Department of Electronic Science

BULLETIN OF INFORMATION
2024 -25

Department of Electronic Science
University of Delhi South Campus
Benito Juarez Road, Dhaula Kuan
New Delhi-110021, India

Phone: +91-11-24110440
Email id: does@south.du.ac.in

http://electronics.du.ac.in/

Department of Electronic Science

The Department of Electronic Science was established in 1985 and is widely recognised as one of the most prestigious Electronic Science Departments in the country. The Department is conducting courses leading to M.Tech in Microwave Electronics and M.Sc. in Electronics. The aim of these programmes is to provide the necessary theoretical background and practical experience in order to meet the requirements of the R&D Organizations and Industries. All students joining the M.Sc. course are required to undergo summer training in the Industry or R&D Organisations. In addition, the M.Tech and M.Sc. students work for one Semester on projects in collaboration with Industry and R&D Organisations. The curriculum of these courses is updated regularly to keep it in consonance with the changing industrial environment. The interface with the Industry is further enhanced by an annual seminar under the Visitor's Programme in which professionals from industry, R&D organizations and academics are invited. Our alumni, now spread over a large number of government and private organizations, facilitate these interactions.

A full range of resources and facilities are available to the students. The department has a well equipped computer laboratory with various circuit simulation and microwave design software for students. In addition, there are well equipped laboratories for experimental work in the following areas: Microwave Measurements, Communication Electronics, Circuit Design, Electrical Machines and Control Systems, Electronic Materials and Semiconductor Devices, Microprocessors and Digital Signal Processing and Optical Electronics.

Attempt is made to assess the students' performance through continuous series of tests and presentations in addition to semester end examinations to ensure highest standards. The Department is actively helping the students in their placement through Campus interviews. Students graduating from the Department have found positions in both government and private organizations working in Space Applications, Telecommunications and Semiconductors.
The students graduating from the programs have the necessary theoretical and practical skills to take on any R&D and Production responsibilities in today's complex and challenging environment. This is evident from the contributions and achievements of our alumni in organizations like ST Microelectronics, Cadence, HFCL, Aricent, Transwitch, SAMEER, ISRO, DRDO laboratories and many more.

The faculty members are actively engaged in research as well as supervision of research leading to the Ph.D. degree in the field of optical electronics, semiconductors, microwaves and microelectronics. The Department has national and international collaborations and projects. The faculty is supported by several research projects funded by the National agencies like UGC, CSIR, DST, MIT, AICTE, DRDO.The laboratory training in the department provides students with an exposure to the state of art technologies. This gives them practical skills to meet the growing challenges of industry, R & D and academics.

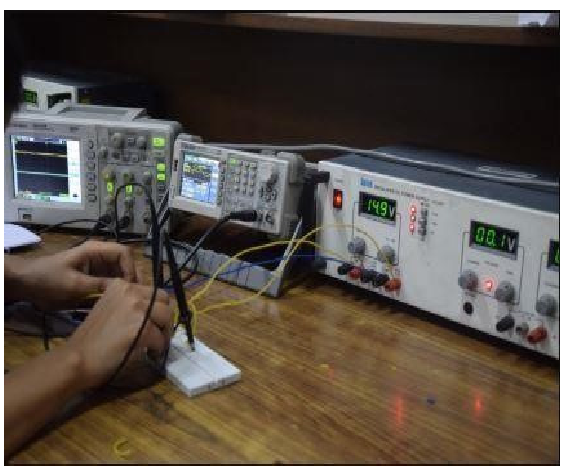
The computer facility of the department is equipped with the latest computers and software packages. A formal course in computational techniques provides all students an understanding of numerical techniques and efficient programming practice in high level programming languages. Students are encouraged to use C/C++. Use of mathematical tools like Mathcad and Matlab for solving class assignments is also encouraged. Circuit simulation tools like PSpice and Electronic Workbench as well as powerful simulation and design tools for microwave circuits are also available. Internet connectivity is available in the computer lab and other laboratories of the Department.

