

# BEng (Hons) Electrical and Electronic Engineering - E430

## 1. Objectives

Electrical & Electronic Engineering encompasses a large variety of topics ranging from electrical machines, power systems, electronics, control and microprocessors, to computer systems and communications. The main objective of the course is to provide a strong foundation on the various major disciplines of electrical engineering and electronics. The course is designed to train students for a career in engineering whilst at the same time give them the opportunity to acquire in-depth knowledge so as to enable them to pursue postgraduate studies in the field of electrical and electronic engineering.

## 2. General Entry Requirements

As per General Entry Requirements for Admission to the University for Undergraduate Degrees.

## 3. Programme Requirements

2 GCE 'A' Level Passes in Mathematics and one of the following subjects: Physics, Physical Science, Engineering Science, Physics with Chemistry.

## 4. (i) Minimum Requirements For Degree Award

For the award of the BEng (Hons) Degree in Electrical and Electronic Engineering, the student must obtain at least 130 credits including 122 credits from all the core modules prescribed by the department and at least 8 credits from the elective modules.

MODULES	CREDITS
Humanities & Management	3
Basic Sciences & Mathematics	12
Engineering (Core)	95
Engineering (Electives)	8
Degree Project	12
<b>TOTAL</b>	<b>130</b>

- For the degree award all core modules prescribed by the department must be completed.
- Practical Training and Industrial training must be completed satisfactorily for the award of the degree.

## (ii) Minimum Requirements For Diploma Award

A student may opt for a Diploma in Electrical and Electronic Engineering provided he/she satisfies the following minimum requirements. The Diploma project would normally be of 8 weeks duration for an input of at least 90 hours.

MODULES	CREDITS
Humanities & Management	3
Basic Sciences & Mathematics	6
Engineering	45
Diploma Project (ELEC 2000(3))	6
<b>TOTAL</b>	<b>60</b>

5. **Programme Duration:** Normal 4 years  
Maximum 7 years

6. **Credits per Year:** Minimum 18, Maximum 48 subject to Regulation 5.

## 7. Assessment

### Continuous and Written Assessment of Modules

Assessment will be based on a written examination of 2 to 3-hour duration (normally a paper of 2 hour duration for modules carrying less or equal to 3.5 credits and 3 hour paper for modules carrying four-six credits) and on continuous assessment done during the semester or year.

Written examinations for all modules, whether taught in semester 1 or in semester 2 or both, will be carried out at the end of the academic year (unless otherwise stated).

The continuous assessment will count for **20% to 30%** of the overall percentage mark of the module(s), except for a Programme where the structure makes for other specific provision(s). Continuous assessment may be based on laboratory work, seminars and/or assignments and **should include at least two (2) assignments/ tests per semester/year per module.**

There will be at least one compulsory class test for all modules taught in semester 1 at the end of semester 1 of the given academic year unless stated otherwise in the Programme Structure.

An overall total of **40%** for combined assessment and written examination components would be required to pass the module, without minimum thresholds within the individual continuous assessment and written examination.

Special examinations (e.g. class tests) will be arranged at the end of semester 1 or semester 2 for exchange students who have registered only for one semester. In case of yearly modules, credits will be assigned on a pro-rata basis.

## 8. Repeat and Termination of Registration

If the CPA of a student is <40% for an academic year, s/he will have to repeat the entire academic year, and retake modules as and when offered. However, s/he will not be required, if s/he wishes, to retake modules for which Grade C or above has been obtained.

Students will be allowed to repeat only once over the entire duration of the Programme of Studies.

Registration of a student will be terminated if

- (i) the CPA < 40% at the end of an academic year and the student has already repeated one year of study; or
- (ii) the maximum duration allowed for completion of the Programme of Studies has been exceeded.
- (iii) If s/he is a year 1 student who has scored a CPA of <25% at the end of an academic year (for yearly programmes). However the Board of Examiners might allow a repeat if there are evidence of compelling circumstances or valid medical grounds.

