

## Course Description

### **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.

#### **BFS 302 Computer Networking for Buildings 3(3-0-6)**

Prerequisite: None

Basic knowledge of data communication: data transmission technology, transmission media, signal interference, etc. Network topology: logical aspect and physical aspect. Local area network technology. Networking equipment: repeaters, signal transceivers/converters, switches/hubs, connectors/interfaces equipment, etc.

#### **BFS 305 Fluid Machines for Buildings 3(3-0-6)**

Prerequisite: CES 381 or consent of Head of School

Reviews of fluid flows in pipes and ducts. Similarity and dimension analysis in fluid machinery. Characteristics of centrifugal and axial-flow pumps, fans, blowers and compressors. Installation, operation and maintenance of fluid machines in buildings.

#### **BFS 307 Engineering Materials 3(3-1-5)**

Prerequisite: None

Metals, plastics, asphalt, wood and concrete as engineering materials. Phase equilibrium diagrams and their interpretation. Testing of material properties. Study of macro and microstructures in relationship with properties of engineering materials. Production processes for products using engineering materials.

#### **BFS 308 Air Conditioning Systems for Buildings 3(3-0-6)**

Prerequisite: MES 310 or MES 311 or EMS 211 or consent of Head of School

Psychrometry and process of air. Cooling load estimation. Refrigeration cycles. Water chiller systems. Air handling system. Cooling towers. Equipment selection. Installation, operation and maintenance of air conditioning systems.

#### **BFS 309 Durability of Construction Materials 3(3-0-6)**

Prerequisite: CES 351 or consent of Head of School

Durability of construction materials such as concrete, reinforcement, steel, glass, plastics, etc. Types of deterioration of the materials, mechanisms of

deterioration, causes of deterioration, factors affecting the deterioration process. Durability test methods. Prevention methods, qualitative and quantitative evaluation of the deterioration. Examples of durability problems in actual structures.

#### **BFS 331 Lighting Design for Buildings 3(3-0-6)**

Prerequisite: SCS 139 or consent of Head of School

Principles of lighting, lighting design for buildings which includes artificial lighting, point, line and area light sources, types and properties of luminaries, polar curves, design methods and calculations, glare index, lighting design standard, luminaire heat recovery system and lighting energy management, hybrid lighting, daylighting of buildings, effect of climate on lighting.

#### **BFS 332 Energy Use and Efficient Systems in Buildings 3(3-0-6)**

Prerequisite: MES 310 or MES 311 or EMS 211 or consent of Head of School

Social and technical aspects of energy use and demands in buildings. Analysis of availability of fuels and consumption. Interactions of users and building performance. Heat and power systems. Heat pumps and heat recovery systems and their integration for services. Energy audit for buildings.

#### **BFS 391 Building Facilities Engineering Laboratory 2(1-3-2)**

Prerequisite: (EPS 301 and (MES 310 or MES 311 or EMS 211)) or consent of Head of School

Laboratory practices and experimental studies cover DC machines, transformers, AC machines, fluid mechanics, heat transfer, thermodynamics and mechanism that are related to buildings. Technical notes on the experimental tests have to be submitted for grading.

#### **BFS 401 Automatic Control for Buildings 3(3-0-6)**

Prerequisite: MES 351 or consent of Head of School

Principles of automatic control. Analysis and synthesis of linear feedback systems by classical and state space techniques. Introduction to nonlinear and optimal

control systems. Digital computer control. Applications of automatic control systems to building systems.

**BFS 402 Electrical System Design in Buildings 3(3-0-6)**

Prerequisite: EPS 301 or consent of Head of School  
Concepts and criteria of electrical system design. Electrical devices and their specifications. Symbols and circuit diagrams. Standard electrical codes and practices. Load characteristics and calculations. Power distribution and wiring design. Infrastructure system design: lighting, heating, air-conditioning, grounding and safety. Case studies of electrical system design in commercial, industrial and residential buildings.

**BFS 406 Building Protection, Repair and Maintenance 3(3-0-6)**

Corequisite: BFS 309 or consent of Head of School  
Review on deterioration of building materials. Concept of life cycle cost. Protection methods against deterioration and corrosion of building materials. Types of defects and damages. Non-destructive tests. Partially destructive tests. Load tests. Materials for repair and selection. Methods and techniques of repair. Rehabilitation and retrofitting.

**BFS 407 Safety Engineering in Buildings 3(3-0-6)**

Prerequisite: None  
Principles and practice regarding safety in building. Accidental prevention and safety control. Fire control. Fire resistance of building materials, safety provisions for fire and other hazards in building. Safety standards and codes. Governmental regulations and inspection procedures.

**BFS 492 Water Supply and Sanitary Engineering Laboratory 1(0-3-0)**

Prerequisite: None  
Laboratory exercises in selected water and wastewater treatment operations and processes such as sedimentation, filtration, softening, adsorption, ion exchange, activated sludge, aerobic and anaerobic digestion.

**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 formulation; 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 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 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 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; Connection; Design practice.

**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 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.

**CES 351 Concrete Technology 3(3-0-6)**

Prerequisite: SCS 139 or consent of Head of School  
Background of concrete, concrete ingredients, types of cement, chemical and physical properties of cement, properties of aggregates, handling of aggregates, chemical admixtures, mineral admixtures, mix designs,

properties of concrete in fresh state, properties of concrete in early age state, properties of concrete in hardened state, quality control of concrete, concrete work in practice.

**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, properties of fresh concrete, strength test of hardened concrete, tensile test of reinforcing steel, test on flexural reinforced concrete member.

**CES 353 Construction Engineering and Management 3(3-0-6)**

Prerequisite: None  
Project delivery system; 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 method 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 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, 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 370 Mechanics of Materials 3(3-0-6)**  
(For non-civil engineering students)

Prerequisite: SCS 138 or consent of Head of School  
Force, stress, and equilibrium; Strain; 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 relationship; 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 column, 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  
The objective of this course is to let the student prepare for Civil Engineering Project. Student must conduct literature review, discuss with his/her advisor and prepare proposal of the project at the end of the course to be ready to conduct project in the subsequent semester.

**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 specialized field of civil engineering as approved by the project advisor must be completed. At the end of the course, the results must be presented orally and a grammatically correct formal report 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 414 Finite Element Methods in Engineering 3(3-0-6)**

Prerequisite: None  
Fundamentals of finite element method, variational principles, development of elements used in structural analysis, finite element methods in static and dynamic analysis, solution techniques and computer implementation.

**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 each component of building including foundation, frame, shear wall, slab, wall and others, in which emphasis is placed on reinforced concrete building.

**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 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 soil, flow of soil in plasticity theory with hardening and softening, introduction to cam-clay model and 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 system.

**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 system; Governing laws of motion; Free vibration response; Response to periodic forces; Analysis of response to arbitrary dynamic loadings by Duhamel integral, dynamics of complex structures: multi-degree-of-freedom system; Formulation of matrix equations of motion by 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 harbor, 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, finance and 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 method; Velocity and flow rate measurement, design of hydraulic structures: dike, spillway, dam, gate, pumping station, sheet pile, countermeasure on sediment control: corrosion, deposition, 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 of 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  
Effect of waves on coastal structures, design of seawalls and breakwaters, jetties, harbors, ship channels and pipelines, intentional and accidental discharge of pollutants, diffusion and spreading, oil spill containment and collection, wave theory and applications to engineering problems, analysis of wave data.

**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, taste and odour 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 kinetic, and electrochemistry.

**CHS 213 Applied Mathematics in Chemical Engineering 3(3-0-6)**

Prerequisite: (MAS 116 and 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

General introduction to chemical engineering: Stoichiometry and material balance calculation; recycling, bypassing and purging; use of chemical and phase equilibrium data; energy balances, use of thermodynamic data; study of typical processes.

**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. Entropy. Power and refrigeration cycles and equipment including gas turbine, internal combustion engines and steam power plant. Basic heat transfer.

**CHS 301 Chemical 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 purposes of the course are 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 313 Statistics for Bioengineering 3(3-0-6)**

Prerequisite: MAS 117 or consent of Head of School

Course covers application of statistics to bioengineering. Topics include probability, descriptive statistics, estimation, hypothesis testing, regression, and experimental design.

**CHS 321 Introduction of Cell Biology 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 322 Cell Biology Laboratory 1(0-3-0)**

Corequisite: CHS 321 or consent of Head of School

Techniques of cultivation, quantitation, isolation, and identification of microorganisms with emphasis on bacteria; effects of physical and chemical agents.

**CHS 323 Biochemistry for Engineers 3(3-0-6)**

Prerequisite: CHS 321 or consent of Head of School

Survey of basic principles of biochemistry and molecular biology, emphasizing broad understanding of chemical events in living systems in terms of metabolism and structure-function relationships of biologically important molecules.

**CHS 331 Chemical Reaction Kinetics and Reactor Design 3(3-0-6)**

Prerequisite: SCS 126 or CHS 212 or CHS 241 or  
consent of Head of School

Introduces the design of chemical reactors via synthesis of chemical kinetics and mass and energy balances. Topics: reaction mechanisms, batch, plug flow and well-stirred reactors; heat and mass transport in reactors, including diffusion to and within catalyst particles.

**CHS 332 Bioreactor Design 3(3-0-6)**

Prerequisite: CHS 331 or consent of Head of School

Modeling and design of batch and continuous bioreactors based on biological growth kinetics and mass balances. Gas-liquid mass transfer for aeration and agitation instrumentation and control.

**CHS 333 Kinetics of Enzymatic System 3(3-0-6)**

Prerequisite: CHS 321 or consent of Head of School

An introduction to the general concepts of enzyme catalysis: analysis of enzyme reaction rate. Topics include binding and hybridization interactions.

**CHS 343 Chemical Engineering Thermodynamics II 3(3-0-6)**

Prerequisite: CHS 242 or consent of Head of School

Thermodynamics of multicomponent, multiphase chemical systems. Properties of mixtures, including colligative properties, chemical reaction equilibrium, and phase equilibrium; non-ideal solutions.

**CHS 351 Unit Operations I 3(3-0-6)**

Prerequisite: CHS 241 or GTS 211 or

consent of Head of School

An integrated study of fundamentals and quantitative design techniques involving flow of fluids. Applications of fluid mechanics including piping, pumping, compression, metering, agitation and separations.

**CHS 352 Unit Operations II 3(3-0-6)**

Prerequisite: CHS 351 or MES 310 or

consent of Head of School

An integrated study of fundamentals and quantitative design techniques involving transfer of heat. Applications of heat transfer by conduction, convection and radiation to design of process equipment.

**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 the senior projects later on. The reports have to be submitted for grading.

**CHS 403 Senior Project I 2(0-6-0)**

Prerequisite: Senior standing

The first course in the senior project course series. A student team will be given a 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.

