DEPARTMENT OF ELECTRONIC &

INSTRUMENTATION SCIENCE,

SAVITRIBAI PHULE PUNE UNIVERSITY,

PUNE- 411007

Syllabus for M.Sc. Electronic-Science

(88 Credits)

Revised July 2023

Department: Department of Electronic and Instrumentation Science

Course: M.Sc. (Electronic Science)

Minimum Duration: Two years

Total number of credits: 88

The MSc. Electronic Science course would consist of total eighty-eight credits to be completed. The overall course structure comprises of 42 credits of major core theory courses and 30 credits of major core laboratory courses. The remaining 16 credits are divided into 8 credits of major elective theory and 8 credits of major elective practical courses. Each semester the students are supposed to opt one theory (worth 2 credits) and one laboratory (worth 2 credits) out of 3 theory and 3 laboratory electives courses. In such fashion each semester the student is supposed to complete 22 credits each semester.

In the second semester the students are supposed undergo On Job Training of 4 Credits followed by Research Project of 10 Credits in semester III and IV. Further to complete the eighty-eight credits to complete the master program, the student could go for courses from electives / MOOCs or opt for courses offered by other departments with the permission from Departmental Committee.

The overall course structure is summarized in the table below:

Courses	**Credits**
Core Courses	
Major Core Theory	42
Major Core Practical's	30
Elective Courses	
Major Elective (Theory)	8 out of 24 (1 course of 2 Cr / Sem)
Major Elective (Practical's)	8 out of 24 (1 course of 2 Cr / Sem)
Total number of credits for award of PG degree	**88**

Semester I		
Subject Code	**Name of the Subject**	**Credits**
Major Core		
ELS 501 MJ	Network Analysis and Digital Signal Processing	4
ELS 502 MJ	Mechatronics and Basic Robotics	4
ELS 503 MJ	Microcontroller Based System Design	2
ELS 504 MJP	Circuit & Tools Laboratory	4
ELS 505 MJ	Research Methodology	4
Major Elective		
Theory (Any One)		
ELS 510 MJ	Properties of Electronic Materials	2
ELS 511 MJ	Advanced Communication System	2
ELS 512 MJ	Power Electronics	2
Laboratory (Any One)		
ELS 513 MJP	Programming with Python Laboratory	2
ELS 514 MJP	PCB Design and Fabrication Laboratory	2
ELS 515 MJP	Simulation Tools Laboratory	2
	Number of credits to be completed in a Semester I	**22**

Semester II		
Subject Code	**Name of the Subject**	**Credits**
Major Core		
ELS 551 MJ	Electromagnetics, RF, Microwaves & Antenna	4
ELS 552 MJ	Integrated Circuit (IC) Technology & Computer Aided Design (CAD) VLSI	4
ELS 553 MJ	Embedded System Design	2
ELS 554 MJP	System Design Laboratory I	4
ELS 555 OJT	On Job Training	4
Major Elective		
Theory (Any One)		
ELS 560 MJ	Basics of Data Science	2
ELS 561 MJ	CMOS System Design	2
ELS 562 MJ	Foundation course in Innovation, Entrepreneurship and IPR	2
Laboratory (Any One)		
ELS 563 MJP	Virtual Instrumentation Laboratory	2
ELS 564 MJP	PLC and SCADA Laboratory	2
ELS 565 MJP	Image Processing Laboratory	2
	Number of credits to be completed in a Semester II	**22**

Semester III		
Subject Code	**Name of the Subject**	**Credits**
Major Core		
ELS 601 MJ	Advanced Communication System and Smart Antennas	4
ELS 602 MJ	Artificial Intelligence for Electronics	4
ELS 603 MJ	Foundation Course in IC Layout Design	2
ELS 604 MJP	System Design Laboratory II	4
ELS 605 RP	Research Project-I	4
Major Elective		
Theory (Any One)		
ELS 610 MJ	Flight Instrumentation	2
ELS 611 MJ	Electronics for Electric Vehicle (EV)	2
ELS 612 MJ	Low Power VLSI	2
Laboratory (Any One)		
ELS 613 MJP	RF Circuit Design	2
ELS 614 MJP	Data Science Laboratory	2
ELS 615 MJP	Internet of Things (IoT)	2
	Number of credits to be completed in a Semester III	**22**

Semester IV		
Subject Code	**Name of the Subject**	**Credits**
Major Core		
ELS 651 MJ	Basics of Automotive Electronics	4
ELS 652 MJ	Fundamentals of Drone Technology	4
ELS 653 MJP	System Design Laboratory III	2
ELS 654 RP	Research Project-II	6
Major Elective		
Theory (Any One)		
ELS 660 MJ	Foundation Course on Nano Electronics	2
ELS 661 MJ	Real Time Operating Systems (RTOS)	2
ELS 662 MJ	5G and Future Trends in Communication	2
Laboratory (Any One)		
ELS 663 MJP	Machine Vision Laboratory	2
ELS 664 MJP	Opto-electronics Laboratory	2
ELS 665 MJP	Cloud Computing for Electronics	2
	Number of credits to be completed in a Semester IV	**22**

UGC recommended courses (Additional 10 credits)

Subject Code	Subject Title	Credits
To be decided by University	Cyber Security/Information security	4
	Human Rights-I	1
	Human Rights-II	1
	Introduction to Indian Constitution	2
	Skill Development Courses	2

ELS 501 MJ: Network Analysis and Digital Signal Processing (4 Credits)

Unit 1: Network elements, Network Graphs, Nodal and Mesh analysis, Tellegen's Theorem: Passive and Lossless Network, First-order Differential Equations, Initial Conditions in Network, Impedance and Admittance Function, Sinusoidal Steady-State analysis form Zero-Poles configuration, Bode Plots, Laplace transform, Transient response of circuit using Laplace transforms. **(1 Credit)**

Unit 2: Two-port Network Parameters: Z, Y, ABCD, S, and h parameters, Block diagram, Stability in Feedback systems, Transfer Functions, Signal representation, State variable method of circuit analysis, AC circuit analysis, DC circuit analysis, Transient response of circuit using Differential equation, Three-phase systems and circuits, Network functions-S domain analysis of circuit, Network synthesis. **(1 Credit)**