The semiconductor devices and materials laboratory provides experimental setups to study and measure various properties of semiconductor materials. These include Hall measurements, Fouprobe method, Vander Pauw Method etc. In addition, characteristics of semiconductor devices like UJT, FET, MOSFET, SCR etc. are also studied. Integrated Circuit Technology has revolutionized electronics. The laboratory provides an exposure to instruments needed in the initial steps for integrated circuits. This includes creation and measurement of vacuum, deposition of thin films on substrates and pattern transfer techniques like photolithography. A C-V plotter is also available to study the characteristics of devices. More recently sophisticated facilities like x-ray diffraction, UV-VIS-NIR spectrophotometer and Kiethley source-meter have been added with support from the DST(FIST)grant.

The Microprocessors laboratory course provides a system level understanding of the 8086 microprocessor involved in the design of microprocessor based electronic equipment. It involves in depth studies of software architecture, instruction set and assembly level programming with PC interfacing. The students also undertake the programming of the microcontroller 8051 and the interfacing of peripherals. Digital Signal Processing technology and applications have seen a rapid growth over the last decade. An exposure to this technology is provided through TMSC2054 DSP chips in standalone mode and with a PC interface. It includes programming for arithmetic operations, waveform generation and the more complex filter designs.

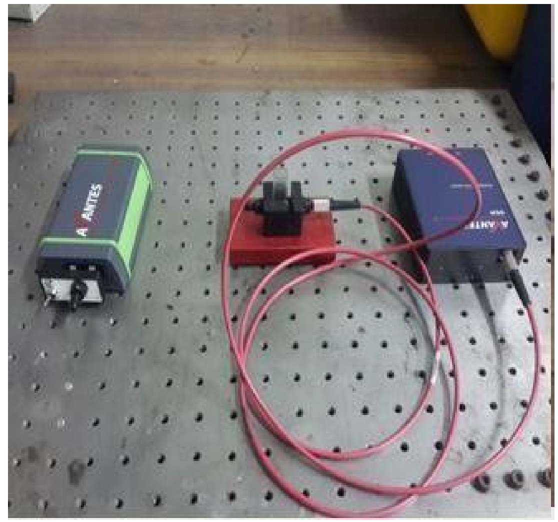
The circuit design laboratory focuses on design of both analog and digital circuits. For a better understanding the design exercises are carried out using discrete active and passive components as well as ICs. Circuit design and simulation software packages like Multisim, PSpice VHDL, active HDL and Electronic Workbench are also used for design and simulation before hardware implementation. Kits for FPGA implementation of digital design are also there. This gives the students a first exposure to design tools used in the semiconductor industry. Advanced simulators like 2D ATLAS, 3D ATLAS, MADICHI and ISE TCAD are also available for use in project work by students.

Communication laboratory provides a package of experiments that give practical understanding and implementation of Analog and Digital Communication Circuits. It includes basic experiments such as AM, FM, PAM, PWM, PCM, DM, and their application in transreceiver systems.

The experiments on system control include SCR controlled DC motor, DC and AC servo motors, error signal generation, angular variation & analysis, PID control of DC motor with computer interface, Programmable Logic Controller (PLC) and DC Motor Position Control.

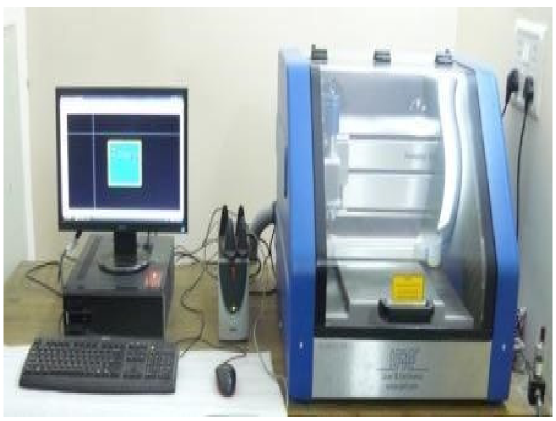
The optical electronics laboratory begins with simple experiments designed to understand wave phenomena like diffraction, polarization, Fourier Optics with a laser source on an optical bench. Online pattern measurements by a CCD array connected to a PC have also been introduced. This is followed by characterization of optical sources and detectors, optical fibers and demonstration of optical communication. Fiber splicing machine is also there in the Lab. In addition assignments based on the software package "Understanding Fiber Optics on a PC" provide a comprehensive understanding of the optical fibre. Powerful tools like BPMCAD from OPTIWAVE, RSOFT, PHOTON DESIGN for design of integrated optical devices based on the beam propagation method, BPMCAD from OPTIWAVE is also available for design projects. Units for understanding lasing action in Nd-Yag laser and study of non-linear effects have also been introduced.



