M.Sc. Electronics

In view of the need based on the shortage of competent manpower at higher level in the area of Electronics, the Department of Applied Sciences and Humanities introduced the Master of Science(M.Sc.) in ‘Electronics’ programme in 1994. This is a two year programme which consists of foursemesters. Each semester consists of 12-15 weeks of instruction followed by end semester examinations. Attempt is made to assess the student’s performance through continuous system oftests, midterm evaluations and end semester examinations to ensure the highest standard as well as practical orientation.

The Course aims at providing strong fundamentals in the broad area of core electronics followed by exposure in applied fields. The overall thrust of this course is on the design and diagnostics of Analog and Digital Electronics, Analog and Digital Communication, Embedded systems and Design, Data communication & Networking and Digital Signal Processing. This course also includes fundamental knowledge on Nanoelectronics, Organic Electronics, Microwave Engineering, VLSI Design, Nanotechnology, Solar photovoltaic Technology, Photonics, and Optical Fiber Systems, which are very important for a modern course in Electronics. Further the students are also exposed to Innovation, Entrepreneurship & Startup Ecosystem.

The objective of this course is to equip the students with the required knowledge and practical training to make them proficient at technologies and trains them to take up projects relevant to theindustrial needs, the R& D activities and self-employment opportunities.

After completion of this course, the students can study further to enhance their qualification. If thestudent holds an interest in research then they may pursue M.Tech., Ph.D and Post-Doctoral research. There are several career opportunities for the students such as Indian Telephone Industries, NPL, A.I.R, Posts and Telegraph Department, Telecommunication, Defence, Railways, Bharat Electronics Limited, DRDO, ISRO, Television Industry and Research & Development, Software Engineering/IT, Hardware Manufacturing etc.

Programme Educational Objectives (PEOs):

The department of Applied Sciences and Humanities in consultation with stake holders has formulated Programme Educational Objectives (PEOs) that are broad statements describing the career and professional accomplishment that the programme is preparing its graduates to achieve in few years, subsequent upon to receiving the degree. The PEOs of M.Sc. in Electronics programme are as follows:

PEO1: Facilitate value-based holistic and comprehensive learning by integrating traditional and innovative learning practices to match the highest quality standards and train students to be effective leaders in their chosen fields and career.

PEO2: Provide a conducive environment to unleash their hidden talents, creative potential, nurture the spirit of critical thinking and encourage them towards higher education so as to cater the needs of the industry/society and contribute for the development of the nation.
PEO3: Equip students with skills needed to adapt better to ever changing global scenarios by encouraging innovative practices, research competence and entrepreneurial skills and gain accessto career opportunities in multidisciplinary domains.

PEO4: Develop a sense of social responsibility, ethics and equity to transform students into commitment-oriented professionals having strong attitude towards sustainable development for betterment of society.

Program Specific Outcomes (PSOs):

Upon completion of this programme the student will be able to

PSO1: Design, analyse, and implement systems in the field of core as well as applied field ofelectronics.

PSO2: Apply knowledge to solve real time problems using the state of the art hardware andsoftware tools.

Course Structure of M. Sc. (Electronics)

Semester-I

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-101	Nano-Electronics	4	4	-	40	60	100
2	EL-102	Microprocessors & Microcontrollers (MOOC)	3+1	4	-	40	60	100
3	EL-103	Signals and Systems	4	4	-	40	60	100
4	EL-104	Computational Methods and Special Functions (CBCS)	4	4	-	40	60	100
5	EL-105	Analog and Digital Electronics	4	4		40	60	100
6	EL-108	Electronics Lab	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-106	Introduction to Nanotechnology	4	4	-	40	60	100

8	EL-107	Energy Resources: Concepts and Technologies	4	4	-	40	60	100
		TOTAL CREDITS	**26**			**TOTAL MARKS**		**650**

Semester-II

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-201	Analog and Digital Communication	4	4	-	40	60	100
2	EL-202	Organic Electronics (CBCS)	4	4	-	40	60	100
3	EL-203	Microwave Engineering (MOOC)	3+1	4	-	40	60	100
4	EL-204	Embedded Systems and Design	4	4	-	40	60	100
5	EL-207	Microprocessor and Communication Engg. Lab	2	-	4	30	20	50
6	EL-208	Seminar	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-205	Power Electronics (MOOC)	3+1	4	-	40	60	100
8	EL-206	Control Systems (MOOC)	3+1	4	-	40	60	100
		TOTAL CREDITS	**24**			**TOTAL MARKS**		**600**

Summer Training during summer vacation between Semester-II and Semester-III

Semester-III

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-301	Data Communication and Networking (CBCS)	4	4	-	40	60	100
2	EL-302	Optical Fiber Systems	4	4	-	40	60	100
3	EL-303	Digital Signal Processing (MOOC)	3+1	4		40	60	100
4	EL-304	Innovation, Entrepreneurshipand Start-up Ecosystem	2	2	-	30	20	50
5	EL-308	Optoelectronics Lab	2	-	4	30	20	50
6	EL-309	Minor Project	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-305	VLSI and Device Modelling	4	4	-	40	60	100
8	EL-306	Solar Photovoltaic Technology	4	4	-	40	60	100
9	EL-307	Data Structures and Algorithms	4	4	-	40	60	100
		TOTAL CREDITS	**22**			**TOTAL MARKS**		**550**

Semester-IV

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-401	Summer Training Assessment	2	-	-	30	20	50
2	EL-402	Dissertation	12	-	-	180	120	300
		TOTAL CREDITS	**14**			**TOTAL MARKS**		**350**

EL-101: Nano-Electronics

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-101.CO1	To introduce the concept of nanoelectronics, and learn the basic physics neededto study fairly broad classes of nanoelectronic devices.
EL-101.CO2	To introduce and learn the band theory of solids needed to study nanoelectronics devices.
EL-101.CO3	To introduce and learn the basic concepts of tunneling which is very importantfor various applications such as MOSFETs, scanning tunneling microscope and resonant tunneling diode.
EL-101.CO4	To introduce and learn Coulomb blockade on the basis of tunneling, single electron devices and single electron transistor.
EL-101.CO5	To explain the principle and application of spintronic devices.

Unit-I: Introduction to Nanoelectronics (10 Lectures)
Recent past, the present and its challenges, Future, Overview of basic Nano-electronics. Quantum Mechanics of Electrons: General postulates of Quantum Mechanics, Time independent Schrodinger Equation, Probabilistic Current density, Multiple Particle Systems, Spin and Angular Momentum.

Unit-II: Band Theory of Solids (10 Lectures)
Crystalline Materials, Electrons in a Periodic Potential, Kronig- Penny Model of Band Structure, Doping in Semiconductors, Interacting System Model, The Effect of Electric Field on Energy Bands, Band structures of some Semiconductors, Electronic Band Transitions, Interactions with Electromagnetic Fields

Unit-III: Tunnel Junctions and Applications of Tunneling (10 Lectures)
Tunneling Through a Potential Barrier, Potential Energy Profiles for Material Interfaces, Metal-Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions. Field Emission, Gate-Oxide Tunneling and Hot Electron Effects in MOSFETs, Scanning Tunneling Microscope, Double Barrier Tunneling and Resonant Tunneling Diode

Unit-IV: Coulomb Blockade and the Single-Electron Transistor (10 Lectures)
Coulomb Blockade, Coulomb Blockade in a Nanocapacitor, Tunnel Junctions, Tunnel Junction Excited by a Current Source, Coulomb Blockade in a Quantum Dot Circuit, The Single-Electron Transistor Single-Electron Transistor Logic

Unit-V: Spintronics (10 Lectures)
Introduction, Overview, History & Background, Spin based transistors, Spin field effect transistors (SPINFET), Spin Bipolar Junction Transistor (SBJT)

Text/Reference Books:

1. George W Hanson, “Fundamentals of nanoelectronics”, Pearson Publications, India (2008)

2. Supriyo Bandyopadhyay, Marc Cahay, "Introduction to Spintronics", CRC Press (2008)
3. Vladimir V. Mitin, Viatcheslav A. Kochelap and Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press (CUP), UK (2008)
4. Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH (2012)
5. Seng Ghee Tan and Mansoor B. A. Jalil, "Introduction to the physics of Nanoelectronics", Woodhead Publishing Limited, New Delhi (2012)

EL-102: Microprocessor & Microcontrollers (MOOCs)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-102.CO1	Distinguish the feature of the 8085 microprocessor, Hardware Architecture and PIN diagram and Demonstrate programming proficiency using the various addressing modes and data transfer instructions of 8085 microprocessor.
EL-102.CO2	Distinguish and analyze the properties of Microprocessors & Microcontrollers and acquaint the knowledge on architecture and programming ofMicrocontroller 8051.
EL-102.CO3	To introduce AVR, ARM and PIC Microcontroller.
EL-102.CO4	Illustrate the interrupts handling and demonstrate peripherals applications in different IC and Know about A/D and D/A converters.
EL-102.CO5	To introduce the feature of 8086 microprocessor, and Demonstrate programming proficiency using the various addressing modes and systemdesign using 8086.