**CHS 404 Senior Project II 3(0-9-0)**

Prerequisite: CHS 403

A continuation of CHS 403. Student team will continue working on the project assigned to them in the first semester. A formal oral presentation of the results to ChE faculty and other students will be arranged and is mandatory. A submission of a final report is also required.

**CHS 405 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.

**CHS 406 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 405.

**CHS 407 Special Problems in Chemical Engineering 3(0-9-0)**

Prerequisite: None

Special problems in chemical 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 academic program.

**CHS408 Special Study in Chemical Engineering 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 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, quantum mechanical approaches, *ab initio* and semiempirical.

**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 wastewater and treatment methods; sources of air pollutants; control methods of particulate and gaseous emissions; hazardous wastes and disposal methods.

**CHS 424 Engineering Properties of Biomaterials 3(3-0-6)**

Prerequisite: CHS 321 or consent of Head of School

Concept of biomaterial; metallic implant materials, bioceramics, biopolymer and composite implant materials, tissue response to implants, medical devices and evaluation, soft and hard tissue replacement, introduction to tissue engineering.

**CHS 425 General Food Science 3(3-0-6)**

Prerequisite: CHS 321 or consent of Head of School

A study of the physical, chemical, and microbiological aspects of foods; the function of and changes in components during preparation and processing of foods.

**CHS 426 Genetics Engineering 3(3-0-6)**

Prerequisite: CHS 321 or CHS 323 or

consent of Head of School

Basic principles of classical and molecular genetics, structure and function of nucleic acids, replication and regulation with emphasis on genetic diseases, mutations, and genetic engineering and its applications.

**CHS 453 Unit Operations in Biochemical Engineering 3(3-0-6)**

Prerequisite: CHS 352 or consent of Head of School

Applications of phase equilibria and mass transfer for stagewise and continuous contact operations such as distillation, absorption, and extraction. Introduction to the separation and purification techniques pertinent to bioprocesses and microbial disinfection.

**CHS 454 Chemical Engineering Laboratory 1(0-3-0)**

Prerequisite: CHS 352 or consent of Head of School

Laboratory practice and experimental studies on topic covered in unit operation I (CHS 351), unit operation II (CHS 352), unit operations in biochemical engineering (CHS 453), unit operations in environmental technology (EVS 321).

**CHS 455 Chemical Engineering Process Design 3(3-0-6)**

Prerequisite: CHS 241 or consent of Head of School

Application of chemical engineering fundamentals to the design of a multi-unit process. Emphasis on use of process simulators. Advanced equipment design, oral and written communication skills and teamwork.

**CHS 456 Transport Phenomena 3(3-0-6)**

Prerequisite: CHS 241 or consent of Head of School

Constitutive equations for momentum, energy and mass transfer. Development of microscopic and macroscopic momentum, energy and mass transfer equations for homogeneous and heterogeneous systems. Analogy and dimensionless analysis. Problems and applications in unit of chemical engineering.

**CHS 457 Chemical Engineering Plant Design 3(3-0-6)**

Prerequisite: CHS 241 or consent of Head of School

Presentation and discussion of process design case studies, selected from a variety of areas in which chemical engineers work. Emphasis on the applications

of engineering science to the solution of real problems, including conceptual design and analysis leading to optimal solutions. Discussion of the trade-offs inherent in design, including economics, environmental impact, and contextual issues. Review of required engineering science and presentation of the basics of process economics.

**CHS 461 Process Dynamics and Control 3(3-0-6)**

Prerequisite: CHS 241 or GTS 211 or  
consent of Head of School

Introduction to dynamic processes and the engineering tasks of process operations and control. Subject covers modeling the static and dynamic behavior of processes; design of feedback control, and stability analysis.

**CHS 462 Biosensor and Bio-instrumentation 3(3-0-6)**

Prerequisite: (CHS 321 and CHS 323) or  
consent of Head of School

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 engineerings.

**CSS 221 Computer Graphics and Multimedia 3(2-3-4)**

Prerequisite: None

The laboratory oriented practical course is designed to introduce the computer as a medium to visualize and analyze numerical data associated with research, business and entertainment. The course presents the theory and practice of creating, storing, manipulating, presenting and animating two and three dimensional graphical objects. The computer graphics is combined with elementary multimedia applications. The laboratory sessions introduce graphical solutions of sample applications (e.g. practical problems in engineering, business, and elementary image processing). The students will have acquired the technical knowledge of various software associated with visualization and multimedia.

**CSS 222 Object-Oriented Programming in JAVA 3(3-0-6)**

Prerequisite: None

Concepts of object-oriented programming; class, inheritance and message passing; fundamentals of Java language and syntax; major class libraries in Java; practice on JAVA programming language. Application of Java to XML data, Java's networking features.

**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 to his/her supervisor who will decide for the final grade of either satisfactory (S) or unsatisfactory (U).

**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; and 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 401 Senior Project I 3(0-9-0)**

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 proposal to their project committee appointed by the department.

**CSS 402 Senior Project II 3(0-9-0)**

Prerequisite: CSS 401 or consent of Head of School

The continuation of CSS 401 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee appointed by the department.

**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 proposal 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, etc.), 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

This course presents theory and practice of software testing. Topics include V&V terminology and foundations, including metrics and measurement (e.g. reliability, usability, performance); Methods for evaluation 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 test cases based on use cases or customer stories; Operational profile-based 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 extractor, and decision units. Techniques to 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 micro array 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, image, 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 "human-friendly" man-machine interface.

**CSS 495 Special Topic in Computer Science I 3(3-0-6)**

Prerequisite: None

Special study on current topics related to in Computer Science and Computer Engineering.

**CSS 496 Special Topic in Computer Science II 3(3-0-6)**

Prerequisite: None

Special study on current topics related to in Computer Science and Computer Engineering.

**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 product, 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.

**EL 171 English Course II 3(3-1-5)**

Prerequisite: None

This is the first course in the English course series. Students will learn to develop skills in listening, speaking, reading, and writing, with a special emphasis on reading. The structure of the course is designed such that the students will develop both listening and writing abilities through examples brought from articles taken from a variety of literatures, and from writing assignments. Both listening and speaking skills are developed by practicing with experienced English instructors and the Program's English coordinator. Additional practice hours may be arranged.

**EL 172 English Course III 3(3-1-5)**  
Prerequisite: EL 171

This course is a continuation from EL 171. While all four skills are still emphasized, students will be introduced to examples and cases, which have complex structure and higher level of difficulty. Advanced training in English conversation is also given. Additional practice hours may be arranged.

**EL 210 English for Engineering I 3(3-1-5)**  
Prerequisite: EL 172

This course specifically emphasizes an ability to use English for technical purposes such as preparation of project proposals and reports, professional oral presentation, etc. Case studies will be taken from technical articles. The main emphasis is an upgrading academic writing skill.

**EL 310 English for Engineering II 3(3-1-5)**  
Prerequisite: EL 210

EL 310 is a free elective course for third and fourth year students. The course is designed to (a) provide advanced training in English Language as used by engineers. Technical vocabulary detailed report writing, presentation skills and technical spoken English are all emphasized. (b) To help students prepare for external examination, in particular TOEFL/IELTS.

**EMS 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.

**EMS 303 Energy Technology and Management Training 0(0-0-0)**  
Prerequisite: Junior standing

Students are required to obtain practical training in the field of energy technology and management at selected private sectors or governmental departments for not less than 240 hour 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 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.

**EMS 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.

**EMS 343 Thermal Environment Control 3(3-0-6)**  
Prerequisite: MES 342 or BFS 308 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. Energy conservation in buildings.

**EMS 381 Measurement and Instrumentation 3(3-0-6)**  
Prerequisite: (TCS 301 or equivalent) and (MES 311 or  
Equivalent) or consent of Head of School

Measurement of temperature, pressure, time fluids flows. Exhaust gas analyzers and emission measurement. Measurement of volt, ampere and power. Oscilloscope, transducers and their applications. Digital techniques in measurement. Data acquisition systems.

**EMS 391 Electrical Energy Laboratory 2(1-3-2)**  
Corequisite: (EMS 381 and EPS 301) or  
consent of Head of School

Laboratory practice and experimental studies study on DC machines, transformers, AC machines. Practice on energy and power measurement of AC electrical loads are also included.

**EMS 392 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.

**EMS 393 Energy Laboratory 2(1-3-2)**  
Prerequisite: (EMS 211 and TCS 303) or  
consent of Head of School

Laboratory practice and experimental studies on electrical energy and power measurement. Measurements of pressure, temperature and fluid flow. Tests and experiments on heat transfer, selected energy systems.

**EMS 413 Advanced Thermodynamics 3(3-0-6)**  
Prerequisite: (MES 311 or equivalent) or  
consent of Head of School

Review of basic concepts and definitions, the first-law and energy, the second law and entropy. Analysis of theoretical and practical engineering cycles including power and refrigeration cycles. Helmholtz and Gibbs energy. Availability and irreversibility. Availability equation for a control mass and applications. Energy and energy equation for a control volume and applications. Second law efficiencies. Chemical availability. Introduction to thermoeconomics and pinch technology.

**EMS 422 Energy System Design 3(3-0-6)**  
Prerequisite: None

System design procedure. Economics of energy systems. Characterization of energy equipment performance by regression analysis of experimental data. Modeling of equipment and processes of energy systems. Energy system modeling and simulation. Selected optimization techniques for energy systems.

**EMS 443 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.

**EMS 444 Power Generation and Environment 3(3-0-6)**  
Prerequisite: (Senior or junior standing) or consent of Head of School  
Thermal power plants and the atmospheric, land and water environment. Hydropower plants: the land, forest and water environment. Nuclear power plants: radioactivity, safety in nuclear fission reactors, and nuclear waste management. Introduction to environmental impact assessment for power plants.

**EMS 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.

**EMS 472 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 economizer, dryers and drying systems, etc.

**EMS 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.

**EMS 494 Energy Seminar 1(0-2-1)**  
Prerequisite: Senior standing  
Students are required to present seminars on current development of energy technology to their classmates and faculties. The seminars may lead to senior projects later on. The reports of the seminars have to be submitted for grading.

**EMS 495 Advanced Energy Laboratory 3(1-6-2)**  
Prerequisite: EMS 391, EMS 392 and senior standing  
The course covers experimental studies on thermal energy and electrical energy. The experiments include various type of refrigeration cycles, air-conditioning system, combustion and emission control, transformers, electrical machine and energy auditing in buildings or industry. Students are required to complete each study and submit the technical report with a given period.

**EMS 496 Senior Projects 3(0-9-0)**  
Prerequisite: Senior standing  
Group Projects include design, analysis and implementation of energy systems. Students are

required to propose their projects during the first semester of their senior year. Students are responsible for presenting and submitting their final reports before the end of the second term.