The Microwave laboratory, with benches for experimental work at the X-band, provides the basic training on microwave measurements. These measurements introduce the basic concepts of waveguides and transmission lines, characterization of Gunn and Klystron sources, cavity resonators, directional couplers etc. Measurements on an antenna turn-table provide basic understanding of the antenna radiation pattern and its parameters. Sophisticated equipment such as Network Analyzer with RF source is also available for measurements on Microwave Integrated Circuits. Advanced Microstrip Trainer Kit is also available in the Lab to impart knowledge about microwave circuits using microstrip technology.

The design and simulation of microwave -integrated circuits forms an important component of the M.Tech. Course. The department has over the time procured some of the electromagnetic simulators: Ensamble from ANSOFT, IE3D and Empire, EESOF's advanced design software and Momentum. Later on the department is equipped with 3D simulators like Computer Simulation Technology (CST) and ANSYS High Frequency Structure Simulator (HFSS). As part of the curriculum students design and simulate various planar microwave circuits like filters, couplers etc., get them fabricated on Rapid Prototype PCB machine LPKF ProtoMat® S100 and finally test them with measurements on the Scalar Network Analyzer and Vector Network Analyzer R&S ZVH8. Also, the radiation characteristics of antenna can be tested in in-house anechoic chamber.






DST –FIST Programme

The department has received major grants from DST under FIST (Funds for Improvement of S&T Infrastructure) programme [448] [PSI-075]. In this programme, three instruments namely Xray diffractometer, UV VIS NIR spectrophotometer and source meter has been procured and commissioned by the department.

FACULTY

	Dr. Harsupreet Kaur (Head of Department) (Associate Professor) Specialization: Microelectronics (Semiconductor Device Modeling and Simulation). Email: harsupreetkaur@gmail.com
	Sr. Professor Mridula Gupta Specialization: Communication, Microwaves and Microelectronics Email id: mridula@south.du.ac.in
	Prof. Manoj Kumar Khanna (Professor) Specialization: VLSI, Communication, Material Science. Email: dr_manojkhanna@yahoo.co.in
	Dr. Kamlesh Patel (Associate Professor) Specialization: Microwave components and characterization. Email: kpatel@south.du.ac.in
	Dr. P. Koteswara Rao (Associate Professor) Specialization: Semiconductor Materials and Devices. Email: krao@south.du.ac.in
	Dr. Vanita jain (Associate Professor) Specialization: Soft Computing, Control Systems, Optimization, System Engineering Email: jain_vanita2001@yahoo.co.in

	Dr. Ashwani Kumar (Associate Professor) Specialization: RF and Microwave Passive Components, Antennas, Electromagnetics, Metasurface, Metamaterial, and Microwave and Terahertz Absorber Email: ashwanikumar7@yahaoo.com
	Dr. Mukesh Kumar Khandelwal (Associate Professor) Specialization: Electromagnetics, RF & Microwave, Microstrip Antennas, MM wave antennas, MIMO, Metamaterials Email: mukesh.khandelwal89@gmail.com
	Dr. Manoj Kumar Mukul (Associate Professor) Specialization: Biomedical Signal Processing, Brain-Computer Interface
	Dr. Biswajeet Mukherjee Associate Professor Specialization: Dielectric Resonator Antennas, Antenna Engineering, Microwave Active & Passive Circuits design, Computational Electromagnetics in FDTD, Product Design in Electronics Email: biswajeetmukherjee@south.du.ac.in, biswajeet.26@gmail.com
	Dr. Amit Birwal (Assistant Professor) Specialization: Microwave Communications, Antenna Design, Internet of Things (IoT), RADAR Email: amit.birwal@south.du.ac.in
	Dr. Yogesh Pratap (Assistant Professor) Specialization: Semiconductor devices, Nanoelectronics, Nano-Bioelectronics, Modelling & Simulation, Email: yogeshpratap@south.du.ac.in