Unit-I: Introduction to Microprocessors & Microcomputers (15 Lectures)
Microprocessor Architecture, Introduction to Assembly language Programming, Operation Bus, Timing (Read/ Write) Cycles, I/O Addressing. Introduction to 8085 Instructions, Addressing Modes, Assembly Language Programs, Stack & Subroutines, Counters & Time Delays

Unit-II: Introduction to 8051 Microcontroller (12 Lectures)
Register Set, Architecture of 8051 microcontroller, I/O and Memory Addressing Interrupts, Instruction Set, Addressing Modes, Introduction to Embedded C Programming, Timer, Serial Communication, 8051 Data Types & Directives, Instructions and related programs.

Unit-III: Introduction to AVR, PIC and ARM Microcontrollers (10 Lectures)
Introduction to AVR family of microcontrollers, Microcontroller, AVR CPU, system clock and clock option., ARM Microcontroller, PIC Microcontroller

Unit-IV: Interfacing Peripherals & Applications (06 Lectures)
IO and Memory Interfacing concepts, 8085 Interrupts, Programmable Peripheral Device- 8255A, Various Modes of 8255A, Programmable Interrupt Controller-8259A, Direct Memory Access (DMA) Controller-8257**)**

Unit V: Introduction to 8051 Microprocessor (07 Lecture)
Introduction to 8086: Microprocessor architecture, Addressing mode, Instruction set and assembler directives, Assembly language programming, Modular Programming, Linking and Relocation, Stacks procedures, Interrupts and interrupt service routines, Byte and String Manipulation, 8086 signals, , System bus timing, System design using 8086, Introduction to advanced processors

Text/Reference Books:

1. R. Gaonkar, “Microprocessor Architecture, Programming and Applications with the 8085”, Penram International Publishing, India (2013)
2. M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, “The 8051 Microcontroller: A Systems Approach”, Pearson, (2012)
3. M. Bates, “PIC Microcontrollers”, Newnes, (2011)
4. M.A. Mazidi, S. Naimi, S. Naimi, “The AVR Microcontroller and Embedded Systems: Using Assembly and C”, Prentice Hall, (2011)
5. W.A. Smith, “ARM Microcontroller Interfacing: Hardware and Software, Eketor, (2010)

EL-103: Signal and Systems

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-103.CO1	To study various kinds of continuous and discrete signals and analogy of the two.
EL-103.CO2	To learn Fourier series and to imply it various problems.
EL-103.CO3	To realize continuous and discrete time systems.
EL-103.CO4	Understanding Z-transform and its applications.
EL-103.CO5	Learning to calculate probability and correlation of various random and distribution functions.

Unit-I: Introduction to Signals & Systems (10 Lectures)
Basic concepts and definitions of continuous and discrete time Signals, their classification, continuous and discrete time system and their properties, linear time invariant systems response for continuous time systems and discrete time systems. Properties of continuous and discrete LTI systems. System representation through differential equations and difference equations

Unit-II: Introduction To Fourier and Laplace Transform Applications (10 Lectures)
Fourier analysis, continuous and discrete time Fourier series and its properties, Fourier transform for continuous and discrete time signals, Magnitude and phase spectra of continuous and discrete

time signal, Response of LTI system using Fourier transform, applications of Fourier transform, Laplace transform and its applications

Unit-III: Sampling (10 Lectures)
Sampling theorem for low-pass signals, Aliasing, Sampling techniques, Impulse sampling, Natural sampling, Flat-top sampling, Aperture effect, Sampling of sinusoidal signals, Sampling theorem for band pass signals, Quantization, Sampling of discrete time signal

Unit-IV: The Z-Transform (10 Lectures)
Basic principles of Z-transform, Z-transform definition, Unilateral and Bilateral Z-transform, Relationship between Z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of Z-transform, Poles and Zeros, Inverse Z-transform using Contour integration, Power Series expansion and Partial fraction expansion, Realization of continuous time systems and discrete time systems

Unit-V: Probability & Random Variable.(10 lectures)
Cumulative distribution functions. Probability distribution function, Relation between probability and probability density, Joint cumulative distribution function, Average value of a random variable, Error function, Rayleigh Probability Density, Mean and variance of the sum of random variable, Probability density of Z=X+Y, Correlation between random variable, Central-limit theorem, Random Process, Auto-correlation

Text/Reference Books:

1. A.V. Oppenheim, A.S. Willsky, S.H. Nawab, “Signals & Systems”, Prentice HallPublications
2. S. Haykin, B. V.Veen “Signals & Systems”, Wiley Publications
3. B.P. LATHI, “Principles of Linear Systems And Signals”, Oxford University Press, India (2009)

EL-104: Computational Methods and Special Functions

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

EL-104.CO1	To understand and implement interpolation, numerical differentiation and integration.
EL-104.CO2	To study Linear system of equations and Differential equations.
EL-104.CO3	To study Legendre’s polynomials and their Applications
EL-104.CO4	To study Bessel Functions and their Applications
EL-104.CO5	To study Hermite and Laguerre polymonials.

Unit-I: Method of Numerical Analysis (Lecture 08)
Interpolation, Errors in polynomial interpolation, Interpolation for equal intervals and unequal intervals, Inverse interpolation, Numerical differentiation and integration, Method of Smoothing and Averaging

Unit-II: Introduction to Linear Systems (Lecture 08)
Triangular systems, Factorization method for solving Ax=b; Partial pivoting strategy, Solving linear system using Gaussian eliminator, Method for solving differential equation, Eigenvalue problems

Unit-III: Legendre Polynomials and Related Functions (Lecture 12)
Introduction, Legendre polynomial, The Generating function, Special values and recurrence formula, Legendre's differential equation, Other representations of the Legendre polynomials, Rodrigue's formula, Laplace integral formula, Legendre series, Orthogonality of the polynomials, Finite and infinite Legendre series, Convergence of the series, Piecewise continuous and smooth functions, Point wise convergence, Legendre functions of the second kind, Basic properties, Associated Legendre functions, Basic Properties of $P_n'(x)$, *Applications*: Electric potential due to asphere, Steady-state temperatures in a sphere

Unit-IV: Bessel Functions and Applications (Lecture 12)
Introduction, Bessel functions of the first kind, The Generating function, Bessel functions of the nonintegral order, Recurrence formulas, Bessel's differential equation, Integral representations, Bessel's problem, Geometrie problems, Integrals of Bessel functions, Indefinite integrals, Definite integrals, Series involving Bessel functions, Orthogonality of Bessel functions, Fourier-Bessel series, Bessel functions of the second kind, Series expansion for $Y_n(x)$, Asymptotic formulas for small arguments, Recurrence formulas, Differential equations related to Bessel's equation, The Oscillating chain, Modified Bessel's function, Spherical Bessel's function, Other Bessel's function: Hankel, Struve, Kelvin, Airy, and Asymptotic formulas, *Applications*: Narrow band Noise and Envelope Detection, Step-index optical fibers

Unit-V: Hermite and Laguerre Polymonials (Lecture 10)
Introduction, Hermite polynomials, Recurrence formulas, Hermite series, Simple harmonic oscillator. Laguerre polynomials, Recurrence formulas, Laguerre series, Associated Laguerre polynomials, Hydrogen atom, Generalized polynomial sets, Gegenbauer polynomials, Chebyshev polynomials, Jacobi polynomials

Text/Reference Books:

1. S.C. Chapra and R.P. Canale, "Numerical Methods for Engineers", 5th Ed., McGraw Hill (2006)
2. Larry C. Andrews, "Special Functions of Mathematics For Engineers", 2^{nd} Ed., Oxford University Press, USA (1998)
3. E.D. Rainville, "Special Functions", The Macmillan Company, New York (1960).
4. Z.X. Wang and D.R. Guo, "Special Functions, World Scientific publishing Co. (1989).

EL-105: Analog and Digital Electronics

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

EL-105.CO1	To understand the fundamentals of Semiconductor devices,
EL-105.CO2	To study the physics and construction of Field Effect transistors.
EL-105.CO3	To understand the basics of Operational amplifier with the help of its various operational parameters and to learn converters, IC-Timer and multivibrators.
EL-105.CO4	To instill the fundamentals of Digital Electronics and to understand various combinational logic modules and to discuss their various applications.
EL-105.CO5	To learn the working and implementation of various sequential circuits.