**EMS 497 Special Topic in Energy Technology I 3(3-0-6)**

Prerequisite: None  
New topics or areas of study not offered in other energy technology courses. Topics may vary from semester to semester.

**EMS 498 Special Topic in Energy Technology II 3(3-0-6)**

Prerequisite: None  
New topics or areas of study not offered in other energy technology courses. Topics may vary from semester to semester.

**EPS 300 Electrical Power Engineering 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 electrical power engineering not less than 160 hours during summer vacation of the third year. Students must submit a report to his/her supervisor who will decide for the final grade of either satisfactory (S) or unsatisfactory (U).

**EPS 301 Basic Electromechanical Energy Conversion 3(3-1-5)**

Prerequisite: TCS 301 or TCS 303 or TCS 311 or TCS 316  
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.

**EPS 302 Advanced Electromechanical Energy Conversion 3(3-0-6)**

Prerequisite: EPS 301  
Principles of electromechanical energy conversion. Three phase transformers. Practical characteristics of DC machines, synchronous and induction machines. Control and operation of electrical machines via power electronics technology. Generalized theory of electrical machines: primitive models, equivalent circuits, analysis of machine behaviors under dynamic and transient, effects of synchronous generators on power system stability. Recent topics in applications of electrical machines.

**EPS 304 Basic Electromechanical Energy Conversion Laboratory 1(0-3-0)**

Prerequisite: EPS 301 or EPS 306  
Laboratory practice and experimental studies on topics covered in EPS 301 or EPS 306.

**EPS 305 Electrical Power Engineering Laboratory 1(0-3-0)**

Prerequisite: EPS 325, EPS 331, EPS 471  
Corequisite: EPS 441  
Laboratory practice and experimental studies on topics covered in EPS325, EPS331, EPS471, EPS441.

**EPS 306 Basic Electrical Machines and Power Systems 3(3-0-6)**  
(For non-electrical power engineering students)

Prerequisite: TCS 301 or TCS 303 or TCS 311 or TCS 316  
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.

**EPS 308 Electrical Machines Laboratory 1(0-3-0)**  
Prerequisite: EPS 324  
Corequisite: EPS 325

Laboratory practice and experimental studies on topics covered in EPS 324 and EPS 325.

**EPS 320 Electromechanical Energy Conversion Laboratory 1(0-3-0)**

Prerequisite: EPS 321  
Corequisite: EPS 322  
Laboratory practice and experimental studies on topics covered in EPS 301 and EPS 323.

**EPS 321 Electromechanical Energy Conversion I 3(3-0-6)**

Prerequisite: SCS 139  
Energy and energy conversion. Electromechanical energy conversion and its fundamentals. Basic principles of rotating electrical machines. DC machines: DC generators and DC motors, construction and windings, characteristics, operation principles, and solid-state control. Special types of DC motors such as moving-coil motors, brushless motors, and stepping motors.

**EPS 322 Electromechanical Energy Conversion II 3(3-0-6)**

Prerequisite: EPS 321  
Construction and characteristics of transformers. Energy conversion in AC machines. Synchronous and induction machines: principles, characteristics, operations, and applications. Three-phase and single-phase induction motors. Control of AC machines. Special types of AC motors such as linear induction motors and universal motors. Machine equivalent circuit; practical operation; protection and applications of machines.

**EPS 323 Electrical Machines 3(3-0-6)**  
Prerequisite: EPS 301

Principles of electromechanical energy conversion. DC motor speed control. Transformer: physical characteristic, equivalent circuit, regulation. Three phase transformers. Synchronous and induction machines: principles, characteristics, operations, and applications. Three-phase and single-phase induction motors. Control of AC machines. Machine equivalent circuit; practical operation.

**EPS 324 Electrical Machines I 3(3-0-6)**  
Prerequisite: TCS 301

Magnetic circuit, Energy and energy conversion. Electromechanical energy conversion and its fundamentals. Basic principles of rotating electrical machines. DC machines: DC generators and DC motors, construction and windings, characteristic, operation

principles, solid-state control and applications. Special types of DC motors such as moving-coil motors, brushless motors, and stepping motors.

**EPS 325 Electrical Machines II 3(3-0-6)**  
Prerequisite: EPS 324

Transformer: construction, operation principle physical characteristic, equivalent circuit, efficiency, regulation, three-phase transformer. AC machines: induction and synchronous machines: construction, operation principles, physical characteristic, equivalent circuit and applications. Single phase induction motor. Control of AC machines.

**EPS 331 Power Systems 3(3-0-6)**  
Prerequisite: TCS 301 or TCS 312 or TCS 316

Basic concepts used in power system analysis such as phasors, complex power, three-phase circuits, and per-unit quantities. Voltage, current and power calculation in single phase and three phase systems. Transmission lines and their impedances. Current and voltage relations in transmission lines. Voltage drop and regulation. Electric power distribution. Power flow analysis. Power system equipment. Introduction to power system protection, monitoring, and control. Short circuit analysis (symmetrical and unsymmetrical).

**EPS 332 Electrical System Design 3(3-0-6)**  
Prerequisite: EPS 331

Basic design concepts, power distribution schemes, codes and standards for electrical installation, electrical drawing, load estimation, wiring design, grounding, short-circuit calculation, coordination of protective devices, power factor improvement, emergency power systems. Lighting design. Infrastructural system design. Electrical system design in commercial; industrial and residential building. Protection design. Specifications and cost estimation. Case studies of electrical system design.

**EPS 351 Electrical Engineering Materials 3(3-0-6)**  
Prerequisite: SCS 139

Fundamental structures and properties of materials used in electrical engineering: dielectric materials, magnetic materials, optical fibers, semiconductors, superconductors, and other materials of interest. Material preparation and manufacturing processes.

**EPS 421 Electric Drives 3(3-0-6)**  
Prerequisite: EPS 301 or EPS 325

Basic concepts of electric drives for both DC and AC motors. Speed-torque characteristic of electric drives. Speed control of electric drives. Starting and braking principles of motors. Transient analysis of electric drives. Selection of motor power ratings. Load diagrams. Industrial applications of electric drives. Important traction and the drive systems; control of traction machines.

**EPS 431 Electrical Power Engineering Project I 2(0-6-0)**

Prerequisite: Senior standing  
Practical projects or problems in electrical power engineering 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.

- EPS 432 Electrical Power Engineering Project II** 3(0-9-0)  
Prerequisite: EPS 431  
The continuation of EPS 432 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee.
- EPS 433 Special Topic in Electrical Power Engineering I** 3(3-0-6)  
Prerequisite: None  
New topics or areas of study not offered in other Electrical Power Engineering courses. Topics may vary from semester to semester.
- EPS 434 Special Topic in Electrical Power Engineering II** 3(3-0-6)  
Prerequisite: None  
New topics or areas of study not offered in other Electrical Power Engineering courses. Topics may vary from semester to semester. Topic covered is different from EPS 433.
- EPS 441 Power System Analysis** 3(3-0-6)  
Prerequisite: EPS 331  
Transmission and distribution networks calculation, load flow, load flow control, symmetrical short circuit analysis, unsymmetrical short circuit analysis, power system protection, transient stability, economic operation, insulation coordination. Grounding.
- EPS 442 Power System Protection** 3(3-0-6)  
Prerequisite: EPS 331, EPS 441  
Fundamental principles of power system protection. Operating principles and design considerations of protective devices and protection systems. Protection of power system apparatus.
- EPS 443 Power System Dynamics and Stability** 3(3-0-6)  
Prerequisite: EPS 441  
Basic concepts, definitions and classifications. Dynamic modeling of various power system components. Transient stability analysis. Small signal (dynamics) stability analysis. Methods of stability improvement. Power system stabilizers. Power system oscillations. Subsynchronous Oscillations. Power electronics devices applications to power system stabilization: FACTS devices and HVDC transmission system. Voltage stability.
- EPS 444 Power System Operation and Control** 3(3-0-6)  
Prerequisite: EPS 441  
Power generation units. Economic dispatch of thermal, hydro units. Unit commitment. Automatic generation control. Power pool and evaluation of power interchange. Power system security, State estimation.
- EPS 445 Power System Planning and Reliability** 3(3-0-6)  
Prerequisite: EPS 441  
Load forecasting. Generation system reliability analysis. Generation system cost analysis. Power flow analysis. Transmission system reliability analysis. Automated transmission system expansion planning.
- EPS 446 Power System Transients** 3(3-0-6)  
Prerequisite: EPS 441  
Causes of overvoltages. Lightning surges. Switching surges. Calculations of overvoltages. Bewley lattice diagram. EMTF concepts. Insulation co-ordination.
- EPS 447 Power Distribution Systems** 3(3-0-6)  
Prerequisite: EPS 441  
Power supply requirements. Customer classification. Over current protection devices and its coordination. Power quality requirements and its control. Reliability of distribution systems. Planning and design consideration of distribution system. Grounding and safety of distribution systems.
- EPS 448 Power System Management under Deregulation** 3(3-0-6)  
Prerequisite: EPS 441  
Electric power industry. Regulation and deregulation. Power grid and power distribution in the deregulated industry. Retail energy service. Ancillary services.
- EPS 449 Computer Applications in Power Systems** 3(3-0-6)  
Prerequisite: EPS 441  
Computer modeling of power system components: synchronous generator, transmission system, FACTS and HVDC link etc. Computer analysis and techniques for load flow, short circuit study, system stability, electromagnetic transient, load flow and stability with power electronic control.
- EPS 451 High Voltage Engineering** 3(3-0-6)  
Prerequisite: EPS 331  
Generation and uses of high-voltage, high-voltage measurement techniques, electric field and insulation techniques, breakdown of gas, liquid and solid dielectrics, test of high-voltage material and equipment, lightning and switching overvoltages, lightning protection. Construction and performance of high voltage equipment.
- EPS 452 Nuclear Power Engineering** 3(3-0-6)  
Prerequisite: EPS 331  
Properties of nuclei, nuclear structure, radioactivity and radiation shielding, nuclear reactions, fission, resonance reactions, moderation of neutrons, Types of nuclear reactors, The neutronics behavior of fission reactors, primarily from a theoretical, one-speed perspective. Criticality, fission product poisoning, reactivity control, reactor stability and introductory concepts in fuel management, slowing down and one-speed diffusion theory.
- EPS 461 Generalized Theory of Electrical Machines** 3(3-0-6)  
Prerequisite: EPS 302 or EPS 322 or EPS 323  
Magnetic materials, Principles of electromechanical energy conversion, Kron and Park primitive machine, D-Q axis analysis, Dynamic of DC machines, Dynamic of synchronous machines, Dynamic of induction machines.
- EPS 462 Electrical Machine Design** 3(3-0-6)  
Prerequisite: EPS 322 or EPS 323  
Basic concepts of electrical machine design: Output equation, specific electric and magnetic loadings, separation of L and D, standard frame. Design of DC

motors, servomotors, step motors, induction motors and transformers. Computer aided design of electrical machines.