	Dr. Vikram Kumar (Assistant Professor) Specialization: RF & Microwave Devices, Modern Antennas Email: vikram@south.du.ac.in

ACADEMIC PROGRAMMES

The Department offers the following programmes at the University of Delhi South Campus

1. **M.Tech. (Microwave Electronics)**
2. **M.Sc.(Electronics)**
3. **Ph.D in Electronic Science**

Master of Technology (MICROWAVE ELECTRONICS) –Two year degree programme

The M.Tech programme in Microwave Electronics is a four semester, i.e., a two year programme.
This programme was initially sponsored by the Department of Electronics, Government of India in 1976. The aim of the programme is to provide necessary theoretical background and practical experience in the fields of Microwave Devices and Circuits, Microwave Communication, Electromagnetics and Antennas, Microwave Integrated Circuit (MIC), and CAD for Microwaves.

ELIGIBILITY FOR THE M.Tech. COURSE

The eligibility requirements for applying to M.Tech in Microwave Electronics Entrance Test are as follows:

A candidate seeking admission to this course must have passed M.Sc. Electronics or M.Sc. Physics with specialization in Electronics of this University or an equivalent examination of other Universities with at least 60% marks or an equivalent grade.

OR

A candidate seeking admission must have passed B.E. Electrical/Electronics/Electronics and Communication/Instrumentation Engineering from University of Delhi or an equivalent examination of other Universities with at least 60% marks or an equivalent grade.

Candidates appearing for the final year of qualifying examinations can also apply provided they are in a position to obtain their qualifying degree before October of the year of admission.

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AGE REQUIREMENT

No student will be qualified for admission to the M.Tech course unless he/she is 21 years of age on or before 1st October of the year of admission. Relaxation of age limit up to a maximum period of six months on the basis of individual merit may be granted by the Vice-Chancellor.

SELECTION PROCEDURE

Candidates for M.Tech. Course will be selected for admission to 33 seats (13 UR, 5 SC, 3 ST, 9 OBC, 3 EWS) on the basis of performance in the entrance test. Out of these, the first 10 students will be eligible for a scholarship of Rs.600/- per month. The applicants seeking admission under Persons with Benchmark Disabilities **(PwD)** and **CW (Armed Forces Quota)** category need to register online as per schedule notified by the University

SEAT DISTRIBUTION

Total Seats: 33(Entrance) + 4*(Sponsored)

Number of seats Offered - Entrance Based					
Total Seats	UR	SC	ST	OBC	EWS
33	13	5	3	9	3

*Four seats are reserved for candidates sponsored by Government R&D Laboratories like DRDO, ISRO, CSIR etc. The sponsored candidates will be considered directly for admission. These candidates need not register on the admission portal. It was recommended that a special provision be made so that sponsored candidates are allowed to fill up form after regular admission and pay fees.

ENTRANCE TEST

The online entrance test (of 2 or 3 hour duration) is conducted by the University or University appointed organization (details available during online application). In general, the test paper is of multiple choice objective type questions and further detail of the instructions will be available on the test paper. The test is based on the following topics:
Engineering Mathematics, Networks Analysis, Basics of Computer Programming and Numerical Techniques, Semiconductor Devices, Analog and Digital Communication, Electromagnetics, Transmission Lines and Basics of Microwaves.

All requisite details about the programme are available at **http://electronics.du.ac.in/**

ADMISSION LIST

The merit list of the candidates for provisional admission to the M.Tech course is put up on the Notice Board of the Department, PG admission section of Delhi University website (http://www.du.ac.in) as well as Department website (http://electronics.du.ac.in). Seats are offered to candidates included in the waiting list in order of merit as and when seats are available. Candidates are required to see the Notice Board of the Department, PG admission section of Delhi University website as well as Department website for this purpose.

ORDINANCE AND SYLLABUS

1. There shall be an M.Tech. Course in Microwave Electronics in the Department of Electronic Science under the Faculty of Interdisciplinary and Applied Science.

2. The duration of the course will be four semesters which is two academic years.

3. A candidate seeking admission to this course must have passed M.Sc. Electronics or M.Sc. Physics with specialization in Electronics of this University or an equivalent examination of other Universities with at least 60% marks or an equivalent grade.

