DEPARTMENT OF ELECTRONIC-SCIENCE,

SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE-7

Syllabus for M.Sc. Electronic-Science (80 Credit System)

Revised May 2018

Department	:	**Electronic Science**
Course	:	**M.Sc.**
Duration	:	**Two years**
Total number of credits	:	**80**

The MSc. Electronic Science course would consist of total eighty credits to be completed.

The overall course structure comprises of 32 credits core theory courses and 20 credits of Compulsory Lab. The students are supposed to opt for at least one departmental electivesin semester II and Semester III which will consist of 2 credits theory clubbed with lab component of two credits. The students can offer 20 credits every semester to complete the 80 credits course. In the first semester twenty credits are compulsory with all credits as core courses, and core lab.

In the second semester the students have to take core courses worth 12 credits and can opt for minimum one or more courses from Department electives which would have a lab component enabling them to specialise in specific aspects. Further to complete the twenty credits the student could go for courses from general electives/open electives/MOOCs or opt for courses offered by other departments. The minimum number of credits to be offered at second semester is 20 and maximum is 24.

In the third semester the students have to take core courses worth 12 credits and can opt for minimum one or more courses from Department electives which would have a lab component enabling them to specialise in specific aspects.Further to complete the twenty credits the student could go for courses from general electives/open electives/ MOOCs or opt for courses offered by other departments. The minimum number of credits to be offered at second semester is 20 and maximum is 24.

In the fourth semester the students are supposed to do a project/internship worth 8 credits. Further to complete the eighty credits to complete the master program, the student could go for courses from general electives / MOOCs or opt for courses offered by other departments.

The overall course structure is summarized in the table below.

Course Structure

Courses	Credits	Total
CoreTheory	32	52
Core Lab	20	
Department Electives	Any 8 from 16	08
Open Electives	MOOCS-20 Other Department-20 General Electives-20 Any 1 from these or Combination of these 3 to make 20 credits	20
	Total	**80**

Semester I		
Core Courses		
Subject Code	**Subject Title**	**Number of Credits**
EL 102	Analog and Digital system principles	4
EL 103	Foundation of Nano Electronics	4
EL 104	Mathematical Methods in Electronics and Network Analysis	4
EL 105	Mechatronics	4
EL 101	Circuits and tools Laboratory	4
TOTAL NUMBER OF CREDITS : 20		

Semester II		
Core Courses		
Subject Code	**Subject Title**	**Number of Credits**
EL 202	Electromagnetics, Microwave and Antenna	4
EL 203	IC Technology and CAD VLSI Tools	4
EL 201	System Design Laboratory I	4
Elective Courses		
Subject Code	**Subject Title**	**Number of Credits**
	*General Elective	
EL-GE01	Optoelectronics and optical fiber communication	4
EL-GE02	Properties of electronic Materials	4
	*Department Elective	
EL-DE01	Fundamentals of Image processing	4
EL-DE02	Virtual Instrumentation	4
EL-DE03	CMOS system design	4
EL-DE04	Microcontroller based system	4
	MOOCS Courses	
EL-ME01	Power Electronics	4
EL-ME02	Neural networks and applications	4
EL-ME03	Digital signal processing	4
TOTAL NUMBER OF CREDITS : 20 (Maximum 24 can be Taken)		

Semester III		
Core Courses		
Subject Code	**Subject Title**	**Number of Credits**
EL 302	Embedded System Design	4
EL 303	Communication Systems	4
EL 301	System Design Laboratory II	4
Elective Courses		
Subject Code	**Subject Title**	**Number of Credits**
	* General Elective	4
EL-GE03	Foundation course in innovation, entrepreneurship and IPR**.**	4
EL-GE04	Mobile and Data Communication Systems	4
	*Department Elective	
EL-DE05	RF Circuits and Antenna Design	4
EL-DE06	Industrial Process Control	4
EL-DE07	Foundation course in IC Layout Design	4
EL-DE08	Networked Embedded Systems and IOT	4
	MOOCS courses	
EL-ME04	Low power VLSI circuits and design	4
EL-ME05	Operating systems and RTOS	4
TOTAL NUMBER OF CREDITS : 20 (Maximum 24 can be Taken)		

	Semester IV	
	Core Courses	
Subject Code	**Subject Title**	**Number of Credits**
EL 401	Project/Internship	8

Elective Courses

Subject Code	**Subject Title**	**Number of Credits**
	* General Elective	
EL-GE05	Solar Photovoltaic/Thermal	4
EL-GE06	Technologies in Smart City	4
	MOOCS courses	
EL-ME05	Non-conventional energy sources	4
EL-ME06	Illumination Engineering	4
EL-ME07	Internet Technology	4
EL-ME08	Energy management systems and SCADA	4
TOTAL NUMBER OF CREDITS : 20 (Maximum 24 can be Taken)		

UGC recommended courses   (Additional 10 credits)

Subject Code	Subject Title	Number of Credits
	Cyber security/Information security	4C
	Skill based credits	4C
	Human rights education	2C

List of courses available as choice based electives for other department students

Semester II/III/IV		
Elective Courses		
Subject Code	**Subject Title**	**Number of Credits**
EL-GE01	Optoelectronics and optical fiber communication	4
EL-GE02	Properties of electronic Materials	4
EL-GE03	Foundation Course in IPR	4
EL-GE04	Mobile and Data Communication Systems	4
EL-GE05	Solar Photovoltaic/Thermal	4
EL-GE06	Technologies in Smart City	4

Semester I

EL-102 : Analog and Digital System Principles   [4 Credits]

Analog System Design: Circuit Design and Analysis using PSPICE – Schematics, attributes and types of analysis in PSPICE, use of PROBE.