Unit-I: Semiconductor Devices (10 Lectures)

Brief review semiconductor diode characteristics and applications, Bipolar Junction Transistor (BJT) and its applications, Transistor fundamentals, Transistor configurations, DC operating point, BJT characteristics and parameters, Fixed bias, emitter bias, With and without emitter resistance, Analysis of circuits and their designs, Variation of operating point and its stability

Unit-II: Field Effect Transistors (10 Lectures)

JFET structure and principle, JFET operation qualitative analysis, Signal transfer, Gain, Small signal equivalent circuit, MESFET structure and its operational principle, applications. MOSFET structure, MOS capacitor band diagram-quantitative analysis, I-V characteristics, small signal equivalent circuit

Unit-III: Operational Amplifiers (10 Lectures)

Operational amplifier characteristics, Applications of op-amps: Inverting amplifier, Non inverting amplifier, voltage follower, Summing amplifiers, Subtractor, Integrator, Differentiator, Comparators, Active filters (first order only), Instrumentation amplifier, D/A converter, Binary weighted method, R-2R ladder method, IC-555 Block diagram, Monostable multivibrator, Astable multivibrator

Unit-IV: Boolean Functions and Combinational Logic Circuits (10 Lectures)

Review of number system and their conversions, Boolean functions, Digital logic gates, Demorgan's theorem, Karnaugh maps method: Two, three and four variable maps, Simplification of expressions, Quine-McCluskey minimization technique, Mixed logic combinational circuits, Multiple output functions, Code conversions, Decoder, Encoder, Priority encoder, Multiplexers as function generators, Binary adder, Substractor, BCD adder, Binary comparator, Arithmetic logic units

Unit-V: Sequential Logic Circuits (10 Lectures)

Sequential circuits, flip-flops, clocked and edge triggered flip flops, timing specifications, asynchronous and synchronous counters, counter design with state equations, Registers, serial in serial out shift registers, tristate register, and timing considerations. State diagrams and tables, transition table, excitation table and equations. Examples using flip-flops. Analysis of simple synchronous sequential circuits, construction of state diagram, counter design.

Text/Reference Books:

1. A. S. Sedra and K. C. Smith, “Microelectronic Circuits”, New York, Oxford University Press (1998)
2. J. Millman and C C Halkias, “Integrated Electronics: Analog and Digital Circuits and Systems”, 2nd Ed., Tata-McGraw Hill Education (2010)
3. Ramakant A Gayakwad, “Op- Amps and Linear Integrated Circuits”, Pearson, India (2015)
4. M. M. Mano and M.D.Clietti, “Digital Design: With an Introduction to Verilog HDL", 6th Ed., Pearson (2018)
5. William I. Fletcher, “An Engineering Approach to Digital Design”, Pearson (2015)

EL-106: Introductions to Nanotechnology (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

*EL-106.*CO1	To understand the fundamentals and basics of nanotechnology.
*EL-106.*CO2	To provide the knowledge of the basics and properties of semiconductor nanostructures.
*EL-106.*CO3	To know the concepts, types and properties of carbon nanotubes.
*EL-106.*CO4	To provide an understanding of the characterization tools for Nanomaterials.
*EL-106.*CO5	To study the applications of nanomaterials for energy systems and devices.

Unit-I: Introduction to Nanotechnology (12 Lectures)
Historical background, Definition and applications of nanotechnology, Quantum phenomena, Size and dimensionality effects, Excitons, Electronic confinement in 1D, 2D and 3D structures, Nanomaterials: History and scope, Classification of nanostructured materials, Applications of nanomaterials, Challenges and future prospects, Growth techniques of nanomaterials: Top-down and bottom-up approaches, Lithographic process and its limitations, Nonlithographic techniques

Unit-II: Semiconducting Nanostructures (08 Lectures)
Metal oxide nanostructures: Background, Synthesis, Properties and Applications Nanochalcogenides: Background, Synthesis, Properties and Applications, Organic Semiconductor Nanostructures: Background, Synthesis, Properties and applications

Unit-III: Carbon Nanomaterials (10 Lectures)
Introduction to carbon allotropes and carbon nanomaterials, Fullerenes: Background, Synthesis, Properties and Applications, CNTs (SWNTs and MWCNTs,): Background, Synthesis, Properties and Applications, Nano-diamonds: Background, Synthesis, Properties and Applications, Graphene: Background, Synthesis, Properties and Applications, Carbon Nano-fibers and Carbon nano-yarns: Background, Synthesis, Properties and Applications

Unit-IV: Characterization Tools for Nanomaterials (14 Lectures)
Introduction, Scattering Techniques: X-Ray Diffraction Methods, Dynamic Light Scattering (DLS), Zeta Potential Analysis Imaging through Electron Microscopy: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning Probe Microscopy (SPM), Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM Characterization through Spectroscopy: UV–Visible Plasmon Absorption and Emission, Vibrational Spectroscopies: FTIR and Raman Spectroscopy, Raman Spectroscopy Based Imaging, X-Ray Photoelectron Spectroscopy (XPS),Auger Electron Spectroscopy, Secondary Ion Mass Spectrometry (SIMS)

Unit-V: Nanomaterials for Energy Applications (06 Lectures)
Introduction, Nanomaterials for Photovoltaic Devices, Nanomaterials for Energy Storage Devices, Nanomaterials for Thermo-electric Devices, Nanomaterials for Hydrogen Storage, Nanogenerators

Text/References Books:

1. Chris Binns, "Introduction to Nanoscience and Nanotechnology", Wiley Survival Guides in Engineering and Science-a John Wiley & Sons Inc., New Jersey (2010)
2. Narendra Kumar and Sunita Kumbhat "Essentials In Nanoscience And Nanotechnology**"** John Wiley & Sons, Inc., Hoboken, New Jersey (2016)
3. B. Bhooshan, "Springer Handbook of Nanotechnology", Springer (2010)
4. Zishan Husain Khan and M. Husain "Advances in Nanomaterials", Springer (2016)
5. Zishan Husain Khan "Recent Trends in Nanomaterials: Synthesis and Properties (Advanced Structured Materials)", Springer (2017)
6. Zishan Husain Khan, "Nanomaterials and Their Applications", Springer (2018)
7. Zishan Husain Khan, "Emerging Trends in Nanotechnology", Springer (2021)

EL- 107: Energy Resources: Concepts and Technologies (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

EL-107.CO1	To understand the concepts of energy technologies.
EL-107.CO2	To provide the deep knowledge of hydro-power plants.
EL-107.CO3	To know the concepts, types and design of thermal power plants.
EL-107.CO4	To provide an understanding of the concepts, design and project planning of nuclear power plants.
EL-107.CO5	To study the of the techno-economic aspects of power projects

Unit-I: Introduction & Orientation (06 Lectures)
Conventional and Non-Conventional Energy, Sources of Conventional energy, Historical, economic and Environmental Perspective, Need of Non-conventional Energy Sources, Types of Non-conventional Energy Sources, Global and National scenario, Basics of Nonconventional Energy Sources, their distribution and limitations

Unit-II: Hydro Power (12 Lectures)

Types of hydropower plants and schemes, hydrology: runoff studies, flood estimation studies, assessment of hydropower potential of a basin, storage and pondage, load studies, elements of hydropower plants and their hydraulic design: dams, intakes, conveyance system, types of power house, hydraulic turbines and pumps, Components and design of hydraulic turbines, Standardization and selection of turbine, Components and design of hydraulic Pumps, Hydropower scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification of Hydropower projects, Conceptualization, Techno-commercial studies, Investigation & Planning, Design Principles, Project Management, Operational issues, Test cases of Hydropower Projects

Unit-III: Thermal Power (12 Lectures)

Types of thermal power tubines, Gas turbines; Open and closed cycles, constant pressure and constant volume cycles, cycles with inter cooling, reheating and heat exchanger, compressor and turbine efficiencies, pressure losses, performance characteristics of various cycles, practical problems. Jet Propulsion: Calculation of thrust, Power, speed and efficiency, turbo - jet and turbo propulsion systems. Compressors, Combustion Systems, Steam turbines; Principle and working, type of turbines, stage to blade, speed ratio for optimum efficiency, diagram efficiency, steam performance. Energy losses in steam turbine, turbine performance at various loads and governing of steam turbines. Constructional details and description of steam turbine, Thermal power scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification, Techno-commercial studies, Investigation & Planning, Design Principles, Project Management, Operational issues, Test cases

Unit-IV: Nuclear Power (10 Lectures)

Introduction to Nuclear Energy, Nuclear power scenario; Global and Indian perspective, Nuclear Reactors and its Components, General Problems of Reactor Operation, Different Types of Reactors, Pressurized Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type. Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants, Nuclear Materials, Nuclear Waste and its disposal, Safety rules, , Policies, Environmental concerns, Sub classification, Techno-commercial studies, Investigation & Project Planning & Design, Project Management, Operational issues, Test cases

Unit-V: Techno-Economic Aspects of Power Projects (10 Lectures)

Techno-commercial aspects of power projects, General scenario of health of power industry with changing times, Analysis of power projects under stress, Techno-economic viability of a power project, conceptualization of a project, Statuary compliances in approval of the report, Bankable project reports, Escalation of cost and interest cost during construction, Socio-economic impact studies, Environmental clearances, Process of determination of tariff of different types of projects.