Unit 3: Linear Time Invariant (LTI) systems and its application, Random Signals, Power Spectral Densities and Random Signals in Linear System: white noise, response of linear system to random input solved problem, Fourier Transform, Z Transform, time and frequency domain response, passive filters, Continuous time signals, Fourier Series and Fourier transform representations and its application, sampling theorem and applications, Discrete time signal, discrete Fourier transform (DFT), Fast Fourier Transform (FFT). (**1 Credit)**

Unit 4: Structure for Realization of Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) system, Digital filters-IIR, FIR, Continuous Time Signal (CTS) and Systems and its application, Discrete Time Signals (DTS) and System and its application, State Space analysis of CTS and DTS: State Model, Transfer Function of CTS and DTS from state model, Use of Laplace, Fourier and Z-transform in Electronics. **(1 Credit)**

Recommended Books:

1. Network Analysis: Von Valkenberg, Pearson.
2. Network Analysis: G. K. Mittal, Khanna Publication.
3. Digital Signal Processing: Sanjit Mitra, Mcgraw Higher Ed Publication.
4. Digital Signal Processing: Alan V. Oppenheim, Ronald W. Schafer, Pearson.
5. Digital Signal Processing: A NagoorKani, Mc Graw Hill Education.
6. Digital Signal Processing Principle, Algorithms, and Application: John G. Proakis, Dimitris G. Manolakis, Prentice Hall.

ELS 502 MJ: Mechatronics and basic Robotics (4 Credits)

Unit 1: Introduction to Mechatronics, Design concept, Intermigrations of Mechanical, Electrical and System design, Types of Mechatronic systems, Basics of Robotic Manipulator, block diagram of robotic manipulator, Robotic manipulator mechanisms, basics of computer controlled robotic manipulator, embedded computer controlled robotic systems. **(1 Credit)**

Unit 2: 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 calliper, micrometer, sine bar). **(1 Credit)**

Unit 3: 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. **(1 Credit)**

Unit 4: Sensors – Positional sensor, Pressure sensor, Level sensor, Rotary sensor, Infra-red sensor, Measurements. Vernier caliper, micrometer screw gauge, sine bar. **(1 Credit)**

Recommended Books:

1. Mechatronics with experiments: Sabri Cetinkunt. Wiley Publications.
2. Mechatronics-Integrated Mechanical Electronic Systems; K. P. Ramchandran, G. K. Vijayaraghavan, Wiley India Editions; ISBN 978-81-265-1837-1.
3. Mechatronics - A Multidisciplinary approach, Bolton, 4th Edition, Prentice Hall, 2009.

ELS 503 MJ: Microcontroller Based System Design (2 Credits)

Unit 1: Introduction to Microcontrollers, specifications, features, criteria for choosing a microcontroller for an application. ARM Processor fundamentals, Registers, processor modes, states and instructions set, conditional execution, pipelining, exception, interrupts and vector table, Core extensions, Memory protection unit and memory management unit. Architecture of ARM and revisions, ARM Instruction set, Thumb Instruction set, Embedded programming in C. **(1 Credit)**

Unit 2: 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. **(1 Credit)**

Recommended Books:

1. ARM System Developer's Guide, Designing and Optimizing System Software, Andrew N. S. loss, Dominic Symes, Chris Wright, Elsevier, 2014.
2. Programming STM32 Microcontroller circuit: STM32 Microcontroller, Keil uVision and STM32CubeMX, Heartbeat Modulation, 2020.
3. Beginning STM32: Developing with FreeRTOS, libopencm3 and GCC, Warren Gay, Apress International, 2018.
4. Embedded Systems: Introduction to ARM Cortex-M Microcontrollers, Jonathan W Valvano, Createspace Independent Publishing Platform; 2nd edition onwards, 2014.

ELS 504 MJP: Circuit and Tools Laboratory (4 Credits)

The laboratory would consist of twelve lab experiments:

A. MicrocontrollerBased Experiments
1. Use of GPIO and Interfacing 3 x 3 Keypad and display the pressed key number on LCD.
2. Interfacing various types of sensors, calibrating the same and displaying on LCD.
3. Interfacing and control of Motors (DC and stepper).
4. Design and development of Data Acquisition and storage of systems for Temperature/pressure /humidity etc.
5. Event stamping using RTC and interrupts.
6. Implementingstandard (UART/ SPI/ I2C) communication protocols.

B Communication Based Experiments.
1. FSK/PSK Generation and Detection.
2. Study the characteristic of Encoder and Decoder.

C.Mechatronics Based Experiments
1. Accelerometer interface and characterisation.
2. Transmission system and Speed measurement.
3. Infra red sensor-based proximity detection and motor drive mechanism.

D.DSP Based Experiments
1. Signal generation, Arithmetic operations, find even and odd component of signal. Convolution, Laplace transform, Fourier transform, State model generation using MATLAB.
2. DC analysis, Transient analysis, AC analysis, characteristics plotting, frequency response using MATALB.

ELS 505 MJ: Research Methodology **(4 Credits)**

Unit 1: History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications. Statistical analysis and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, Non-response and methods of recovering the missing response. **(1 Credits)**

Unit 2: Various software's for statistical analysis. The module will consist of case studies of the research performed in various subjects using statistical methods. Error and noise analysis, curve fitting. Creating questionnaire. Data analysis from answers, Selection of research topic (case study based). Selection of research topic (case study based) **(1 Credits)**

Unit 3: Literature search, selection of research topic (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, effective verbal and non-verbal communication, field data collection, safety in field. **(1 Credits)**

Unit 4: Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology. Writing research paper and/or thesis, making a presentation, writing a research proposal. **(1 Credits)**

Recommended Books:

1. 'History of the Scientific Methods' by Martin Shuttleworth
2. 'The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664.
3. 'Research Methodology', C. R. Kothari, New Age International Publisher.