Design and analysis of BJT/FET differential and multistage amplifiers, current sources, current mirrors, and active loads, small signal circuit analysis

Operational Amplifiers (OPAMP)-characteristics and Applications- Integrator, Differentiator, Wave-shaping circuits, Active filters, Oscillators, Schmitt trigger circuit, Nonsinusoidal oscillators and timing circuits

Design and analysis of Signal conditioning circuits, Current to voltage, voltage to current, voltage to frequency, frequency to voltage converters, Phase Locked loop and its application circuits.

Digital System Design:
Digital System design concepts, approaches, basic combinatorial and Sequential Circuits

Implementation of systems like ALU, Stop watch …
Finite state machines, Control Unit design

Applications of FSM like Sequence detector, sequence generator, Stepper control Programmable logic devices ROM, PAL, FPGA, CPLD etc

PLD based System design applications

Text/Reference Books:

1. Analysis and Design of Analog Integrated Circuits: Grey and Mayer
2. Electronic Circuit analysis and design: D.A.Neaman, McGraw Hilll
3. Microelectronic Circuits Analysis and Design: Rashid, PWS pub.
4. Electronic Devices and circuit theory: R.L Boylestad and L.Nashelsky,Pearson
5. M. Mano, Digital Logic and Computer Design, Prentice-Hall India.
6. M. Morris Mano, Michael D. Ciletti, "Digital Design", Pearson, 2013.
7. Tocci, Wedmer and Moss," Digital "systems principles and applications", 10'th edition Pearsons

EL-103 : Foundation of Nano Electronics   **[4 Credits]**

Region of nanostructures, scaling of devices in silicon technology, estimation of technology limits, Uncertainty principle, Experiments on duality, Schrodinger's equation and its applications to square well potential, square potential barrier (1D).

Infinite array of potential wells, Barrier penetration, applications to tunnel diode, Josephson effect, Perturbation theory and its applications, Scattering. Binomial and related distributions, Phase space, Statistical ensembles, applications of classical statistical mechanics, Quantum statistics, Brownian motion, Random walk problem.

Concept of Chemical potential, partition function and its applications in computing thermodynamic quantities.

Quantum electronic devices, electrons in mesoscopic structures, short channel MOSFET, split-gate transistor, electron wave transistor, electron spin transistor, quantum cellular automata

Bioelectronics, molecular processor, DNA analyzer as biochip, Molecular electronics, Fullerenes, nanotubes, switches based on Fullerenes and nanotubes , Nanoelectronics with tunneling devices, resonant tunneling diode(RTD), three terminal RTDS, RTD based memory, basic logic gates and dynamic logic gates, principle of single electron transistor, Coulomb blockade.

Text / Reference Books:
1.Nanoelectronics and Nanosystems: K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2005)
2.Quantum Mechanics: Schiff L.I.
3. Fundamentals of Statistical Mechanics and Thermal Physics: Reif

EL-104 : Mathematical Methods in Electronics and Network Analysis [4 Credits]

Differential equations and their solutions, Introduction to Signals and Systems, Bessel functions of first and second kind

Introduction to statistics, Population and Sample and Types of Data, Measures of Central Tendency, Measures of Dispersion and Discrete Probability Distribution, Laplace transform and its applications, Analysis of LTI Continuous Time System using Laplace Transform, Z-Transform

Network elements, Network Graphs, Nodal and Mesh analysis, Zero and Poles, Bode Plots, Laplace transforms, Two-port Network Parameters, Transfer functions, Signal representation. State variable method of circuit analysis. AC circuit analysis, Transient analysis

Reference books
1. Goon Gupta and Das Gupta : Fundamentals of Statistics, Vol. 1, The World Press Pvt. Ltd., Kolkata.
2. Miller and Fruend : Modern Elementary Statistics. PEARSON publication.
3. Snedecor and Cochran : Statistical Methods, Oxford and IBH Publishers.
1. Mathematical methods for Physics: Arfken, A.G. Academic Press.
2. Digital Signal Processing: SanjitMitra,Mcgraw Higher Ed publication.
3. Mathematical methods for physicists and Engineers: M.A. Boas
4. Network Analysis: Von Valkenberg,PEARSON

EL 105 :   Mechatronics   [4 Credits]

Introduction to mechatronics, Design concept, Intermigrations of Mechanical, Electrical and System design, Types of motions – Linear, Circular, Simple harmonic motion, Quick return mechanism. Conversion of motion.
Mechanical components – Pulley, Gears, Levers, Linkages, Screw, Fasteners, Hand tools, Gear train, measurement instruments (Vernier caliper, micrometer, sine bar)

Automobile- Two/four stroke I C engine, Power cycle, Hydraulic and pneumatics – Cylinder, Motor, Direction control valve, Circuit diagram. Degree of freedom and controls. Type of joining – Screwing, Riveting, Welding, Press fitting, Latches.