Text/Reference Books:

1. P. S. Nigam, "Handbook of Hydroelectric Engineering", Nem Chand & Bros., Roorkee (2008)
2. William Shepard and Li Zhang, "Electricity generation using wind power", 2nd Ed., World Scientific, Singapore (2017)
3. P. L. Ballany, "Thermal Engineering", Khanna Publishers (2002)

4. Robert L. Loftness, “Nuclear Power Plants: Design, Operating, Experience and Economics”, D Van Nostrand Company Inc, New Jersey (1964)

EL-108: Electronics Lab

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Course Objectives:

EL-109.CO1	To study the characteristics of UJT, DIAC and TRIAC
EL-109.CO2	To study transfer characteristics of JFET and MOSFET
EL-109.CO3	Understanding BJT and learning its CE characteristics through hands-on.
EL-109.CO4	To determine of semiconductor parameters such as band gap, temp. coef.
EL-109.CO5	To understand the working of relaxation oscillator.

List of Experiments

1. To determination of temperature coefficient of junction voltage and energy bandgap
2. To study of depletion capacitance and its variation with reverse bias
3. To determine reverse saturation current and material constant
4. To study the drain and transfer characteristics of JFET
5. To study the application of transistor as an amplifier
6. To study the drain and transfer characteristics of MOSFET
7. To study the characteristics of MOSFET
8. To study the characteristics of DIAC
9. To study the static emitter characteristics of UJT
10. To study the characteristics of BJT in CE configuration
11. To study relaxation oscillator
12. To study the I-V characteristics of SCR
13. To determine the reverse saturation current and material constant η

EL-201: Analog and Digital Communication

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-201.CO1	Explain the concept of amplitude and angle modulations.
EL-201.CO2	Describe various data and pulse transmission schemes.
EL-201.CO3	Compare different types of shift keying techniques.
EL-201.CO4	To learn the basics of Information theory.
EL-201.CO5	Calculation of noise in analog & digital communication system.

Unit-I: Analog Communication (15 Lectures)

Introduction: Historical Background, Applications, Primary Resources and Operational Requirements, Underpinning Theories of Communication Systems Amplitude Modulation: Amplitude Modulation, Virtues, Limitations, and Modifications of Amplitude Modulation, Double Sideband-Suppressed Carrier Modulation, Quadrature Carrier Multiplexing, Single-Sideband Modulation, Vestigial Sideband Modulation, Angle Modulation: Basic Definitions, Properties of Angle-Modulated Waves, Relationship between PM and FM Waves. Narrow-Band Frequency Modulation, Wide-Band Frequency Modulation, Transmission Bandwidth of FM Waves, Generation of FM Waves, and Demodulation of FM Signals

Unit-Ii: Digital Communication (10 Lectures)
Pulse Modulation: Transition from Analog to Digital Communications: Sampling Process, Pulse-Amplitude Modulation, Pulse-Position Modulation, Completing the Transition from Analog to Digital, Quantization Process, Pulse-Code Modulation, Delta Modulation, Differential Pulse-Code Modulation, Line Codes, Baseband Data Transmission: Baseband Transmission of Digital Data, The Intersymbol Interference Problem, The Nyquist Channel. Raised-Cosine Pulse Spectrum. Baseband Transmission of M-ary Data, The Eye Pattern

Unit-III: Digital Band-Pass Modulation Techniques (08 Lectures)
Introduction, Binary Amplitude-Shift Keying, Phase-Shift Keying, Frequency-Shift Keying Summary of Three Binary Signaling Schemes, Noncoherent Digital Modulation Schemes, M-ary Digital Modulation Schemes

Unit-IV: Introduction To Information Theory (09 Lectures)
Measure of information, source encoding, error-free communication over a noisy channel, channel capacity of a discrete memoryless channel, channel capacity of a continuous memoryless channel, practical communication systems in light of Shannon's equation, frequency-selective channel capacity, Multiple-input-multiple-output communication systems, Capacity of MIMO Channels Transmitter without Channel Knowledge, Transmitter with Channel Knowledge

Unit-V: Random Signals and Noise (08 Lectures)
Probability and Random Variables, Expectation, Transformation of Random Variables, Gaussian Random Variables, The Central Limit Theorem, Random Processes, Correlation of Random Processes, Spectra of Random Signals, Gaussian Processes, White Noise, Narrowband Noise, Noise in Communication Systems, Signal-to-Noise Ratios, Electrical Noise, Noise Figure, Equivalent Noise Temperature, Noise in Analog communication system, Noise in Digital communication system

Text/References Books:

1. Simon Haykin, Michael Moher, “Introduction to Analog and Digital Communications”, 2nd Ed., John Wiley & Sons Inc, USA (2007)
2. Simon Haykin, “Communication Systems”, 4th Ed., John Wiley & Sons, (2004)
3. B. P.Lathi, “Modern Analog and Digital Communication Systems”, 4th Ed., Oxford University Press, (2010)

EL-202: Organic Electronics (CBCS)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-202.CO1	To understand the charge transport in organic semiconductors through various models
EL-202.CO2	To study the construction, working and applications of organic transistors
EL-202.CO3	To study the construction, working and applications of organic LED
EL-202.CO4	To study the construction, working and applications of organic solar cells
EL-202.CO5	To study various devices involving hybrid optoelectronics

Unit-I: Fundamentals of Organic Semiconductors (12 Lectures)
General Overview of Organic Semiconductors and Electronics, Electronic configuration and concepts of atomic orbital, Hybridization and overlapping of orbital, Molecular orbital, LCA theory, Bonding and Anti-bonding orbital, Sigma bonding and Pi bonding, Origin of bandgap in organic semiconductors, Charge Transport in organic Semiconductors, Optical and Electric properties of organic semiconductors

Unit-II: Organic Transistors (08 Lectures)
Introduction, P-Channel and N-Channel Materials, Gate Dielectrics and Electrode Materials of organic semiconductors, Current research and Market Scenario

Unit III: Organic LEDs (10 Lectures)
Introduction, organic light emitting diodes (OLEDs), Hole and electron transporting materials, Light emitting materials, Passive and Active Matrix OLEDs, White OLEDs, Fabrication of OLEDs, Application of OLEDs, Current market and research scenario

Unit-IV: Organic Photovoltaics (12 Lectures)
Introduction to organic photovoltaic's, Energy diagram of organic photovoltaic's, Excitons, Wannier Excitons, Charge transfer Excitons, Frankel Excitons, Exciton diffusion, Excitonic Energy transfer, Exciton donor and accepter material, Different design of organic photovoltaics, Fabrication of organic solar cells , application of organic solar cells, Current market and research scenario

Unit-V: Hybrid Optoelectronics (08 Lectures)
Hybrid Solar cell: Introduction, Materials, Application, current R&D Status, Hybrid OLED: Introduction, Materials, Application, Current R&D Status

Text/References Books:

1. " Conjugated Polymers: Theory, Synthesis, Properties, And Characterization", 3rd Ed., Edited by Terje A. Skotheim and John R. Reynolds, CRC Press (2006)
2. "Conjugated Polymers Processing and Applications", 3rd Ed., Edited by Terje A. Skotheim and John R. Reynolds, CRC Press (2006)

3. Sam-Shajing Sun and Niyazi Serdar Sariciftci, "Organic Photovoltaics Mechanisms, Materials, and Devices", CRC Press (2017)
4. Donald A. Neamen, "Semiconductor Physics and Devices Basic Principles", McGraw Hill publications (2003)

EL-203: Microwave Engineering (MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-203.CO1	To understand the basic concepts of microwaves and its transmission.
EL-203.CO2	To understand the propagation through the transmission lines and waveguides.
EL-203.CO3	To understand the microwave generation, passive components and network analysis using scattering parameters.
EL-203.CO4	To understand the working of microwave devices and active circuits and learn the test methods at the microwave frequencies.
EL-203.CO5	To understand the modern trends in microwaves engineering and working of microwave systems.

