors, curves, and surfaces in space; partial differentiation; directional derivatives and the gradient vector; integration, techniques of integrations and logarithmic functions. Three-dimensional analytic geometry. Differential and integral calculus of functions of two or three variables: partial derivatives, multiple integrals, Lagrange multipliers, and Green's Theorem.

GTS 121 General Science I 3(3-1-5)
Prerequisite: None
An introduction to chemistry; the gaseous state. States of matter and solutions. Chemical equilibrium. Acids and bases. Electrochemistry. Vectors. Forces. Friction. Moment of inertia. Momentum and energy.

GTS 122 General Science II 3(3-1-5)
Prerequisite: None
Interplay of structure and function, particularly at the molecular, cellular, and organismal level of organization. Study of the characteristics of the major groups of plant and animal life. Introduction to the principles and applications of microbiology, with a study of the general characteristics of microorganisms and their applications.

GTS 132 Introduction to Biological Science 3(3-1-5)
Prerequisite: None
Interdisciplinary study of the living world, covering a variety of topics ranging from biological molecules and metabolism of organic compounds, genes, and their functions to more complex topics in human biology, biotechnology, bioinformatics, and other applications.

GTS 133 Environmental Studies 3(2-2-5)
Prerequisite: None
The ecology of natural systems, ecosystems, and growth. Food production and land use. Extinction and genetic resources. Sources of energy, energy utilization and related environmental issues. Control of pest and weeds. Water resources and water pollution. Air pollution. Solid waste. The environment and human health.

GTS 201 Standardized English Tests 2(2-1-3)
Prerequisite: EL 172 or consent of Head of School
This course will prepare students to take standardized English tests. The structure and content of each test will be examined in detail in order to familiarize students with the different sections. Different types of questions will be considered and students will learn how to answer each type. A review of speaking, listening, reading and writing skills will be covered. Sample tests will be given for each skill, including reading, writing, listening and speaking.

GTS 202 English Language Structures 3(3-1-5)
Prerequisite: EL 172 or consent of Head of School
The course aims to further develop students' English proficiency. The course emphasizes academic writing from basic sentences and paragraphs to more complex structures. The English structures covered in this course will aid the students in preparing for standardized English examinations.

GTS 210 Mathematics for Technologists III 3(3-1-5)
Prerequisite: GTS 117 or consent of Head of School
This course includes the study of vectors in the plane and space, systems of linear equations, vectors, vector spaces, linear transformations, inner products, eigenvalues and eigenvectors. Introduction to matrices and determinants and complex numbers.

GTS 211 Differential Equations and Numerical Methods 3(3-0-6)
Prerequisite: GTS 117 or MAS 117 or consent of Head of School
Ordinary differential equations of the first order. Linear ordinary differential equations of higher order. Laplace transformation. Fourier analysis – Fourier series, integrals and transforms. Partial differential equations. Error analysis. Eigenvalue problems. Nonlinear equations. Approximation and interpolation. Numerical differentiations and integration. Numerical solutions of differential equations.

GTS 212 Calculus for Technologists I 3(3-0-6)
Prerequisite: None
Limits and continuity of functions. Derivatives, rules of differentiation-product and quotient rules, higher order derivatives, chain rule. Derivative of implicit functions. Applications of differentiation. Indefinite integration and techniques of integration – integration by substitution, integration by parts, trigonometric substitution, integration by partial fractions.

GTS 213 Calculus for Technologists II 3(3-1-5)
Prerequisite: GTS 212
Applications of integration – areas, consumer surplus. Separable differential equations – population growth, flow processes, finance and investment models, sequence and series-power series, Taylor and Maclaurin series. Functions of several variables. Partial derivatives – chain rule, optimization.

GTS 231 Law and Technology 3(3-1-5)
Prerequisite: None
Study of relations between law and technology – exploration of issues in both private and public laws pertaining to the application of technology. Implications of technology on law development internationally. Legal issues involving e-commerce, e-contracting, intellectual property, privacy, torts, consumer protection, product liability, professional negligence, professional liability, environmental and natural resources, legal principles on common commercial transaction and business organizations.

GTS 302 Technical Writing 2(2-1-3)
Prerequisite: EL 172 or consent of Head of School
Students learn and practice writing and presentation of technical reports, which include reports of laboratory experiments, in-depth technical reports, overview articles of technical topics for the general public, as well as executive summaries.

GTS 303 Communications in Business 2(2-1-3)
Prerequisite: EL 172 or consent of Head of School
This course teaches the organizational skills needed to prepare for writing business/marketing ideas. First, ideas are organized. These ideas are transformed into well written short paragraphs. Next, the paragraphs are edited. Students participate in editing other students' writings. Students present some of their original work to the rest of the class through poster presentations and short speeches. In addition, students are required to produce a business/marketing style resume.

GTS 401 Intensive English Proficiency 6(6-0-12)
Prerequisite:
1. Student has completed all course work according to respective curriculum.
2. Student has taken at least 5 times: any acceptable English proficiency test (TOEFL, TU-GET, IELTS and Institutional TOEFL).
3. Student should have a minimum score of 400 for paper-based TOEFL, or equivalent score when using other tests.

Students who pass this course will have similar English skills to those students who satisfy the English Proficiency requirement. The course content will be based primarily on the Institutional TOEFL (ITP) exam; however, materials may be drawn from other tests (e.g., IELTS or TOEIC). Strategies for answering the different types of exam questions will be discussed and practiced in class. Special emphasis will be placed on helping students improve their individual weaknesses in the listening, reading or structure sections of the exam. An S (satisfactory) or U (unsatisfactory) grade is given.

IES 201 Industrial Engineering Mathematics 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
This course presents elementary differential equations and numerical methods for industrial engineers. Emphases are placed on first-order ordinary differential equations; linear ordinary differential equations of higher order; power series representation and gamma functions; Laplace and inverse transform methods; mathematical modeling, computers, and error analysis; fundamentals of unconstrained and constrained

optimizations such as golden-section search, quadratic interpolation, gradient methods, and linear programming; least-squares regression; interpolation. Some heuristic algorithms such as Simulated Annealing, Particle Swarm Optimization, etc., will also be introduced. The implementation of these techniques using mathematical software packages, e.g., MATLAB and/or LINGO, for Industrial Engineering applications will also be covered.

IES 301 Manufacturing Tools and Operations 3(2-3-4)
Prerequisite: None
This course emphasizes fundamentals of engineering and measurement, particularly the correct and safe use of machine tools. Students are provided with hands-on experience in fitting, welding, foundry, and fabrication.

IES 302 Engineering Statistics 3(3-1-5)
Prerequisite: MAS 117 or GTS 117 or consent of Head of School
This course discusses fundamentals of probability, discrete and continuous probability distributions, conditional probability, moment generating functions, discrete and continuous random variables, sampling distributions, hypothesis testings of the means, variances, and proportions. Regression analysis will also be introduced.

IES 303 Engineering Management and Cost Analysis 3(3-0-6)
(For non-industrial engineering students)
Prerequisite: None
The course presents a broad and fundamental view of management systems (in both classical and modern aspects), including structures and functions of interrelated departments. Philosophy and quantitative aspects of inventory management, quality assurance, project management, etc. are emphasized. Students are also introduced to basic concepts and applications of an economic evaluation of engineering projects. Topics covered include interest formulas, time value of money, economic decision making involving several alternatives, etc. This course is not intended for industrial engineering students.

IES 304 Industrial Engineering Training 0(0-0-0)
Prerequisite: Junior standing
Students are provided with on-the-job training at selected modern industrial or service facilities. The purpose of the course is to allow the students opportunities to observe how industrial engineers function, to learn how to collaborate with co-workers, and to develop self-responsibility. The training period must not be less than 240 hours. Students must submit a report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on student's performance, quality of the report, and supervisor's comments.

IES 305 Senior Project I 1(0-3-0)
Prerequisite: Senior standing or consent of Head of School
The first course in the senior project course series. A student team will be given a real world problem which they must determine appropriate approaches and actions to obtain feasible solutions. This involves establishment of initial contacts, project proposal development, preliminary data collection, data analysis, verification of the results, and practical implementation. A presentation of the progress and a submission of the status report are due at the end of the semester.

IES 307 Independent Studies in Industrial Engineering 3(0-9-0)
Prerequisite: None
This course is specifically intended for qualified students who aim to pursue a graduate degree in industrial engineering or related fields. Students will learn to develop research skills by participating in on-going research projects conducted by faculty members. They will be involved in the literature search, design of an experiment, data collection and analysis, and the preparation of a technical report, through close supervision from responsible faculty.

IES 308 Engineering Tools and Operations 2(1-3-2)
(For non-industrial and non-mechanical engineering students)
Prerequisite: None
This course emphasizes safe uses of engineering tools and fundamentals of machining, fitting, and welding operation. Students are provided with experience in benchworking, welding, etc.

IES 311 Ergonomics 3(3-0-6)
Prerequisite: None
The course emphasizes human-machine-environment systems, workplace layout, tool design, occupational fatigue, environmental effects on human performance which include the effects of noise, vibration, and atmospheric factors. Participation in supervised experiments or a completion of a semester project under instructor's supervision is mandatory.

IES 312 Methods Analysis and Work Measurement 3(3-0-6)
Prerequisite: None
This course emphasizes the measurement and evaluation of work methods and how improvement can be introduced. Topics include visual and micromotion study techniques, motion economy, time study, and work sampling. The development and use of standard time data and computerized techniques will be covered.

IES 313 Industrial Plant Design 3(3-0-6)
Prerequisite: None
Modern methods applied to facility layout and location design are discussed. Logistics of motion of people and materials, flow analysis, plant layout, and material handling techniques are covered. Students will study the mathematical approaches and computer packages applicable for solving facility layout and location problems.

IES 314 Industrial Hygiene and Occupational Health 3(3-0-6)
Prerequisite: None
Analysis of the effects of various environmental stressors on people at work, including their interference with performance and development of acute and chronic health problems. Study of how numerous airborne contaminants, noise, thermal extremes, etc. affect workers alone and in combination. Topics include: measurement and evaluation techniques, TLV's, control methodologies, and legal requirements for employers.

IES 315 Methods Analysis and Work Measurement Laboratory 1(0-3-0)
Corequisite: IES 312 or consent of Head of School
This laboratory course demonstrates a practical use of modern apparatus available for motion and time study applications. Process charts and a time study board will be utilized to not only analyze manufacturing and service operations, but also improve productivity.

IES 321 Operations Research I 3(3-1-5)
Prerequisite: (MAS 210 and IES 302) or
consent of Head of School
Basic operations research models, algorithms, and their applications are discussed in this course. Topics covered are linear programming and its extensions; transportation model; game theory; network flow analysis; queueing theory; and simulation modeling.

IES 322 Operations Research II 3(3-0-6)
Prerequisite: IES 321 or consent of Head of School
This course covers selected deterministic and probabilistic models, algorithm, and their applications. Markov decision problems, dynamic programming, inventory control models, game theory, search methods, and non-linear programming will be introduced.