Major Elective Theory

ELS 510 MJ: Properties of Electronic Material (2 Credits)

Unit 1: Electrical properties of metals: Conductivity, reflection and absorption, Fermi surfaces, superconductivity, thermoelectric phenomena. Conduction in metals oxides, amorphous materials. Thermal properties, Wiedemann-Franz Law.
Dielectric Properties of materials: Macroscopic electric field, local electric field at anatom, dielectric constant and polarizability, ferroelectricity, antiferroelectricity, phase transition, piezoelectricity, ferroelasticity, electrostriction. **(1 Credit)**

Unit 2: Optical properties of materials: Optical constants and their physical significance, Kramers – Kronig Relations, Electronic intern-bond 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, Electroluminescence.
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. **(1 Credit)**

Recommended 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.

ELS 511 MJ: Advanced Communication System (2 Credits)

Unit 1: Elements of communication system and its fundamental limitations. FM transmitter and receiver. FM Transmitters: Using Frequency multiplication & mixing, Frequency stabilized reactance FM transmitter, Intermediate frequency and principle of super-heterodyne receiver. (**1 Credit)**

Unit 2: 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. (**1 Credit)**

Recommended 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.

ELS 512 MJ: Power Electronics **(2 Credits)**

Unit 1: Power devices: Construction, operating principles, ratings, characteristics, triggering circuits and operating parameters of following solid state power devices–SCR, Thyristors types - phase control, inverter grade, asymmetrical (ASCR) reverse conducting, (RCT), Gate assisted Turn off (GATT), Bidirectional diode (DIAC), TRIAC, commutation techniques, power transistors, power MOSFETS, IGBT's. Gate triggering circuits. (**1 Credit)**

Unit 2: AC regulators, speed control of a.c. and d.c. motors, Stepper and synchronous motors, Variable Frequency Drive (VFD), half bridge and full bridgeinverters, series and parallel operations of inverters and converters. Three phase-controlled rectifier, Switch Mode Power Supply, Uninterrupted Power Supply. (**1 Credit)**

Recommended Books:

1. Power Electronics N. Mohan, J.M. Undeland, and W.P. Robbins, John Wiley
2. Power Electronics M.D. Singh, K.B. Khanchandani, TMH
3. Industrial Electronics T. E. Kissell, PHI
4. Fundamentals of Power Electronics R. W. Erickson, D. Maksimovic
5. Uninterruptible power supplies A, King and W. Knight, McGraw Hill
6. Uninterruptible power supplies J.Platts, J. S. Aubyn. P. Peregrinus, IEE power series

Major Elective Practical

ELS 513 MJP: Programming with Python Laboratory (2 Credits)

The practical sessions would be based on following experiments:

1. Create a list and perform the following methods 1) insert () 2) remove () 3) append() 4) len() 5) pop() 6) clear()

2. (i) Write python programs to perform the arithmetic and logical operations. (ii) Write a python program which accepts the radius of a circle from user and computes the area. (iii) Write a python program to create a package (Engg), sub -package(years),modules (sem) and create staff and student function to modul. e

3. Write a python program to i) check whether the given string is palindrome or not. ii) Factorial of a number , iii) Check whether the number is prime or not.

4. Write a Python function that takes two lists and returns True if they are equal otherwise false

5. (i) Write a program to double a given number and add two numbers using lambda() . (ii) Write a program for filter() to filter only even numbers from a given list. (iii) Write a program for map() function to double all the items in the list? . (iv) Write a program to find sum of the numbers for the elements of the list by using reduce().

6. (i) Demonstrate a python code to print try, except and finally block statements. (ii) Write a python program to open and write “hello world” into a file (iii) Write a python program to open a file and check what are the access permissions acquired by that file using os module.

7. (i) Using a numpy module create an array and check the following: 1. Type of array 2. Axes of array 3. Shape of array 4. Type of elements in array. (ii) Write a python program to concatenate the dataframes with two different objects

8. (i) Write a python code to set background color and pic and draw a circle using turtle module. (ii) Write a python code to set background color and pic and draw a square and fill the color using turtle module. (iii) Write a python code to perform addition using functions with pdb module.

ELS 514 MJP: PCB Design and Fabrication Laboratory (2 Credits)

1. Design
    a. Schmitt Trigger Circuit
    b. Clipping and Clamping Circuit
2. Creation of schematics, Material Selection and Simulation of circuit.
3. PCB design andfabrication.
4. Component Assembly, Soldering and De-soldering.
5. Technical assessment and presentation.
6. Exercises on PCB design and fabrication (2 PCBs)

ELS 515 MJP: Simulation Tools Laboratory (2 Credits)

The practical sessions would give hands on experience of the following topics:

1. Modulation techniques using MATLAB.
2. Simulate kinematics and dynamics of robotic systems using MATLAB Simulink tools.
3. Projectile Mapping using MATLAB.
4. Design, simulate, and test ALU using Xilinx software and Spartan FPGA board.
5. Implementation of combinational/sequential circuit using HDL.
6. Design, simulate, and test of Combinational and Sequential circuits using Xilinx software and Spartan FPGA board.

ELS 551 MJ: Electromagnetic, RF, Microwaves & Antenna (4 Credits)

Unit 1: 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. (**1 Credit)**

Unit 2: 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. (**1 Credit)**

Unit 3: 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. (**1 Credit)**

Unit 4: 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 (**1 Credit)**

Recommended 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.

ELS 552 MJ: Integrated Circuit (IC) Technology & Computer Aided Design (CAD) VLSI **(4 Credits)**

Unit 1: 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 centre and foundry. **(1 Credit)**

Unit 2: Moore's law, IC fabrication technologies; n-MOS 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. **(1 Credit)**

Unit 3: CAD VLSI tools, Hierarchical design of VLSIs, behavioural description, RTL, Logic circuit, gate, circuits, Xilinx, SPICE. **(1 Credit)**

Unit 4: ASIC Design Flow: Partitioning, Floor-planning, placement, global and channel routing. Physical & Logical Design of Integrated Circuits. **(1 Credit)**

Recommended Books:

1. Analysis & Design of Analog Integrated Circuits, P. Gray, P. Hurst, S. Lewis, R. Meyer, Wiley.
2. Application Specific Integrated Circuits, M.J. S. Smith, Addison-Wesley.
3. Basic VLSI Design- Douglas A. Pucknell.