## 9. List of Modules - BEng (Hons) Electrical and Electronic Engineering

<b><u>CORE MODULES</u></b>		<b>Hrs/Wk</b>	<b>Credits</b>
		<b>L+P</b>	
<b>BASIC SCIENCES &amp; MATHEMATICS</b>			
ELEC 1006Y(1)	Mathematics for Electrical Engineers 1	3+0	6
ELEC 2007Y(3)	Mathematics for Electrical Engineers 2	3+0	6
<b>ENGINEERING</b>			
ELEC 1002Y(1)	Electronics 1	3+1	7
ELEC 1003Y(1)	Electrical Engineering	2+1	5
CSE 1018Y(1)	Computer Programming	1.5+2	5
ELEC 1005Y(1)	Measurement Systems	2+1	5
ELEC 1200	Practical Training/Software Development	8 weeks	0
ELEC 2002Y(3)	Electronics 2	2+1	5
ELEC 2003Y(3)	Electromagnetics & Analog Communications	3+1	7
ELEC 2004Y(3)	Circuits, Signals and Systems	3+0	6
ELEC 2005Y(3)	Power Systems 1	2+0	4
ELEC 2006Y(3)	Electrical Machines	2+1	5
ELEC 3001Y(5)	Microprocessors	2+2	6
ELEC 3002Y(5)	Control Systems 1	2+0	4
ELEC 3003Y(5)	Power Electronics	2+1	5
ELEC 3004Y(5)	Digital Communications	2+1	5
ELEC 3005Y(5)	Electronic Systems Design	2+1	5
ELEC 3006Y(5)	Digital Signal Processing	2+2	6
ELEC 3201(5)	Engineering Design	2+2	3
ELEC 3200	Industrial Training	10 weeks	0
ELEC 4000(5)	Degree Project	-	12
ELEC 4001Y(5)	Power Systems 2	2+0	4
ELEC 4002Y(5)	Power Electronic Drives	2+0	4
ELEC 4003Y(5)	Control Systems 2	2+0	4
<b>HUMANITIES &amp; MANAGEMENT</b>			
COMS 1010(1)	Communication Skills	D.E.	3
<b><u>ELECTIVES</u></b>			
<b>ENGINEERING</b>			
ELEC 4021Y(5)	Data Communications and Networking	2+0	4
ELEC 4022Y(5)	Mobile Communications	2+0	4
ELEC 4011Y(5)	Instrumentation Systems	2+0	4
ELEC 4013Y(5)	Antenna Theory	2+0	4
ELEC 4014Y(5)	Optoelectronics	2+0	4
ELEC 4015Y(5)	RF and Microwave Engineering	2+0	4
ELEC 4016Y(5)	Image Processing	2+0	4
ELEC 4035Y(5)	Nanoelectronics	2+0	4

### **NOTE 1: Engineering Electives**

Students are required to take a minimum of 8 credits from Year 4 elective modules in the engineering elective category.

### **NOTE 2:**

Students are allowed to choose any elective module contained in GEMs list available at the Faculty's Office. However, the offer of the electives would be subject to availability of resources and existence of a critical mass of demand for the modules. Students are requested to contact their Programme Coordinator before entering any module under the GEMs in their module registration form.

### **NOTE 3:**

For a student to clear the modules ELEC 1200 and ELEC 3200, s/he must achieve Grade S (Satisfactory) in each of these modules.

### **NOTE 4: Core module for Diploma**

ELEC 2000(3): Diploma Project (6 credits)