IES 323 Production Planning and Control 3(3-0-6)
Prerequisite: None
A study of the components and functions of integrated production, planning, and control systems. Consideration is given to material, equipment, and manpower requirements for optimizing continuous and intermittent manufacturing operations. Topics discussed include demand forecasting, hierarchical production planning, capacity planning, line balancing, operation sequencing and scheduling, etc.

IES 324 Production Sequencing and Scheduling 3(3-0-6)
Prerequisite: IES 323 or consent of Head of School
This course discusses techniques of sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems. Both deterministic and stochastic models are introduced.

IES 325 Advanced Topics in Operations Research 3(3-0-6)
Prerequisite: (IES 321 and IES 322) or
consent of Head of School
This is an advanced course continuing from IES 321 and IES 322. Topics covered in IES 321 and IES 322 will be further discussed in more detail. In addition, other advanced operations research topics, algorithms, and applications in linear programming, integer programming, nonlinear programming, network models, and dynamic programming will be introduced.

IES 331 Quality Control 3(3-0-6)
Prerequisite: IES 302 or consent of Head of School
Methods used to achieve higher product quality, to prevent defects, to locate chronic sources of trouble, to measure process capability, and to use inspection data to regulate manufacturing processes are emphasized. Preparation of statistical control charts and selection of suitable sampling plans are discussed. Total quality control, quality control circles, and ISO 9000 standards are also studied.

IES 332 Factory Automation and Control Methods 3(3-0-6)
Prerequisite: None
This course discusses the design, automation, and integration of supporting subsystems in the overall manufacturing environment. These subsystems include flexible manufacturing system (FMS) cells, robotic cells, automated warehousing (AS/RS), automated material handling systems (conveyor, AGV, etc), and automated inspection systems. Their functional characteristics and computerized controls are covered. Additionally, the course discusses linear and proportion-integral-differential (PID) control systems, system reliability analysis, open and closed loop control systems, system response, etc.

IES 333 Computer Integrated Manufacturing 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
The components of computer integrated manufacturing (CIM) including the design of information frameworks and network protocols required to orchestrate full manufacturing automation are examined, first individually, then as a single macro system. Process planning, NC programming, CAD/CAM interfacing, and database systems are studied in the context of a CIM environment.

IES 334 Industrial Robotics and Applications 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Intended to provide students with a knowledge of robotics in manufacturing systems. The field of robotics is studied with emphasis given to the role of programmable robots in manufacturing. Students will obtain hands-on experience about hardware and software available for various industrial robot systems.

IES 335 Metrology 3(3-0-6)
Prerequisite: SCS 139 or consent of Head of School
This course is a problem-based course on metrology. This course involves the principles and applications of precision or fine measuring equipment, e.g., optical, laser, and electro-magnetic devices. Standards and accuracy of measurement are also discussed.

IES 336 Industrial Instrument and Controlling Systems 3(3-0-6)
Prerequisite: None
This course covers principles and applications of instruments, particularly measuring and controlling instruments, employed in various kinds of industrial processes and manufacturing. Measuring instruments are typically used for electrical measurement, distance measurement, color detection, pressure measurement, level measurement, and temperature measurement. Additionally, this course includes mechanical and electrical controlling device such as Programmable Logic Control (PLC). The driving system is also mentioned. Finally, the design of measuring and controlling systems is discussed to integrate all industrial instruments mentioned in the course together.

IES 337 Automation of Production Systems 3(3-0-6)
(For non-industrial engineering students)
Prerequisite: None
The course discusses the design, automation, and integration of supporting sub-systems in the production environment, which includes flexible manufacturing

systems (FMS) cells, automated warehousing (AS/RS), automated material handling systems (conveyor, AGV, etc.), and automated inspection. The functions of integrated production planning, production systems, and manufacturing automation are studied. Consideration is given to the linkage between manual and automated tasks of controlling and monitoring the progress of the product as it is being processed, assembled, moved, and inspected in the factory. The components of computer integrated manufacturing (CIM) are also discussed.

IES 341 Engineering Economy 3(3-0-6)
Prerequisite: None
Introduction to the principles of engineering economics for utilization and evaluation of capital investments. This course covers time value of money, net present value, rate of return, depreciation, and selection of the best economic investment alternative. Decisions involving multiple choice replacement, uncertainty, and risk will also be discussed.

IES 342 Industrial Cost Analysis and Control 3(3-0-6)
Prerequisite: None
The course provides an understanding of the tools and techniques applicable for cost analysis and control. Topics discussed include financial analysis of the accounting system, standard costs, variance analysis, cost-volume-profit relationships, cost estimation, and utilization of accounting data for control of operations.

IES 343 Safety Engineering 3(3-0-6)
Prerequisite: None
The principles and practices of safety engineering in product and facilities design are discussed. Among the topics treated are safe practices and hazard control, safety standards and codes, inspection procedures, governmental regulations, and safety statistics. The Occupational Safety and Health Act (OSHAct) and Thai legislation will be examined and compared. Engineering ethics, moral principles and social responsibility are also covered.

IES 344 Value Engineering 3(3-0-6)
Prerequisite: None
An application of value engineering methods in reducing production cost without sacrificing quality is discussed in this course. Major emphases are placed on both product and integrated production system designs. An introduction to concurrent engineering concepts is also given.

IES 345 Project Feasibility Study 3(3-0-6)
Prerequisite: IES 341 or consent of Head of School
This course is a problem-based course on a project feasibility study. Fundamental concepts of a project feasibility study is discussed in detail. The course emphasizes essential qualitative and quantitative aspects of the feasibility study such as marketing evaluation, proposal development (preparation and presentation), economic analysis, project planning and scheduling, etc.

IES 346 Product Safety Engineering 3(3-0-6)
Prerequisite: None
A presentation of the techniques available to design and production engineers to minimize hazards of product design and manufacture. The effect of legal precedents on design, manufacturing, advertising, marketing, and using a product are discussed. Topics such as reliability prediction and failure analysis methods, assuring the quality of manufactured products, loss control systems, safety engineering precepts, ergonomics principles, design review, etc. are also covered.

IES 351 Maintenance Engineering 3(3-0-6)
Prerequisite: None
The course emphasizes the concepts and utilizations of maintenance as applicable to industrial and service systems. Examples of topics included are industrial safety and productivity aspects of maintenance, reliability of system components, preventive and emergency maintenance, scheduling of maintenance activities, etc.

IES 352 Reliability in Engineering Systems 3(3-0-6)
Prerequisite: IES 302 or consent of Head of School
This course emphasizes the determination of systems reliability from a knowledge of characteristics and reliability of individual system components. Topics covered include reliability concepts, failure rates, systems analysis, optimization, maintenance, etc. Techniques for the formulation and evaluation of reliability models are also discussed.

IES 353 Pollution Control and Waste Treatment 3(3-0-6)
Prerequisite: None
Discussion of the physical, chemical, and biological processes which influence the extent of air, water, and land pollution; methods for monitoring, controlling, and preventing pollution; methods of waste treatment; chemical wastes and hazardous wastes.

IES 361 Manufacturing Process Design 3(3-0-6)
Prerequisites: IES 301 or consent of Head of School
Introduction to the theory and practice of manufacturing processes. Study covers various types of casting, and metal forming processes and technologies. This course emphasizes process selection and design of cost effective manufacturing processes. Linkage between process design, and production planning and control is considered.

IES 362 Manufacturing Engineering Laboratory I 1(0-3-0)
Prerequisite: Junior standing
This course provides hands-on exercises on CAD/CAM, CNC machine programming and control (lathe and milling), and robot programming and control.

IES 363 Manufacturing Engineering Laboratory II 2(1-3-2)
Prerequisite: Senior standing
The laboratory course provides practical integration between measuring and controlling instrument used in a manufacturing environment. Physical property measuring such as pressure, temperature and level is focused on. Mechanical and electrical control devices, such as Programmable Logic Control (PLC), are emphasized.

IES 364 Manufacturing Processes and Technologies 3(3-0-6)
Prerequisite: IES 361 or consent of Head of School
This course covers non-traditional manufacturing processes and technologies for metal parts, and those for plastic and composite-material parts. Manufacturing

processes for electronic devices, and printed circuit boards are studied.

IES 365 Jig, Fixture, and Mold Design 3(3-0-6)
Prerequisite: (IES 301 and MES 302) or
consent of Head of School
This course covers fundamentals of jig, fixture, and mold design. The topics include types, classifications, functions, and applications of jig, fixture, and mold, and also design economics. Computer aided design (CAD) concept is introduced to develop jig, fixture, and mold. Hands-on exercises of CAD are provided.

IES 371 Engineering Management 3(3-0-6)
Prerequisite: None
This course is specifically designed for industrial engineering students to appreciate the applications of industrial engineering techniques in managing both manufacturing and service systems. Students learn the fundamentals of engineering economics and gain an understanding of the management process. Major topics covered include concepts and theories of modern management, capital investment justification methods, project organization and management, legal, quality, and staffing issues.

IES 372 Materials Management and Inventory Control 3(3-0-6)
Prerequisite: IES 323 or consent of Head of School
This course emphasizes the philosophy of materials management and quantitative techniques used in controlling level of inventories in an organization. Classifications of inventory from different perspectives are presented. Both deterministic and probabilistic inventory models are discussed. Modern materials management systems, e.g., MRP-II and JIT, are also studied.

IES 373 Computerized Management Control 3(3-0-6)
Prerequisite: IES 371 or consent of Head of School
A treatment of the managerial functions of planning, operating, and control in which the computer is used as an information source and an operating device. Applications to order processing, warehousing, machine and process control, forecasting, scheduling, and management reporting. Special problems in manpower scheduling using PERT and CPM techniques are discussed.

IES 374 Management Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Structure and design of computer-based information systems are discussed. Topics included are computer hardware and software, database models, database management systems, system analysis, design, and implementation.

IES 375 Organization Design 3(3-0-6)
Prerequisite: IES 371 or consent of Head of School
The course discusses a study of different types of organizational structures, from traditional to modern, in order to develop the structure that is suitable for the objectives and strategies of individual organizations. Topics emphasized include an analysis of advantages and disadvantages of different structures, allocation of business functions, human relations, co-operation between departments, and factors affecting efficiency and productivity of the organization.

IES 376 Logistics and Supply Chain Management 3(3-0-6)
Prerequisite: None
This course is specifically designed for students to understand the principles of logistics and supply chain management. Major topics include logistic planning, cooperation and management in the supply chain, transportation, material purchasing and inventory control, packaging, integration between production planning and distribution among partners in the chain, and information systems. The present and future roles of logistics in the supply chain management are also discussed.

IES 391 Applied Statistical Methods 3(3-0-6)
Prerequisite: IES 302 or consent of Head of School
This course emphasizes statistical analysis techniques and their applications. Topics discussed include a review of hypothesis testing, goodness-of-fit tests, regression analysis, and analysis of variance. Special attention is given to their applications in engineering fields.