ELS 553 MJ: Embedded System Design **(2 Credits)**

Unit 1: 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. **(1 Credits)**

Unit 2: Introduction to ARM 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. **(1 Credits)**

Recommended 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.

ELS 554 MJP: System Design Laboratory I **(4 Credits)**

A. Embedded System Design Experiments

1. Design and development of Digital Watch.
2. Familiarization and Use of SPI and I2C communication protocol.
3. Interfacing and use of Touch Screen Panel.
4. Design and development of Smart Home.
5. Design and development of Solar tracking system.
6. Use of Raspberry pi and cloud data storage.

B. Xilinx based Experiments

1. Design and development of Stop watch.
2. Design and implement sign magnitude adder.
3. Design and implement barrel shifter.

C. Communication based Experiments

1. Design of Yagi-Uda Antenna in 4NEC2 Software.
2. Measurement of Antenna Parameters on VNA and Spectrum Analyser.
3. Measurement of Antenna radiation Pattern.

ELS 555 OJT: On Job Training **(4 Credits)**

Major Elective Theory

ELS 560 MJ: Basics of Data Science **(2 Credits)**

Unit 1: Linear Algebra, Analytic Geometry, Matrix Decompositions, Vector Calculus, Probaility and Distributions, Contiunus Optimization. Introduction to machine Learning, center machine learning problem-data, models, and learings, Empirical Risk Minimization, parameter estimation, Probailistics Modeling and Inference, Directed Graphical models, Linear regression. **(1 Credits)**

Unit 2: Dimensinality reduction with Principal Component Analysis, Density Estimation with Gaussian Mixture Models, Kernal Methods, Optimization, Classification with Support Vector Machines.Introduction to optimization Problems, Graph-theoretic Models, Stochastic Thinking, Random Walks, Monte Carlo Simulation, Confidence Intervals, Sampling and Standard Error, Understanding Experimental data. **(1 Credits)**

Recommended Books:

1. Marc Peter Deisenroth, A. Aldo Faisal,' Mathematics for Machine Learning', Cambridge University Press (2020).
2. Introduction to Computation and Programming Using Python: With Application to Understanding Data, Guttag, John. 2nd ed. MIT Press, 2016.
3. Data Science from Scratch, Joel Grus, O'Reilly.
4. A Hand-On Introduction to Data Science, Chirag Shah, Cambridge University Press.
5. The Element of Statistical Learning, Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer.

ELS 561 MJ: CMOS System Design **(2 Credits)**

Unit 1: CMOS IC design process, MOSFET capacitances, Amplifiers, common source amplifier, 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. **(1 Credit)**

Unit 2: 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. **(1 Credit)**

Recommended Books:

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

ELS 562 MJ: Foundation course in Innovation, Entrepreneurship and IPR (2 Credits)

Unit 1: Knowledge – characteristics and role in economic growth, Tacit and codified 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, Fundamentals of, Discovery of Entrepreneurial Opportunities, Stakeholders, relationships, networks and resources. A description of the business – Entrepreneurial characteristics, Tools, processes, the Business Model Canvas, Building and communicating the case, how new ventures evolve. Types of Companies and opportunities. (**1 Credit)**

Unit 2: Intellectual Property Rights: An Introduction, Appropriation of knowledge: knowledge monopoly and its consequences, Pre-IPR system of protection: Secrecy/Trade guilds/Cartel. 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 Grant commercialisation. (**1 Credit)**

Recommended 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.

Major Elective Practical

ELS 563 MJP: Virtual Instrumentation Laboratory (2 Credits)

A. Basic LabVIEW Workshop Training:

Familiarization of Virtual Instrumentation and LabVIEW: Virtual instrumentation, virtual instrument and traditional instrument, hardware and software in virtual instrumentation, role of hardware and 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.

LabVIEW Programming: Mathematical and logical expressions, loops, tunnel, arrays, strings shift register, arrays, strings, clusters, structures, State machines, sub-VI's global and local variables, property nodes, generation of .EXE file.

Data Acquisition and Processing: Waveform generation, waveform conditioning, dynamic data conversion to arrays, MyDAQ and My RIO card configurations, block diagram, sampling and signal acquisition, measurement, control of GPIOs and communication interfaces. LINX for Arduino and LABVIEW Interfacing: Controlling GPIOs, Sensor Interfacing, Relay interfacing, PWM, motor control, and data acquisition.

Virtual Instruments Software Architecture (VISA): Interfacing devices and controllers manufactured by third party (other than National Instrument's) via Serial, GPIB, IEEE 488.2.

Image Processing: Camera Interfacing, read images, intensity control, image histogram, image segmentation, smoothing filter.

B. LabVIEW in Practice (Lab Experiments):

1. Create a VI for performing array operations. (Largest and smallest, Swap array elements, Bubble sort).
2. Design VIs for the following a) roots of quadratic equation, b) Password based system,c) Identification of birth in train compartment, d) 7 segment display.
3. Familiarization of NI My DAQ Card. Design and implement a VIs for the following a) LED blinking, b) LM35 based data acquisition, c) Interfacing IR pair and Relay.
4. LINX Arduino LabVIEW interfacing a) LED blinking, b) LM35 based data acquisition, c) Interfacing IR pair and Relay, d) DC and Servo motor interfacing.
5. Image acquisition and processing using LabVIEW a) Webcam interfacing b) Intensity control, c) Image histogram, d) Image segmentation.
6. VISA bus Interfacing using LabVIEW.
7. Case Studies / Project Like Experiment.

ELS 564 MJP: PLC and SCADA Laboratory (2 Credits)

A. Basic PLC and SCADA Workshop Training:

Digital Control, PLC, Ladder Logic Programming, Introduction to Supervisory Control and Data Acquisition SCADA Architecture (First Generation-Monolithic, Second Generation-Distributed, Third generation Networked Architecture), Communication Requirements, Desirable properties, Applications of SCADA.

B. List of Lab Experiments:

1. Study and Implementation of ON –OFF Controller using Nuvoton Board.
2. Study characteristics of P, PI, PD and PID controllers using MATLAB Simulink.
3. Development of programs and control for PLC based pick and place robot.
4. Implementation of for PLC based bottle filling plant.
5. Design of interfaces for monitoring and control of elevator system.
6. Design and implement PLC based conveyor system.
7. Introduction to SCADA software and SCADA HMI Design.
8. SCADA Design: Case Study.