## 10. Programme Plan - BEng (Hons) Electrical and Electronic Engineering

LEVEL 1			
Code	Semester 1 & 2 Module	Hrs/Wk L+P	Credits
<b>CORE</b>			
ELEC 1002Y(1)	Electronics 1	3+1	7
ELEC 1003Y(1)	Electrical Engineering	2+1	5
ELEC 1005Y(1)	Measurement Systems	2+1	5
ELEC 1006Y(1)	Mathematics for Electrical Engineers 1	3+0	6
CSE 1018Y(1)	Computer Programming	1.5+2	5
ELEC 1200	Practical Training/Software Development	8 weeks	0
COMS 1010(1)	Communication Skills	D.E	3
LEVEL 2			
Code	Semester 1 & 2 Module	Hrs/Wk L+P	Credits
<b>CORE</b>			
ELEC 2002Y(3)	Electronics 2	2+1	5
ELEC 2003Y(3)	Electromagnetics & Analog Communications	3+1	7
ELEC 2004Y(3)	Circuits, Signals and Systems	3+0	6
ELEC 2005Y(3)	Power Systems 1	2+0	4
ELEC 2006Y(3)	Electrical Machines	2+1	5
ELEC 2007Y(3)	Mathematics for Electrical Engineers 2	3+0	6
LEVEL 3			
Code	Semester 1 & 2 Module	Hrs/Wk L+P	Credits
<b>CORE</b>			
ELEC 3001Y(5)	Microprocessors	2+2	6
ELEC 3002Y(5)	Control Systems 1	2+0	4
ELEC 3003Y(5)	Power Electronics	2+1	5
ELEC 3004Y(5)	Digital Communications	2+1	5
ELEC 3005Y(5)	Electronic Systems Design	2+1	5
ELEC 3006Y(5)	Digital Signal Processing	2+2	6
ELEC 3201(5)	Engineering Design	2+2	3
ELEC 3200	Industrial Training	10 weeks	0
LEVEL 4			
Code	Semester 1 & 2 Module	Hrs/Wk L+P	Credits
<b>CORE</b>			
ELEC 4000(5)	Degree Project	-	12
ELEC 4001Y(5)	Power Systems 2	2+0	4
ELEC 4002Y(5)	Power Electronic Drives	2+0	4
ELEC 4003Y(5)	Control Systems 2	2+0	4
<b>ELECTIVES*</b>			
ELEC 4021Y(5)	Data Communications and Networking	2+0	4
ELEC 4022Y(5)	Mobile Communications	2+0	4
ELEC 4011Y(5)	Instrumentation Systems	2+0	4
ELEC 4013Y(5)	Antenna Theory	2+0	4
ELEC 4014Y(5)	Optoelectronics	2+0	4
ELEC 4015Y(5)	RF and Microwave Engineering	2+0	4
ELEC 4016Y(5)	Image Processing	2+0	4
ELEC 4035Y(5)	Nanoelectronics	2+0	4

NOTE: \* Students should choose a minimum of 2 electives

## 11. Outline Syllabus

This outline syllabus is not prescriptive and is intended to serve as a guide only.

Note: Pre-requirement (PQ).

### **CORE MODULES**

#### **ELEC 1002Y(1) - ELECTRONICS 1 (L/P – 3+1, CREDITS – 7)**

PN Junction, Diode Circuits and Applications, Bipolar Junction Transistors, Field-Effect Transistors, Operational Amplifier and Applications, Number Systems, Boolean Algebra, Combinational Logic Circuits, Flip Flops, Digital Arithmetic.

#### **ELEC 1003Y(1) - ELECTRICAL ENGINEERING (L/P – 2+1, CREDITS – 5)**

Passive electrical elements, Current and Voltage Sources, Instantaneous, average and rms quantities, form factor, Kirchhoff's laws, Dc circuit analysis, Network Theorems, Magnetism and Electromagnetic Induction, Magnetic circuits, Single Phase Ac circuits and phasor diagrams, Power triangles, Power factor and correction, Ac circuit analysis using complex notation, Series and parallel resonance, 3 phase circuit analysis, Star and delta connected supplies and loads, Balanced and unbalanced 3-phase systems.