OR

A candidate seeking admission must have passed B.E. Electrical/Electronics/Electronics and Communication/Instrumentation Engineering from University of Delhi or an equivalent examination of other Universities with at least 60% marks or an equivalent grade.

Scheme of Examination

1. English shall be the medium of instruction and examination.

2. Examinations shall be conducted at the end of each Semester as per the Academic Calendar notified by the University of Delhi.

3. The system of evaluation shall be as follows

3.1 Each theory paper will carry 100 marks out of which 20 marks shall be reserved for internal assessment based on test, seminar and assignments and 5 marks for attendance as per University guidelines. In the case of a student who repeats one or more theory papers, the internal assessment marks will be carried forward. The duration of written examination for each paper shall be three hours.

3.2 Examinations for practicals for each semester 1 and 2 will comprise of 100 marks. Practical examination for each semester 1 and 2 would be for 6 hours duration.

3.3 Examinations for practicals for third semester will comprise of 200 marks. Practical examination for third semester would be for 6 hours duration.

3.4 Students will be required to work on the major project in Semester IV. The project can be carried out either completely in the Department or in collaboration with some Industry or an R & D Organization. In the later case, collaboration is to be established by the individual project supervisor.
On completion of the project work, the candidate will submit a dissertation and appear in a viva-voce examination. Total marks for dissertation shall be 400. The minimum marks required to pass the fourth Semester shall be 50% in project. A candidate, who fails in the Semester IV Examination, will be required to repeat the Project. However, he/she may be allowed to complete it in the span period.

4.Examinations for courses shall be conducted only in the respective odd and even semesters as per the Scheme of Examination. Regular as well as Ex- Students shall be permitted to appear/reappear in courses of odd semesters only at the end of odd semesters and for even semester with the even. There will be no scope of improvement or revaluation.

PASS PERCENTAGE AND PROMOTION CRITERIA

(a) The minimum marks required to pass any paper in a semester shall be 40% in theory and 40% in Practical, wherever applicable. The student must secure 40% in the End semester Examination (30/75) and 40% in the total of End Semester Examination & Internal Assessment of the paper in each theory paper.
(b) No student will be detained in I or III Semester on the basis of his/her performance in I or III Semester examination; i.e. the student will be promoted automatically from I to II and III to IV semester.
(c) A student shall be eligible for promotion from 1st year to 2nd year of the course provided he/she has passed 50% papers of I and II semester taken together. However, he/she will have to clear the remaining paper/s while studying in the 2nd year of the programme.
(d) Students who do not fulfill the promotion criteria (c) above shall be declared fail in the Part concerned. However, they shall have the option to retain the marks in the papers in which they have secured Pass marks as per Clause (a) above.
(e) A student who has to reappear in a paper prescribed for semester I/III may do so only in the odd semester examinations to be held in November / December. A student who has to reappear in a paper prescribed for Semester II/IV may do so only in the even Semester examinations to be held in April / May.
(f) A student who reappears in a paper shall carry forward the internal assessment marks, originally awarded and the result will be prepared on the basis of candidate's current performance in the examination.
(g) A student who fails in any semester's practical examination will be declared fail in that semester and will have to later re-admission in the concerned semester in the span period only.

DIVISION CRITERIA

Successful candidates will be classified on the basis of the combined results of Part I and Part II examinations as follows:

Candidates securing 60% and above	:	1st Division
Candidates securing 50% and above but less than 60%	:	2nd Division
Candidates securing 40% and above but less than 50%	:	3rd Division

SPAN PERIOD

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of four years from the date of admission to the Part I/Semester 1 of the M.Tech. programme.

ATTENDANCE REQUIREMENT

No student shall be considered to have pursued a regular course of study and be eligible to take examination unless he/she has attended 2/3rd of the total number of lectures and practicals conducted in each semester, during his/her course of study.

NOTE:

a) The promotion/passing/attendance/other rules are subject to change from time to time by the University, and the rules prevailing at that time will be applicable.

b) Scholarship will be discontinued if the student fails to score at least 60% marks in any examination.

c) Subject to the statutes and ordinance of the University, M.Tech. Course student shall remain under the control and discipline of the Head, Department of Electronic Science.