Unit-I: Introduction to Microwaves and Microwave Transmission (08 Lectures)
History of Microwaves, Microwave Frequency bands, General Applications of Microwaves, Advantages of Microwaves, Concept of Mode, Characteristics of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission

Unit-II: Analysis of Microwave Transmission Lines and Waveguides (12 Lectures)
Transmission line equations & solutions, reflection and transmission coefficient, standing wave andstanding wave ratio, line impedance and admittance, impedance matching, using stub line, application of smith chart in solving transmission line ,problems Introduction to strip lines**,** Microstrip lines, parallel strip lines, coplanar strip lines, shielded strip lines , Rectangular and circularwaveguides-theory and analysis.

Unit-III: Microwave Network Analysis And Passive Microwave Devices (10 Lectures)
Equivalent Voltages and currents for non-TEM lines, Network parameters for microwave Circuits,Scattering Parameters**,** Microwave Passive components: Directional Coupler, Power Divider,Magic Tee, Wave-guide Corners, Bends, Twists, Attenuator, Circulator, Isolator and Resonator,Microwave. Microwave tubes: Klystron Amplifiers, Reflex klystron oscillators, Magnetronoscillators and Travelling Wave Tube Amplifiers

Unit-IV: Active Components (10 Lectures)
Tunnel diode, Varactor diodes, Step recovery diodes, Schottky Barrier diodes, PIN diodes, Gunn Diodes, IMPATT and TRAPATT diodes, Parametric Amplifiers, Microwave Transistors, Microwave oscillators and Mixers, Microwave Measurements: Power, Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering

parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal, Noise at microwave frequency and measurement of noise figure, Measurement of Microwave antenna parameters

Unit-V: Modern Trends in Microwaves Engineering and Systems (10 Lectures)
Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference (EMI), Electromagnetic Compatibility (EMC), Monolithic Microwave IC fabrication, RF MEMS for microwave components, Microwave Imaging Microwave Systems: Wireless Communications Systems, Radar Systems, Radiometer Systems, Satellite Communication, Remote sensing, Microwave Propagation, Microwave Antennas

Text/References Books:

1. Samuel Y. Liao, "Microwave Device and Circuits", 3rd Ed., Pearson (2003)
2. David M. Pozar, "Microwave Engineering", 4th Ed., John Wiley & Sons, (2012)
3. Robert E. Collin, "Foundation for Microwave Engineering", 2nd Ed., McGraw Hill,(1998)

EL-204: Embedded Systems and Design

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

EL-204.CO1	To provide a clear understanding on the basic concepts, building blocks of embedded systems.
EL-204.CO2	To learn the fundamentals of embedded processor modelling, bus communication in processors and input/output interfacing.
EL-204.CO3	To introduce on processor scheduling algorithms, basics of real time operating system.
EL-204.CO4	To discuss on aspects required in developing a new embedded processor, different phases and modelling of embedded system
EL-204.CO5	To involve discussions/practice/exercise onto revising and familiarizing the concepts acquired for improved employability skills.

Unit-I: Introduction to Embedded Systems (10 Lectures)
Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor & memory devices- DMA, Memory management methods- memory mapping, cache replacement concept, Timer and Counting devices, Watchdog Timer, Real Time Clock

Unit-II: Embedded Networking and Interrupts Service Mechanism (10 Lectures)
Embedded Networking: Introduction, I/O Device Ports & Buses Serial Bus communication protocols RS232 standard RS485 USB Inter Integrated Circuits (I2C) interrupt sources, Programmed-I/O busy-wait approach without interrupt service mechanism ISR concept multiple interrupts –context and periods for context switching, interrupt latency and deadline Introduction to Basic Concept Device Drivers.

Unit-III: RTOS Based Embedded System Design (10 Lectures)
Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and nonpreemptive scheduling, Task communication shared memory, message passing-, Interprocess Communication synchronization between processesemaphores, Mailbox, pipes, priority inversion, priority inheritance comparison of commercial RTOS features RTOS Lite, Full RTOS, VxWorks, µC/OS-II, RT Linux.

Unit-IV: Software Development Tools (10 Lectures)
Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, In Circuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co-Design. Overview of UML, Scope of UML modeling, Conceptual model of UML, Architectural, UML basic elements Diagram- Modeling techniques - structural, Behavioral, Activity Diagrams.

Unit-V: Embedded System Application Development (10 Lectures)
Objectives, different phases and modeling of the embedded product development life cycle (EDLC), Case studies on smart card, Adaptive cruise control in a car, Mobile phone software for key inputs

Text/Reference Books:

1. Raj Kamal, “Embedded Systems Architecture Programming and Design”, 2nd Ed., Tata MC Graw-Hill (2015)
2. Tim Wilmshurst, “Designing Embedded Systems with PIC Microcontrollers: Principles and Applications”, Elsevier (2010)
3. Steve Heath, “Embedded Systems Design”, 2nd Ed., Newnes Publications (2003)
4. Tammy Noergaard, “Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers”, Elsevier (2005)

EL-205: Power Electronics (Elective, MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-205.CO1	Understand the differences between signal level and power level devices.
EL-205.CO2	Learn to analyse controlled rectifier circuits.
EL-205.CO3	Learn to analyse the operation of DC-DC choppers.
EL-205.CO4	Learn to analyse the operation of DC-DC boost converters.
EL-205.CO5	Learn to analyse the operation of voltage source inverters.

Unit-I: Power Switching Devices (08lectures)
Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGB

Unit-II: Thyristor Rectifier (09 Lectures)

Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.

Unit-III: DC-DC Buck Converter (07 Lectures)
Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Unit-IV: DC-DC Boost Converter (6 Lectures)
Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Unit-V: Single-Phase and Three-Phase Voltage Source Inverter (20 Lectures)
Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage Three-phase voltage source inverter: Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phase sinusoidal modulation

Text/Reference Books:

1. M. H. Rashid, "*Power electronics: circuits, devices, and applications*", Pearson Education India, (2009)
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, (2007)
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, (2007)
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, (2009)

EL-206: Control Systems (Elective, MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-206.CO1	To understand the modelling of linear-time-invariant systems using transfer function and state-space representations.
EL-206.CO2	To understand the concept of stability and its assessment for linear-time invariant systems
EL-206.CO3	To study frequency response analysis of Control system.
EL-206.CO4	To learn the designs of simple feedback controllers.
EL-206.CO5	To introduce optimal control and nonlinear control system.

Unit-I: Introduction to Control Problem (06 Hours)

Industrial Control examples. Mathematical models of physical systems, Control hardware and their models, Transfer function models of linear time-invariant systems, Feedback Control: Open-loop and Closed-loop systems, Benefits of Feedback, Block diagram algebra.

Unit-II: Time Response Analysis (12 Hours)
Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Unit-III: Frequency Response Analysis (08 Hours)
Relationship between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability using Nyquist criterion – gain and phase margins, Closed-loop frequency response

Unit-IV: Introduction to Controller Design (12 Hours)
Stability, Steady-state accuracy, Transient accuracy, Disturbance rejection, Insensitivity and robustness of control systems, Root-loci method of feedback controller design, Design specifications in frequency-domain, Frequency-domain methods of design, Application of proportional, integral and derivative controllers, Lead and lag compensation in designs, Analog and digital implementation of controllers

Unit-V: State Variable Analysis (12 Hours)
Concepts of state variables, State space model, Diagonalization of State Matrix, Solution of state equations, Eigenvalues and stability analysis. Concept of controllability and observability, Pole-placement by state feedback, Discrete-time systems, Difference equations, State-space models of linear discrete-time systems, Stability of linear discrete-time systems
Introduction to Optimal Control and Nonlinear Control: Performance indices. Regulator problem, Tracking problem. Nonlinear system-basic concepts and analysis

Text/Reference Books:

1. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, (1997)
2. B. C. Kuo, “Automatic Control System”, Prentice Hall, (1995)
3. K. Ogata, “Modern Control Engineering”, Prentice Hall, (1991)
4. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International, (2009)

EL-207: Microprocessor and Communication Engineering Lab:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Course Objectives:

EL-207.CO1	To learn basic assembly programming and implement subroutines in 8085 to interface external interfacing devices.
EL-207.CO2	To learn basic programming of 8051 microcontroller and interface external interfacing devices for various applications.