**EPS 471 Power Electronics 3(3-0-6)**

Prerequisite: TCS 322 or TCS 325 or TCS 302

Characteristics of power electronics devices, power diode, SCR, GTO, power bipolar, power MOSFET, IGBT, characteristics of magnetic material, power transformer core, ferrite core, iron powder core, converters, AC to DC converter, DC to DC converter, cycloconverter, inverter, DC to AC converters, frequency changer, solid state motor drive, direct current motor control, induction motor control, synchronous motor control.

**EPS 472 Power Quality 3(3-0-6)**

Prerequisite: EPS 441

Definitions. Standards for power quality. Power system harmonics. Voltage sag calculations. Filter designs. Power conditioners.

**EPS 473 Advanced Inverter Principles 3(3-0-6)**

Prerequisite: EPS 471

Controlled rectifier theory and characteristics. Inverter principles: various types of commutated inverters-forced commutated and self-commutated inverters, inverter voltage control, and methods of improving inverter output wave shape. AC-to-DC power conversion: Applications to High Voltage Direct Current (HVDC) Transmission System, Flexible AC Transmission Systems (FACTS) etc.

**EPS 481 Illumination Engineering 3(3-0-6)**

Prerequisite: EPS 332

Physical radiant and photometric quantities. Measurements of light. Radiation from incandescent sources. Gaseous conduction and phosphorescence. Lamps and lighting fittings. Optical properties of construction materials. Lighting calculations for interior and exterior.

**EPS 491 Electronic Motor Drives 3(3-0-6)**

Prerequisite: EPS 301, EPS 421

Study of motor drives controlled by power electronic methods. Theory and analysis of electric motion control in industrial, robotic, and traction systems. Transducers in electric drives.

**ES 211 Ecology 3(3-0-6)**

Prerequisite: None

A study of the structure and functions of natural ecosystem, with particular emphasis on the cycles of matter and energy, food chain and food web, aquatic ecology and environment.

**ES 247 Environmental System and Data Analysis 3(3-0-6)**

Prerequisite: None

System analysis for variety of environmental data, applications of statistical methods in data analysis, computer applications for data storage and analysis.

**ES 319 Biology for Environmental Engineers 3(3-0-6)**

Prerequisite: None

Cells and cell structure, introduction to microbiology, microbial ecology, metabolic diversity in

microorganisms, microbial biotechnology, enumeration of coliform bacteria, sampling and analysis of bacteria in water, bacterial disinfection and sterilisation.

**ES 322 Water and Wastewater Analysis 3(3-0-6)**

Prerequisite: SCS 126 or GTS 121

or consent of Head of School

Basic analytical and instrumental methods used in water and wastewater quantitative measurements, analytical techniques and limitations for various environmental parameters such as alkalinity, chemical oxygen demand, biological oxygen demand, etc.

**ES 332 Environmental Economics 3(3-0-6)**

Prerequisite: EC 210 or consent of Head of School

A study of the environmental problems by means of economic analysis, the role of modern economic theories in solving environmental problems, the relationship between environment and economy, the causes and impacts of environmental deterioration, the economic principles and government policy on pollution control, the principle of capital analysis, the application of economic principles to the projects and measures on the development and protection of the environment, the formulation of effective economic policy and measures in solving environmental problems.

**ES 428 Urbanisation and Urban Environment 3(3-0-6)**

Prerequisite: None

Study of urbanization processes, environmental problems relating to urbanization such as high rise building, traffic, air pollution, solid waste, water supply, and energy. Planning, solution findings, and proper measures will be given.

**ES 431 Environmental Impact Assessment 3(3-0-6)**

Prerequisite: EVS 150 or consent of Head of School

Study of environmental and resources management with respect to air, water, soil, forest, marine, estuary and waterways; assessment of impacts that are possibly arising from project development; elements of environmental impact assessment reports.

**ES 432 Environmental Law 3(3-0-6)**

Prerequisite: None

Basic problems of environmental protection, goals of social and economic development and their contradiction, legislations concerning the control of multimedia pollutions; important laws affecting environmental quality such as environmental standards and regulations, enhancement and conservation of national environmental quality act, public health act, toxic substance act, factory act, consumer protection law, food and drug law; international problems of environmental protection.

**EVS 150 Environmental Studies 3(3-0-6)**

Prerequisite: None

The ecology of natural system, ecosystem, and growth. Food production and land use. Extinction and genetic resources. Sources of energy, energy utilisation and related environmental issues. Control of pest and weeds. Water resources and water pollution. Air pollution. Solid waste. The environment and human health.

**EVS 211 Environmental Chemistry 3(3-1-5)**  
Prerequisite: SCS 126 or GTS 121  
or consent of Head of School

Principles of chemistry and thermodynamics as applied to fundamental understanding of environmental samples including natural water, wastewater, treated water, and the atmosphere, aquatic chemistry, global environmental concerns such as the destruction of the ozone layer, acid precipitation, and groundwater contamination, factors controlling chemical concentrations, acid-base equilibria, solubility equilibria, complex formation, and electrochemistry.

**EVS 213 Water and Wastewater Analysis Laboratory 1(0-3-0)**

Prerequisite: SCS 126 or GTS 121  
or consent of Head of School

Laboratory exercises to provide students appropriate experimental procedures for water and wastewater analysis; ability to determine important water and wastewater parameters such as BOD, COD, solids, hardness, alkalinity, pH, etc.; and skill to perform and interpret chemical and microbiological tests on water and wastewater.

**EVS 311 Industrial Hygiene Engineering 3(3-0-6)**  
Prerequisite: None

Principles and practices of safety engineers, safety and accidental management and control, environmental effects on human performances which include the effects of noise, vibration, and other factors. Indoor air quality monitoring and control, ventilation system design, hood selection, related regulations and auditing procedures.

**EVS 312 Environmental Technology Laboratory 1(0-3-0)**

Prerequisite: EVS 211 or SCS 126 or  
consent of Head of School

Laboratory exercises in selected water and wastewater treatment operations and processes such as sedimentation, filtration, softening, adsorption, ion exchange, activated sludge, aerobic and anaerobic digestion.

**EVS 313 Environmental Technology Training 0(0-0-0)**  
Prerequisite: Junior Standing

Students are provided with on-the-job training at selected governmental agencies, state enterprises, research institutes, and private companies. The purposes of this course are to provide the students with opportunities to gain first handed experience as an environmental technologist, to develop self responsibility and teamwork. The training period must not be less than 240 hours. Students must submit a report at the end of the training period.

**EVS 315 Air and Noise Pollution Control 3(3-0-6)**  
Prerequisite: None

Basic atmospheric sciences, atmospheric diffusion, deposit, and washout of pollutants, major emission source control techniques and devices such as mechanical collectors, electrostatic precipitators, baghouse filters, wet scrubbers; global air pollution issues and international agreement, sources of noise pollution, noise propagation and indicators, noise pollution abatement and control.

**EVS 316 Advanced Environmental Technology Laboratory 1(0-3-0)**

Prerequisite SCS 126 or GTS 121  
or consent of Head of School

A laboratory course designed to provide students with experience in environmental sampling. The course will cover both quantitative and qualitative analysis of environmental samples. Analytical methods include measurement of environmental contaminants as well as various treatment processes such as acid digestion, activated sludge system and phytoremediation.

**EVS 321 Unit Operations in Environmental Technology 3(3-0-6)**

Prerequisite: EVS 211 or CHS 241 or  
consent of Head of School

Theoretical aspects relating to various unit operations used in water and wastewater treatment including sedimentation, coagulation, precipitation, filtration, adsorption, ion exchange, and membrane technology.

**EVS 323 Building Sanitation 3(3-0-6)**

Prerequisite: EMS 211 or MES 341 or CHS 241 or  
consent of Head of School

Fundamental of building sanitation; law and regulations; illumination; ventilation; water supply systems and pipe works for cold and hot water; drainage and vent systems; fire protection; site drainage; design of wastewater treatment and solid waste management for individual building.

**EVS 331 Social Aspect of Environmental Management 3(3-0-6)**

Prerequisite: None

Analysis of social factors affecting environmental problems such as urbanisation, industrialisation, globalisation, technological progress; strategies and remedial measures to solve the problems at both macro and micro-scales; roles of government and non-government organisations on environmental management.

**EVS 332 Pollution Prevention 3(3-0-6)**

Prerequisite: EVS 150 or consent of Head of School

The concepts and implementation of waste minimization and pollution prevention in various sectors such as industries, offices, and service sectors, total quality environmental management, waste recycling and exchanges, roles of international standards, ISO 14000.

**EVS 333 Energy and Environment 3(3-0-6)**

Prerequisite: None

Energy resources and utilization in the global context and a case study of Thailand. Fossil-based energy, environmental impact of mining and fuel processing. Air pollution and global warming from fossil fuels utilization. Energy conservation technologies including energy cascading. Hydro energy harnessing and its environmental impact and mitigation. Other non-fossil-fuel options: biomass, solar, wind and geothermal energy. Nuclear power technology, radioactive waste management and economic feasibility of nuclear power stations.

**EVS 334 Fundamental of Industrial Operations and Processes 3(3-0-6)**

Prerequisite: EVS 150 or consent of Head of School  
Unit operations and unit processes commonly encountered in industrial operations and waste treatment such as separation, mixing, drying, etc. Types of major industries and typical production schemes. Roles of certain equipment such as boiler, cooling tower in manufacturing processes and their contributions to resource consumption and waste production.

**EVS 335 Environmental Quality Management 3(3-0-6)**

Prerequisite: EVS 150 or consent of Head of School  
Basic knowledge of large-scale transportation and transformation of contaminants in subsurface environment; material balance; physical, chemical and biological processes in natural waters such as lake, river, estuaries; important transport and transformation of selected pollutants in atmosphere such as wet and dry deposition; environmental standards, criteria, indicator and indices; environmental issue and priorities.

**EVS 336 Principles of Natural Resource Management 3(3-0-6)**

Prerequisite: None  
A study of interrelationship of ecosystems, problems of natural resources deterioration, basic theory, concepts and practice in natural resource management, guidelines and preventive measures based on holistic approach of efficient resource management, management direction of natural resources and environment with emphasis on case studies, introduction to the development and use of system models for studying the dynamics of natural and managed systems.

**EVS 413 Environmental Technology Seminar 1(0-2-1)**

Prerequisite: Senior standing or Program's consent  
The objective of this course is to prepare individual or groups of students for conducting senior project in the subsequent semester. Various seminar topics will be organized to facilitate the preparation including conceptual planning, project formulation, proposal preparation, and presentation. Students are required to submit a project proposal and give a presentation at the end of the semester.

**EVS 414 Senior Project 3(0-9-0)**

Prerequisite: Senior standing  
Individual or group projects in various areas of environmental technology including experimental design, data collection and analysis, data interpretation, presentation and final report preparation. Students are required to give an oral presentation of the results to general audience including participating students and appointed committee members.