Revision of three phase, single phase supply Conversion of A.C. to D.C and Vice versa. Various types of motors: A/C motors Single phase, Three phase, Variable frequency drives, D/C motor, BLDC, Stepper motor, servo motor
Sensors – Positional sensor, Pressure sensor, Level sensor, Rotary sensor, Infra red sensor, Measurements. Vernier caliper, micrometer screw gauge, sine bar.
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Case studies : Bar code reader, Micro wave oven, Electronic printers, Digital camera, Remote control, Washing machine, Elevator, Robotics- Hydraulic, Electrical.

Assignments/practical

- Establishing required out put speed and torque with specified input, by using gears, pulley and chain arrangement.
- Control of speed of 3 phase induction motor by frequency, poles and gears.
- Regulating D.C./BLDC/ steeper motors.
- Controlling motion, speed and position of belt conveyer.
- Programing of 'Bottle filling' system.
- Programing of elevator.
- Programing of plotter.
- Programing of Robot.

Reference books

1. Mechatronics with experiments: Sabri Cetinkunt. Wiley Publications.
2. Mechatronics: Bradley, Dawson, Burd and Loader Nelson Thornes
3. Industrial Electronics: Thomas Kissel Prentice Hall of India
4. Robotic Engineering: R.D. Klafter, T.A. Chmielewski, M.Negin, PHI.

Semester II

El -201: System Design I Lab   **[4 credits]**

The laboratory will introduce the students to :

- Various concepts of system design
- Design and implement signal conditioning circuits for Sensors
- Interfacing output devices like LED's, LCD displays, optocouplers, relays, motors
- Study and design power supplies

The lab would consist of twelve lab exercises :

➢ <u>6</u> compulsory
➢ 4 elective to be chosen from 8
➢ one small system developed worth <u>two</u> lab sessions

EL – 202:   Electromagnetic, Microwave and Antenna   [4 credits]

Maxwell's equations, correspondence of field and circuit equations, characteristic impedance and admittance, S-matrix, lossless and lossy Transmission lines, standing wave and standing wave ratio, impedance matching techniques like $\lambda/4$ transformer, single and double stubs use of Smith's chart. Skin depth.

Waveguides: propagation modes, types of waveguides, waveguide components- E and H plane T, Magic 'T' microwave couplers, matched terminations, directional couplers, circulators and isolators, Phase shifters, cables, connectors and Adapters

Microwave: Klystron and Magnetron, travelling wave tube, Microwave switches, Microwave transistors, microwave diodes: Varactor, GUNN diode, PIN diode, IMPATT, TRAPATT, GaAs FET. Power Thermistor, diode, short key diode.

Antennas: Types of antennas: Short dipole antennas, antenna arrays, isotropic, dipole, broadside and end fire arrays, Yagi-Uda, log periodic and rhombic antenna, Reflector antennas, Reconfigurable antennas, Phased array antennas, Cognitive radio, Microstrip Antennas.
Antenna parameters: S parameter, VSWR, Gain, Radiation resistance, Radiation pattern, beam width, bandwidth, efficiency, Polarization.

Friis Transmission equation, Radar-cross equation,

Text / Reference Books:
1. Electromagnetic: J.D. Kraus, McGraw Hill.
2. Microwave devices and circuits: S.Y. Liao, Prentice Hall.;
3. Solid State Electronic Devices: Ben G. Streetman, Pearson Publication, seventh edition.
4. Antenna Theory: Analysis and Design: Constantine A. Balanis, Wiley Publication.4th edition.
5. Antenna theory and design: Robert S. Elliott, Prentice-Hall publication.
6. Broadband Microstrip Antennas: Girish Kumar, K. P. Ray,Artech House publication.
7. Microwave and Radar Engineering: M. Kulkarni, Umesh Publication.

EL-203 : IC Technology and CAD VLSI Tools   [4 Credits]

Introduction to Integrated Circuit Technology, Types of IC's, Custom and semicustom designs, standard cell, gate array, FPGA, CPLD and PLDs, FPGA Design Flow, design center and foundry.

Moore's law, IC fabrication technologies; nMOS fabrication, CMOS fabrication approaches, Basics of MOS transistor action, Electrical Properties; I-V characteristics; The Non-saturated Region , The Saturated Region , MOS Transistor Threshold Voltage, MOS Transistor Transconductance and Output Conductance, MOS Transistor Figure of Merit ,The Pass Transistor, transmission gate.

CAD VLSI tools, Hierarchical design of VLSIs, behavioral description, RTL, Logic circuit, gate, circuits, Xilinx, SPICE.

ASIC Design Flow: Partitioning, Floorplanning , placement, global and channel routing,

Text/Reference Books

Analysis & Design of Analog Integrated Circuits, P. Gray, P. Hurst, S. Lewis, R. Meyer, Wiley

Application Specific Integrated Circuits, M.J. S. Smith, Addison-Wesley

Basic VLSI Design- Douglas A. Pucknell.

ELECTIVE COURSES

General Elective

EL-GE 01 : Optoelectronics and optical fiber communication : [4 credits]

Lamps and illumination systems, LEDs – working principle and applications, LED lighting, Display devices, indicators, numeric, alphanumeric and special function displays, Liquid Crystal Display elements, Plasma Displays, Multimedia projectors.Semiconductor lasers, - Fabry-Perot lasers, Distributed Feedback, (DFB) lasers, Distributed Bragg Reflection (DBR) lasers

Photodetectors types and applications, PN and PIN Photodiodes, Avalanche Photodiodes (APD) Optocouplers, Opto interrupters, LASCR. used in safety interlocks, power isolators, rotary and linear encoders and remote control. Intrinsic and Extrinsic Fiber optic sensors.