IES 392 Systems Simulation 3(3-0-6)
Prerequisite: IES 302 or consent of Head of School
This course is a problem-based course on systems simulation. This course introduces the application of discrete time simulation modeling for the analysis of complex manufacturing and service systems, using case examples in warehousing, material handling, banking, etc. Applications of continuous time and combined discrete-continuous simulation modeling will also be illustrated. Students will gain first-hand practice on how to use state-of-the-art simulation software through a series of laboratory exercises or a realistic semester project.

IES 393 Quantitative Methods in Forecasting 3(3-0-6)
Prerequisite: IES 302 or consent of Head of School
An analytical approach to forecasting based on time series techniques, with applications to marketing, operation planning, inventory control, and management. Techniques include regression, auto-regression, moving average processes, and exponential smoothing. Applications and computational efficiency are stressed.

IES 394 Artificial Intelligence in Industrial Engineering 3(3-0-6)
Prerequisite: None
To provide insight into concepts and techniques of intelligent systems. Topics covered include search methodologies, knowledge representation, components of knowledge-based systems, design of knowledge bases, and inferencing. Applications of knowledge-based systems in design of products, processes, systems as well as machine diagnostics, production planning and scheduling will also be introduced.

IES 395 Special Topics in Industrial Engineering I 3(3-0-6)
Prerequisite: None
This course is designed for topics related to industrial engineering, but not presently offered as either a required or technical elective.

IES 396 Special Topics in Industrial Engineering II 3(3-0-6)
Prerequisite: None
This course is designed for topics related to industrial engineering, but not presently offered as either a required or technical elective. Topics covered are different from IES 395.

IES 401 Senior Project II 6(0-18-0)
Prerequisite: IES 305 or consent of Head of School
A continuation of IES305. An individual student or a team of students will work on the individual or group projects assigned to them. The projects can be intensively conducted in industrials or within the institute. After a project is completed, students are responsible for submitting their final report and giving a presentation.

IES 402 Special Study in Industrial Engineering I 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics or areas of study related to industrial engineering, but not presently offered as either a required or technical elective. Topics covered are different from IES 403.

IES 403 Special Study in Industrial Engineering II 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics or areas of study related to industrial engineering but not presently offered as either a required or technical elective. Topics covered are different from IES 402.

IES 404 Extended Industrial Training 6(0-40-0)
(For Extended Industrial Training Track)
Students are provided with extensive on-the-job training at selected modern industrial facilities. The purpose of the course is to allow the students opportunities, to work and intensively conduct an individual research or practical project for at least 17 weeks under the close supervision of faculty members and main supervisors assigned by the training company. After the project is completed, students are responsible for submitting their final reports and giving a presentation.

ITS 100 Introduction to Computers and Programming 3(2-3-4)
Prerequisite: None
Computer system components and organization. Hardware and software interaction. Introduction to data processing and databases. Algorithms and programming languages. Programming in high-level languages. Program design and development. Practical laboratories are essential parts of the course, designed to develop students' programming skills and understanding of computer system. These skills are important foundations for other technical courses.

ITS 101 Programming and Algorithms 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
High-level programming languages. Types, control flows, iteration, functions and procedures. Program structure. Storage allocation. String processing. Recursive programs. Algorithm design. Program debugging.

ITS 102 Object Oriented Programming 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Concepts of object oriented programming and introduction to software engineering principles. Topics include data structure fundamentals, abstraction, encapsulation, inheritance, polymorphism, overloading, pointer and reference variables, recursion and various important algorithms. Modeling and application with classes, member functions, constructors and destructors, public, private and protected access, static and non-static members, virtual functions and standard I/O.

ITS 103 Object-oriented Programming Laboratory 1(0-3-0)
Prerequisite: ITS 100 or consent of Head of School
Hands-on practice and experiments of topics on object-oriented programming.

ITS 201 Discrete Mathematics 3(3-0-6)
Prerequisite: None
Sets and Projections. Boolean algebras. Relations. Automation. Formal grammars. Graphs and algorithms.

ITS 221 Data Structures and Algorithms 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Concepts of data structures. Data structures and programming. Basic data structures: stacks, queues, linked lists, trees, graphs, etc. Recursion. Hash tables. Sorting and searching algorithms.

ITS 223 Programming Laboratory I 1(0-3-0)
Prerequisite or Corequisite: ITS 221 or consent of Head of School
Students practice hands-on programming topics included in Data Structures and Algorithms.

ITS 224 Numerical Computation 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Basic concepts of problem analysis, computation, and solution. Using computers to find numerical solutions of scientific equations. Algorithms. Programming methods. Polynomial interpolation. Numerical differentiation. Numerical integration.

ITS 227 Algorithm Design 3(3-1-5)
Prerequisite: ITS 100 or consent of Head of School
Definitions of algorithm. Analysis of algorithm. Divide and conquer. Dynamic programming. Graph algorithms. Greedy algorithms. State space searches. NP-completeness and intractability. Hands-on practice on algorithm design and implementation.

ITS 229 Human Computer Interface Design 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Design concepts of hardware and software interface. Overview of the trends in human interfaces design. Graphical user interface, interactive software design. Hardware technology for human interfaces.

ITS 231 Data Structures and Algorithms Laboratory 1(0-3-0)
Prerequisite: ITS 100 or consent of Head of School
Hands-on practice and experiments of topics on data structures and algorithms.

ITS 300 Information Technology Training 0(0-0-0)
Prerequisite: Junior standing or consent of Head of School
Practical training in the private sector or governmental departments in the field of Information Technology. Not less than 240 hours during the summer vacation of the third year. Student must submit a report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on student's performance, quality of the report, and supervisor's comments.

ITS 322 Database Management Systems 3(3-0-6)
Prerequisite: None
Database systems architectures. Relational data models. Query languages. Database security, integrity, and concurrency.

ITS 323 Introduction to Data Communications 3(3-0-6)
Prerequisite: None
An overview of basic knowledge related to the process of data exchange between computers. Topics include analog and digital data transmission systems, various network topologies, client-server models, and structure/mechanism of the 5-layer simplified OSI model: application, transport, network, data-link, and physical layers.

ITS 324 Foundation of Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Basic concepts and applications of information systems and management information systems. Decision support systems, intelligent systems, expert systems, data mining and data warehouse, and electronic commerce.

ITS 327 Computer Network Architectures and Protocols 3(3-0-6)
Prerequisite: None
Network models. OSI layers. Transmission media. Local area networks. Design concepts of protocols. Routing algorithms. Applications of networks.

ITS 328 Microprocessor Applications 3(3-0-6)
Prerequisite: ECS 382 or consent of Head of School
Structure, components, operation, and design of microprocessor-based systems. Memory systems design and organization. Basic peripheral interfacing. Applications of microprocessors. Assembly language programming.

ITS 329 System Analysis and Design 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Software models and software modeling methodologies. Basic abstraction mechanisms in software modeling. Modeling techniques, processes, and languages. Software development process. Object-oriented system analysis and design. Hands-on practice on software development process and system analysis and design.

ITS 331 Information Technology I Laboratory 1(0-3-0)
Prerequisite: ITS 231 or consent of Head of School
Hands-on practice and experiments of topics on information systems.

ITS 332 Information Technology II Laboratory 1(0-3-0)
Prerequisite: ITS 231 or consent of Head of School
Hands-on practice and experiments of topics on software technology and data communications.

ITS 333 Information Technology III Laboratory 1(0-3-0)
Prerequisite: ITS 231 or consent of Head of School
Hands-on practice and experiments of topics on software technology.

ITS 334 Advanced Computer Programming 3(2-2-5)
Prerequisite: ITS 100 or consent of Head of School
Programmer ethics. Advance techniques for programming software. Programming in high-level languages, structures and techniques. Integrated components using several programming languages. Software engineering principles. Project on program design, debugging, and development of scientific and engineering applications.

ITS 335 IT Security 3(3-0-6)
Prerequisite: None
Introduction to computer security and cryptography: security services, threats and attacks, encryption, authentication, digital signatures. Software security: database security, security of general purpose operating systems, trusted operating systems, malicious software, safe programs. Network security: firewalls, intrusion detection systems, Internet security protocols, Denial-of-Service attacks. Security management: organizational policies, physical security, planning and risk analysis, emergency response and disaster recovery, security audits, legal and ethical issues.

ITS 336 Artificial Intelligence 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Overview of current research and applications of artificial intelligence. Introduction to the languages of artificial intelligence such as Prolog or LISP. Search techniques. Knowledge representation, reasoning, inference. Machine learning. Expert systems.

ITS 341 Management Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Structure and design of computer-based information systems. Topics included are computer hardware and software, database models, database management systems, system analysis, design and implementation.

ITS 342 3D Computer Animation 3(3-0-6)
Prerequisite: CSS 221 or consent of Head of School
Introduction to techniques for computer animation such as keyframing, procedural methods, motion capture, and simulation. Overview of story-boarding, scene composition, lighting and sound track generation. 3D images and animations, application software.

ITS 343 Business Application Programming 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Introduction to computer programming with an emphasis on business applications. Transaction processing systems and management support systems. Principles of program design. Programming structures. Data structures. Program testing. Debugging. Implementation of programs with graphical user interfaces and event driven code.

ITS 391 Data Structures for Information Processing 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Concepts of data structures. Data structures and programming. Basic data structures: stacks, queues, linked lists, trees, graphs, etc. Recursion. Hash tables. Sorting and searching algorithms.

ITS 393 Networking and Collaborative Computing 3(3-0-6)
Prerequisite: None
Introduction to data communication, networks, distributed processing and collaborative computing. Technical and management aspects of computing networks and distributed systems supporting a wide range of organizational functions from organizational process to strategic decision making; from personal to group to organizational computing. Social and organizational implications of the telecommunications technology.

ITS 400 Project Development 1(0-3-0)
Prerequisite: Senior standing or
consent of Head of School
Practical projects or problems in Information Technology for individual students or groups of students under supervision of faculty members. Students are required to submit and present the project proposal to their project committee appointed by the school.

ITS 403 Senior Project 6(0-18-0)
Prerequisite: Senior standing or
consent of Head of School
Practical projects or problems in information technology for individual student or group of students under supervision of faculty members. Students are required to submit and present the project report to their project committee appointed by the school.

ITS 411 Advanced Computer Networks 3(3-0-6)
Prerequisite: ITS 327 or consent of Head of School
Integrated Services Digital Networks (ISDN), high-speed networks. Application and system integration. International networks, standards, and regulations.

ITS 412 Tele-services and Services Architecture 3(3-0-6)
Prerequisite or Corequisite: ITS 327 or
consent of Head of School
In modern telecommunications, service providers experience market expansion and changes in service provisioning technologies. This course aims at presenting students with an architectural foundation, which is based on the convergence of computer, tele-communication, and digital content technologies. Topics include Intelligent Networks, Common Object Request Broker Architecture (CORBA), and common service architectures available in several telecommunication standards.

ITS 413 Internet Technologies and Applications 3(3-0-6)
Prerequisite or Corequisite: ITS 327 or ITS 393 or
consent of Head of School
An overview of Internet technologies and applications. Topics to be covered include TCP/IP first generation (IPv4), TCP/IP new generation (IPv6), integration with ATM, new infrastructures (e.g., Internet 2, gigapops, IP over SONET, and IP over WDM), IP telephony, video over IP, multimedia applications over IP.