**EVS 421 Water Engineering 3(3-0-6)**

Prerequisite: EMS 211 or MES 341 or CHS 241 or consent of Head of School  
Planning, water quality regulations, demand forecasting, sources of fresh water, design of environmental systems for water purification: coagulation, flocculation, setting and floatation, clarification and disinfection, water collection and distribution, pumping systems.

**EVS 422 Wastewater Engineering Design 3(3-0-6)**

Prerequisite: EVS 321 or equivalent or consent of Head of School  
Design of facilities for physical, chemical, and biological treatment of wastewater; mass balances and hydraulic flow regimes; biological principles of wastewater treatment; growth kinetics; effluent disposal.

**EVS 431 Environmental Health and Sanitation 3(3-0-6)**

Prerequisite: None  
Environmental requirements for rural areas such as toilets, water supply, vector control, and parasitic disease prevention; associated environmental determinants of human disease, toxicology, and epidemiology and public health microbiology; indicator microorganisms; community health promotion.

**EVS 432 Solid and Hazardous Waste Management 3(3-0-6)**

Prerequisite: None  
Planning of solid and hazardous wastes management, sources, classification, transfer and transport options, processing alternatives and energy recovery, recycling, disposal, cost and environmental impacts.

**EVS 441 Selected Topics in Environmental Technology I 3(3-0-6)**

Prerequisite: Senior standing or Program's consent  
Environmental technology topics selected to meet the interests and experience of students and instructor. The topics must not be covered by other courses. Topic varies to keep pace with current developments.

**EVS 442 Selected Topics in Environmental Technology II 3(3-0-6)**

Prerequisite: Senior standing or Program's consent  
Environmental technology topics selected to meet the interests and experience of students and instructor. The topics must not be covered by other courses. Topic varies to keep pace with current developments.

**EVS 443 Special Study in Environmental Technology 3(3-0-6)**

Prerequisite: Senior standing or Program's consent  
An in-depth study of a topic in the field of Environmental Technology.

**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 levels of organization; Study of the characteristics of the major groups of plant and animal life. An introduction to the principles and applications of microbiology, with a study of the general characteristics of microorganisms and their applications.

**GTS 131 Integrated Life Science 3(3-1-5)**

Prerequisite: None

To understand the relationships among plants, animals and humans and the environmental factors that influencing perception, thought, response processes and the behavior of humans throughout the growth and development of life in order to maintain homeostatic adaptation for survival and health.

**GTS 211 Differential Equations and Numerical Methods 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. Laplace transformation. Fourier analysis - Fourier series, integrals and transforms; Partial differential equations. Error analysis, eigenproblems, nonlinear equations, approximation and interpolation, numerical differentiations and integration. Numerical solution of differential equations.

**GTS 231 Law and Technology 3(3-1-5)**

Prerequisite: None

A study of the relation between law and technology, exploration of issues in both private and public laws pertaining to the application of technology, implication 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 210 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 English for Business and Communication I 3(3-1-5)**

Prerequisite: EL 172 or consent of Head of School

This course teaches the organizational skills needed to prepare for writing business/marketing ideas. Ideas are first 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 304 English for Business and Communication II 3(3-1-5)**

Prerequisite: GTS303 or consent of Head of School

This course emphasizes the business writing and marketing presentation skills necessary for a successful business. Students will write and present many different types of advertising materials such as newspaper ads and multimedia marketing. There will also be some essays and reports. Students will spend more time editing other students' writings. All writings and presentations will emphasize a more marketing oriented approach.

**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 function; 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, and 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 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 system (in both its classical and modern aspects), including its 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 purposes of the course are 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

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 306 Senior Project II 3(0-9-0)**

Prerequisite: IES 305

A continuation of IES 305. Student team will continue working on the project assigned to them in the first semester. A formal oral presentation of the results to IE faculty and other students will be arranged and is mandatory. A submission of a final report is also required. Field trips to industrial plants or business corporations will be organized to allow students to observe applications of IE techniques in the real world.

**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 the 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 the 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 the 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 circle, and ISO 9000 standard 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 050 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 050 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 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 System 3(3-0-6)**

Prerequisite: None

This course covers principles and applications of instrument, particularly measuring and controlling instrument, employed in various kinds of industrial process and manufacturing. The measuring instruments is typically used for electrical measurement, distance measurement, color detector, 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 system is discussed to integrate all industrial instrument mentioned in the course together.

**IES 337 Automation of Production System 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 concept is also given.

**IES 345 Project Feasibility Study 3(3-0-6)**

Prerequisite: IES 341 or consent of Head of School

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 or consent of Head of School  
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 or consent of Head of School  
The laboratory course provides practical integration between measuring and controlling instrument used in manufacturing environment. Measuring instrument is focussed on the physical property measuring such as pressure, temperature and level. Controlling instrument is emphasized in both mechanical and electrical control devices such as Programmable Logic Control (PLC).

**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 050 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 relation, co-operations 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 system. 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 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: IES305  
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 Studies in Industrial 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 covers new topics or areas of study related to industrial engineering, but not presently offered as either a required of technical elective. Topics covered are different from IES 403.

**IES 403 Special Studies in Industrial Engineering II 3(3-0-6)**  
Prerequisite: Consent of Head of School  
This course is intended for students wish to participate in the 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.

**INS 300 Instrumentation and Control Training 0(0-0-0)**  
Prerequisite: Junior standing or permission from instructor  
Practical training in private sectors or governmental departments in the field of instrumentation and control not less than 240 hours during summer vacation of the third year. Students must submit a report to his/her supervisor who will decide for the final grade of either satisfactory (S) or unsatisfactory (U).

**INS 361 Measurements and Instrumentation 3(3-0-6)**  
Prerequisite: TCS 301 or TCS 311 or TCS 316 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.

**INS 362 Electronic Instrumentation 3(3-0-6)**  
Prerequisite: TCS 301 or TCS 311 or TCS 316 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 system.

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

**INS 381 Feedback Control Systems 3(3-0-6)**  
Prerequisite: TCS 301 or TCS 312 or TCS 316 or  
consent of Head of School

System representation. Mathematical models of systems. Closed-loop and open-loop control system. Transfer function. 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 INS 381 and is therefore recommended.

**INS 391 Instrumentation Project I 2(0-6-0)**  
Prerequisite: Senior standing

Practical projects or problems in instrumentation 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.

**INS 392 Instrumentation Project II 3(0-9-0)**  
Prerequisite: INS 391

The continuation of INS 391 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee.

**INS 464 Computer Interfacing and Instrumentation 3(3-0-6)**

Prerequisite: TCS 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.

**INS 465 Biomedical Instrumentation 3(3-0-6)**  
Prerequisite: INS 361 or INS 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.

**INS 466 Optical Metrology 3(3-0-6)**  
Prerequisite: INS 361 or INS 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.

**INS 467 Introduction to Industry Automation 3(3-0-6)**

Prerequisite: INS 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.

**INS 468 Real-time and Embedded Systems 3(3-0-6)**  
Prerequisite: ITS 050 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, real-time scheduler, process synchronization, memory management, interrupts. Real-time modeling languages, state chart diagrams and sequence diagrams. Real-time system and embedded system applications.

**INS 480 Robotics Laboratory 1(0-3-0)**  
Prerequisite: INS 481 or consent of Head of School

Laboratory practice and experimental studies on topics covered in INS 481.

**INS 481 Introduction to Robotics 3(3-0-6)**  
Prerequisite: INS 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 literatures.

**INS 482 Digital Control Systems 3(3-0-6)**  
Prerequisite: INS 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.

**INS 483 Linear System Theory 3(3-0-6)**  
Prerequisite: INS 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.

**INS 484 Nonlinear System Analysis 3(3-0-6)**  
Prerequisite: INS 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.

**INS 485 Optimization Techniques 3(3-0-6)**  
Prerequisite: MAS 210  
Optimization concepts. Types of optimization problems. Calculus of variations. Lagrange multipliers. Gradient techniques. Linear programming. The simplex method. Nonlinear and dynamic programming.

**INS 486 Adaptive Control Systems 3(3-0-6)**  
Prerequisite: INS 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.

**INS 487 Stochastic Systems 3(3-0-6)**  
Prerequisite: TCS 315 or IES 302,  
INS 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.

**INS 491 Instrumentation Seminar 1(0-3-0)**  
Prerequisite: Senior standing  
Presentation and discussion of recent advances and research in instrumentation, sensors, transducers, actuators, and control by guest lecturers, faculty, and students. Topics may vary from semester to semester. S/U grading.

**INS 492 Topics in Instrumentation 3(3-0-6)**  
Prerequisite: None  
New topics or areas of study not offered in other instrumentation and control courses. Topics may vary from semester to semester.

**INS 493 Special Problems in Instrumentation and Control 3(0-9-0)**  
Prerequisite: Senior standing  
Special problems in instrumentation and control 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 academic program.

**ITS 032 Computer Graphics Applications 3(2-3-4)**  
Prerequisite: None  
Visualizing and analyzing numerical data associated with scientific and business applications. Graphical solutions to sample applications (e.g. practical problems in general calculus, engineering, business, physics and elementary image processing). Methods of creating, storing, manipulating, presenting and animating two and three dimensional graphical objects. Practice with the graphical software tools such as Mathematica, MathCAD, Corel Draw, PhotoShop and 3D-StudioMax.

**ITS 033 Programming and Algorithms 3(3-0-6)**  
Prerequisite: ITS 050 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 050 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.

**ITS 051 Introduction to Computers and Programming 3(3-1-5)**  
Prerequisite: None  
Computer system organization. Computer system components. Hardware and software interaction. Applications of computers. Software packages and applications. Introduction to data processing and database management. Programming languages. Introduction to high-level programming languages, structures and techniques. Program design and development with assignments and projects.

**ITS 052 Computers and Programming Laboratory 1(0-3-0)**  
Prerequisite: ITS 051 or consent of Head of School  
Projects on program design, debugging and development on scientific and engineering application.

**ITS 221 Data Structures and Algorithms 3(3-0-6)**  
Prerequisite: ITS 050 or ITS 051 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 222 Principles of Programming Languages 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 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.

**ITS 223 Programming Laboratory I 1(0-3-0)**

Corequisite: ITS 221 or consent of Head of School

Students perform hands-on programming topics in data structures and algorithms.

**ITS 224 Numerical Computation 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or  
consent of Head of School

Basic concepts of problem analysis, computation and solution. Utilizing computer for finding numerical solutions of scientific equations. Algorithms of computation. Programming methods. Polynomial interpolation; numerical differentiation, numerical integration.

**ITS 225 Operating System 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or  
consent of Head of School

Basic concepts of operating systems; processes; interprocess communication and synchronization; input-output; file systems; memory management.