EL-207.CO3	Learning to modulate and demodulate an input wave through AM and FM.
EL-207.CO4	Learning the generation and reception of SSB-AM and to modulate and demodulate an input wave through DSBSC
EL-207.CO5	Learning different modulation techniques like PWM, PPM and PAM and digital modulation techniques – FSK and TDM-PCM

List of Experiments

1. Write a program to add and subtract two 16 bit numbers and to multiply two 8 bit numbers.
2. Write a program to sort a given series of 8-bit numbers in ascending and descending order.
3. Write a program to generate Fibonacci Series using subroutine.
4. Write a program to generate square, triangular, sawtooth and staircase wave using 8255.
5. Interfacing 8051 with temperature controller and traffic controller module.
6. To study the amplitude/frequency modulation and demodulation.
7. To study the modulation and demodulation of DSBSC and SSB.
8. To study the frequency shift keying (FSK) and phase shift keying (PSK).
9. To study PCM, PAM, PWM and PPM modulation and demodulation.

EL-208 Seminar

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Student will choose topic of his/her interest. S/he will do literature review and present his/her understanding before his/her supervisor as well as the class. The student may take same topic for the summer training (in summer vacation), minor project (in 3rd semester) and dissertation (in 4th semester).

EL-301: Data Communication and Networking (CBCS)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-301.CO1	To understand the basic concepts of operating systems and networking
EL-301.CO2	To learn the details of communication mediums and data
EL-301.CO3	To understand the different Networking Methods
EL-301.CO4	Learning to work with different internet protcols
EL-301.CO5	To understand different networking models and their applications

Unit-I: Introduction to Operating Systems and Networking (08 Lecture)
Multitasking, Inter-process communication, Issues in concurrent access to shared data, Introduction to telephone exchange, Network criteria and physical structure, Interconnection of networks: internetwork, protocols and networking standards, Standard Organization, Introduction to 7 layer OSI Model

Unit-II: Physical Layer (09 Lecture)
Transmission media: Twisted pair, coaxial cable, microwave links, optical fibers, communication satellites, repeaters; Transmission techniques: Data and signals, digital and analog transmission, multiplexing; Switching techniques; Introduction to ISDN and protocols

Unit-III: Data link layer (12 lecture)
Relationship with layer 1 and 3; Data packet formation; Error detection and correction techniques; Multiple access: protocols and methods; LANs: Ethernet, Wired LAN, Virtual LAN, Bridge

Unit-IV: Network Layer (10 Lecture)
Relationship with layer 2 and 4; concept of packet switching, connection less and connection oriented service, Virtual circuit, and data structure requirements; retransmission and duplicate packet problem; Routing: Flow control, shortest path routing algorithms, GGP, sliding window

Unit-V: Transport Layer (16 Lecture)
Relationship with layer 2 and 4; quality of service, congestion management; Hierarchical addressing, process to process delivery, TSAP, Buffering, Transport Layer Interface.
Layer 5, 6 & 7: session, presentation and application layer, OSI session service primitives, Client server model, RPC Data representation and compression, Cyphering and Decyphering data, FTP and SMTP Internet Protocols: TCP/IP, UDP/IP, ARP, RARP, SNMP, ICMP

Text/References Books:

1. Behrouz A. Forouzan, "Data Communication and Networking", 4th Ed., McGraw-HilI
2. Andrew S.Tanenbaum, "Computer Networks", 4th Ed., Pearson (2014)
3. Rarnier Handel, N.Huber, Schroder, "ATM Networks Concepts, Protocols Applications'', Addison Welsey (1999)
4. W. Stallings, "Data & computer communication", 2nd Ed., Pearson (1988)

EL-302: Optical Fiber Systems

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-302.CO1	To comprehend the basic elements of optical fiber transmission link, fiber modes and structure configurations.
EL-302.CO2	To visualize the significance of the different kind of losses, signal distortion inoptical wave guides, signal degradation factors and dispersion management techniques in optical system performance.
EL-302.CO3	To compare the various optical source materials, LED structures, quantum efficiency as well as structures and figure of merit of Laser diodes and to studyof different photodetectors
EL-302.CO4	To analyze the system performance of optical transmitters, receivers and optical amplifiers..
EL-302.CO5	To analyze and integrate fiber optical network components in variety of networking schemes, SONET/ SDH and operational principles WDM.

Unit-I: Overview of Optical fiber Communications (08 Lectures)
Electromagnetic spectrum, Optical Spectral bands, Evolution of fiber optic system, Multiplexing Techniques, Elements of an optical fiber transmission link with the functional description of each block, WDM concepts, transmission widows, advantages of optical fiber link over conventional copper systems, applications of fiber optic transmission systems

Unit-II: Optical Fibers: Structures, Wave guiding and Fabrication (10 Lectures)
Optical laws and definitions, optical fiber modes and configurations, Mode theory, Step Index and Graded Index (GI) fibers, single mode and graded index fibers, Derivation for numerical aperture, V number and modes supported by step index fiber, mode field, Numerical aperture and modes supported by GI fibers, fiber materials, linearly Polarized modes fiber fabrication techniques, and mechanical properties of fibers, fiber optic cables, Attenuation, signal distortion in optical waveguides, pulse broadening in graded index fiber, Characteristics of Single Mode Fibers, mode coupling, International Standards for optical transmission fibers

Unit-III: Optical Sources and Detector (05 Lectures)
Semiconductor physics background, Light emitting diode (LEDs)- structures, materials, Figure of merits, characteristics & Modulation. Laser Diodes -Modes & threshold conditions, Diode Rate equations, resonant frequencies, structures, characteristics and figure of merits, single mode lasers, Modulation of laser diodes, Spectral width, temperature effects, and Light source linearity Photodetectors: Principles of operation, types, characteristics, figure of merits of detectors photodiode materials, photodetector noise, detector response time, temperature effects on gain, comparison of photodetectors

Unit-IV: Optical Receiver Operation **(**10 Lectures)
Receiver operation, Preamplifier types, receiver performance and sensitivity, Eye diagrams, Coherent detection, Specification of receivers. Transmission Systems: Point –to-point link – system considerations, Link power budget and risetime budget methods for design of optical link, BER calculation Optical Amplifiers: Semiconductor optical Amplifier, EDFA, Raman Amplifier, Wideband OpticalAmplifiers

Unit-V: Advances in Optical Fiber Systems (12 Lectures)
Principles of WDM, DWDM, Telecommunications & broadband application, SONET/SDH, MUX, Analog & Digital broadband, optical switching Overview of Optical Components: Optical couplers, Tunable sources and Filters, optical MUX/DEMUX, Arrayed waveguide grating, optical add drop multiplexer (OADM), optical cirulators, attenuators, optical cross connects, wavelength converter, Mach-Zender Interferometer Fiber Optical Measurements: Test Equipments, OTDR, Set ups for Measurement of Attenuation,Dispersion, NA and EYE pattern.

Text/Reference Books:

1. Gerd Keiser, “Optical Fiber Communications”, 4th Ed. (Mc Graw Hill)
2. John M. Senior, “Optical Fiber Communication”, PHI/Pearson
3. Djafar Mymbaev and Lowell L, Scheiner, “Fiber optical communication Technology”, Pearson
4. G. Agrawal, “Fiber optic Communication Systems”, John Wiley and sons

EL-303: Digital Signal Processing (MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-303.CO1	Understanding the details of DFT and its types.
EL-303.CO2	Learning to design digital filters and their software implementation.
EL-303.CO3	To study two dimensional signal processing and its application in filter designing.
EL-303.CO4	To understand the finite word length effect and its effect on digital signal processing
EL-303.CO5	To insist the details of multirate signal processing and different DS processors

Unit-I: Frequency Domain Sampling (10 Lectures)
Introduction to DFT, Frequency Domain Sampling: The Discrete Fourier Transform, Properties of the DFT, DFT as a linear Transformation, Relationship of DFT to other transforms, frequency analysis of signals using DFT, Computation of DFT and FFT algorithms

Unit-II: Digital Filters (15 Lectures)
FIR and IIR filters, definition and design of digital filters, Implementation of discrete time systems, Structure for FIR and IIR systems, Software implementation

Unit-III: Finite word length effects in digital filters (07 Lectures)
Fixed point arithmetic, effect of quantization of the input data due to finite word length, Product round off, need for scaling; Zero input limit cycle oscillations: Limit cycle oscillations due to overflow of adders, Table look up implementation to avoid multiplications.