ELS 565 MJP: Image Processing Laboratory (2 Credits)

The laboratory sessions would be consisting of following experiments using MATLAB software:

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. Program for measuring dimensions of given object.
5. Counting number of coins using template matching technique.
6. Program on image registration.

ELS 601 MJ: Advanced Communication System and Smart Antennas (4 Credits)

Unit 1: Wireless Communication Radio wave propagation, Physical modelling for wireless channels, Path loss and Shadowing, outage probability under path loss and shadowing, time and frequency coherence, Statistical multipath channel models, narrowband fading models, wideband fading models, Discrete-time model, Space-time channel models. AWGN channel capacity, capacity of flat fading channels, channel distribution Information known at transmitter or receiver and both capacity comparisons, Capacity of frequency selective fading channels-time invariant- time variant. **(1 Credit)**

Unit 2: Ultra-wideband (UWB) communication systems: UWB concepts, advantages and challenges, single band versus multiband, FCC emission limits, UWB applications; UWB sources and antennas: UWB pulse generation.UWB antennas; Pulse-detection and multiple-access techniques: Conventional pulse-detection techniques, pulse modulation and detection techniques, UWB multiple-access techniques; Interference issues: Interference with WLAN, cellular & GPS. **(1 Credit)**

Unit 3: Architecture of a Smart Antenna System: Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Applications of Smart Antennas. Smart Antenna Configurations Fixed Sidelobe Cancelling, Retrodirective Arrays, Beamforming, Adaptive Arrays, Butler Matrix, Spatial Filtering with Beamformers, Switched Beam Systems, Multiple Fixed Beam System. Uplink Processing, Diversity Techniques, Angle Diversity, Maximum Ratio Combining, Adaptive Beamforming, Fixed Multiple Beams versus Adaptive Beamforming, Downlink Processing. Angle-of-Arrival Estimation Fundamentals of Matrix Algebra, Array Correlation Matrix, AOA. **(2 Credits)**

Recommended Books:

1. D. M. Pozar, Microwave Engineering, 3nd Edition, John Wiley & Sons.
2. R. Sorrentino and G. Bianchi, Microwave and RF Engineering, John Wiley & Sons.
3. Reinhold Ludwig and Gene Bogdanvov, ―RF Circuit Design – Theory and Application, 2nd Edition, Pearson, 2012.
4. E.da Silva, ―High Frequency and Microwave Engineering, Butterworth Heinmann publications, Oxford, 2001.
5. T. C. Edwards, Foundations of Interconnects and Microstrip lines, John Wiley & Sons.

ELS 602 MJ: Artificial Intelligence for Electronics **(4 Credits)**

Unit 1: Mathematics and Statistics for AI: Linear Algebra, Probability Distributions, Sampling and Sampling Techniques, Eigenvalues, Eigenvectors and Eigen decomposition, Inferential Statistics, Application of Inferential Statistics, Understanding the Data, Relationship Between Variables, Data Visualization. **(1 Credit)**

Unit 2: Basics of Machine learning: Introduction to Machine Learning, Data Wrangling and Manipulation, Supervised Learning, Feature Engineering, Supervised Learning Classification, Unsupervised Learning, Time Series Modelling, Ensemble Learning, Recommender Systems, Text Mining. **(1 Credit)**

Unit 3: Essentials of Generative AI: Generative AI and its Landscape, Explainable AI, Conversational AI, Ethical Considerations in Generative AI Models, Conversational AI, Responsible Data Usage and Privacy, AI Technologies for Innovation, ChatGPT and its Applications **(1 Credit)**

Unit 4: Applications of AI in Electronics: Vision with AI and Speech Recognition with AI.

(1 Credit)

Recommended Books:

1. Artificial Intelligence A Modern Approach, Stuart Russell And Peter Norvig, Third Edition, Pearson Education, Inc. 2003.
2. Machine Learning Using Python, Pradhan Manaranjan, U Dinesh Kumar, Wiley & Sons, 2019.
3. Introduction To Artificial Intelligence, Charniak, Pearson Education India. 2012.
4. Fundamentals Of Artificial Intelligence And Machine Learning (Pb) by Pradhan Manaswini, DPS Publishing House, 2019.

ELS 603 MJ: Foundation Course in IC Layout DesignIC Layout Design (2 Credits)

Unit 1: Basics of Resistor Layout: Measuring resistance using concept of squares, Poly resistors: equivalent resistance estimation for poly resistor, Basic resistor layout, contact resistance,changing of body material. Real world resistor analysis: Delta effects contacts, body, head. Spreading resistance. Total resistance equation, Extreme options for resistor, High value low precision resistors, low resistance value high precision, Current density equation for resistor layout, tolerance proof resistors, Diffusion resistors, Double poly resistors, Bipolar BiCMOS technology resistors. Capacitor Layout: Capacitor properties preview, Capacitance layout basic equation, areacapacitance, periphery capacitance, Delta effects on capacitance, Types of capacitors, N well capacitors, Parasitic capacitance, Metal capacitor, stacked metal capacitor, Nitride capacitor. Transistor Layout- Device layout objectives, Device sizing, significance of SPICE, splitting of long device, fingering, device area minimizing, Source drain sharing, Device interconnection technique, Compact layout. Parasitics: Parasitic capacitance, Parasitic resistance, Parasitic inductance, Device parasitic, CMOS transistor, Bipolar transistor, Full custom options. Matching Techniques: Importance of matching & communication, Simple matching, rootdevice matching, interdigitating devices, Dummy devices, Common centroid, cross quading, symmetry, matching signal path, device size choices. **(1 Credit)**

Unit 2: Stick diagram: MOS layers, stick diagrams, nMOS & amp; CMOS design style, Lambda baseddesign rules, Double metal process rules, contact cuts, CMOS lambda-based design rules, Layout diagrams, symbolic diagrams, translation to Mask form, mask layout-NAND, NOR,2:1 multiplexer. Scaling of CMOS circuits: Ideal scaling theory, Constant field scaling & effects, scaling effect on transconductance, delay, power dissipation, channel resistance & capacitance, junction capacitance. Short channel effects: Threshold voltage variation, Mobility degradation with vertical field, velocity saturation, Hot carrier effects, output impedance variation. Failure Mechanisms- Electrical overstress, contamination, Surface effects, parasitic, Electromigration, Antenna effect, ESD, Analog layout- Crosstalk, Shielding, High speed devices layout, High voltage layout, I/O cell layout, Power dissipation types, LDO. **(1 Credit)**

Recommended 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.
5. Design of Analog CMOS integrated Circuits, Behzad Razavi, Mc Graw Hill publication.