**ITS 226 Programming Laboratory II 1(0-3-0)**

Corequisite: (ITS 225 and CSS 222) or  
consent of Head of School

Selected topics covered in operating system and object-oriented programming.

**ITS 300 Information Technology 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 Information Technology not less than 240 hours during summer vacation of the third year. Students must submit a report to his/her supervisor who will decide for the final grade of either satisfactory (S) or unsatisfactory (U)

**ITS 321 Discrete Mathematics 3(3-0-6)**

Prerequisite: None

Set and Projection. Boolean algebra. Relations. Automation. Formal grammar. Graph and algorithms.

**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 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 050 or ITS 051 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 325 Computer Architectures 3(3-0-6)**

Corequisite: TCS 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.

**ITS 326 Compiler Design 3(3-0-6)**

Prerequisite: ITS 222 or consent of Head of School

Introduction to the compilation of programming languages; principles and practice of lexical and syntactic analysis; error analysis.

**ITS 327 Computer Network Architectures and Protocols 3(3-0-6)**

Prerequisite: None

Network models; OSI layers; transmission media; local area network; design concepts of protocols; routing algorithms; application of network.

**ITS 328 Microprocessor Applications 3(3-0-6)**

Prerequisite: TCS 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 050 or ITS 051 or  
consent of Head of School

Software models and software modeling methodologies. Basic abstraction mechanisms in software modeling. Modeling techniques, process and languages. Software development process. Object-oriented system analysis and design.

**ITS 330 Object Oriented Programming 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or  
consent of Head of School

Concepts of object oriented programming.

**ITS 331 Information Technology I Laboratory 1(0-3-0)**

Prerequisite: ITS 223 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 223 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 223 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 050 or ITS 052 or consent of Head of School  
Programmer ethics, Programming in high-level languages, structures and techniques. Software engineering principle. Project on program design, debugging and development on scientific and engineering application.

**ITS 351 Information Technology I 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
*Computer Information Systems* related topics will be selected. The course serves as the guideline for its expert in the computer information systems field. Topics include, information systems design and implementation, system analysis, multimedia application, and introduction to business related application software. The lecture will also lead to hands-on practice and experiments

**ITS 352 Information Technology II 3(3-0-6)**

Prerequisite: TCS 371 or consent of Head of School  
Hardware and communications related topics will be selected. This course serves as the guideline for its expert in the hardware and communications field. Topics include, microcomputer controlled automatic system, personal computer hardware, local area network, peripheral devices, and overview of principles and functions of the state-of-the-art computer and communications devices. The lecture will also lead to hands-on practice and experiments.

**ITS 353 Information Technology III 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
*Software technology* related topics will be selected. The course serves as the guideline for its expert in the software technology field. Topics include, UNIX operating system, Engineering Workstation system management, database system design and implementation, compiler design and implementation, Internet application, and introduction to software development tools. The lecture also will lead to hands-on practice and experiments.

**ITS 391 Data Structures for Information Processing 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 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 392 Business Application Programming 3(3-0-6)**

Prerequisite: None  
This course is an introduction to computer programming with an emphasis on business applications. Students are introduced to transaction processing systems and management support systems. The course covers

principles of program design, programming structures, data structures, program testing, and debugging. Emphasis is placed on the implementation of programs with graphical user interfaces and event driven code.

**ITS 393 Networking and Collaborative Computing 3(3-0-6)**

Prerequisite: None  
This course provides an introduction to data communication, networks, distributed processing and collaborative computing. The course will study the 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. The social and organizational implications of the telecommunications technology are also examined.

**ITS 401 Senior Project I 3(0-9-0)**

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 proposal to their project committee appointed by the department.

**ITS 402 Senior Project II 3(0-9-0)**

Prerequisite: ITS 401 or consent of Head of School  
The continuation of ITS 401 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee appointed by the department.

**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 proposal 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: 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 an architectural foundation, which is based on the convergence of computer, telecommunication, an 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: 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 Realtime System Engineering 3(3-0-6)**

Prerequisite: ITS 050 or ITS 052 or consent of Head of School

Systematic methodology and techniques for developing process-intensive realtime software, e.g., telecommunications software. Topics include software development methodologies, object-orientation, specification languages, verification, SDL and UML.

**ITS 421 Intelligent Systems 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School

Solving problem by searching; heuristic search methods; games as search problems. Knowledge representation, reasoning and logic. First-order logic. Knowledge-based system 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

The course will introduce data warehousing and data mining, and study their principles, algorithms, implementations and applications. 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

The course will introduce students to the underlying economic aspects of the electronic marketplace in order to provide them with an understanding of the foundation for the development 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 425 Management Information Systems 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 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.

**ITS 431 Mobile Computing 3(3-0-6)**

Corequisite: None

Topics include mobile data communication, mobile resource management, network protocols for mobile environment, distributed computing, resolving conflicts and ensuring primary keys, authentication process, design secure and efficient mobile computing solution, backup and recovery in the mobile environment, mobile performance design, replication solution and introduction to ubiquitous computing.

**ITS 432 Real-time and Embedded Systems 3(3-0-6)**

Prerequisite: ITS 050 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, real-time scheduler, 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: None

An introduction to information systems for accounting and finance, including the roles, 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. Also cover financial analysis, basic principles in financial management in both 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 451 Artificial Intelligence 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School

Overview of current research and application 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 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.

**ITS 453 Natural Language Processing 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School

Language analysis, models of inference, text structures, machine translation.

**ITS 454 Intelligent and Autonomous Systems 3(3-0-6)**

Prerequisite: ITS 325 or consent of Head of School  
Overview of intelligent and autonomous systems. Architecture of computer systems for autonomous mobile robots. Sensor information processing; operating system for autonomous system.

**ITS 455 Software Engineering 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Methodology and strategy 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: ITS 225 or consent of Head of School  
Study architectures, algorithms and languages required 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: ITS 325 or consent of Head of School  
Volatile and non-volatile storage, silicon memory, hard disk, CD-ROM. Design concept of memory module for various computer systems.

**ITS 458 Computer Graphics 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Representation and manipulation of graphic data. Representation and transformations of two-dimensional space, three-dimensional space. Illumination and shading modes.

**ITS 459 Multimedia Technology 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Multimedia storage models and structures; video/audio interface; media synchronization; image computing; interactive software design.

**ITS 460 Human Interface Design 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Design concept of hardware and software interface. Overview of the trends of human interface design. Graphic user interface, interactive software design. Hardware technology for human interface.

**ITS 461 Visual Information Processing 3(3-0-6)**

Prerequisite: ITS050 or ITS051 or consent of Head of School  
Computer extraction and identification of objects in visual scenes. Fundamental techniques, current topics, and application.

**ITS 462 Computer Aided Design Technology 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Introduction to computer aided design software. Requirements and techniques for developments of CAD.

Two-dimension and three dimension representation, data structures, computer graphics.

**ITS 463 Computer Aided Education 3(3-0-6)**

Prerequisite: ITS 050 or ITS 051 or consent of Head of School  
Introduction to computer aided education software. Requirements and techniques for developments of CAE. Education concepts, multimedia application, user interface, development tools.

**ITS 464 Computer Simulation 3(3-0-6)**

Prerequisite: ((ITS 050 or ITS 051) and IES 302) or consent of Head of School  
Simulation of discrete and continuous dynamic systems; programming techniques and languages; statistical aspects of simulation.

**ITS 465 Information Technology in Business 3(3-0-6)**

Prerequisite: None  
Case study of how businesses are utilizing information technology to gain competitive 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 network. Computer and network system administration.

**ITS 471 Advanced Programming Language 3(3-0-6)**

Prerequisite: ITS 222 or consent of Head of School  
Formal grammars; context-free languages; the theory of programming language compilers.

**ITS 472 Advanced Operating Systems 3(3-0-6)**

Prerequisite: ITS 225 or consent of Head of School  
Architecture of graphic user interface based operating system. Architecture of operating systems for high performance computers. Relationship between computer Architecture and operating system.

**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: (ITS 325 and ITS 225) or consent of Head of School  
Architecture of engineering workstation, mini computer and super computer.

**ITS 481 Topics in Hardware and Communications I 3(3-0-6)**

Prerequisite: Consent of Head of School  
Study 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  
Study 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  
Study 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  
Study topics of current interest in Software Technology.

**ITS 485 Topics in Software Technology II 3(3-0-6)**

Prerequisite: Consent of Head of School  
Study topics of current interest in Software Technology.

**ITS 486 Topics in Software Technology III 3(3-0-6)**

Prerequisite: Consent of Head of School  
Study 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  
Study 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  
Study 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  
Study 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 and information system, and plan 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 050 or ITS 051 or consent of Head of School  
Foundations and principles of knowledge-based systems, including propositional logic, first-order logic and reasoning. Knowledge representation, integration and evolution. Knowledge engineering. Intelligent databases, object-oriented, extended-relational, logic-based, 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 Topic in Information Technology I 3(3-0-6)**

Prerequisite: None  
Special study on current topics related to in Information and Communication Technology.

**ITS 496 Special Topic in Information Technology II 3(3-0-6)**

Prerequisite: None  
Special study on current topics related to in Information and Communication Technology.

**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 derivative, 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 sum.

**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; Vector algebra in three dimensions; 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, extreme of functions, function 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, system of linear equations, Gauss elimination, eigenvalue problems, eigenvalue 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 - method 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,

eigenproblems, nonlinear equations, approximation and interpolation, numerical differentiations and integration, and numerical solution of ordinary differential equations.

**MCS 151 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 201 Mathematics for Mechatronics 3(3-0-6)**

Prerequisite: None

Introduction to applied mathematics for simulation. Applications of mathematical modeling in various areas. that is n-linkage systems, thermal systems, mechanical systems, electrical systems. Mathematical software packages used in the design and prototyping of mechatronics systems are introduced such as MATLAB and SIMULINK, the de facto standard in system modeling and technical computation with a variety of toolboxes. Data acquisition system for real-time PC-based analysis including conventional software package.

**MCS 251 Computer Aided Design 2(1-3-2)**

Prerequisite: None

Basic principle of engineering drawing, orthographic drawing and sketching, sectional views and conventions, detail drawing, assembly drawing, dimensioning, three dimensioning, use of computer aided design software for detail design and drafting in various engineering fields.

**MCS 311 Hydraulic and Pneumatic Systems and Control 3(3-0-6)**

Prerequisite: None

Introduction to hydraulic and pneumatic control systems. Properties and behaviour of power fluids. Hydraulic and pneumatic components-symbols and functions. Hydraulic and pneumatic circuits. Various applications of control circuits. Programmable Logic Controller PLC for controls. Dynamic modeling and control in hydraulic and pneumatic systems.