Optical Fiber Theory, Parameters of Optical Fibers, Types of Optical Fibers-Single Mode and Multi Mode Fibers, Step Index & Graded Index Fibers. Modal Properties-Waveguide Parameter (V Number), Cut-off wavelength, Dispersion-Intermodal and Intramodal dispersion

Loss Mechanism in Optical Fibers-Adsorption and Scattering, Fresnel Reflection, Micro bending & Macro bending, Connector types and Splices, Misalignment and Mismatch losses.

Fiber-Optic transmitters and receivers , Direct Modulators, External Modulators-Electro-Optic Modulators, Electro-Absorption Modulators, Noise in detection process, Noise Equivalent Power (NEP).

Single Channel System Design, Power budgeting, Transmission Capacity Budgeting, Dispersion Compensation, Nonlinear effects in optical fibers-Stimulated Brillouin Scattering (SBS), Self-Phase Modulation (SPM), Cross-Phase Modulation (XPM), Four-Wave Mixing (FWM).

Text / Reference Books:

1. Optical Engineering Fundamentals B.H. Walker, PHI
2. Electro-Optical Instrumentation Sensing and Measuring with Lasers: SilvanoDonati, Pearson
4. Fiber optics and Optoelectronics: R.P. Khare, Oxford Press.
5.Optical Fiber Communication Principles and Systems A. Selvarajan, S.Kar and Srinivas, TMH
6. Optical Fiber Communications G. Keiser, TMH

EL-GE02 : Properties of Electronic Materials   [4 Credits]

Electrical properties: of metals: Conductivity, reflection and absorption, Fermi surfaces, superconductivity, thermoelectric phenomena. Conduction in metals oxides, amorphous materials.

Dielectric Properties of materials: Macroscopic electric field, local electric field at anatom, dielectric constant and polarizability, ferroelectricity, antiferroelectricity, phase transition, piezoelectricity, ferroelasticity, electrostriction.

Optical properties of materials: Optical constants and their physical significance, Kramers – Kronig Relations, Electronic internbond and intra bond transitions Relations between Optical properties and band structure – colour of material (Frenkel Excitons), Bond Structure determination from optical spectra reflection, refraction, diffraction, scattering, dispersion, photoluminescence, Electroluminiscence.

Magnetic Properties of Materials: Dimagnetism, paramagnetism, various contributions to par and dia magnetism, Adia- batic demagnetization, Paramagnetic susceptibility. Ferromagnetism, ferrimagnetism, ferrites, antiferromagnetism, curic point, temperature dependence of saturation magnetization, saturation magnetization at absolute zero, magnons and their thermal excitation, dispersion relation, Neutron Magnetic scattering, Ferrimagnetic and antiferrimagnetic order, domains and domain walls, magnetic resonance. Coercive force, hysterisis, methods for parameters measurements.

Polymers: Structure of polymers, polymerization mechanism, characterization techniques, optical electrical, thermal and dielectric properties of polymers.
Defects in crystals and their effects on mechanical, electrical and optical properties. Diffusion in materials.

Text Books:
1. Electronic Properties of materials, R.E. HummelSpringer New York publication
2. Solid State Physics, Dekkar,Mcgraw Higher Ed publication
3. Introduction to Solid State Physics, C.Kittle,Wiley publication
4. Solid State Physics, Ashcroft, Mermin,Cengage LearningPublication
5. Principles of Electronic materials &dev, S.O. Kasap,Mcgraw Higher Ed Publication
6. Elementary Solid state physics,M.Ali Omar; Pearson Publication.

<u>Department Elective</u>

EL-DE 01 : Image processing : [4 credits]

Image acquisition, Image representations, Image digitalization, Sampling, Quantization, Histograms, Image Quality, Noise in Images

Basic operations on images, Image Enhancement, Pixel intensity transformations, Histogram equalization and matching, noise removal, Edge sharpening, Spatial Filtering, Image smoothing, Morphological operations: erosion, dilation.

Image processing applications, Machine Vision, Blob analysis, Metrology, Feature extraction, Pattern Matching, Biometrics etc

Lab exercises
1. Implement and study point processing operations for Image analysis
2. Implement Spatial processing operations for image smoothening and edge enhancement
3. Morphological operations: erosion, dilation for image analysis
4. Implementing system for measuring dimensions of given object
5. Use template matching for counting number of coins/ image registration
6. Develop a PCB inspection system

Text / Reference Books:

1.Digital Image Processing Rafael C. Gonzalez , Richard E. Woods, Prentice Hall
2.Fundamentals of Digital Image Processing, A.K. Jain, Prentice Hall

EL-DE02 : Virtual Instrumentation   [4 Credits]

Virtual instrumentation, virtual instrument and traditional instrument, hardware and software in virtual instrumentation, role of hardware in virtual instrumentation, role of software in virtual instrumentation , virtual instrumentation for test, control and design.

Introduction to Lab-VIEW

Advantages of Lab-VIEW, software environment , LabVIEW based system design approach:Front Panel, Block Diagram, Icon/Connector Pane,

Programming tools: loops, tunnel, shift register, arrays, cluster, structures, creating a sub-VI's and sub-VI as icons.