ELS 604 MJP: System Design Laboratory II **(4 Credits)**

A. Cadence based system design

1. Design of cascaded CMOS inverters.
2. Design of ratioed current mirrors.
3. Design of D flip flop.

B. Flight Instruments

1. Familiarization with used of sensors used in flights instrumentation (Any four): altitude, flow, strain, vibration, angular displacement, gyroscope and accelerometer.
2. Study of modulation and demodulation techniques used for telemetry.
3. GPS based trajectory tracking.

C. Communication

1. Design of Loop Antenna in MATLAB Software
2. Design of Microstrip Patch antenna in HFSS Software
3. To Study Transmission line characteristics in AWR Software

D. Electronic Vehicle

1. Understanding and familiarization with the use of devices and components used in EV's (any four): Silicon Carbide MOSFETs, Silicon IGBT, DC-link capacitor, boost inductor, EMI filter, Integrated IGBT modules, Integrated chip-level temperature & current sensors.
2. Design and development of charging circuitry for lithium ion battery.
3. Design, build and test three phase BLDC motor control circuitry.

ELS 605 RP: Research Project-II **(4 Credits)**

Major Elective Theory

ELS 610 MJ: Flight Instrumentation **(2 Credits)**

Unit 1: Basic concepts of measurements: Generalized characteristics of sensors, instruments, and measurement systems. Measurement of physical quantities such as pressure, force, altitude, temperature, flow, strain and vibration, and angular displacement etc. Inertial sensors: gyroscope and accelerometer with recent advancements therein. Real Time Signal conditioning and processing: Operational amplifiers, instrumentation and Charge amplifiers. Analog to digital and digital to analog converters. Data acquisition system. **(1 Credits)**

Unit 2: Data transmission: Signal transmission by analog and digital means, methods of modulation and demodulation, multiplexing time division and frequency division, telemetry systems.Tracking and data fusion: Trajectory tracking devices such as Electro-optic tracking systems, thermal imagining system, scanning techniques, detectors and range analysis and multi sensor data fusion for trajectory analysis. **(1 Credits)**

Recommended Books:

1. E.O. Doebelin, Measurement Systems: Application and Design, 4thEd, McGraw Hill International, New York, 1990.
2. J.M. Lloyd, Thermal imaging system, Plenum Pub., New York, 1975.
3. D. Patranabis, Telemetry Principles, Tata McGraw Hill, New York, 2000.
4. Aircraft Instrumentation and Systems, S. Nagabhushana, L. K. Sudha, I. K. International Publishing House Pvt. Ltd, 2013.

ELS 611 MJ: Electronics for Electric Vehicle (EV) (2 Credits)

Unit 1: EV System Architecture: Motivation for hybrid and electric vehicles, Hybrid-Electric Vehicle Power trains, Vehicle Energy Storage System Design Motors & motive power splitting concepts, and interface within power train system, Vehicle Development Process Overview, and System test considerations. Performance Parameters of EV: Efficiency, vehicle range, safety, reliability, life, size, weight, power dissipation, power density etc. Devices and Components used in EVs: Silicon Carbide MOSFETs, Silicon IGBT, DC-link capacitor, boost inductor, EMI filter, Integrated IGBT modules, Integrated chip-level temperature & current sensors. Packaging of the devices used for EVs: surface-mount devices (SMD) DPAK or D2PAK. **(1 Credits)**

Unit 2: Basics of Energy storage elements: Ragone Chart, Theory of Ragone Plots,Ragone Plot of a Battery,Battery characterisation and testing systems & Battery life cycle, Modular battery packs,packaging, thermal control and legislative implications. Supercapacitors: Materials and Construction, Basic Model, Series and Parallel Connections. Control Electronics: Basic Concepts of DC–AC Inverters, Single-Phase DC–AC Inverter, Three-Phase DC–AC Inverter, BLDC Motor and Control, Operation of BLDC Motor, Torque and Rotating Field Production, BLDC Motor Control, BLDC Motor Torque–Speed Characteristics, Sensor-less BLDC Motor Control, AC Induction Motor and Control.Basic Configuration of PHEV /BEV Battery Charger, Concept of Onboard Chargers (OBC) Power Factor and Correcting Techniques, Controls of Plug-In Charger. **(1 Credits)**

Recommended Books:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi, 2011.
2. Chang Liang Xia," Permanent Magnet Brushless Dc Motor Drives and Controls" Wiley 2012.
3. Electric Vehicle Engineering, PerEnge, Nick Enge, Stephen Zoepf, McGraw Hill, 2021.

ELS 612 MJ: Low Power VLSI **(2 Credits)**

Unit 1: Sources of Power dissipation, Dynamic Power Dissipation, Short Circuit Power, Switching Power, Glitching Power, Static Power Dissipation, Degrees of Freedom.

Supply Voltage Scaling Approaches: Device feature size scaling, Multi-V_{DD} Circuits, Architectural level approaches: Parallelism, Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management. **(1 Credits)**

Unit 2: Switched Capacitance Minimization Approaches: Hardware Software Trade off, Bus Encoding, Two's complement Vs Sign Magnitude, Architectural optimization, Clock Gating, Logic styles.

Leakage Power minimization Approaches: Variable-threshold-voltage CMOS (VTCMOS) approach. Multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, Transistor stacking, Dual-V_t assignment approach (DTCMOS). **(1 Credits)**

Recommended Books:

1. Low-Power VLSI Circuits and Systems,Ajit Pal, Springer Publication.
2. Low-Power CMOS VLSI Circuit Design. Kaushik Roy, Sharat Prasad. Wiley publication.