ITS 414 Real-time System Engineering 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Systematic methodology and techniques for developing process-intensive real-time software, e.g., tele-communications software. Topics include software development methodologies, object-orientation, specification languages, verification, SDL and UML.

ITS 421 Intelligent Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Solving problems by searching. Heuristic search methods. Games as search problems. Knowledge representation, reasoning and logic. First-order logic. Knowledge-based systems and knowledge engineering. Uncertain knowledge and reasoning. Probabilistic reasoning systems. Machine learning.

ITS 422 Introduction to Decision Support Systems 3(3-0-6)
Prerequisite: None
Features, uses, and design strategies of decision support systems. Model-based, data-based, and knowledge-based support systems to aid managerial problem solving.

ITS 423 Data Warehouses and Data Mining 3(3-0-6)
Prerequisite: ITS 322 or consent of Head of School
Introduction data warehousing and data mining. Principles, algorithms, implementations, and applications of data mining and data warehouse. Topics include data warehousing technology: data cube methods, data warehouse construction and maintenance; data mining techniques: characterization, association, classification, clustering, and similarity-based mining.

ITS 424 Electronic Commerce 3(3-0-6)
Prerequisite: None
Introduction to economic aspects of the electronic marketplace. Electronic Commerce foundations. Development method of new business models. Topics included are electronic commerce and the Internet, characteristics of digital products and processes, product information, market efficiency, copyright protection, and electronic payment systems.

ITS 431 Mobile Computing 3(3-0-6)
Prerequisite: None
Topics include mobile data communication, mobile resource management, network protocols for mobile environments, distributed computing, resolving conflicts and ensuring primary keys, authentication processes, secure and efficient mobile computing designs, backup and recovery in mobile environments, mobile performance design, replication solutions and introduction to ubiquitous computing.

ITS 432 Real-time and Embedded Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Design and development of real-time systems, real-time programming and real-time operating systems, multitasking and other concurrent-system concepts, real-time schedulers, process synchronization, memory management, interrupts. Real-time modeling languages, state chart diagrams and sequence diagrams. Real-time system and embedded system applications.

ITS 441 Accounting Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Introduction to information systems for accounting and finance, including their role, in identifying, recording, and classifying financial transactions. Characteristics of various types of accounts. Accounting principles and concepts for measuring financial transactions. Preparation of financial statements. Financial analysis and the basic principles of financial management in the allocation and acquisition of funds.

ITS 442 Entrepreneurship for IT Business Development 3(3-0-6)
Prerequisite: None
Technology viability assessment, legal issues associated with forming a new company, competitive positioning, market analysis and market opportunity assessment, product life-cycle planning, marketing strategy, organization management, intellectual property management, patenting, technopreneurship, business plan, venture capital, entrepreneurial ethics.

ITS 452 Knowledge Base System 3(3-0-6)
Prerequisite: ITS 221 or consent of Head of School
Knowledge acquisition and representation. Rule-based systems, frame-based systems. First-order logic, relational algebra, and relational calculus. Fundamentals of logic programming. Logic for knowledge representation. Architecture of a knowledge-base system. Fundamentals of deductive databases. Top-down and bottom-up query processing.

ITS 453 Natural Language Processing 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Language analysis, models of inference, text structures, machine translation. Practical and theoretical issues related to getting computers to perform useful and interesting tasks involving human language. Syntactic and semantic analysis, discourse analysis, knowledge representation, and machine learning. Practical applications of natural language processing, such as information extraction, question answering and machine translation.

ITS 454 Intelligent and Autonomous Systems 3(3-0-6)
Prerequisite: CSS 224 or consent of Head of School
Overview of intelligent and autonomous systems. Architecture of computer systems for autonomous mobile robots. Sensor information processing; operating systems for autonomous systems.

ITS 455 Software Engineering 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Methodologies and strategies for developing medium and large scale software. Topics include software management, problem analysis, cost estimation, system design techniques, system testing and performance evaluation, and system maintenance.

ITS 456 Parallel and Distributed Processing 3(3-0-6)
Prerequisite: CSS 225 or consent of Head of School
Architectures, algorithms, and languages for parallel and distributed processing. Pipeline computing; super computing; multi-processing control; dataflow computing. Distributed computer systems; distributed file systems; distributed shared memory.

ITS 457 Data Storage and Memory Devices 3(3-0-6)
Prerequisite: CSS 224 or consent of Head of School
Volatile and non-volatile storage, silicon memory, hard disks, CD-ROMS. Design concepts of memory modules for various computer systems.

ITS 458 Computer Graphics 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Representation and manipulation of graphic data. Representation and transformation of two-dimensional space, three-dimensional space. Illumination and shading modes.

ITS 459 Multimedia Technology 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Multimedia storage models and structures; video/audio interfaces; media synchronization; image computing; interactive software design.

ITS 461 Visual Information Processing 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Computer extraction and identification of objects in visual scenes. Fundamental techniques, current topics, and applications.

ITS 462 Computer Aided Design Technology 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Introduction to computer aided design software. Requirements and techniques for developments of CAD. Two-dimensional and three-dimensional representations, data structures, computer graphics.

ITS 463 Computer Aided Education 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Introduction to computer aided education software. Requirements and techniques for developments of CAE. Education concepts, multimedia applications, user interfaces, development tools.

ITS 464 Computer Simulation 3(3-0-6)
Prerequisite: ITS 100 or IES 302 or
consent of Head of School
Simulation of discrete and continuous dynamic systems; programming techniques and languages; statistical aspects of simulations.

ITS 465 Information Technology in Business 3(3-0-6)
Prerequisite: None
Case study of how businesses are utilizing information technology to gain competitiveness in the border-less world communities. Relationship between information technology and business.

ITS 466 Office Automation and Administration 3(3-0-6)
Prerequisite: None
Work flow study, office computer system design, public and private communications networks. Computer and network system administration.

ITS 467 Computer Game Design and Development 3(3-0-6)
Prerequisite: None
Introduction to computer game design methodology and implementation techniques. Hands-on development of computer games with latest game programming languages and development environments. Video games with object-oriented and component-based approaches.

Various software technologies relevant to computer game design: game engines, game programming environments, performance and optimization, collision detection, 2D and 3D graphics and computer animation, sound effects and music, interactivity and user interface, multiplayer games, data-driven game design and AI approaches to game development.

ITS 469 IT Project Management 3(3-0-6)
Prerequisite: None
Project manager skills, project planning and reporting, project teams, the project management lifecycle, project planning phase, analysis and design phases, construction, test planning, and preparation phases, rollout planning and implementation phase, project management methodologies, managing rapid application development, risk management, change management, knowledge management, internet and project management.

ITS 472 Advanced Operating Systems 3(3-0-6)
Prerequisite: CSS 225 or consent of Head of School
Architecture of graphical user interface based operating systems. Architecture of operating systems for high performance computers. Relationship between computer architecture and operating systems.

ITS 473 Advanced Database Management System 3(3-0-6)
Prerequisite: ITS 322 or consent of Head of School
Object-oriented databases, transaction processing, query optimization, and performance evaluation.

ITS 474 Advanced Computer Architecture 3(3-0-6)
Prerequisite: CSS 224 or CSS 225 or
consent of Head of School
Architecture of engineering workstations, mini computers and super computers.

ITS 481 Topics in Hardware and Communications I 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Hardware and Communications.

ITS 482 Topics in Hardware and Communications II 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Hardware and Communications.

ITS 483 Topics in Hardware and Communications III 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Hardware and Communications.

ITS 484 Topics in Software Technology I 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Software Technology.

ITS 485 Topics in Software Technology II 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Software Technology.

ITS 486 Topics in Software Technology III 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Software Technology.

ITS 487 Topics in Computer Information Systems I 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Computer Information Systems.

ITS 488 Topics in Computer Information Systems II 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Computer Information Systems.

ITS 489 Topics in Computer Information Systems III 3(3-0-6)
Prerequisite: Consent of Head of School
Topics of current interest in Computer Information Systems.

ITS 491 Information System Development 3(3-0-6)
Prerequisite: None
This course provides a foundation in systems analysis and design concepts, methodologies, techniques, and tools. Students will learn to analyze an organizational problem, define user requirements, design an information system, and plan an implementation. Methodologies covered will include the traditional life cycle approach as well as newer methodologies such as an object-oriented approach, joint applications development (JAD), and prototyping.

ITS 492 Intelligent Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Foundations and principles of knowledge-based systems, including prepositional logic, first-order logic, and reasoning. Knowledge representation, integration, and evolution. Knowledge engineering. Intelligent databases: object-oriented, extended-relational, logic-based, and active databases, and constraint management. Intelligent information retrieval, digital libraries, and networked information retrieval. Semantic Web. Uncertainty management and reasoning under uncertainty.

ITS 493 Information Organization and Retrieval 3(3-0-6)
Prerequisite: None
Organization, representation, and access to information. Categorization, indexing, and content analysis. Data structures. Design and maintenance of databases, indexes, classification schemes, and thesauri. Use of codes, formats, and standards. Analysis and evaluation of search and navigation techniques.

ITS 495 Special Topics in Information Technology I 3(3-0-6)
Prerequisite: None
Special study on current topics related to Information and Communication Technology.

ITS 496 Special Topics in Information Technology II 3(3-0-6)
Prerequisite: None
Special study on current topics related to Information and Communication Technology.

ITS 499 Extended Information Technology Training 6(0-40-0)
Prerequisite: Senior standing or consent of Head of School
Extensive on-the-job training of at least 17 weeks at a selected organization that provides information technology services — an individual comprehensive research or practical project related to the training must be intensively conducted under close supervision of faculty members and supervisors assigned by the training organization. At the end of the training, the student must submit a report of the project and also give a presentation.

MAS 116 Mathematics I 3(3-1-5)
Prerequisite: None
Mathematical induction; functions; limits; continuity; differential calculus – derivatives of functions, higher order derivatives, extrema, applications of derivatives, indeterminate forms; integral calculus – integrals of functions, techniques of integration, numerical integration, improper integrals; introduction to differential equations and their applications; sequence and series – Taylor's expansion, infinite sums.

MAS 117 Mathematics II 3(3-1-5)
Prerequisite: MAS 116 or consent of Head of School
Analytic geometry in calculus – polar and curvilinear coordinates; three-dimensional space – vectors, lines, planes, and surfaces in three-dimensional space; function of several variables; calculus of real-valued functions of several variables and its applications – partial derivatives, extremes of functions, functions of higher derivatives, Lagrange multipliers; topics in vector calculus – line and surface integrals, Green's theorem.

MAS 210 Mathematics III 3(3-1-5)
Prerequisite: MAS 117 or consent of Head of School
Linear algebra – vector spaces, linear transformation, matrices, determinants, systems of linear equations, Gaussian elimination, eigenvalue problems, eigenvalues and eigenvectors, diagonalization, complex matrices; introduction to complex analysis – complex numbers, analytic functions, complex integration, conformal mapping; calculus of variations; introduction to tensor analysis – cartesian tensors and their algebra.