#### **CSE 1018Y(1) - COMPUTER PROGRAMMING (L/P – 1.5+2, CREDITS – 5)**

Types of problems solved by computers; Flowcharts and Pseudocodes; different levels of programming languages, Introduction to C language; Data types; operators and expressions; Data Input and Output; Conditional statements; Branching and iterative structures; Functions (including nested functions & value and reference parameters); recursion; arrays ; files processing;structures; Object Oriented Paradigm v/s structured programming; C++ as an Object Oriented Language; Inheritance; Polymorphism; Overloading constructors & operators; Late binding and virtual keyword; Data Structures & the Standard Template Library

#### **ELEC 1005Y(1) - MEASUREMENT SYSTEMS (L/P – 2+1, CREDITS – 5)**

Statistic characteristics of measurement systems, Sensing elements: Resistive, capacitive, inductive, electromagnetic, piezoelectric, thermo-electric, optical types. Current and voltage sensors, Signal conditioning elements, Dynamic Characteristics of Measurement systems, Analogue ac and dc measuring instruments: moving coil, moving iron and electrodynamic instruments, Measurement of current, voltage, resistance, power and energy, Digital measuring instruments, Classification of data and errors, Error bands. Uncertainty analysis, Detectors and their signal conditioning circuits, Introduction to PC Based data acquisition systems.

#### **ELEC 1006Y(1) - MATHEMATICS FOR ELECTRICAL ENGINEERS 1 (L/P - 3+0, CREDITS - 6)**

Complex numbers: polar and rectangular forms, arithmetics, DeMoivre theorem, Euler formula. Application to ac circuits.

Linear algebra: vector space and subspace, solution of systems of linear equations, eigenvalues and eigenvectors, determinants. Application to circuit analysis and control.

Calculus: Continuity, limits, derivatives, Cauchy and Riemann sums, integrals, fundamental theorem of calculus, ordinary differential equations.

Function of several variables: chain rule, mean value theorem, partial derivatives, Jacobian, double and triple integrals.

Vector calculus: coordinate systems, scalar and vectors fields, gradient, divergence and curl, line integral, surface integral, volume integral, integral theorems. Application to electromagnetic fields.

#### **ELEC 1200 - PRACTICAL TRAINING/SOFTWARE DEVELOPMENT**

Electrical and Electronic Workshop Practice. Simulation software for Electrical/ Electronic Engineering . Mini Design Project, Software development.

#### **COMS 1010(1) - COMMUNICATION SKILLS (D.E)**

Writing skills, non-verbal communication, modes of speech delivery and presentation aids, speeches, perception and listening skills, business and technical writing.

**ELEC 2002Y(3) - ELECTRONICS 2 (PQ: ELEC 1002Y(1)) (L/P – 2+1, CREDITS – 5)**

Analog electronics:

Low frequency amplifier circuits:  $r_e$  models ; ‘h’ and ‘y’ parameters, high frequency response, small signal hybrid - pi model. Negative feedback : Analysis of various NFB amplifiers, effects of NFB on amplifier system performance. Power Amplifiers: class A, class B and class AB operations; crossover and harmonic distortions; push-pull amplifiers. Oscillators: Hartley, Colpitts,R-C and Wien bridge types, crystal oscillators. Operational amplifiers and their applications. Waveform generators, Schmitt triggers, Precision full-wave rectifier, Timer circuits.

Digital electronics:

Digital System Components. Combinational logic circuits, Design using MSI components. Sequential Logic: Analysis and Design. Finite State Machines. ADC, DAC.

**ELEC 2003Y(3) - ELECTROMAGNETICS & ANALOG COMMUNICATIONS (L/P – 3+1, CREDITS – 7)**

Electric Charge and Current, Electric Field strength, Magnetic fields, dipoles, magnetic forces, Electromagnetic induction, Induction and magnetic energy, Dielectric materials, Maxwell’s equations, electromagnetic waves, co-axial lines, waveguides.

Amplitude and angle modulation, Noise in AM, FM, PM, introduction to digital modulation techniques.

**ELEC 2004Y(3) - CIRCUITS, SIGNALS & SYSTEMS (PQ: ELEC 1003Y(1)) (L/P – 3+0, CREDITS – 6)**

Systems and signals: continuous time and discrete time, differential and difference equations, impulse response and convolution, frequency response and transfer functions, continuous-time Fourier series and transform, Laplace transform, Z-transform.