Major Elective Practical

ELS 613 MJP: RF Circuit Design Laboratory **(2 Credits)**

1. Design a 2.4 GHz LC Oscillator in AWR Software.
2. Design Band Pass Filter in AWR Software.
3. Design Low Noise Amplifier (LNA) in AWR Software.
4. Design of planer microstrip array antenna in HFSS Software.
5. Study different transmission line characteristics in HFSS Software.
6. Design of power divider in HFSS Software.

ELS 614 MJP: Data Science Laboratory (2 Credits)

1. Python program on Data Pre-processing: Removing Duplicates, Transformation of Data using function or mapping, replacing values, Handling Missing Data for given data set.
2. Python program on Regression: Linear Regression for given data set.
3. Python program on Logistic Regressionfor given data set.
4. Python program on Analytics Types: Predictive, Descriptive and Prescriptivefor given data set.
5. Python program on Classification: Naïve Bayes, Decision Trees for given data set.
6. Python program on clustering for given data set.

ELS 615 MJP: Internet of Things (IoT) **(2 Credits)**

A. Basic IoT Workshop Training:

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.

B. The laboratory sessions would give hands on experience of the following experiments:

1. Wireless data acquisition using sensor nodes.
2. Setting up a WSN for smart home like applications.
3. Implement and simulate network topologies using NS2 tools.
4. Connecting devices at the edge and to the cloud.
5. Processing data offline and in the cloud.
6. Mini Project: Designing an IoT system.

ELS 651 MJ: Basics of Automotive Electronics **(4 Credits)**

Unit 1: Automotive Fundamentals: Evolution of Automotive Electronics, Automobile Physical Configuration, Engine Control, Ignition System- Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition Timing, Differential, Suspension, Brakes, Steering System, Concept of an Electronic Engine control system, Effect spark timing and EGR on performance, Control Strategy, Electronic Fuel control system, Electronic Ignition.

(1 Credits)

Unit 2: Automotive Sensors and Actuators: Airflow rate sensor, Strain Gauge MAP sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (02/EGO) Lambda Sensors, Piezoelectric Knock Sensor, Solenoid, Fuel Injector, EGR Actuator, Digital Speed Sensor, Throttle Actuator. **(1 Credits)**

Unit 3: Digital Engine Control Systems: Digital Engine control features, Control modes for fuel Control, EGR Control, Electronic Ignition Control -Closed loop Ignition timing, Spark Advance Correction Scheme, Integrated Engine Control System, Secondary Air Management. **(1 Credits)**

Unit 4: Automotive Networking: Bus Systems- Classification, Applications in the vehicle, Coupling of networks, Examples of networked vehicles, Buses - CAN, LIN, FlexRay, Ethernet. Automotive Diagnostics-: Timing Light, Engine Analyzer, ESD (Electrostatic Discharge) Protection & measurement, On-board diagnostics, Off-board diagnostics, Expert Systems, Occupant Protection Systems -Accelerometer based Air Bag systems. **(1 Credits)**

Recommended Books:

1. William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier Publishing.
2 Robert Bosch GmbH (Ed.) Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th edition, John Wiley & Sons Inc., 2007.

ELS 652 MJ: Fundamentals of Drone Technology (4 Credits)

Unit 1: Introduction to drones and their applications, Key features of drone regulations for civil use, operational and procedural requirements, no drone zones, operations through digital platform, enforcement actions, relevant sections of aircraft act-1934, Structural classification of drones, classifications of drone structures and their suitability, applications and uses of drone frame materials, classifications and applicability of propeller motors, drone propeller materials, design parameters for propellers, composition and structuring of electronic speed controller, flight control board, characteristics of FCB and their structure. **(1 Credits)**

Unit 2: Drone Battery and Management: Introduction of Battery, Description of Li-Po Battery, Charging / Discharging of Battery. Back up, Ratings, Shelf Life, Maintenance and safety of Battery. Selection criteria of Battery for Drone application, Selection criterion of motor for drone application. Working and application of BLDC motor, **(1 Credits)**

Unit 3: Sensors for UAV and Drones: Wi fi devices, RADAR and range finder, GPS receiver, Gyro sensor, Speed and Distance sensor, Image sensor, TOF sensor, Chemical sensor. Cameras in drones and selection criteria of camera for different range. Barometers, Accelerometer, Magnetometer, remote control for drone. Radio Control System: Introduction of radio control system, Controllers, Transmitter and Receiver, Flight Controllers, Electronic Speed Controller, Battery Eliminator Circuit, Universal Battery Eliminator Circuit, Connections and Interfaces of Devices in Drones. **(1 Credits)**

Unit 4: Introduction to Drone Programming: Introduction to programming language used in drone: C and Python. Installation of cards. Auto Pilot software i.e. Ardupilot, Openpilot. Drone flying and operation, Drone accessories and maintenance. Drone Applications, Case studies, Future of drones. **(1 Credits)**

Recommended Books:

1. Robert L. Boylestad / Louis Nashelsky"Electronic Devices and Circuit Theory", Latest Edition, Pearson Education.
2. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill.
3. H S Kalsi, "Electronic Instrumentation", Latest Edition, TMH Publication.
4. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost (Green Energy and Technology) by Gianfranco Pistoia, BoryannLiaw , Springer.
5. Wireless Communications | Second Edition | By Pearson: Principles and Practice.
6. Drone Technology in Architecture, Engineering and Construction (, Tal Daniel).

ELS 653 MJP: System Design Laboratory III (4 Credits)

1. Testing of batteries, battery maintenance, starter motor and alternator.
2. Understanding of ignition system, head light, traffic indicators, and electric horn.
3. Design and development of BLDC motor control circuitry.
4. Automatic wiper control
5. Familiarization with the use of various sensors used in automotive: Any four (Position (Angular, Magnetic, Hall effect, Optical Crankshaft) Position Sensor, and Throttle Angle Sensor (TAS), Exhaust Gas Oxygen (02/EGO) Lambda Sensors, Piezoelectric Knock Sensor, Solenoid, Fuel Injector, EGR Actuator, Digital Speed Sensor, Throttle Actuator).
6. Implementation of communication protocols used in automotive. (CAN, LIN, FlexRay).
7. Understanding and design and development of drone battery management system.
8. Familiarization with the use of various sensors used in drone: Any four Wi fi devices, RADAR and range finder, GPS receiver, Gyro sensor, Speed and Distance sensor, Image sensor, TOF sensor, Chemical sensor. Cameras in drones, Barometers, Accelerometer, Magnetometer, remote control for drone.
9. Understanding basics of flight controller and its components.
10. Drone programming using ArduPilot and Openpilot software.
11. Understanding and implementation of various electronic circuit protection strategies for automotive as well as drone application.
12. Reprogramming and field testing of UAV/drones.