MAS 215 Differential Equations 3(3-0-6)
Prerequisite: MAS 117 or consent of Head of School
Ordinary differential equations of the first order; linear ordinary differential equations of higher order – matrix notation, homogeneous solutions, method of variation of parameters; general ordinary differential equations – series solutions, Bessel functions, Laplace transformation; Fourier analysis – Fourier series, integrals and transforms; partial differential equations – methods of separating variables, applications of Laplace and Fourier transforms; applications to initial-value and boundary-value problems.

MAS 256 Numerical Methods 3(3-0-6)
Prerequisite: MAS 215 or consent of Head of School
This course emphasizes the theories and techniques of numerical analysis. Topics include error analysis, eigenvalue problems, nonlinear equations, approximation and interpolation, numerical differentiations and integration, and numerical solution of ordinary differential equations.

MCS 321 Real-time and Embedded Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Design and development of real-time systems. Real-time programming and real-time operating system, multitasking and other concurrent-system concepts, scheduling, process synchronization, memory management, interrupts. Real-time modeling languages, state chart diagrams and sequence diagrams. Real-time system and embedded system applications.

MCS 322 Introduction to Mechatronics 3(3-0-6)
Prerequisite: None
Introduction to integration of mechanical, electrical and computer systems for information processing and control of machines and devices. Basic electronics, signal processing, micro-controller and microprocessor, sensors and actuators. Control architecture in mechatronic systems. Overview of electro-mechanical design and embedded systems in topics of current interest in mechatronics.

MCS 361 Mechatronic Instrumentation 3(3-0-6)
Prerequisite: ECS 302 and (MES 211 or MES 310 or MES 311) or consent of Head of School
Analysis, characteristics and applications of instruments used in engineering mechatronics including transducers, sensors, actuators, etc. Measurement principles. Integrated sensors actuators. Programmable Logic Control (PLC) Data Acquisition Systems.

MCS 382 Computer Interfacing 3(3-0-6)
Prerequisite: ECS 382 or consent of Head of School
Architectural view of microprocessor-based systems. Components of microprocessor-based systems. Detailed descriptions of the components: electronics, functions, and interfaces. System bus. Interrupts, DMA and I/O. Interfacing techniques.

MCS 451 Introduction to Robotics 3(3-0-6)
Prerequisite: ECS 381 or consent of Head of School
Operation principles, analysis, and design of robots. Mechanical manipulators: kinematics, dynamics, trajectory planning, and control. Robotic vision and visual feedback. Robot programming languages. Control algorithm design. Current topics of interest from the literature.

MCS 483 Dynamic Systems and Control 3(3-0-6)
Prerequisite: MES 351 or consent of Head of School
Mathematical modeling of mechanical, electrical, pneumatic, hydraulic and combined physical systems using unified approach such as Bond graph technique. Introduction state-variables, system response, stability using laplace transform technique. System characteristics; controllability and observability. Open and closed loop responses of control systems. Solution to state equation by direct analysis and digital computer methods.

MES 211 Thermofluids 3(3-1-5)
Prerequisite: SCS 138 or GTS 121 or consent of Head of School
Concepts of system, state and process. Energy and energy equations. Second law of thermodynamics, reversibility and entropy Thermodynamic cycles.

Continuity and momentum equations. Velocity and flow measurement. Fluid flow in pipes. Fluid machinery. Modes and concepts of conductive, convective and radiative heat transfer. Engineering heat transfer equations and applications.

MES 231 Engineering Mechanics 3(3-1-5)
(For non-mechanical engineering students)
Prerequisites: SCS 138 or consent of Head of School
Force systems; resultants; equilibrium; trusses; frames and machines; internal force diagrams; mass and geometric properties of objects; fluid statics; kinematics and kinetics of particles and rigid bodies; Newton's second law of motion.

MES 300 Engineering Drawing 3(2-3-4)
Prerequisite: None
Introduction to basic principle of engineering drawing including lettering, applied geometry, orthographic drawing and sketching, sectional views and conventions, detail drawing, assembly drawing, dimensioning, three dimensioning, basic descriptive geometry dealing with points, lines & planes and their relationships in space and basic developed views. Introduction to Computer Graphics.

MES 302 Introduction to Computer Aided Design 2(1-3-2)
Prerequisite: MES 300 or consent of Head of School
Use of industrial Computer Aided Design Software for detail design and drafting in various engineering fields such as in mechanical, civil, and electrical engineering. Introduction to three-dimensional wireframe, surfacing and solid modeling using CAD tools.

MES 303 Mechanical Engineering Training 0(0-0-0)
Prerequisite: Junior standing
Students are required to obtain practical training in the field of mechanical engineering at selected private sectors or governmental departments for not less than 240 hours during summer vacation of the third year. The objective is to allow the students to have opportunities to experience actual working conditions other than what is learned in the classrooms and laboratories. Students must submit a report at the end of the training period, Satisfactory (S) or Unsatisfactory (U) grade will be given based on student's performance, quality of the report and supervisor's comments.

MES 310 Thermodynamics 3(3-1-5)
(For non-mechanical engineering students)
Prerequisite: None
Definitions and basic concepts. SI units. Properties of pure substances and ideal gases. Heat and work. First and second laws of thermodynamics and their applications. Entropy. Power and refrigeration cycles and equipment including gas turbine, internal combustion engines and steam power plant. Basic heat transfer.

MES 311 Thermodynamics 3(3-1-5)
Prerequisite: None
Basic concepts. Work and heat. Zeroth law of thermodynamics, temperature and its measurement. The first law of thermodynamics and energy. Pure substances and their properties. The first law for steady flow process and enthalpy. The second law of thermodynamics and thermodynamic heat engines. Reversibility and irreversibility. Entropy. Ideal gas. Mixtures.

MES 312 Combustion and Emission Control 3(3-0-6)
Prerequisite: MES 311 or equivalent or
consent of Head of School
Properties of fossil fuels. Production of synthetic fuels from biomass, coal, oil shales and tar sands. Stoichiometry, Combustion processes and emission control in boilers and furnaces, internal combustion engines and gas turbines.

MES 321 Heat Transfer 3(3-0-6)
Prerequisite: MES 211 or MES 310 or MES 311 or
consent of Head of School
Steady-state conduction. Natural convection. Forced convection. Thermal radiation. Unsteady-state conduction. Combined heat transfer problems. Condensation and boiling heat transfer. Heat exchangers.

MES 331 Solid Mechanics I 3(3-1-5)
Prerequisite: SCS 138 or consent of Head of School
Concepts of internal force and stress and deformation and strain. Analysis of stress and strain, Mohr's circles for stress and strain, stress-strain relationship. Stress and strain in thin-walled pressure vessels. Thermal stresses. Energy method. Torsion of circular shaft, thin-walled tubes, and close-coiled helical spring. Shear force, bending moment and bending stress in beams. Deflection of beams.

MES 332 Solid Mechanics II 3(3-0-6)
Prerequisite: MES 331 or consent of Head of School
Generalized concepts of strain and Hooke's law. Thick-walled cylinders and shrink fits. Rotating discs. Open-coiled helical springs and impact loads. Axisymmetric bending of circular plates. Buckling of columns. Use of Mohr's circles for transformation of stress and strain, yield and fracture criteria. Virtual work and energy methods.

MES 333 Design of Machine Elements 3(3-0-6)
Prerequisite: MES 332 or consent of Head of School
Theories of failure for static and dynamic loading. Design of mechanical components such as rotating shafts, bearing, welding, screw, springs and power transmission devices. Introduction to the use of computer as a tool in problem solving of mechanical design.

MES 341 Fluid Dynamics 3(3-1-5)
Prerequisite: SCS 138 or consent of Head of School
Motion of fluid particles and stream lines. Momentum equations and applications. Energy equations and applications. Laminar and turbulent internal flows. Flow of fluid around a body. Boundary layers. Similarity and dimensional analysis. Theories and designs of centrifugal and axial-flow pumps, fans, water turbines and cavitation. Flows in open channels. Compressible flow.

MES 342 Refrigeration and Air Conditioning 3(3-0-6)
Prerequisite: (MES 310 or MES 311) and
(CES 381 or MES 211 or MES 341) or
consent of Head of School
Refrigeration cycles and properties of refrigerants. Evaporative cooling and cooling towers. Refrigeration load estimation. Design of refrigeration systems. Equipment selection and design. Psychromatric

properties and processes of air. Criteria for thermal comfort. Cooling load estimation. Design of air-conditioning systems. Equipment selection and design.

MES 350 Engineering Statics 3(3-1-5)
Prerequisite: SCS 138 or consent of Head of School
Method of solving engineering problem using fundamental principles of mechanics, resultant and resolution of forces and couples, equilibrium of particles, rigid bodies and various structures, concept of friction, centroid, mass center and center of gravity, moment of inertia of area and mass, virtual work.

MES 351 Engineering Dynamics 3(3-1-5)
Corequisite: SCS 138 or consent of Head of School
Dynamics of particles: velocity, acceleration, force, momentum, laws of motion, work, power, energy, impulse, impact of elastic bodies, projectiles, circular motion. Dynamics of rigid bodies: moment of inertia and radius of gyration of various rigid bodies, rigid-body motion, force and acceleration, work and energy, impulse and momentum.

MES 352 Mechanics of Machinery 3(3-0-6)
Prerequisite: MES 351 or consent of Head of School
Kinematics and dynamics of machines; displacement velocity, acceleration, and force analysis of linkage, cams and gear systems. Balancing of rotating and reciprocating machine parts; gyroscopic effects, critical speeds; energy variation in machinery. Mechanism design.

MES 361 Automotive Engineering 3(3-0-6)
Prerequisite: (MES 331 and MES 351) or
consent of Head of School
Dynamics of vehicles, structures, suspensions, steering, brakes and drive-train. Vehicle performance and handling modes. Basic internal combustion processes, engines components, supercharging, turbo-charging and compounding. Electrical systems in automobile. Introduction to the design of passenger vehicles.

MES 371 Material Science for Engineers 3(3-1-5)
Prerequisite: None
The course discusses properties and structure of material including metals, alloys, ceramics, polymers, wood, concrete, composites, and solid-state materials. Study of microstructures in relationship with mechanical properties of materials and phase equilibrium diagrams. Effects of production processes on microstructure of materials, degradation and failure analysis.

MES 381 Measurements and Instrumentation 3(3-0-6)
Prerequisite: MES 310 or MES 311 or
consent of Head of School
Measurements of temperature, pressure, time, speed, area, volume and measuring devices. Fluid flow measurements. Power measurements. Heating values of fuels, calorimeter and exhaust gas analysers. Data monitoring and acquisition systems.

MES 382 Vibration and Noise Control 3(3-0-6)
Prerequisite: MES 351 or consent of Head of School
Vibration: linear system equation, free and forced responses, systems with two degrees of freedom. Behaviour of sound waves. Sources of environment noise and vibration and their impacts. Instrumental and practical measurement. General physiological and subjective responses to noise and vibration. Regulations, criteria, methods and techniques to reduce and control environmental noise and vibration.