Circuits: s-domain circuit analysis, transient circuit analysis, two-port networks, network functions, first-order and second-order transfer functions, L-C network synthesis, Y-matrix circuit formulation, active circuit synthesis, analogue filter design.

**ELEC 2005Y(3) - POWER SYSTEMS 1 (PQ: ELEC 1003Y(1)) (L/P – 2+0, CREDITS – 4)**

Generating Stations, Power System Economics, Line Parameters, Performance of Transmission Lines, Distribution Systems, Fault Analysis, Power System Protection.

**ELEC 2006Y(3) - ELECTRICAL MACHINES (PQ: ELEC 1003Y(1)) (L/P – 2+1, CREDITS – 5)**

Magnetic Circuits and Energy Conversion in Machines. Transformer Theory, Connection and Operation. DC Machines: Principles and Characteristics/Operation of DC Motor and Generators. Synchronous ac machines and Induction Machines: Principles, Applications and Operation.

**ELEC 2007Y(3) - MATHEMATICS FOR ELECTRICAL ENGINEERS 2 (PQ: ELEC 1006Y(1))(L/P - 3+0, CREDITS - 6)**

Series methods: Taylor and Maclaurin series, Legendre polynomials and curve fitting, orthogonal and orthonormal basis functions, Fourier series. Application to solution of initial-value and boundary-value problems.

Complex function theory: complex plane, limits and derivatives, Cauchy-Riemann equations, contour integrals, Cauchy’s theorem. Residues. Application to linear systems.

Probability and statistics: axioms, conditional probability and Baye’s rule, discrete and random variables, distributions, samples and estimations, linear regression. Application to communication systems.

Random processes: ensemble and time averages, stationarity, ergodicity, power spectral density. White noise. Amplitude modulation.

Numerical methods: numerical solution of systems of linear equations, numerical differentiation and integration, numerical solution of differential equations. Software implementation.

**ELEC 3001Y(5) - MICROPROCESSORS (L/P – 2+2, CREDITS – 6)**

Binary and Hexadecimal representation of numbers. Binary arithmetic. Architecture of 8085 microprocessor. 16-bit and 32-bit microprocessors. Introduction to Assembly level and Machine Code programming. Internal Registers. Software Concepts Addressing Modes, Data transfers. Instruction sets for 8085. Data Processing. Further Programming. Test and Branch. Stack (software and hardware), subroutines, CALL instructions. Encoder/decoder, tristate, interfacing. Memory Systems RAM and ROM type of memories, EPROM and EEPROM, commercial memory chips. Memory and bit maps, address decoding, memory interfacing. Microprocessor timing and instruction design timing diagram and conventions, T-states, M-cycles, I-cycles, Instruction length and execution time.

Interrupts: RST Instructions and implementation of interrupts. Multiple interrupts and priorities, RIM and SIM Instructions. A/D and D/A conversions. Successive Approximation A/D converters. Programmable Interface chips: Intel 8155 and 8255 and their different modes of operation. Interfacing A/D converters and printers via Intel 8255. DMA. Serial communication, Standards: RS-232C. Asynchronous serial I/O. Data transmission to TTY and data reception from TTY. Serial I/O using programmable chip, Intel 8251A Programmable Communication Interface

**ELEC 3002Y(5) - CONTROL SYSTEMS 1 (L/P – 2+0, CREDITS – 4)**

Modelling of mechanical, hydraulic, pneumatic, and electrical systems. Block Diagrams, Transfer functions, Signal Flow Graphs and their reduction. State space representation of SISO systems. System Analysis: Transient response of SISO systems, steady-state errors, stability, Routh-Hurwitz criterion, root-locus method.

Frequency Response Analysis: Bode diagram, Nichols Chart Analysis, polar plots, Nyquist plot and stability criterion.