ELS 654 RP: Research Project- II **(6 Credits)**

Major Elective Theory

ELS 660 MJ: Foundation Course on Nano Electronics **(2 Credits)**

Unit 1: 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). Quantum statistics, Brownian motion, Random walk problem. Concept of Chemical potential, partition function and its applications in computing thermodynamic quantities. **(1 Credits)**

Unit 2: Quantum electronic devices, electrons in mesoscopic structures, short channel MOSFET, short channel effects. Graphene 2D materials, Fullerenes, nanotubes, switches based on Fullerenes and nanotubes, Nanoelectronics with tunneling devices, resonant tunneling diode(RTD), RTD based logic gates, principle of single electron transistor, Coulomb blockade, split gate transistor, electron wave transistor, electron spin transistor, quantum cellular automata, q-bits and Introduction to quantum computing. **(1 Credits)**

Recommended Books:

1. Quantum Mechanics: Schiff L.I.
2. Nano electronics and Nanosystems: K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2005).
3. Fundamentals of Statistical Mechanics and Thermal Physics ByReif.

ELS 661 MJ: Real Time Operating System (RTOS) (2 Credits)

Unit 1: Introduction Real Time Systems, Basics of Task scheduling, Cyclic executives, Cyclic scheduler, Event-driven schedulers, Rate Monotonic Algorithm (RMA), Rate Monotonic Analysis, Resource sharing among Real-Time Tasks, Priority Inversion. Priority Ceiling Protocol, PCP Priority Inversion, Unix as a Real-Time operating system, Survey of commercial RTOS, Real-Time Communication, Real-Time Databases. RTOS v/s GPOS, definition and classification of RTOS, Requirements, Specification and Execution of Program, Compiling and Linking, Loading and Execution of Programs, Preemptive Multitasking, Task Switch, Semaphores. Ring Buffers. **(1 Credits)**

Unit 2: Kernel Implementation- Kernel Architecture, Hardware Model, Task Switching, Semaphores, queues, Interprocess Communication, Serial Input and Output, Interrupt Processing, Memory Management. Bootstrap, System Start-up, Task Parameters, Task Creation, Task Activation and task Deletion, Application Monitor Session and Monitor Implementation, Development Environment. Case Studies: PCOS, RT Linux, Lynx etc.
(1 Credits)

Recommended Books:

1. Dr. Jurgen Sauermann, Melanie Thelen,'Realtime Operating System'.
2. Krishna and Shin, "Real-Time Systems," Tata McGraw Hill. 1999.
3. Jane W. S. Liu, "Real-Time Systems", Pearson Education, 2009.
4. Philip A. Laplante, Seppo J. Ovaska, "Real-Time Systems Design and Analysis", Wiley, 2012.
5. Rajib Mall, "Real-Time Systems: Theory and Practice," Pearson, 2008.
6. Andrew S. Tanenbaum, Herbert Bos," Modern Operating System", Pearson.

ELS 662 MJ: 5G and Future Trends in Communication (2 Credits)

Unit 1: 5G channel modelling and use cases: Modelling requirements and scenarios, Cognitive radio: Architecture, spectrum sensing, Software Defined Radio (SDR). Diversity, exploiting multipath diversity, transmit diversity. The 5G architecture: Introduction, NFV and SDN, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Physical architecture and 5G deployment. Device-to-device (D2D) communications: from 4G to 5G. **(1 Credit)**

Unit 2: The 5G radio-access technologies: Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multipleaccess systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Medium access control for nodes on the move, Radio access for massive machine type communication. **(1 Credit)**

Recommended Books:

1. R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and Candidate Technologies., John Willey & Sons, West Sussex, 2017.
2. Manish, M., Devendra, G., Pattanayak, P., Ha, N., 5G and Beyond Wireless Systems PHY Layer Perspective, Springer Series in Wireless Technology
3. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock,, Millimeter Wave Wireless Communication., Pearson Education, 2015.
4. M. Vaezi, Z. Ding, and H. V. Poor,, Multiple Access techniques for 5G Wireless Networks and Beyond., Springer Nature, Switzerland, 2019

Major Elective Practical

ELS 663 MJP: Machine Vision Laboratory (2 Credits)

The laboratory sessions would be based on theory and give hands on experience of the following experiments using MATLAB:

1. Program Interest Point Detection
2. Texture analysis
3. Binary Shape Analysis
4. In-Vehicle Vision System
5. Statistical Pattern Recognition
6. Stereo Reconstruction

ELS 664 MJP: Opto-electronics Laboratory (2 Credits)

There will be 6 practical's based on following experiments:

1. Study of characteristic of various light sources and detectors
2. Optical Fiber communication Training Set- Coupling, Power Measurements, Attenuation measurements, Measurement of bending losses and Numerical Aperture.
3. MATLAB program to illustrate propagation of light, guided modes, calculate dispersion curves in optical fiber.
4. Study and implement of Fiber optics-based sensor.
5. Study of spectroscopic analysis of different light sources using StellarNet Spectrometer.
6. Design, calculate and visualize Light illumination for various scenario by using DIALux simulator.

ELS 665 MJP: Cloud Computing for Electronics (2 Credits)

1. To develop Web Application in Cloud.
2. To learn design and development process involved in creating cloud-based applications.
3. To learn to implement and use parallel programming with Hadoop.
4. Transfer the file from one virtual machine to another virtual machine.
5. Cloud Applications:1- Healthcare: ECG analysis in cloud IoT-enabled.
6. Cloud Applications:2- Smart Agriculture.