MES 383 Hydraulic and Pneumatic Control 3(3-0-6)
Prerequisite: MES 341 or consent of Head of School
Static and dynamic modeling of hydraulic and pneumatic components and systems. Energy and power transfer and impedance matching concepts. Dynamic performance and stability of open and closed-loop servodrives. Introduction to hydraulic and pneumatic control system design.

MES 390 Basic Mechanical Engineering Laboratory 1(0-3-0)
(For non-mechanical engineering students)
Prerequisite: MES 211 or MES 310 or MES 311 or
consent of Head of School
A service course for students with major outside mechanical engineering. Experimental practices cover fluid mechanics, heat transfer, thermodynamics, combustion and emission, mechanism, physical and mechanical properties of materials. Technical notes on the experimental tests have to be submitted for grading.

MES 391 Mechanical Engineering Laboratory I 2(1-3-2)
Prerequisite: MES 310 or MES 311 or
consent of Head of School
Students are required to conduct tests and experiments on physical and mechanical properties of materials, mechanisms, fluid mechanics, thermodynamics and heat transfer, combustion and internal combustion engines. Reports or technical notes on the tests and experiments have to be submitted for grading.

MES 392 Mechanical Engineering Laboratory II 2(1-3-2)
Prerequisite: MES 310 or MES 311 or
consent of Head of School
Students are required to conduct tests and experiments on physical and mechanical properties of materials, mechanisms, fluid mechanics, thermodynamics and heat transfer, combustion and internal combustion engines. Reports or technical notes on the tests and experiments have to be submitted for grading.

MES 393 Thermal Energy Laboratory 2(1-3-2)
Prerequisite: MES 311 or equivalent or
consent of Head of School
Tests and experiments cover fluid mechanics, thermodynamics, heat transfers selected thermal energy systems and measurements on flow, pressure, temperature, etc. Report/ technical notes on the tests/ experiments have to be submitted for grading.

MES 403 Senior Project I 1(0-2-1)
Prerequisite: Senior standing
Students are required to present seminars on current development of mechanical engineering to their class mates and faculties. The seminars may lead to senior projects later on. The reports of the seminars have to be submitted for grading.

MES 405 Special Study in Mechanical Engineering I 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students wish to participate in the exchange program. It is designed for topics related to mechanical engineering, but not presently offered as either a required or technical elective.

MES 406 Special Study in Mechanical Engineering II 3(3-0-6)
Prerequisite: Consent of Head of School
(For Exchange Track)
This course is intended for students wish to participate in the exchange Track. It is designed for topics related to mechanical engineering, but not presently offered as either a required or technical elective.

MES 407 Senior Project II 6(0-18-0)
Prerequisite: Senior standing
(For Senior Project Track)
A final course involving individual or group projects including design, analysis and implementation of mechanical systems selected from various interesting areas within mechanical engineering. Students are required to propose their projects during the first semester of their senior year. After a project is completed, students are responsible for submitting their final report and giving a presentation.

MES 408 Mechanical Project or Extended Mechanical Engineering Training 6(0-40-0)
(For Extended Mechanical Engineering Training Track)
Students are provided with extensive on-the-job training at selected modern mechanical engineering facilities. The purpose of the course is to allow the students opportunities, to work and intensively conduct an individual research or practical project for at least 17 weeks under the close supervision of faculty members and main supervisors assigned by the training company. After the project is completed, students are responsible for submitting their final report and giving a presentation.

MES 413 Advanced Thermodynamics 3(3-0-6)
Prerequisite: MES 211 or MES 311 or
consent of Head of School
Review on basic concepts and definitions, the first-law and energy, the second law and entropy. Thermo-mechanical availability and irreversibility. Availability equation for a control mass and applications. Energy and mass equations for a control volume and applications. Second law efficiencies for control mass and control volume applications. Chemical availability. Energy analysis of engineering cycles. Thermoeconomics.

MES 422 Thermal System Design 3(3-0-6)
Prerequisite: (MES 321 and MES 341) or
consent of Head of School
Design procedure. Comparison between a workable system and optimum system. Equation fitting for equipment and processes characterization. Modeling of equipment and processes based on physical laws. Simulation of thermal systems. Selected optimization techniques such as Lagrange multiplier, search methods, linear programming, etc.

MES 434 Mechanical System Design 3(1-6-2)
Prerequisite: MES 333 or consent of Head of School
Mechanical engineering system design involving practical problems in various industries. Students, working in groups, will investigate the design methodology and process from concept through final design including detailed analysis of all mechanical components of the system, by which knowledge of all engineering disciplines, is required. Projects are proposed from various areas of study within mechanical engineering. Students submit a final report and present their projects at the end of semester.

MES 443 Environmental Control Engineering 3(3-0-6)
Prerequisite: MES 342 or consent of Head of School
Review of properties of moist air and refrigerants, refrigeration cycles, refrigeration processes and cryogenics. Solar energy fundamentals and applications. Heat transfer in building structures. Heating and cooling loads. Thermal environmental control systems. Design of refrigeration and air conditioning systems. Energy conservation in buildings.

MES 444 Renewable Energy Resources 3(3-0-6)
Prerequisite: None
Global and regional resources, conversion technologies and economics of renewable energy such as hydropower, biomass energy, solar energy, wind energy and geothermal energy.

MES 462 Turbomachinery 3(3-0-6)
Prerequisite: ((MES 310 or MES 311) and MES 341) or
consent of Head of School
Review of thermodynamics of compressible flow. Principles, designs and applications of centrifugal and axial flow machines, i.e. centrifugal turbine and compressor, axial flow turbine and compressor, impulse and reaction steam turbine and laval nozzle. Steam and gas turbine plants: theories, applications, performance characteristics of practical cycles. Erosion problems in steam and gas turbine components.

MES 471 Electrical Energy Management 3(3-0-6)
Prerequisite: Senior or junior standing or
consent of Head of School
Basic concepts. Management of electrical energy. Distribution circuits and equipment. Electrical tariff. Load and demand management. Power factor and loss management. Applications of thermodynamics to the analysis of electromagnetic circuits, transformer, motor and generator.

MES 472 Advanced Engineering Materials 3(3-0-6)
Prerequisite: MES 371 or consent of Head of School
Mechanical behavior and environmental degradation of polynamic metal and ceramic matrix composites. Manufacturability of advanced engineering materials. Use of composite materials in novel engineering designs. Material selection methods using such criteria as a cost-to-strength basis or weight-to-strength basis to the design of mechanical products.

MES 473 Energy Economics 3(3-0-6)
Prerequisite: None
Depletion of energy resources. Energy pricing. Fiscal instruments of energy policy. Uncertainty and energy policy. Energy analysis and energy policy. Environmental policy and energy development. Energy

analysis and energy policies of selected countries. Energy project appraisal.

MES 474 Thermal Energy Management 3(3-0-6)
Prerequisite: Senior or junior standing or consent of Head of School
Efficient uses of thermal equipment and systems such as boilers and steam equipment, evaporator and condenser, pre-heater and economiser, dryers and drying systems, etc.

MES 493 Extended Mechanical Engineering Laboratories 3(1-6-2)
Prerequisite: (MES 391 and (MES 392 or MES 393)) or consent of Head of School
Students are required to conduct extended tests and experiments on thermo-fluid systems such as fluid machinery systems, gas turbines, refrigeration and air conditioning systems, etc. Component modeling and system simulation are expected in the reports submitted for grading.

MES 494 Special Topic I in Mechanical Engineering 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other mechanical engineering courses. Topics may vary from semester to semester and will not be the same as the one offered in Special Topic II MES 495.

MES 495 Special Topic II in Mechanical Engineering 3(3-0-6)
Prerequisite: None
New topics or areas of study not offered in other mechanical engineering courses. Topics may vary from semester to semester and will not be the same as the one offered in Special Topic I MES 494.

MTS 211 Principles of Business 3(3-1-5)
Prerequisite: None
This subject provides a broad overview of the world of business preparing students for various business-related subjects. It offers a comprehensive introduction of every aspect of business and the environment in which business operates. Emphasis is placed upon business organizations in general, including the objectives and overall responsibilities of business enterprises within their social and economic context. The fundamentals of business which spans the range of all functional areas-management, accounting, marketing, operations, information systems, finance and legal studies will be introduced. Students will learn the language of the business world and the legal forms of business. Additionally, topics in small business and entrepreneurship will also be covered.

MTS 212 Principles of Management 3(3-1-5)
Prerequisite: None
A study of organization and management trails evolution of thoughts and theory of management. Management functions which are planning, organizing, directing, and controlling are emphasized on effects of human factors in organization and management ethics.

MTS 231 Statistical Methods for Managers 3(3-1-5)
Prerequisite: GTS 111 or MAS 117 or consent of Head of School
This course introduces fundamentals of probability and statistic: descriptive statistics, probability, discrete random variables and probability distributions, continuous random variables and probability distributions, point estimation, interval estimation, tests of hypotheses, analysis of variance, and regression analysis.

MTS 232 Production and Operations Management 3(3-0-6)
Prerequisite: None
This course is intended to present various functions in modern manufacturing and service organizations that are important to their business operations. These functions include defining operations strategy, decision analysis, designing the operating system, facility design, project management, supply-chain management, forecasting, capacity and aggregate planning, inventory management, scheduling, and quality management.

MTS 233 Introduction to Supply Chain Management 3(3-0-6)
Prerequisite: None
This course introduces the general principle of domestic and international supply chain systems. Major topics include introduction to logistics, transportation, production planning, inventory control, purchasing and procurement, packaging, supply chain integration, and information technology for supply chain management.

MTS 251 Resource Economics 3(3-0-6)
Prerequisite: None
A study of the natural and energy resources by means of economic analysis, the relationship between environment and economy, the causes and impacts of environmental deterioration as explained by economic theory, the economics of environmental quality. The application of economic theories to various kinds of resources, economic theories and instruments in resource management, demand and supply for resource and energy, price and income elasticities, environmental policy and energy development, environmental and energy policies analysis.

MTS 252 Materials Science 3(3-0-6)
Prerequisite: None
The course introduces a wide range of industrial materials, under the two main categories of structural and functional materials. Traditional and engineered structural materials discussed include metallic alloys, ceramics, polymers and composites. For the functional materials, semiconductors, superconductors, magnetic materials and smart materials will be presented. Finally, failure and properties degradation are discussed.

MTS 253 Mechanics for Technologists 3(3-0-6)
Prerequisite: None
Dynamics of particles: velocity, acceleration, force, momentum, laws of motion, work, power, energy, impulse, impact of elastic bodies, projectiles, circular motion. Concepts of internal force and stress and deformation and strain. Stress and strain in thin-walled tubes, and close – coiled helical springs.