Signal Processing: waveform generation, waveform conditioning, dynamic data conversion to arrays, spectral

Data Acquisition : DAQ card configurations, block diagram, sampling and signal acquisition, measurement.

Practicals:

1. Create a VI for performing addition/subtraction/multiplication/division of given numbers. If answer is above 100 indicate it using LED.
2. Design a display for the basic calculator keypad. (event structure)
3. Creating a VI for waveform generation and manipulations.
4. Design a water level control system.(shift register)
5. Create a VI to acquire waveform data from signal generator and store the waveform data in array.(accuracy of stored data)
6. Create a VI to acquire and plot temperature sensor data. (sampling parameter variations)

Text/Reference Books

Analog electronics with LabVIEW- Kenneth L. Ashley
Virtual-Instrumentation-Using-LabVIEW- Jovitha Jerome, PHI Learning Private Limited (2010)
PC Interfacing for Data Acquisition and Process Control- Gupta, S. and Gupta, J.P.,Instrument Society of America (1988).

EL-DE03 : CMOS System Design   [4 Credits]

CMOS IC design process, MOSFET capacitances, Amplifiers, common source amplifer, source follower, common gate amplifiers, push pull amplifier, noise and distortion in amplifiers, Differential amplifiers, source coupled pair, current source load, CMRR, noise, matching considerations, Basic CMOS opamp design, characterization of opamp, opamp compensation, Basic CMOS comparator, characterization.

CMOS digital circuits, logic gates, static logic gates, dynamic logic gates, DC and switching characteristic

Mixed signal systems, Data converter fundamentals, converting analog to digital signals, sample and hold characteristics, ADC specifications, DAC specifications.
Power Analysis, sources of power dissipation, static and dynamic power dissipation, Power Optimization Techniques, Adaptive Power Supply.

Practicals
1. Study I-V characteristics of MOSFET.
2. Design of MOS capacitor.
3. Design basic logic gate.
4. Current mirror.
5. Design a basic differential amplifier.
6. Design a comparator.

Text/Reference Books
CMOS VLSI Design- Weste and Harris
CMOS Circuit Design, Layout, and Simulation -R. Jacob Baker, Harry W. Li & David E. Boyce
Digital Integrated Circuits- A Design Perspective, Rabaey, Chandrakasan, and Nikolic.
Design of Analog CMOS Integrated Circuits, B. Razavi, McGraw Hill

EL-DE04 : Microcontroller based system   [4 Credits]

Introduction to Microcontrollers, specifications, features, criteria for choosing a microcontroller for an   application
Memory hierarchy and their interfaces
Input- Output interfaces: synchronous and asynchronous transfers, interrupts, DMA, Serial data transfer Communication Protocols: I2C, SPI, CAN, …
Tools used for designing, testing and debugging
Real world interfacing: Key board, display, sensors, signal conditioning, ADC's, DAC, Motors
Case studies: Weighing machine, elevator, microwave oven, etc

Lab component 2 credits

The practical session would give hands on sessions related to following aspects
Interfacing Keyboard/LCD
Interfacing various types of sensors, calibrating the same and displaying on LCD
Implementing standard communication protocols
Interfacing Motors DC and stepper motors
Designing systems for Temperature, pressure, humidity, distance measurement
Designing system to control speed, angular displacement of motors.

Text/Reference Books

Programming & Customizing 8051 Micro controller – Myke Predko
8051 Microcontroller Programming- Haung
Programming & Customizing The AV R microcontroller- Dhananjay V Gadre
Embedded microcontroller System – Jonathan Valvano.
Design with PIC Microcontrollers- John Pitmann
Embedded C Programming & Atmel AVR – Richard Barnett – Thomson   Publication

MOOCS Courses

EL-ME01   Power Electronics   [4 Credits]

EL-ME02   Neural Networks and Application   [4 Credits]

EL-ME03   Digital Signal Processing   [4 Credits]

Total Number of Credits : 20 (Maxmimum 24 can be taken)

SEMESTER III

El -301: System Design II Lab   **[4 credits]**

The laboratory will introduce the students to:

- Various concepts of embedded system design
- IDE's. Simulation and development tools
- Implementing simple systems using ARM Cortex M devices
- Design and implement interfaces for various applications
- Design and realize application systems

The lab would consist of twelve exercises :

- ➢ <u>6</u> compulsory
- ➢ 4 elective to be chosen from 8
- ➢ one small system developed worth <u>two</u> lab sessions

EL 302 Embedded System design   **Credits 4**

Introduction to Embedded Systems: Design strategies, Challenges, Design considerations and requirements, HW-SW Co Design, processor selection and tradeoffs.

Embedded Processor Architecture: Harvard/Princeton, CISC and RISC architectures, Pipelining, Super-scalar Execution, application specific standard processors, reconfigurable logic; system-on-a-chip and distributed embedded systems.