**ELEC 3003Y(5) - POWER ELECTRONICS (PQ: ELEC 2004Y(3)) (L/P – 2+1, CREDITS – 5)**

Characteristics of Power Semiconductor devices, Losses and Thermal flow models in switching devices, thermal design, switching aid and snubber circuits, Switch Mode Dc-dc Converters: Buck, Boost, Buck-boost and bridge topologies, Continuous and Discontinuous Modes of Operation, Closed loop control of dc-dc converters. Introduction to controlled rectification. Gate drive circuit design: Transformer and opto-isolated drive circuits; Protection of power electronic devices, Single phase dc to ac inverters. Harmonic reduction techniques. Dc motor drive operating modes; Control of dc brushed motor drives using switch mode power converters.

**ELEC 3004Y(5) - DIGITAL COMMUNICATIONS (PQ: ELEC 2003Y(3)) (L/P – 2+1, CREDITS – 5)**

Introduction to digital communications systems, waveform coding, baseband transmission, Detection and estimation, digital modulation techniques, spread spectrum techniques

**ELEC 3005Y(5) - ELECTRONIC SYSTEMS DESIGN (PQ: ELEC 2002Y(3)) (L/P – 2+1, CREDITS – 5)**

Sequential Systems (Review) : Counters and Shift Registers, LFSR.

Finite State Machines: Clock-Mode and Incompletely Specified Sequential Machines, Fundamental-Mode Sequential Machines. Races and Hazards.

Programmable Logic Devices. PAL and PLA. Sequential Logic Design.

Fault Diagnosis and Testing : Test Pattern Generation, Path Sensitisation, Boolean Difference, D-Algorithm, PODEM. Design For Testability , Built in Self –Test. System Reliability.

**ELEC 3006Y(5) - DIGITAL SIGNAL PROCESSING (PQ: ELEC 2004Y(3)) (L/P – 2+2, CREDITS – 6)**

Continuous-time to discrete-time conversion and back, discrete-time systems and definition of DSP, DTFT, filter specifications, sampling rate conversions, DFS, DFT, FFT, filter structures, IIR filter design, FIR filter design, autocorrelation and power spectral density of random signals, applications.

**ELEC 3201(5) – ENGINEERING DESIGN (L/P – 2+2, CREDITS – 3)**

Graphical representation and standards of electronic components. International Electrotechnical Committee (IEC) Standards for electronic devices and components (Conductor types and sizes, Cable types and colours, Plugs and sockets, Domestic appliances, Lighting, RCCB, RCBO etc). Introduction to BS 7671 (MS 63) Requirements for electrical installations: Protection for safety, Selection and erection of wiring system and equipment, Special installations and locations. Electrical Safety. Automation – Relays, Contactors, motors

and PLCs. Design for Quality. Energy Efficiency. Environmental and Energy efficient systems. Liability and Ethics. Design project/Case studies.

#### **ELEC 3200 - INDUSTRIAL TRAINING**

Students will be attached to a firm or organization for a period of at least 10 weeks. The objective is to provide students with the opportunity to apply theoretical knowledge to solve real world problems in Electrical and Electronic Engineering and to work within the organisational structure of the firm. Students have to perform satisfactorily in this module before qualifying for the award of the degree.

#### **ELEC 4000(5) - DEGREE PROJECT**

Degree project in Electrical/ Electronic Engineering and/or related areas, involving hardware and/or software implementation.

#### **ELEC 4001Y(5) - POWER SYSTEMS 2 (PQ: ELEC 2005Y(3)) (L/P – 2+0, CREDITS – 4)**

Load Flow Studies, Optimal System Operation, Automatic Generation Control, Power System Stability, Power System Security, State Estimation.

#### **ELEC 4002Y(5) - POWER ELECTRONIC DRIVES (PQ: ELEC 3003Y(5)) (L/P – 2+0, CREDITS – 4)**

3-phase dc to ac inverter configurations, Single phase and three-phase switch mode ac to dc converter topologies; continuous and discontinuous modes of operation. Motor drive applications and selection criteria, Mechanical system requirements and torque speed characteristics, Synthesis of low frequency ac voltages for motor drives, Inverter based Induction motor adjustable speed drives, Speed control using 3-phase ac voltage controllers, Single phase thyristor-based ac voltage controllers, Power Quality issues and Uninterruptible Power Supply Systems.