Unit-IV: Two Dimensional Signal Processing (06 Lectures)
Introduction of two dimensional signal properties and their operations, Convolution, Two dimensional Z-Transform, Two Dimensional DFT, Two dimensional windows, Two dimensional FIR filter design

Unit-V: Introduction to Multirate Signal Processing and DSP Processors (12 Lectures) Multirate Digital Signal Processing: Decimation, Interpolation, Sampling rate conversion by arational factor; Frequency domain characterization of Interpolator and Decimator; Polyphase decomposition;
Features of DSP processors - DSP processor packaging (Embodiments)- Fixed point v/s floating point DSP processor data paths - pipelining - TMS320 family of DSPs (architecture of C5x)-Memory architecture of a DSP processor (Von Neumann - Harvard) - Addressing modes

Text/Reference Books:

1. John G Proakis and Dimitris C Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, 3rd Ed., Pearson Education, (2006)

2. Sanjit K Mitra, “Digital Signal Processing - A Computer based approach”, Tata McGrawHill, New Delhi, (2001)
3. Oppenheim & Schafer, “Digital Signal Processing”, PHI
4. Alan V Oppenheim, “Applications of Digital Signal Processing”, Prentice hall Inc., Englewood Cliffs, New Jersy (1978).

EL-304: Innovation, Entrepreneurship and Start up Ecosystem

Credits: 2	2 Hours per week (L-T-P:2-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course objectives:

EL-304.CO1	To learn the basics of Entrepreneurship & Innovation.
EL-304.CO2	To learn the concepts and practices for Entrepreneurial Development.
EL-304.CO3	To study start-up ecosystem.
EL-304.CO4	To learn start-up project planning and analysis.
EL-304.CO5	To learn Start-Up Project Scalability processes.

Unit-I: Entrepreneurship & Innovation-Definition, Objective and Features (08 Lectures) Key terminology: Entrepreneurship & innovation; Difference between Entrepreneurship and Traditional Businesses; Entrepreneurs and Intrapreneurs; Technological Entrepreneurship: Characteristics and needs of Innovation

Unit-II: Entrepreneurial Development (08 Lectures)
Business Planning; Mid-career Dilemmas; Entrepreneurial Growth and Competitive Advantage; Changing Role of Entrepreneurs. Entrepreneurship Development Institute; Entrepreneurship development Programs.

Unit-III: Start-Up Ecosystem **(**08 Lectures)
General presentation about startup development phases (from formation, to validation to scaling) specifically from the support role’s perspective; Key terminology: idea & innovation, entrepreneurship & start-ups; Innovation megatrends; Why startups; Startup as a category; Understanding & mapping startup ecosystems; Public-private partnerships; Developing startup ecosystems; Maturity levels and measures for startup ecosystems; Measuring and Collecting valuable data; Use of startup data

Unit-IV: Start-Up Project Planning and Analysis **(**08 Lectures)
Focus on the formation phase, which is the most crucial phase for co-founding team building; Preparing for the journey: what things to focus on and why?; Value of ideas & how to innovate more systematically; Building BIG visions; Measuring potential; Success & failure factors; Mission, Vision & Strategy; Co-founder team building; Idea team fit; Shareholder agreement (SHA); Confirming team commitment; Problem / solution fit; Market timing and journey; Planning in short & long term; Evaluating opportunities; Funding options and strategies at this stage; Additional tools & resources for self learning

Unit-V: Start-Up Project Scalability Report **(**08 Lectures)
Focus on scaling phase, which is the most crucial phase for getting serious about building a real and scalable business; What things to focus on and why?; Business planning; Go to market strategies; Born global & internationalization; Scaling metrics (KPI's); Recruiting; Building processes; Funding options; Working with big companies; Methods & tools; Additional tools & resources for self-learning

Text/Reference Books:

1. Peter F. Drucker, "Innovation and Entrepreneurship", (Special Indian Edition), Routledge
2. R. Hisrich, M. Peters and D. Shepherd, "Entrepreneurship", 11th Ed., McGraw Hill
3. Nicolai J. Foss & Tina Saebi, "Business Model Innovation - The Organizational Dimension", Oxford University Press
4. Taxmann, "Guide to Start-Ups"
5. S.S. Khanka, "Entrepreneurship Development", S. Chand Publishers

EL-305: VLSI and Device Modeling (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 30 Marks Internal Assessment: 20 Marks

Course Objectives:

EL-305.CO1	To understand the concepts of MOS transistors operations and to know the fabrication process of CMOS technology and its layout design rules
EL-305.CO2	To know the concepts of power estimation and delay calculations in CMOS circuits.
EL-305.CO3	To learn about the VLSI circuit components and physical design.
EL-305.CO4	Synthesize digital circuit using VHDL.
EL-305.CO5	Implement efficient techniques at circuit level for improving power and speed of combinational and sequential circuits

Unit-I: Review of Microelectronics and Introduction to MOS Technology (10 Lectures) Introduction to IC Technology; The IC Era; MOS and Related VLSI Technology; MOS Transistors; Enhancement and Depletion Mode Transistor Actions, NMOS Fabrication; CMOS Fabrication; Latch-up in CMOS Circuits, CMOS Inverter, BiCMOS Technology. MOS and BICMOS Circuit Design Process: MOS Layer; Stick Diagrams; Design Rules and Layout; CMOS Rules, Symbolic Diagrams

Unit-II: Basic Circuit Concepts (10 Lectures)
Sheet Resistance Concept Applied to MOS Transistors and Inverters; Area Capacitances of Layers; Standard Unit of Capacitance Cg, Inverter Delays; Driving Large Capacitive Loads; Propagation Delays; Wiring Capacitances; Choice of Layers. Scaling of MOS Circuits: Scaling Models and Scaling Factors; Limitations of Scaling

Unit-III: Subsystem Design and Layout (10 Lectures)
Architectural Issues; Switch Logic; Gate (Restoring) Logic; Subsystem Design Process: Illustration of Design Processes. Design of ALU, Adders. System Timing Considerations, Real World of VLSI

Design; Design Styles and Philosophy; Interface with the Fabrication House; CAD Tools for Design and Simulation, Test and Testability

Unit-IV: VHDL (10 Lectures)
Hardware Description Languages, Introduction to VHDL, Data objects, Classes and data types, Operators, Overloading, Logical operators, Entity and Architecture declaration, Introduction to behavioral, dataflow and structural models, VHDL Statements: Assignment statements, sequential Statements and process, Conditional statements, Case statements, Array and Loops, Resolution functions, Concurrent statements, Packages & Libraries

Unit-V: Combinational Circuit Design (10 Lectures)
VHDL Models and Simulation of Multiplexers, Encoders, Decoders, Code converters, Comparators, Implementation of Boolean functions etc. Sequential Circuit Design: VHDL Models and Simulation of Shift registers, Counters etc. Design of Microcomputer: Architecture of a simple Microcomputer system, Implementation of a microcomputer system using VHDL. Design with CPLDs and FPGAs: PLDs, ROM, PLAs, CPLDs and FPGA

Text/Reference Books:

1. Douglas A. Pucknell and Kamran Eshraghian, “Basic VLSI Design”, 3rd Ed., PHI, (2007)
2. Bhasker, “A VHDL Primmer”, Prentice Hall, 3rd Ed., (1999)
3. Charles. H. Roth, “Digital System Design using VHDL”, PWS , (1998)
4. KC.Chang, “Digital Design & Modeling with VHDL & Synthesis”, IEEE Computer Society Press, (1997)
5. Neil H. E. Weste, David Harris and Ayan Banerjee, “CMOS VLSI Design- Circuits and System Perspective”, Pearson Education, 4th Ed., (2011)

EL-306: Solar Photovoltaic Technologies (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course Objectives:

EL-306.CO1	To study the concept of PV systems.
EL-306.CO2	To study about PV devices, modules and arrays and their technical parameters.
EL-306.CO3	To study the components and working of solar power plant
EL-306.CO4	To study the concepts of solar power management
EL-306.CO5	To learn Grid Codes and Standards

Unit-I: Introduction to photovoltaic (PV) systems (08 Lectures)
Historical development of PV systems, Overview of PV usage in the world, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, geometric and atmospheric effects on sunlight, Photovoltaic effect, conversion of solar energy into electrical energy, behavior of solar cells.

Unit-II: Photovoltaic Devices, Array and Modules **(**08 Lectures)

Solar cells, basic structure and characteristics: Single-crystalline, multicrystalline, thin film silicon solar cells, emerging new technologies, Electrical characteristics of the solar cell, equivalent circuit, modeling of solar cells including the effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current. Solar cell arrays, PV modules, PV generators, shadow effects and bypass diodes, hot spot problem in a PV module and safe operating area. Terrestrial PV module modeling

Unit-III: Solar Power Plant: Components and Working (08 Lectures)
Types of Solar Power Plant: Off grid, Grid Connected, Hybrid, Interfacing PV modules to loads, direct connection of loads to PV modules, connection of PV modules to a battery and load together, DC-DC Converters, Inverters.