MTS 254 Introduction to Management Science 3(3-1-5)
Prerequisite: None
This course discusses the application of quantitative methods in solving management problems. Topics discussed include linear programming modeling,

graphical method for solving linear programming problems, graphical methods for sensitivity analysis, assignment problems, network models, integer linear programming, goal programming, analytic hierarchy process, decision analysis, project management, simulation, and forecasting models.

MTS 301 Management Technology Training 0(0-0-0)
Prerequisite: Junior standing
Students are provided with on-the-job training at selected industrial or service organizations. The purpose of this course is to allow the students opportunities, to learn through hands-on experience how various modern technologies can be applied to manage facilities and systems. Moreover, students will learn how to collaborate with co-workers, coordinate project activities, and develop self-responsibility. The training period must not less than 240 hours. Students must submit a written report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on the student's performance, the quality of the report, and the supervisor's comments.

MTS 302 Extended Management Technology Training 6(0-40-0)
Prerequisite: Junior standing
This extended management technology training provides students with intensive on-the-job training at selected industrial or service organizations. The training period must not be less than 480 working hours. This intensive training will enable students to work with company personnel to solve real problems, not simulated ones. Students will gain hands-on experience on how various modern technologies are applied to manage facilities and systems. Moreover, they will learn how to collaborate with colleagues, coordinate project activities, and develop self-responsibility. In addition to a designated supervisor at the company, a faculty member will be assigned to co-supervise the student's training program. An approved industrial project is expected to be carried out by the student. At the end of the training period, the student must give an oral presentation of his/her work and submit a written report of the assigned project to the company and the MT Program.

MTS 304 Extended Engineering Management Training 6(0-40-0)
Prerequisite: Senior standing
The extended engineering management training provides students with intensive on-the-job training at selected industrial or service organizations. The training period must not be less than 480 working hours. This intensive training will enable students to work with company personnel to solve real problems, not simulated ones. Students will gain hands-on experience on how various modern technologies are applied to manage facilities and systems. Moreover, they will learn how to collaborate with colleagues, coordinate project activities, and develop self-responsibility. In addition to a designated supervisor at the company, a faculty member will be assigned to co-supervise the student's training program. An approved industrial project is expected to be carried out by the student. At the end of the training period, the student must give an oral presentation or his/her work and submit a written report to the assigned project to the company and the EM Program.

MTS 309 Engineering Management Training 0(0-0-0)
Prerequisite: Junior standing
Students are provided with on-the-job training at selected industrial or service organizations. The purpose of this course is to allow the students opportunities, to learn through hands-on experience how various modern technologies can be applied to manage facilities and systems. Moreover, students will learn how to collaborate with co-workers, coordinate project activities, and develop self-responsibility. The training period must not less than 240 hours. Students must submit a written report at the end of the training period. Satisfactory (S) or unsatisfactory (U) grade will be given based on the student's performance, the quality of the report, and the supervisor's comments.

MTS 311 Fundamental Financial Accounting 3(3-1-5)
Prerequisite: None
A study of the evolution of accounting; the functions of accounting in identifying, recording, and classifying financial transactions; characteristics of various types of accounts; the accounting principles and concepts for measuring these financial transactions; a preparation of financial statements; the usefulness and limitations of accounting information as well as preparation of financial statements for an entity with incomplete accounting records.

MTS 312 Principles of Marketing 3(3-1-5)
Prerequisite: None
The course introduces the definition and roles of marketing as one of business functions. Modern marketing concepts, marketing system, consumer behavior, marketing mix, tools for marketing management and responsibility and ethics of marketers are discussed.

MTS 313 Organizational Behavior 3(3-1-5)
Prerequisite: (MTS 211 and MTS 212) or
consent of Head of School
This subject provides an introduction to the study of individual and group behavior from an organizational as well as an individual perspective. Basic principles from psychology and sociology will be presented, with an emphasis on their application to management of organizations. The subject purposes to explore specific subject areas: group processes, decision making, motivation, leadership, organizational culture, power and politics, conflict and negotiation, and communication as well as other relevant and important issues facing organizations today. It will teach tomorrow's managers to develop, train, and motivate high-performance employees.

MTS 314 International Trade and Business 3(3-0-6)
Prerequisite: MTS 211 or consent of Head of School
The course includes international and globalization of business; global trade; global trade theories; global business environment (cultural, political, social, etc.), international competitiveness, international operations, international marketing, international financial management, expatriate managers, global strategic planning, strategy adaptations (marketing, human resources, etc.).

MTS 315 Laws and Regulations on International Logistics 3(3-0-6)
Prerequisite: None
Logistics systems and legal framework for the domestic and international movement of goods. Operational characteristics of providers of exporting and importing services. The effects of government trade policies on global logistics.

MTS 331 Economic Decision Analysis 3(3-0-6)
Prerequisite: None
This course provides fundamental concepts and tools for economic decision-making for business projects. The topics include money–time relationships and equivalence, cash flow analysis, minimum attractive rate of return (MARR) of an investment, several methods for investment appraisal such as present worth analysis (PW), annual worth analysis (AW), internal and external rate of return analysis (IRR and ERR), benefit and cost ratio (B/C), etc., effect of inflation, depreciation techniques, impact of depreciation and tax on decision analysis, sensitivity analysis and risk analysis for investment alternatives.

MTS 332 Quality Management 3(3-0-6)
Prerequisite: MTS 231 or consent of Head of School
This course focuses on quality control and management in both manufacturing and service environments. The topics cover statistical process control (SPC) concepts and practices in several types of control charts and sampling plans, including analytical tools such as check sheets, Pareto charts, cause-and-effect diagrams, etc., management, quality and productivity relationships, concepts of quality assurance and total quality management (TQM).

MTS 333 Production and Inventory Management 3(3-0-6)
Prerequisite: GTS 212 or MAS 116 or consent of Head of School
The focus of this course is to point out the relationship between inventory and production for management aspects. Various qualitative and quantitative topics on production in inventory management for both dependent and independent demands are discussed such as economic order quantity (EOQ), economic lot sizing (EPS0, just in time (JIT), materials requirement planning (MRP), manufacturing resources planning (MRP II), enterprise resources planning (ERP), production planning, and capacity planning.

MTS 334 Applications of Business Statistics 3(3-1-5)
Prerequisite: MTS 231 or consent of Head of School
This course emphasizes applications of statistical analysis techniques. Topics discussed include a review of hypothesis testing, analysis of variance, regression analysis, and other fundamental methods of statistics. The applications of business statistical tools will be covered.

MTS 335 Enterprise Planning and Control Systems 3(3-0-6)
Prerequisite: None
The design, analysis and implementation of enterprise-wide resource planning and control systems; demand forecasting, aggregate planning, decision support models for production planning, master scheduling, shop floor control; application of information technologies such as ERP and MRP II to operations planning and control.

MTS 336 Operations Scheduling 3(3-0-6)
Prerequisite: None
This course emphasizes models for sequencing and scheduling activities including: static and dynamic problems; deterministic and stochastic models, single machine processing; parallel machine processing; flow-shop and job-shop scheduling, project scheduling, workforce scheduling, exact and heuristic solution methods, and applications in manufacturing environments.

MTS 337 Transportation Issues in Logistics 3(3-0-6)
Prerequisite: None
The characteristics of the various modes of domestic and international transportation, factors that influence transport demand; costs; market structures; carrier pricing, Carrier operation and service characteristics and their influence on other supply chain costs and supply chain performance such as routes; labor; competition.

MTS 338 Warehouse Operations Management 3(3-0-6)
Prerequisite: None
Fundamental operations in warehouse management including roles of warehousing, warehouse technology such as bar codes, radio frequency identification (RFID) for inventory control system, modern warehouse operations, classifying products, materials handling equipments and system, racking and shelving, the aisle width decision, information technology for warehouse operations, health and safety issues.

MTS 339 Purchasing and Supply Management 3(3-0-6)
Prerequisite: None
An overview of the procurement and purchasing activities in a supply chain are discussed. Discussion topics include supplier evaluation and selection, pricing, negotiation, contracts, inventory management, quality, buying decisions and plans, cost analysis, purchase agreements, and purchasing analysis of capital equipment, services, institutional and government purchases.

MTS 340 Introduction to Inventory Management 3(3-0-6)
Prerequisite: None
Introduction of inventory management, types of inventory, inventory problem classifications; inventory cost; independent demand systems; deterministic and probabilistic models; single order quantities, dependent demand systems, material requirement planning (MRP), just-in-time (JIT), inventory valuation.

MTS 351 Management Systems Optimization 3(3-1-5)
Prerequisite: (GTS 112 or MAS 210, MTS 231 and MTS 254) or consent of Head of School
Basic operations research models and their applications are introduced. The course covers topics on linear programming, simplex method, duality and sensitivity analysis, transportation model, nonlinear programming, deterministic dynamic programming, deterministic inventory models, game theory, probabilistic dynamic programming, probabilistic inventory models, queuing models, and Markovian decision processes.

MTS 352 Work Design and Analysis 3(3-1-5)
Prerequisite: None
This course introduces essential concepts in operation analysis, Simplification of work procedure, work

measurement to eliminate and/or reduce non-production activities. Additionally, an integrated system of human, machine (equipment), and work environment, a so-called H-M-E system, is discussed. Factors that influence the physical well-being of workers and issues in workplace ergonomics and safety are studied in detail.

MTS 381 Business Information Systems 3(3-0-6)
Prerequisite: ITS 100 or consent of Head of School
Topics included are strategic uses of information systems; information systems in business functions; computer hardware and software; telecommunications and networks; electronic commerce; data and knowledge management; decision support systems; intelligent systems; and systems development.

MTS 382 Database Systems and Applications 3(3-1-5)
Prerequisite: ITS 101 or consent of Head of School
Logical data models, relational database systems, structured query language (SQL), conceptual modeling; database design, Web-connected databases, transaction management, data warehousing, data mining, database administration issues, focuses on the use/management of business data in areas such as finance, accounting, production, and etc.

MTS 383 E-Business 3(3-1-5)
Prerequisite: ITS 101 or consent of Head of School
This course offers the learning that is needed to develop electronic business. Topics include: developing a strategy; business-to-consumer (B2C) and business-to-business (B2B) marketing; pricing; customer relationship management (CRM); supply chain management; bar codes and radio frequency identification (RFID) for inventory management system; planning, developing, and maintaining Web sites and supporting information systems; business processes; online payments; International, legal, privacy, and security issues. A unique feature is an ongoing project within the course that provides an opportunity to develop electronic commerce implementation plans.

MTS 384 Information Systems Softwares 3(3-0-6)
Prerequisite: None
Students will learn how to use selected up-to-date information systems software programs and apply them to help to manage primary functions of a business organization. A review of core business operations is also provided prior to the learning of software applications.

MTS 391 Special Topics in Management Technology 3(3-0-6)
Prerequisite: None
This course is designed for topics related to Management Technology, but not presently offered as either a required or technical elective.

MTS 392 Current Topics in Management Technology I 3(3-0-6)
Prerequisite: None
This course is designed for current topics related to Management Technology, but not presently offered as either required or elective courses.

MTS 393 Current Topics in Management Technology II 3(3-0-6)
Prerequisite: None
This course is designed for current topics related to Management Technology, but not presently offered as either required or elective courses. Topics covered are different from MTS 392.