**MCS 321 Real-time and Embedded Systems 3(3-0-6)**

Prerequisite: ITS 050 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 341 Mechatronics Instrumentation 3(3-0-6)**

Prerequisite: TCS 302 and (MES 310 or MES 311 or EMS 211) 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 System.

**MCS 350 Mechatronics Training 0(0-0-0)**

Prerequisite: Junior standing

Students are required to obtain practical training in the field of mechatronics at selected private sectors or governmental departments for not less than 240 hours covering 30 working days 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 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.

**MCS 351 Mechatronics Laboratory 2(1-3-2)**

Prerequisite: None

Students are required to conduct tests and experiments on mechatronic systems. Reports or technical notes on the tests and experiments have to be submitted for grading.

**MCS 352 Microcontroller and Computer Interfacing 3(3-0-6)**

Prerequisite: TCS 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.

**MCS 361 Mechatronic Instrumentation 3(3-0-6)**

Prerequisite: TCS 302 and (MES 310 or MES 311 or EMS 211) 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 System.

**MCS 382 Computer Interfacing 3(3-0-6)**

Prerequisite: TCS 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 441 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.

**MCS 451 Introduction to Robotics 3(3-0-6)**

Prerequisite: INS 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 452 Mechatronics Project I 1(0-2-1)**

Prerequisite: Senior standing

This course is to let the students prepare for Mechatronics Projects. Students are required to present proposals on current development to their class mates and faculties. The reports of the proposals have to be submitted for grading.

**MCS 453 Mechatronics Project II 3(0-9-0)**

Prerequisite: MCS 452 or consent of Head of School

The continuation of MCS 452 to the completion stage of the project. A sequent course involving individual or group projects including design, analysis and implementation of mechatronic systems selected from various interested areas within mechatronics. Students are required to submit complete project reports and present project results to their committees.

**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.

**MCS 491 Mechatronics Seminar I 1(0-3-0)**

Prerequisite: Senior standing

Presentation and discussion of recent advances and research in Mechatronics by guest lecturers, faculty, and students. Topics may vary from semester to semester. S/U grading.

**MCS 492 Mechatronics Seminar II 1(0-3-0)**

Prerequisite: Senior standing

Presentation and discussion of recent advances and research in Mechatronics by guest lecturers, faculty, and students. Topics may vary from semester to semester. S/U grading.

**MCS 493 Topics in Mechatronics I 3(3-0-6)**

Prerequisite: None

New topics or areas of study not offered in other Mechatronics courses. Topics may vary from semester to semester.

**MCS 494 Topics in Mechatronics II 3(3-0-6)**

Prerequisite: None

New topics or areas of study not offered in other Mechatronics courses. Topics may vary from semester to semester. Topic covered is different from TCS 493.

**MCS 495 Special Problems in Mechatronics 3(0-9-0)**

Prerequisite: Senior standing

Special problems in Mechatronics 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 department.

**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 relationship 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 telecommunications. 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 160 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 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 321 Heat Transfer 3(3-0-6)**

Prerequisite: MES 310 or MES 311 or EMS 211 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 331 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 equation and applications. Energy equation 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 (MES 341 or CES 381 or EMS 211) 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. Psychometric 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)**

Prerequisites: 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 Measurement and Instrumentation 3(3-0-6)**

Prerequisite: MES 310 or MES 311 or consent of Head of School

Measurement of temperature, pressure, time, speed, area, volume and measuring devices. Fluid flow measurement. Power measurement. 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: EMS 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 403 Senior Project I 1(0-2-1)**

Prerequisite: Senior standing

Students are required to present reports on current developments of mechanical engineering to their classmates and faculty members. The reports may lead to senior projects later on. The reports have to be submitted for grading.

**MES 404 Senior Project II 3(0-9-0)**

Prerequisite: Senior standing

A final course involving individual or group projects including design, analysis and implementation of mechanical systems selected from various interested 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 405 Special Studies in Mechanical Engineering I (3-0-6)**

(For exchange program)

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 413 Advanced Thermodynamics 3(3-0-6)**

Prerequisite: MES 311 or EMS 211 or consent of Head of School

Review on basic concepts and definitions, the first-law and energy, the second law and entropy. Thermomechanical 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 industries. Students, working in groups, will expose the design methodology and process from concept through final design including detail analysis of all mechanical components of the system by which knowledge of all engineering disciplines are 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 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 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 493 Extended Mechanical Engineering Laboratories 3(1-6-2)**

Prerequisite: (MES 391 and (MES 392 or EMS 392)) 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 in Mechanical Engineering I 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 in Mechanical Engineering II 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 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: 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 pressure vessels. Torsion of circular shaft, thin-walled tubes, and close-coiled helical spring.

**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 purposes of this course are 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 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 purposes of this course are 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 behaviour, 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 relationship 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 sheet, Pareto chart, cause-and-effect diagram, etc., capability analysis, costs of quality control and management, quality and productivity relationship, concepts of quality assurance and total quality management (TQM).

**MTS 333 Production and Inventory Management 3(3-0-6)**

Prerequisite: MAS 116 or consent of Head of School

The focus of this course is to point out the relationship between inventory and production in management aspect. Various qualitative and quantitative topics for production and inventory management for both dependent and independent demands are discussed such as economic order quantity (EOQ), economic lot sizing (ELS), 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 on 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 MRPII 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 transportations, factors that influence transport demand; costs; market structures; carrier pricing, Carrier operating 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; etc., 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: (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 process.

**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 050 or ITS 051 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 033 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 033 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 (RFI) for inventory management system; planning, developing, and maintaining Web sites and supporting information systems; business processes; online payments and international, legal, privacy, and security issues. A unique feature is an ongoing project within the course that provides an opportunity to develop the electronic commerce implementation plans.

**MTS 391 Special Topics in Management Technology 3(3-0-6)**

Prerequisite: None

This course is designed for topics related to Management Technology, but no 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 no 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 no presently offered as either required or elective courses. Topics covered are different from MTS 392.

**MTS 403 Senior Project Development 1(0-3-0)**

Prerequisite: Senior standing

Each individual or a team of students will select a real world problem as their project topics. The topic must relate to their areas of study. A project proposal must be prepared and submitted to the project advisor for approval. This process involves reviewing related theories and past research studies, drawing the scope of study, selecting an appropriate approach for problem solving and developing the project proposal. The report and the presentation of the project are required 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 industrials 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 human resource manager,

emphasizing the importance and usage of HRM as a strategic partner of the organization in today's world. The subject purposes to examine the breadth of activity essential for effective people resourcing within an organization. It addresses the range of activities associated with the acquisition, and 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 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 process, 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 432 Logistics Management 3(3-0-6)**

Prerequisite: (MTS 253, MTS 351 and MTS 333) or consent of Head of School

This course covers distribution logistics by emphasizing quantitative techniques to optimize corporate profit and customer service. Examples of topics included in the course are transportation modes, inventory policies, warehousing and order processing, outsourcing, and supplier selection.

**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 heuristic, 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: MTS 232 or consent of Head of School

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 452 Computerized Management Technology Laboratory 1(0-3-0)**

Prerequisite: Junior standing or consent of Head of School

This laboratory provides hands-on practices on computerized tools for modern management through a variety of software programs for manufacturing and

business applications such as statistical analysis, quantitative analysis, quality control, project management, etc.

**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. The project feasibility study under uncertainty is also included.

**MTS 481 Business Process Simulation 3(3-1-5)**

Prerequisite: MTS 231 or consent of Head of School

In-depth study of the application of computer simulation techniques to business decision making and process improvement. Students will be introduced the concept of using simulation modeling for analyzing the complex business process such as multi-teller banks, computer networks, automated manufacturing systems, and airport terminals. Topics will include basic statistics, discrete-event simulation approaches, simulated data analysis, and simulation variance reduction techniques. Simulation software packages are extensively used in this class. A term project will be given within the course that provides an opportunity to develop the complete simulation study suited to the learner's interests.

**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 the 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 the 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 the 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 the 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 bodies: statics of particles and rigid bodies, analysis of simple structures, friction, work, momentum, rotation, vibrations, and waves. Mechanics of fluid: 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 field and magnetic field; dielectric and capacitor, magnetic induction and Faraday's law of induction, inductor, electromagnetic theorem and applications, AC circuits, fundamental electronics; optics: reflection, refraction, interference, diffraction, polarization, and optic equipment, application of optics, LASER, modern Physics.

**SCS 140 Pre-Mathematics and Sciences 3(3-1-5)**

Prerequisite: None

This course is designed for students who have insufficient mathematics, physics, and chemistry backgrounds. Its objective is to improve basic knowledge of students to be able to study MAS 116 (Mathematics I), SCS 138 (Applied Physics I), and SCS 126 (Chemistry for Engineers) effectively. The topics covered are all basic topics in those courses, for example, 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, the 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 the opportunity to use state-of-the-art apparatus in a modern laboratory to recapitulate fundamental concepts covered in the SCS 138.

**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 the opportunity to use state-of-the-art apparatus in a modern laboratory to recapitulate fundamental concepts covered in the SCS 139.

**TCS 300 Communications Training 0(0-0-0)**

Prerequisite: Junior standing

Practical training in private sectors or governmental departments in the field of communications engineering not less than 240 hours during summer vacation of the third year. Students must submit a report to his/her supervisor who will decide for the final grade of either satisfactory (S) or unsatisfactory (U).

**TCS 301 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.

**TCS 302 Basic Electronic Circuits 3(3-1-5)**

(For non-major students)

Prerequisite: TCS 301 or TCS 303 or TCS 311 or consent of Head of School

Introduction to voltage amplifiers, Bode plots. Operational amplifier (Op-amp) as voltage amplifiers, and 1<sup>st</sup>-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.

**TCS 303 Basic Electrical Engineering 3(3-1-5)**

(For non-major students)

Prerequisite: None

A service course covering electrical engineering principles and technology for students in other majors. 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.

**TCS 304 Basic Electrical Engineering Laboratory 1(0-3-0)**

(For non-major students)

Corequisite: TCS 301 or TCS 303 or TCS 311 or consent of Head of School

A service course for students in other majors. Laboratory practice and experimental studies on topics covered in TCS 301 or TCS 303.

**TCS 305 Basic Electrical Engineering with Applications 3(2-2-5)**

(For non-major students)

Prerequisite: None

A service course for students in other majors. 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.

**TCS 310 Basic Electrical Engineering Laboratory 1(0-3-0)**

Prerequisite: TCS 311 or TCS 316 or

consent of Head of School

Laboratory practice and experimental studies on topics covered in TCS 311 or TCS 316.

**TCS 311 Circuit Analysis I 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. Mutual inductance and ideal transformers. Laplace transform and its application to circuit analysis.

**TCS 312 Circuit Analysis II 3(3-0-6)**

Prerequisite: TCS 311 or consent of Head of School

Network graphs. Node and mesh analysis. Cut-set and loop analysis. State equations. Network responses: natural frequencies, network functions, impulse responses, frequency responses, resonance. Network theorems. Fourier analysis: Fourier series, Fourier transform, applications to network analysis. Two-port circuits. Introduction to computer-aided circuit analysis and design.