ARM Architecture and Organization, Introduction to Cortex- M3 Architecture, Programming Model and Instruction Set, Memory Model, Exception Handling, Peripheral Programming,

Memory hierarchy, Memory interfacing, decoding, Memory Management and Address Translation. Polled and Interrupt driven I/0, DMA, Interrupt structure, Interrupt servicing, I/O peripherals, Timers / Counters, PWM, WDT, Bus interfaces UART, SPI, I2C, CAN, USB etc

Operating systems principles, embedded operating systems, Introduction to Boot loaders and Board Support Packages, RTOS basics, Tasks, Processes and Threads, Process Management and Inter Process Communication

Text/Reference books:

1. Embedded system design, F. Vahid, T. Gargivis, John Wiley and Sons

2. Embedded Systems Design, Steve Heath, Elsevier

3. The Art of Designing Embedded Systems, Jack G. Ganssle, Academic Press.

4. The Art of Programming Embedded Systems, Jack G. Ganssle, Academic Press.

5. Embedded Systems- Architecture, Programming and Design, Raj Kamal, TMH

6. Computers as Components: Principles of Embedded Computer Systems Design, Wayne Wolf, Morgan Kaufmann

EL 303 Communication Systems   **Credits 4**

Elements of communication system and its fundamental limitations.
Modulation: Need of Modulation, Basic principles of amplitude, frequency and phase modulation, Demodulation. FM transmitter and receiver. Basic concepts of information theory, Digital modulation and Demodulation, PM, PCM, ASK, FSK, PSK, Time-division Multiplexing, Frequency-Division Multiplexing
Intermediate frequency and principle of super-heterodyne receiver
Noise: Spectral analysis and signal transmission through linear systems, Random signals and Noise, Noise temperature and noise figure, radio wave propagation, guided and unguided waves. Wired and wireless transmission.
Sampling theory: Sampling process, sampling theorem, signal reconstruction. Study of WIFI module and GPS module with its application. Encoding and Decoding techniques.

Text/Reference Books:
1. Electronics Communication systems: William Schweber
2. Electronic Communication systems: G.Kennedy and B.Davies
3. Modern Digital and Analog Communication systems: B.P.Lathi
4. Digital Communications: Bernard Sklar
5. Advanced Electronic Communications systems: W.Tomasi
6. Digital Signal Transmission, Chris Bissell, David Chapman
7. Introduction to the global positioning systems: second edition, Ahmed El-Rabbany.
8. Understanding GPS Principles and Applications Second Edition Elliott D. Kaplan Christopher J. Hegarty
9. Wi-Fi Handbook Building 802.11b Wireless Networks: Frank Ohrtman, Konrad Roeder, McGraw-Hill.

General Electives

EL-GE03 Foundation course in innovation, entrepreneurship and IPR.   Credits 4

Knowledge, Innovation and Entrepreneurship, Knowledge – characteristics and role in economic growth, Tacit and codified knowledge, Knowledge as public good and 'market failure', Market for knowledge, Incentives for creation of new knowledge, Fundamentals of Innovation, Creativity and Problem Solving, Types and sources of innovation, Design Thinking, Innovation ecosystems, Capturing value from innovation, The innovative organization, Innovation opportunities identification

Fundamentals of, Discovery of Entrepreneurial Opportunities, Stakeholders, relationships, networks and resources, A description of the business - The market analysis (SWOT analysis, industry background, competitor analysis, market analysis) based on primary and secondary resources - The strategic plan - The financial plan, Developing and refining product-market fit, Marketing research in an environment of innovation and dynamism, Gaining marketing advantages in spite of limited marketing resources, Tools, processes, the Business Model Canvas, Building and communicating the case, How new ventures evolve

Intellectual Property Rights: An Introduction, Appropriation of knowledge: knowledge monopoly and its consequences, Pre-IPR system of protection: Secrecy/Trade guilds/Cartel, IPR: Consequentiality, right based justification and economic justification, Evolution of IP Statutes – Origin and Internationalization, International organizations and Treaties (pre- TRIPs era): Paris Convention, Berne Convention, Rome convention, IPIC Treaty, Budapest Treaty. CBD, UPOV convention. WIPO, GATT, FAO, UNCTAD,

Basic forms of IPRs: Patent, copyright, trademark, industrial design, Patents and Patent information Need for Patent, Patentable and Non-Patentable Invention, Types of Patent application in India, PCT System, Guidelines for Registration of Patent, Patent filing, Opposition and Grant

Text/Reference Books:
1. Csikszentmihalyi, M., "Creativity: Flow and the psychology of discovery and invention", Harper Perennial.
2. Michalko, M., "Thinkertoys a handbook of creative-thinking techniques" Ten Speed Press.
3. Pink, D. H., "A whole new mind. Why right-brainers will rule the future", The Berkley Publishing Group
4. Prabuddha Ganguli "Intellectual Property Rights" Tata McGraw Hill
5. R. Radhakrishnan, S. Balasubramanian, "Intellectual Property Rights : Text and Cases", Excel Books
6. Richard Stim, "Intellectual Property: Patents, Trademarks and Copyrights", Cengage Learning

EL-GE04 Mobile & Data Communication Systems   **Credits 4**

Mobile communication systems, cellular concepts, role of base station and mobile switching centres, Hands-off considerations, frequency reuse, roaming, SMS, GSM, GPRS, CDMA and EDGE architecture.

Telecommunication Network management overview, Wireless Network fundamentals, OSI model layers, architecture, broadband systems. Introduction to Emerging technologies IP multimedia systems, GSM/CDMA, Wi-Fi, Wi-Max, Blue Tooth, 3G/4G &5G Next Gen. Networks (NGN), IP/ mobile TV

Data communication networks and services, application and layered architecture, OSI model, IEEE 802.3 and IEEE 802.11, Network topologies, LAN and MAC, Data link control, Bridging, switching, addressing, Transmission systems, circuit switching networks, routing, signalling and traffic management

Packet switching networks, Internetworking – Repeaters, bridges, routers and gateways. Introduction to Routing protocols TCP/IP and Internetworking, TCP/IP protocol suite TCP/IP Sockets Client-Server, computing, Name Service, Application protocols over TCP/IP, IPV6, network architectures and protocols, network security, ATM

Networks, High speed LANs – Fast and Gigabit Ethernet, FDDI. Wireless LANs. Bluetooth, Wi-Fi WLAN, WAP and

Mobile computing.