#### **ELEC 4003Y(5) - CONTROL SYSTEMS 2 (PQ: ELEC 3002Y(5)) (L/P – 2+0, CREDITS – 4)**

Controller design: Proportional, PI, PD, PID, Phase-Lead, Phase-Lag and Lead-Lag compensators design in continuous time and frequency domain. Process Control models, Tuning rules for PID controllers, Ziegler-Nichols tuning. Control systems analysis and design by state-space methods. Digital Control: Linear discrete dynamic system analysis, the z-transform, sampling and reconstruction, system time-response characteristics, stability analysis techniques, digital controller design.

### **ELECTIVE MODULES**

#### **ELEC 4021Y(5) - DATA COMMUNICATIONS AND NETWORKING (PQ: ELEC 3004Y(5)) (L/P – 2+0, CREDITS – 4)**

Data communications fundamentals, asynchronous and synchronous transmissions, data synchronizations, data link control protocols, switching techniques, ISDN, X.25, Frame Relay, ATM, Internetworking. Network services and Architectures, Network routing and Addressing, Congestion Control, Queuing theory and network queues, Quality of Service, network management, delay and loss performance models.

#### **ELEC 4022Y(5) - MOBILE COMMUNICATIONS (PQ: ELEC 3004Y(5)) (L/P – 2+0, CREDITS – 4)**

Historical development, Fundamentals of cellular communications, Modulation techniques for cellular communications, Propagation and propagation path loss. Narrow Band System Performance. Wideband System Principles, Access technologies, GSM system, UMTS.

#### **ELEC 4011Y(5) - INSTRUMENTATION SYSTEMS (L/P – 2+0, CREDITS – 4)**

Piezoelectric, electrochemical, ultrasonic and optical sensors. Loading effects in instrumentation systems, Identification of dynamic characteristics, Dynamic errors and compensation techniques, Effects of noise and interference and methods of reducing their effects, Reliability analysis of instrumentation systems, Telemetry and applications.

#### **ELEC 4013Y(5) - ANTENNA THEORY (L/P – 2+0, CREDITS – 4)**

Antenna theory and characterization, antenna parameters, wire and aperture antennas, microstrip patch antennas, antenna arrays, radio propagation principles and models, multipath, fading, noise and interference, antennas for mobile communications, integrated and miniaturized antennas technologies including

MIC/MMIC techniques, link budget design, VSATs, diversity measures ( spatial, polarization, space-time), measurement techniques, beamforming

**ELEC 4014Y(5) - OPTOELECTRONICS (L/P – 2+0, CREDITS – 4)**

Light and Electromagnetic waves, Review of semiconductor devices, Electroluminescence, Optical Sources. Heterostructures, Electro-Optic Modulation, Detection of Optical Signals, Solar Cells, Modules and arrays, Photovoltaic system sizing, Optical cavities, Fiber optical waveguides.

**ELEC 4015Y(5) - RF AND MICROWAVE ENGINEERING (L/P – 2+0, CREDITS – 4)**

Basic theory of high frequency circuits, transmission line theory, propagation coefficient, reflection coefficient for a terminated line, impedance transformation, impedance matching, VSWR, Smith Chart, two-port networks (z, y and h parameters), Interconnected two-port networks, s-parameters, insertion and return loss.

**ELEC 4016Y(5) - IMAGE PROCESSING (L/P – 2+0, CREDITS – 4)**

Image formation and acquisition, representation and formats, frequency domain representation, FIR filters for image processing, image processing basics, image enhancement, image restoration, image coding.

**ELEC 4035Y(5) – NANO ELECTRONICS (L/P – 2+0, CREDITS – 4)**

Fundamental physics and quantum mechanics: Particles and waves mechanics; Materials for nanoelectronics; Growth, fabrication, and measurement techniques for nanostructures; Electron transport in semiconductors and nanostructures; Molecular electronics; Nanostructure and nanoelectronic devices and applications; Spintronics and its applications.

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