**TCS 313 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; partial differential equations; boundary value problems; applications in electrical engineering; Vector spaces; basis and dimension; linear mapping; linear operators; matrices, equivalence of matrices analysis; systems of linear equation; similarity transformation; Cayley-Hamilton theorem.

**TCS 314 Computer and Numerical Tools in Electrical Engineering 3(2-2-5)**

Prerequisite: (MAS 117 and TCS 311) or consent of Head of School

The course emphasizes theories and techniques of numerical analysis and usages of computer softwares for electrical engineering. Topics include finite difference, interpolation, numerical differentiation and integration. Introduction to MATLAB and PSPICE and other computer tools in electrical engineering.

**TCS 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 function, cumulative distribution function, functions of random variables, expectations; law of large numbers, central limit theorem; introduction to random processes, random noise, Gaussian random process, autocorrelation and power spectral density.

**TCS 316 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.

**TCS 317 Computer Graphics and Tools in Electrical Engineering 3(2-2-5)**

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 telecommunications: MATLAB, PSPICE, LaTeX, etc.

**TCS 318 Data Structures, Algorithms, and Object Oriented Programming 3(2-2-5)**

Prerequisite: ITS 050 or ITS 052 or consent of Head of School

Concepts of data structures; basic data structures; stacks, queues, linked list, 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.

**TCS 319 Java Programming 3(2-2-5)**

Prerequisite: ITS 050 or ITS 052 or consent of Head of School

Concepts of object-oriented programming; class, inheritance and message passing fundamentals of Java programming language and its syntax; major class libraries in Java; Java applets; graphic user interface programming; practice on Java programming language.

**TCS 320 Electronic Circuits Laboratory 1 (0-3-0)**

Prerequisite: TCS 321 or TCS 324 or consent of Head of School

Corequisite: TCS 322 or TCS 325 or consent of Head of School

Laboratory practice and experimental studies on topics covered in TCS 321 or TCS 324 and TCS 322 or TCS 325.

**TCS 321 Electronic Circuits I 3(3-0-6)**

Prerequisite: TCS 311 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.

**TCS 322 Electronic Circuits II 3(3-0-6)**

Prerequisite: TCS 321 or consent of Head of School

Introduction to differential amplifiers and current mirrors. Operational Amplifiers-741 op-amp circuits, feedback amplifiers, frequency response, Bode plot, stability, phase compensation. Comparators. Waveform generators and waveshaping. Active filters. Switched-capacitor filters. Power electronic circuits: Regulated power supplies, regulators, and power amplifiers.

**TCS 323 Physical Electronics 3(3-0-6)**

Prerequisite: TCS 321 or TCS 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.

**TCS 324 Electronic Devices and Basic Circuits 3(3-0-6)**

Prerequisite: TCS311 or TCS316 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 1<sup>st</sup>-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 emitter, common base and common collector amplifiers. Field-effect transistors (MOS and CMOS), DC and AC analysis of common source, common gate and common drain amplifiers.

**TCS 325 Analog Circuits 3(3-0-6)**

Prerequisite: TCS321 or TCS324 or consent of Head of School

Differential amplifiers and current mirrors. Frequency response, 2<sup>nd</sup>-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.

**TCS 331 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.

**TCS 332 Principles of Communications 3(3-0-6)**

Prerequisite: ((TCS 315 or IES 302) and TCS 372) 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.

**TCS 350 Communication Laboratory 1(0-3-0)**

Prerequisite: TCS 332 or consent of Head of School  
Laboratory practice and experimental studies on topics covered in TCS 332.

**TCS 351 Communication Networks and Transmission Lines 3(3-0-6)**

Prerequisite: TCS 331 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.

**TCS 352 Telecommunications 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 353 Data Communications 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 370 Digital Circuit Laboratory 1(0-3-0)**

Corequisite: TCS 371 or consent of Head of School  
Laboratory practice and experimental studies on topics covered in TCS 371.

**TCS 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.

**TCS 372 Signals and Systems 3(3-0-6)**

Prerequisite: TCS 313 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.

**TCS 382 Microprocessors 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 391 Telecommunications Project I 2(0-6-0)**

Prerequisite: Senior standing

Practical projects or problems in telecommunications 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.

**TCS 392 Telecommunications Project II 3(0-9-0)**

Prerequisite: TCS 391

The continuation of TCS 391 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee.

**TCS 394 Computer Interfacing 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 395 Seminar 1(0-3-0)**

Prerequisite: Senior standing

Presentation and discussion of recent advances and research in communications by guest lecturers, faculty, and students. Topics may vary from semester to semester.

**TCS 396 Project Development 1(0-3-0)**

Prerequisite: Senior standing

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.

**TCS 398 Senior Project 6(0-18-0)**

Prerequisite: TCS 396

The continuation of TCS 396 to the completion stage of the project. Students are required to submit complete project reports and present project results to their project committee.

**TCS 421 Semiconductor Device Theory 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 422 Analog Filter Design 3(3-0-6)**

Prerequisite: TCS 322 or TCS 325 or consent of Head of School

Review of 1<sup>st</sup> and 2<sup>nd</sup> order analog filters, i.e. bilinear transfer functions and frequency response, cascade design with 1<sup>st</sup>-order filters, the 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.

**TCS 423 Operational Amplifier Design 3(3-0-6)**

Prerequisite: TCS 322 or TCS 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. Non-linear circuit applications.

**TCS 424 Analog Integrated Circuits 3(3-0-6)**

Prerequisite: TCS 322 or TCS 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.

**TCS 425 Digital Integrated Circuits 3(3-0-6)**

Prerequisite: TCS 322 or TCS 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).

**TCS 426 Integrated Circuit Fabrication 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 427 Introduction to VLSI Design 3(3-0-6)**

Prerequisite: ((TCS 322 or TCS 325) and TCS 371) 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.

**TCS 428 Current-Mode Analog Integrated Circuits 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 429 Noise Reduction Techniques 3(3-0-6)**

Prerequisite: TCS 322 or TCS 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. Classic, cable and system issues.

**TCS 431 Industrial Electronics 3(3-0-6)**

Prerequisite: (EPS 301 and (TCS 321 or TCS 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.

**TCS 441 Communication Electronics 3(3-0-6)**

Prerequisite: TCS 322 or TCS 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.

**TCS 442 Microwave Principles 3(3-0-6)**

Prerequisite: TCS 331 or consent of Head of School  
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.

**TCS 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.

**TCS 452 Digital Communication Systems 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 453 Satellite Communication Systems 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 454 Fiber Optics 3(3-0-6)**

Prerequisite: TCS 331 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.

**TCS 455 Mobile Communications 3(3-0-6)**

Prerequisite: TCS 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.

**TCS 456 Optical Communications 3(3-0-6)**

Prerequisite: TCS 331 or consent of Head of School  
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.

**TCS 461 Electromagnetic Wave Propagation 3(3-0-6)**

Prerequisite: TCS 331 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.

**TCS 462 Antennas 3(3-0-6)**

Prerequisite: TCS 331 or consent of Head of School  
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.

**TCS 471 Switching Theory 3(3-0-6)**

Prerequisite: TCS 371 or consent of Head of School  
Models for sequential circuits: state tables and state diagrams, clock and pulse modes, and Mealy and Moore model. 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 synchronous sequential circuits (ASC): races, cycles, hazards, and synthesis of ASC. Introduction to fault diagnosis, Sequential circuit and regular expression.

**TCS 472 Digital Signal Processing 3(3-0-6)**

Prerequisite: TCS 372 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).

**TCS 473 Digital Filter Design 3(3-0-6)**

Prerequisite: TCS 372 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 wordlength effects and sensitivity analysis.

**TCS 474 Digital Speech Processing 3(3-0-6)**

Prerequisite: TCS 372 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.

**TCS 475 Digital Image Processing 3(3-0-6)**

Prerequisite: TCS 372 or consent of Head of School  
Digital image fundamentals. Image transformations. Image enhancement. Image restoration. Image compression. Image segmentation. Representation schemes and descriptors.

**TCS 476 Adaptive Filtering 3(3-0-6)**

Prerequisite: TCS 372 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.

**TCS 477 Signal Processing for Communication Systems 3(3-0-6)**

Prerequisite: TCS 472 or consent of Head of School  
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.

**TCS 491 Telecommunications Seminar I 1(0-3-0)**

Prerequisite: Senior standing  
Presentation and discussion of recent advances and research in telecommunications by guest lecturers, faculty, and students. Topics may vary from semester to semester.

**TCS 492 Telecommunications Seminar II 1(0-3-0)**  
Prerequisite: Senior standing  
Presentation and discussion of recent advances and research in telecommunications by guest lecturers, faculty, and students. Topics may vary from semester to semester.

**TCS 493 Topics in Telecommunications I 3(3-0-6)**  
Prerequisite: None  
New topics or areas of study not offered in other telecommunications courses. Topics may vary from semester to semester.

**TCS 494 Special Problems in Telecommunications 3(0-9-0)**  
Prerequisite: Senior standing  
Special problems in telecommunications 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 department.

**TCS 495 Topics in Telecommunications II 3(3-0-6)**  
Prerequisite: None  
New topics or areas of study not offered in other telecommunications courses. Topics may vary from semester to semester. Topic covered is different from TCS 493.

**TCS 496 Special Study in TC I 3(3-0-6)**  
Prerequisite: Consent of Head of School  
Topics related to current development and fundamental knowledge in telecommunication technologies.

**TCS 497 Special Study in TC II 3(3-0-6)**  
Prerequisite: Consent of Head of School  
Topics related to current development and fundamental knowledge in telecommunication technologies.

**TU 110 Integrated Humanities 3(3-0-6)**  
Prerequisite: None  
To study different aspects of man from the beginning till now, such as beliefs, intellectual developments and creativities. And how to survive in this changeable world with the problems that we are facing in this globalization technomania society through concentration on one's inner self.

**TU 120 Integrated Social Sciences 3(3-0-6)**  
Prerequisite: None  
A study of the origin of social science in the modern world, the separation of social science from science, the acceptance of scientific paradigm for the explanation of social phenomenon. Analysis of significant disciplines, concepts and theories in social science by pointing out their strengths and weaknesses when applied to social problems. Analysis of current 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  
A study of scientific concept, theory and rule concerning inorganic particle from the planetary level to particle level, and to molecule and atom levels, the interaction between atom and to molecule, chemical and inorganic

chemical reaction relating to biological condition of living things and the evolution of life on the planet. The exploring of basic concepts in science and technology that are pertinent to modern day living, important debates concerning the relationship between science and technology and the environment and society and their distinctive features as separate fields of knowledge.

**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.