Text /Reference Books:
1. Telecommunication T.Vishwanathan, PHI
2. Mobile Cellular Telecommunications, W.C.Y. Lee, McGraw Hill
3. Future Developments in Telecommunication, J. Martin, PrenticeHall
4. Data Networks D. Bertsekas, R. Gallagher
5 Computer Networking Tanenbaum, PHI
6. Computer Networks U.Black, PHI

Department Electives:

EL-DE05 RF Circuit and Satellite Communication   **Credits 4**

Part 1: RF Transceiver Architectures: Receiver front end general design philosophy, Intermodulation, 3rd order intercept point (IP3), Noise Figure, sensitivity, selectivity.
RF Filter Design: Ideal and approximate filter types, Transfer function and basic filter concepts, filter design issues, RF filter design.
Amplifier design: Stability consideration, Amplifier design for maximum gain, constant gain circles, constant noise figure circles, Low noise amplifier, RF Power amplifier.
Other RF circuits: Power combiner/divider, directional couplers, hybrid coupler, isolator.

Part 2: Satellite communication
Fundamentals: concepts, history, developments.
Orbital mechanics and launching: Keplers law, perturbation, orbital effects, types of orbits, launching satellite, launch vehicle technology.
Satellite subsystem: Attitude and orbit control, thermal control, Power supply, propulsion, telemetry, tracking and command, transponder and antennas.
Satellite link design. Applications of satellites and advances in satellite communication.

Text/Reference books:
1. Analog Communication Kennedy and Davies
2. Microwave devices, circuits & Subsystems for Communication Engineering, Glover, Pennock, and Shepherd
3. RF circuit design, by Chris Bowick
4. RF circuit design by R. Ludwig and P.Bretchko
5. RF Circuit Design, Reinhold Ludwig, Pavel Bretchko, Pearson
6. Satellite communications: Dennis Roddy

EL-DE06 Industrial Process control   **Credits 4**

Introduction to functional elements of control system, control strategies, continuous and discrete state controller, Open loop control systems, Closed loop control systems - feedback, feed forward and adaptive control strategies. Data logger, supervisory and direct digital control systems.

Open-loop and close-loop control system, Error amplifier, on-off controller, Proportional (P), Proportional-Integral (PI). Proportional-Derivative (PD), PID controllers, Dynamic behaviour of control systems-servomechanism, characteristics parameters of control systems-Accuracy, Sensitivity, Disturbances, Transient response, Stability of linear control systems. Methods of determining stability- Routh-Hurwitz stability criterion, root locus and frequency response methods of control system analysis, Bode and Nyquist plots.

Digital Control, PLC, Ladder diagrams, Supervisory Control and Data Acquisition, typical SCADA System Architecture, Communication Requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA. SCADA Architecture (First Generation-Monolithic, Second Generation-Distributed, Third generation Networked Architecture).

Lab exercises and project like experiment
The practical session would give hands on sessions related to following aspects

 Study characteristics of P, PI, PD and PID controllers using MATLAB Simulink

 Design and implementation of different temperature controllers using PLC/SCADA system.

 Development of programs for PLC/SCADA based pick and place robot/ bottle filling plant.

 Design of interfaces for monitoring and control of elevator system

 Design and implement PLC-SCADA based conveyor system

 Text/Reference books:
1. Process Control Instrumentation Technology: Curtis Johnson
2. Automatic Control Systems: B.C. Kuo PHI.
3. Modern Control Systems: R.C. Dorf and R.H. Bishop, Addison Wesley
4. Control Engineering Theory and Practice: M.N. Bandopadhyay, PHI

EL-DE07 Foundation course in IC layout design   **Credits 4**

Basics of Resistor Layout, Capacitor Layout, Transistor Layout- fingering, device area minimizing, Stick diagram-Lambda based design rules, mask layout-NAND, NOR, 2:1 multiplexer, Scaling of CMOS circuits, Short channel effects, Analog layout- Crosstalk, Shielding, device matching theories, Failure Mechanisms- Electromigration, Antenna effect, ESD, High speed devices layout, High voltage layout, I/O cell layout, power dissipation types, LDO.

Lab exercises and project like experiment using Cadence Virtuoso Tool

 1. Simulation and Layout of a CMOS inverter/NMOS inverter.
2. Simulation and layout of CMOS based differential amplifier
3. Design and simulation of basic memory cell (D flip flop) using minimum transistor approach.
Encounter Tool:
1. Two input NAND gate
2. 4:1 multiplexer
3. comparator

Text/Reference books:
1. The Art of Analog Layout, A. Hastings, Prentice Hall
2. IC Mask Design: Essential layout techniques. C. Saint, J. Saint.
3. CMOS Circuit Design, Layout and Simulation, Baker, Li Boyce,
4 IC layout basics: a practical guide. C. Saint, J. Saint.