MTS 403 Project Proposal Development 1(0-3-0)
Prerequisite: Senior standing or
consent of Head of School
Students (as a team or as individual) will select real-world problems as their project topics. Each topic is subject to approval by a faculty member with specialization area that closely matches the topic. For each project, a proposal must be developed through close consultation with an assigned faculty member. This project proposal development involves reviewing related theories and past research studies, drawing the scope of study, selecting an appropriate approach for problem-solving, defining relevant activities, creating a Gantt chart based on the given time frame, and drafting the project proposal. The proposal (after receiving an approval of the project advisor) must be orally presented at the end of the semester.

MTS 404 Senior Project 6(0-18-0)
Prerequisite: MTS 403 or consent of Head of School
A continuation of MTS 403. An individual student or a team of students will work on the senior project. The projects can be intensively conducted in industry or within the institute. After a project is completed, students are responsible for submitting their final report and giving a presentation.

MTS 411 Management Accounting 3(3-1-5)
Prerequisite: MTS 311 or consent of Head of School
An introductory course in cost accounting for corporate planning and management decisions. The course will focus on concepts and models for improving efficiency and promoting effectiveness through budgetary control, standard costing, and other management accounting tools for decision-making.

MTS 412 Business Finance 3(3-1-5)
Prerequisite: MTS 311 or consent of Head of School
A study of the roles, functions and objectives of financial management, various types of business organizations and tax involved. Discussions will also cover financial analysis, basic principles in financial management in both allocation and acquisition of funds.

MTS 413 Human Resources Management 3(3-1-5)
Prerequisite: (MTS 211 and MTS 212) or
consent of Head of School
This course covers the principles of human resource management, concepts and practices as well as the roles and responsibilities of a human resource manager, emphasizing the importance and usage of HRM as a strategic partner of the organization in today's world. The subject purpose is to examine the breadth of activity essential for effective people resourcing within an organization. It addresses the range of activities associated with the acquisition, management, and release of staff. Specific topics include employee recruitment, selection, orientation, training and development, retention, performance management, rewards and compensation, benefits, counseling, employment legislation, safety and

health issues, labor relations, and multinational human resources.

MTS 414 Psychology in Management Technology 3(3-0-6)
Prerequisite: MTS 212 or consent of Head of School
This course focuses on leadership in organizations, helping students to understand the psychology of modern management and how to become efficient leaders and supervisors in organizations and businesses. The course focuses on four main topics; efficient leadership styles, work motivation, job satisfaction and the meaning of work (MOW). Various models and theories of leadership are explored, as well as the basis of high job satisfaction and work motivation. Meaning of work is presented in a context of the transition of society from primarily agricultural of the modern industrial and service orientated society. Students get training and insight into modern management consulting techniques, as well as in using interviews and analyzing real life quantitative data collected in industry, and using modern statistical package programs. This course provides knowledge about important psychological factors that leaders face in industry and business, and on theoretical application to solve real-life problems.

MTS 431 Facility Location and Layout Planning 3(3-0-6)
Prerequisite: (MTS 232 and MTS 351) or consent of Head of School
This course introduces quantitative techniques, both heuristic and optimization, for selecting a suitable site for facility location based on qualitative and quantitative factors. Requirements such as production processes, flow of materials, activity relationships, and personnel that affect facility layout are discussed. The application of systematic layout planning will be explained in detail. Other topics such as warehouse operations, loading docks, material handling, and facility maintenance are also discussed.

MTS 433 Analysis Techniques for Complex Supply Chain Management Problems 3(3-0-6)
Prerequisite: None
This course deals with real-world complex supply chain management (SCM) problems from both the individual and integrated viewpoints of the SCM components. Well-known heuristic and meta-heuristic techniques such as greedy heuristics, genetic algorithms (GA), simulated annealing (SA), ant colony optimization (ACO), etc. will be introduced. Selected SCM problems will be illustrated and their solution approaches will be explained.

MTS 451 Project Management 3(3-0-6)
Prerequisite: None
This course introduces concepts of project management and techniques for planning, utilizing, and controlling of resources to accomplish specific goals. While the focus is on technically-oriented projects, the principles discussed are applicable to the management of any project. Topics include estimation of project duration, time-cost consideration, workforce allocation, cash flow forecasting, financial and performance control, and documentation.

MTS 453 Business Project Analysis 3(3-0-6)
Prerequisite: MTS 331 or consent of Head of School
This course introduces the concept of feasibility study for business projects in both qualitative and quantitative aspects. Qualitative feasible study covers the study of business opportunity, marketing, competitor analysis, cost and revenue concepts, etc. Quantitative feasibility study covers project's cost and revenue estimation, principles of investment, sources of capital money, costs of capital money, corporate tax consideration, break-even analysis, project cash flows analysis techniques, capital budgeting decision, and business proposal development. A project feasibility study with uncertainty is also included.

MTS 454 Introduction to Service Oriented Architecture 3(3-1-5)
Prerequisite: None
The concepts of service orientation to a business process or information technology; Enterprise Service Bus (ESB); service connection methods; Component Business Modeling (CBM); Business Process Execution Language (BPEL); and Web Services Description Language; Reusability of Services; the SOA Lifecycle, SOA Standards, and SOA Reference Architectures.

MTS 455 Business Process Management 3(3-0-6)
Prerequisite: None
The Process Perspective; Process Management; Process Modeling, Analysis and Design; Business Process Management Framework; Business Process Management Systems (BPMS); Enterprise Process Management Program Planning; BPM Implementation Strategies; Key Skills, Roles and Responsibilities in implementing BPM; Business Process Architecture; BPM Value Proposition.

MTS 481 Business Process Simulation 3(3-1-5)
Prerequisite: MTS 231 or consent of Head of School
The study of the application of computer simulation software to business decision making problems, statistics problems, discrete-event simulation approaches, simulated data analysis, simulation variance reduction techniques.

MTS 491 Special Study in Management Technology I 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics or areas of study related to management technology, but not presently offered in general basic courses, basic courses in Science and Mathematics, compulsory courses and compulsory elective courses of the management technology curriculum. Topics covered must be different from MTS 492.

MTS 492 Special Study in Management Technology II 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics or areas of study related to management technology but not presently offered in general basic courses, basic courses in Science and Mathematics, compulsory courses and compulsory elective courses of the management technology curriculum. Topics covered must be different from MTS 491.

MTS 493 Special Study in Engineering Management I 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics

or areas of study related to engineering management but not presently offered in general basic courses, basic courses in Science and Mathematics, compulsory courses of the engineering management curriculum. Topics covered are different from MTS 494.

MTS 494 Special Study in Engineering Management II 3(3-0-6)
Prerequisite: Consent of Head of School
This course is intended for students who wish to participate in an exchange program. It covers new topics or areas of study related to engineering management but not presently offered in general basic courses, basic courses in Science and Mathematics, compulsory courses of the engineering management curriculum. Topics covered are different from MTS 493.

SCS 126 Chemistry for Engineers 3(3-1-5)
Prerequisite: None
Properties of gases, liquids, solids; properties of solutions; chemical equilibrium; acid and bases; electrochemistry; organic chemistry and polymer; atomic structure and bonding.

SCS 138 Applied Physics I 3(3-1-5)
Prerequisite: None
Mechanics of particles and rigid-body – statics of particles and rigid bodies, analysis of simple structures, friction, work, momentum, rotation, vibrations, and waves; mechanics of fluids – properties of fluids, pressure measurement, forces on plane and curved areas, buoyancy and stability of bodies, fluid flow concepts, heat, thermal properties, and modes of heat transfer.

SCS 139 Applied Physics II 3(3-1-5)
Prerequisite: SCS138 or consent of Head of School
Elements of electromagnetism – electric fields and magnetic fields, dielectrics and capacitors, magnetic induction and Faraday's law of induction, inductors, electromagnetic theory and applications, AC circuits, fundamental electronics; optics – reflection, refraction, interference, diffraction, polarization, optical equipment, application of optics and LASER; modern physics.

SCS 140 Pre-Mathematics and Sciences 3(3-1-5)
This course is designed for students who have insufficient background in mathematics, physics, and chemistry. Its objective is to improve basic knowledge of students to be able to study mathematics, physics, and chemistry effectively. Differential and Integral calculus, Trigonometric functions, Logarithmic functions, Limits, chain rule, L'Hospital rule; Motion in three dimensions, Rotational motion, Angular momentum, Equilibrium of rigid bodies, Fluid mechanics, Harmonic oscillation; Thermodynamics, Chemical equilibrium, Atomic structure.

SCS 176 Chemistry Laboratory 1(0-3-0)
Corequisite: SCS 126 or consent of Head of School
This laboratory course is designed to not only provide hands-on experience to students taking SCS 126 but also strengthen the understanding of the subjects taught in the course. Through a series of laboratory exercises, students will learn how to use selected apparatus essential for chemistry experiments and how to safely handle chemical substances.

SCS 183 Physics Laboratory I 1(0-3-0)
Corequisite: SCS 138 or consent of Head of School
A series of physics experiments is designed to demonstrate theories taught in SCS 138. Students will have opportunities to use state-of-the-art apparatus in a modern laboratory to recapitulate fundamental concepts covered in the SCS 138 course.

SCS 184 Physics Laboratory II 1(0-3-0)
Corequisite: SCS 139 or consent of Head of School
A series of physics experiments is designed to demonstrate theories taught in SCS 139. Students will have opportunities to use state-of-the-art apparatus in a modern laboratory to recapitulate fundamental concepts covered in the SCS 139 course.

TU 110 Integrated Humanities 3(3-0-6)
Prerequisite: None
To study the past of humankind through ages, reflecting beliefs, thoughts, intellectual and creative development of human beings. To instill analytical thinking, with an awareness of the problems that humanities are confronting, such as, impact of technological development, violence, wars, and world crises, in order that we could continue to live efficiently amidst this changing world.

TU 120 Integrated Social Sciences 3(3-0-6)
Prerequisite: None
The Integrated Social Sciences course shows that this is important for human beings by studying the origin of social sciences in the modern world, the separation of social science from science, and the acceptance of the scientific paradigm for the explanation of social phenomena. Analysis of significant disciplines, concepts and theories in social science by pointing out their strengths and weaknesses when applied to social problems. Analysis of contemporary issues with the application of social theories so that each issue is understood from the individual perspective, group perspective and macro–social, national and world perspectives.

TU 130 Integrated Sciences and Technology 3(3-0-6)
Prerequisite: None
Basic concepts in science, scientific theories and philosophies. Standard methods for scientific investigations. Important evolutions of science and technology influences on human lives. Impacts of science and technology on economics, societies and environments. Current issues involved with the impacts of science and technology on moral, ethical and human values.

TU 140 Thai Studies 3(3-0-6)
Prerequisite: None
Evolution of Thai society-settlement, government, economy, social values, and way of life; factors that determine Thai society and culture; artistic and technological creativity; geography and natural resources; trends in social and cultural development.