Unit-IV: Solar Power Management (08 Lectures)
Power conditioning and maximum power point tracking (MPPT) algorithms based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms, Inverter topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency.

Unit-V: Grid Codes and Standards **(**08 Lectures)
Grid Codes, Anti Islanding protection, LVRT protection, HVRT Protection, Active and Reactive Power Control, Advance Control for Inverters, Feasible operating region of inverter at different power factor values for grid-connected systems

Text/Reference Books:

1. Michael Stock, Larsen and Keller, "Photovoltaics: Designs, Systems and Applications", Education
2. Catherine Waltz, "Photovoltaics: Engineering and Technology for Solar Power", Syrawood Publishing House
3. D. Goswami, "Principles of Solar Engineering", CRC Press
4. Solanki S. Chetan, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI, New Delhi, (2012)

EL- 307 Data structures and Algorithms (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 30 Marks Internal Assessment: 20 Marks

Course Objectives:

EL-307.CO1	To study the basics of data structure and algorithms to implement various methods
EL-307.CO2	Learning to implement Stack, Queue and link list
EL-307.CO3	Learning to implement Trees and Graph with the help of algorithms
EL-307.CO4	To learn the basics of C++ to implement data structures

EL-307.CO5	To learn object oriented approach involving C++ for efficient programming

Unit-I: Basic of data structure and Algorithms (12 Lectures)
Difference between data structure and data type, Built in data structure, i.e. array and user defined data structure, i.e., Stack, Queue etc. Array: representation of an array, types of array,i.e.1-Dimentional array ,2-dimentional array and n -dimensional Array, row and column major implementation of different types of array. Implementation of different types of array. Algorithm: time and space complexity of algorithm; asymptotic notation: big oh notation etc., Sorting algorithm: Bubble sort, selection sort, insertion sort, merge sort and quick sort. Searching algorithm: linear search and binary search.

Unit-II: Stack Queue and Linked List Stack (12 Lectures)
Introduction: Push and pop operation, array implementation of stack; application stack: evaluation of postfix expression, conversion of an expression from infix to postfix, Recursion and tower of Hanoi problem. Queue: Introduction, operation on queue i.e. insertion and deletion, Full and empty type of queue: linear queue, circular queue, Priority queue, and double ended queue, queue implementation. Linked List: Concept of linked list, inserting and removing nodes from the linked list, types of linked list: single and double linked list, implementation of stack and queue using linked list.

Unit-III: Trees and Graphs (12 Lectures)
Trees: Concepts of Trees , Binary Trees, Strictly binary Trees, Complete binary Trees, Almost complete binary Trees, Height and Depth of a Tree, Array and Linked representation of Binary trees , Tree search Algorithms , Binary search Trees(BST) , Tree traversal algorithms: In order , Preorder, and Post order. Graphs: Vertex and edge, types of graphs: Directed / undirected, Connected/Disconnected, Cyclic/acyclic, Representation of graphs: Adjacency Matrices, Operations on graph, traversing a graph; Spanning trees, and Minimum cost spanning trees.

Unit-IV: Basic of C++ (08 Lectures)
Beginning with C++, Constants, Variables, Operators, Expressions, Control structures, Loops, Arrays and Pointers, Functions prototype, Call by value, Call by Reference, Inline function, Function overloading. Class and objects: specifying a class, program based on classes and objects.

Unit-V: Advanced C++ (06 Lectures)
Constructors and Destructors, Multiple constructors in class, Dynamics Constructors and Destructors, Operators overloading; Rules for operators overloading, Overloading unary and Binary operators, Polymorphism and related programs.

Text/Reference Books:

1. Seymour Lipschutz, “Theory and problem of Data structures”, Tata McGraw Hill Book Company Ltd.
2. Seymour Lipschutz, “Data Structures with C”, Schaum’s Outline Series.
3. Herbert Schildt; “C++: The Complete references”, Tata McGraw Hill Publishing Company Ltd.
4. K.R. Venugopal, B.Rajkumar, and T.Ravi Shankar, “Mastering C++”, Tata McGraw Hill Publishing Company

EL-308 Optoelectronics Lab:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Course Objectives:

EL-308.CO1	To study the characteristics of optoelectronic devices.
EL-308.CO2	To study and verify Malus Law
EL-308.CO3	To study the current and voltage characteristics of LED with change in temperature
EL-308.CO4	Understanding optical fibres and to calculate their bending losses and numerical aperture.
EL-308.CO5	To learn the operational principle of opto-coupler.

List of Experiments:

1. To study the characteristics of photovoltaic cell.
2. To study the characteristics of photoconductive cell.
3. To study the characteristics of PIN photodiode.
4. To study the characteristics of phototransistor.
5. To study the characteristics of optocoupler.
6. To study the polarization phenomenon using He-Ne laser.
7. To study the diffraction pattern of grating.
8. To study the temperature effect on the I-V characteristics of light emitting diode (LED).
9. To study the beam profile by determining the power distribution within the beam.
10. To determine Numerical aperture of single-mode and multi-mode optical fibre.
11. To study the bending loss of single-mode and multi-mode optical fibre
12. To measure the weight using multimode optical fibre by observing output power loss

EL-309 Minor Project:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Student will choose topic of his/her interest in 1st semester. S/he will do literature review and present his/her understanding before his/her supervisor as well as the class. The student may take same topic for the summer training (in summer vacation), minor project (in 3rd semester) and dissertation (in 4th semester).

EL-401: Summer Training Assessment

Credits: 2		End Semester Examination: 20 Marks Internal Assessment : 30 Marks

The student will take training in industry or R&D labs during the summer vacation between Semester-II and Semester-III and submit the Summer Training Report. The student will make presentations on the Summer Training Report in 4th Semester for evaluation. The student may select a topic related to his/her topic of Seminar (2nd Semester) and Minor Project (3rd Semester).

EL-402: Dissertation

Credits: 12		End Semester Examination: 120 Marks Internal Assessment : 180 Marks

The student will undertake major project in industry or R&D labs during 4th Semester and submit the Dissertation. The student will make presentations on the Dissertation for evaluation. The student may select a topic related to his/her topic of Seminar (2nd Semester) and Minor Project (3rd Semester).

Core/Elective MOOC courses

For registration to MOOCs Courses, the students shall follow NPTEL Site http://nptel.ac.in/ or https://onlinecourses.nptel.ac.in/ as per the NPTEL policy and norms. The student may choose a course through SWAYAM https://swayam.gov.in/ also. The students can register for these courses through NPTEL directly as per the course offering in Odd/Even Semesters at NPTEL. These NPTEL courses (recommended by the University) may be cleared during the respective semester (I/II/ III) of M. Sc. Electronics. After successful completion of these MOOC courses the students, shall, provide their successful completion NPTEL status/certificates to the University (COE) through the department of study only. A student has to complete the MOOC course of total 60 hours (4 credits). The evaluation is based on certificate/course completion document and CIE. The list of available courses are listed in following Table

Course	Name of the Course with MOOC link and Name of Instructor	Credit
EL-102 Microprocessor and Microcontroller	Microprocessor and Microcontroller https://nptel.ac.in/courses/108/105/108105102/Prof. Santanu Chattopadhyay, IIT Kharagpur	04
EL-203 Microwave Engineering	1. Microwave Engineering https://nptel.ac.in/courses/108/103/108103141/Prof. Ratnajit Bhattacharjee Department of Electrical Engineering, IIT Guwahati OR 2. Microwave Theory and Techniques https://nptel.ac.in/courses/108/101/108101112/Prof. Girish Kumar Department of Electrical Engineering, IIT Bombay	04

EL-205 Power Electronics	1. Power Electronics https://nptel.ac.in/courses/108/102/108102145/ Prof. G. Bhuvaneshwari Department of Electrical & Electronics Engg, IIT DelhiOR 2. Fundamentals of Power Electronics https://nptel.ac.in/courses/108/101/108101126Prof. Vivek Agarwal Department of Electrical Engineering, IIT Bombay	04
EL-206 Control Systems	1 Control Systems https://nptel.ac.in/courses/107/106/107106081/Prof. C.S.Shankar Ram, Department of Design Engineering, IIT Madras OR 2. Control Engineering https://nptel.ac.in/courses/108/106/108106098/ PROF. RAMKRISHNA PASUMARTHY Department of Electrical Engineering, IIT Madras	04
EL-303 Digital Signal Processing	Digital Signal Processing and its Applications https://nptel.ac.in/courses/108/101/108101174/Prof. Vikram M. Gadre, Department of Electrical Engineering, IIT Bombay	04