EL-DE08 Networked embedded systems and   IOT   **Credits 4**

Networked Embedded Systems and their applications, Wireless Communication protocols like Bluetooth, Zigbee, Wi-Fi IEEE 802.11, Home RF, 6LoWPAN

Communication Protocols for In-Vehicle Networks CAN (Controller Area Network), LIN (Local Interconnect Network), MOST (Media Oriented Systems Transport) and Flex Ray standards and protocols.

 Introduction to the Internet of Things, Elements of an IoT system.**,** Typical IoT applications, Wireless technologies for IOT, quality of service, resource reservation and scheduling, and performance measurements.

Case studies: sensor -networks, smart homes, smart highways etc

 Lab exercises and project like experiment

- Wireless data acquisition using sensor nodes
- Setting up a WSN for smart home like applications
- Implement and simulate network topologies using tools.
- Connecting devices at the edge and to the cloud.
- Processing data offline and in the cloud.
- Mini-project: Designing an IoT system (group exercise).

Text/Reference books:

1. Wireless Communications and Networks, William Stallings, Prentice Hall
2. Principles of Embedded Networked System Design, G. Pottie and W.Kaiser, Cambridge University Press
3. Protocols and Architectures for Wireless Sensor Networks, H. Karl and A. Willig, John Wiley & Sons.
4. Wireless Sensor Networks, Raghavendra, S. Cauligi, Kluwer Academic Publishers.
5. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
6. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)

MOOCS Course

EL-ME04 Low power VLSI circuits and design   **Credits 4**

NPTEL Course
Low Power VLSI circuits and systems: Ajit Pal, IIT, Kharagpur.

EL-ME05 Real Time Operating Systems   **Credits 4**

NPTEL Course
Real-Time Operating Systems: Prof. Rajib Mall, IIT Kharagpur

Semester IV

EL-401   **Project/Internship**   **[8 Credits]**

EL-GE05: Solar Photovoltaic Systems / Thermal   **[4 Credits]**

Photo thermal systems: Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Thermal Analysis of Solar Collectors Performance of Solar Collectors, estimations of power obtained from solar energy.

Photovoltaic basics: structure and working of solar cells and panels, types of solar cells, electrical properties and performance of solar cell

Stand-alone PV systems: Schematics, components, inverters, batteries, charge conditioners, balance of system components for DC and/or AC applications, typical applications for lighting, water pumping etc.

Grid-connected systems: schematics, components, charge conditioners, interface components, balance of system, components, PV System in Buildings.

Design and analysis of PV systems, F Chart Method, φ-F Chart method, Utilizability, Modelling and Simulation of Solar Energy Systems, radiation and its load analysis, sizing and reliability testing.

Installation techniques, Commissioning and Engineering Practices, MPPT charge controllers, Solar power tracking and monitoring using PLC and SCADA systems,. Energy yield and economics of a PV systems.
Case studies: 600W / 12 kW PV system

Recommended Books
1. CS Solanki: Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.
2. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications Prentice- Hall, 2008

EL-GE06: Technologies in Smart Cities [4 Credits]

Urbanization and its challenges, opportunities for smart and sustainable cities, Introduction to technologies used smart cities: Internet of Things, Wireless sensing networks, Big data, Cloud computing, Artificial intelligence, Machine vision, etc.

Smart sensors: Construction and working of smart sensors, smart temperature sensors, humidity/moisture sensors, acoustic sensors, gas sensors, pressure sensors, acceleration sensors, level sensors.

Introduction to Cloud Computing, cloud computing platforms, parallel programming in the cloud distributed storage systems, virtualization, cloud security, multicore operating systems.

Big Data introduction, definition and taxonomy, value for the enterprise, setting up the demo environment first steps with the Hadoop ecosystem. The Hadoop ecosystem, introduction, components: MapReduce/Pig/Hive/HBase, Handling data and files using Hadoop

Networking and security in smart cities: Smart city metrics, dash boarding, mobility, shared services, standards and protocols, ownerships, cyber-security, safety and privacy.
Case Studies: Smart Buildings, Smart city service management

Recommended Books
1. Picon, A. *Smart Cities: A Spatialised Intelligence*. John Wiley & Sons, 2015
2. Kyung, C., Lin, Y., Liu, Y. and Yasuura, H. *Smart Sensors and Systems*. Cham: Springer International Publishing 2015.
3. Schwab, K. *The Fourth Industrial Revolution*. Crown Publishing Group2017.
4. Townsend, A. M. *Smart cities: Big data, civic hackers, and the quest for a new utopia*. WW Norton & Company, 2013.
5. Alba E, Chicano F, Luque G. Smart Cities. Cham: Springer International Publishing; 201

MOOCS:

EL_ME05: Non-Conventional Energy Resources, NPTEL, Dr. Prathap Haridoss, IIT Madras.

NPTEL, Dr.L.Umanand, IISc, Bangalore

EL_ME06: Illumination Engineering, NPTEL, Prof N.K. Kishore, IIT Kharagpur

EL_ME07: Internet Technology, NPTEL Prof. Indranil Sengupta, IIT Kharagpur

EL_ME08: Energy Management Systems and SCADA, NPTEL, Dr. K. Shanti Swarup, IIT Madras

UGC recommended courses(Additional 10 credits)		
Subject Code	**Subject Title**	**Number of Credits**
	Cyber security/Information security	4
	Skill based credits	4
	Human rights education	2