PROGRAMME STRUCTURE

Part I: Semester I

1.1	Electromagnetic Theory and Transmission Lines	100
1.2	Microwave and MM-Wave Planar Transmission Lines	100
1.3	Microwave Measurement Techniques and Industrial Microwaves	100
1.4	Microwave Devices	100
1.5	Microwave Measurements Laboratory	100
	TOTAL	**500**

Part I: Semester II

2.1	Microwave Passive Components	100
2.2	Antenna Theory and Techniques	100
2.3	Communication Theory and Wave Propagation	100
2.4	Computational Electromagnetics	100
2.5	Computational Laboratory	100
	TOTAL	**500**

Part II: Semester III

3.1	Microwave Active Circuits	100
3.2	Communication Systems	100
3.3	Microwave Integrated Circuits (CAD, Fabrication and Measurements)	200
	TOTAL	**400**

Part II: Semester IV

4.1	Major Project (six months duration)	400
TOTAL (FOUR SEMESTERS)		**1800**

Detailed Syllabus

1.1 Electromagnetic Theory and Transmission Lines

Maxwell's equations, generalized current concept, energy and power, complete power, singularities of the field; Introduction to waves: Plane waves in dielectric and conducting media, reflection and refraction of waves; Basic theory of transmission lines; Computation of RLCG parameters of two wire and classical lines; Smith chart and its applications; Scalar, vector and Hertz potentials and their relations to fields, and gauges; Theorems and concepts: The source concept, duality, uniqueness, image theory, the equivalence principle, fields in half space, reciprocity, construction of solutions; Concept of modes, rectangular wave guide, rectangular cavity, partially filled wave guides, dielectric slab guide, surface guided waves, non-resonant dielectric(NRD) guide; Modal expansion of fields and its applications.

1.2 Microwave and MM-Wave Planar Transmission Lines

Review of development and application of the modern transmission line structures as interconnect and as a medium for realization of components for the MIC and MMIC; Quasi-static and frequency dependent closed form models of microstrip line for effective relative permittivity, characteristic impedance, and dielectric and conductor losses; Effect of conductor thickness, top shield and side-walls on the propagation characteristics of a microstrip line; Closed form models for the coplanar waveguide line for effective relative permittivity, characteristic impedance, and dielectric and conductor losses; Introduction to slot line; Characteristics of coupled microstrip and coupled coplanar waveguide; Circuit models of discontinuities in microstrip lines and the coplanar waveguides: Open ended, short, gap, step, bent, T--Junction. Microstrip line resonator; Microstrip patch resonators-rectangular, circular and ring; Quasistatic space domain and spectral domain analysis of microstrip line, coupled microstrip line and coplanar waveguide.

1.3 Microwave Measurement Techniques and Industrial Microwaves

Microwave Waveguide Components: Attenuators, phase shifters, matched loads, detectors and mounts, slotted-sections, E-plane tee, H-plane tee, hybrid tees, directional douplers, tuners, circulators and isolators; Signal generators: Fixed frequency, sweep frequency and synthesized frequency oscillators;

Noise sources and noise meters used in microwave measurements; Frequency meters and VSWR meters; Measurements of frequency, attenuation, VSWR and impedance; Cavity measurements: Q--factor, bandwidth; Dielectric and magnetic properties of materials: Cavity and Waveguide methods; Measurements of power: Calorimetric and Microwave bridges; Principles of time domain and frequency domain reflectometry, spectrum analyser and network analyser; Measurement of Scattering parameters of passive and active devices.

Microwave in process control instrumentation; Microwave waste disposal; Microwave in agriculture and medicine, hyperthermia etc.; Microwave heating; Microwave absorbers; EMC and EMI.

1.4 Microwave Devices

Microwave Transistor; Microwave Tunnel Diode; Varacter Diode; Schottky Diode; MESFET:
Principle of operation, equivalent circuit, cut off frequency, power frequency limitations; MOS Structures; MOSFET: mechanism, modes of operation, transconductance, max operating frequency and microwave applications; HEMT: Structure, operation, characteristics, transconductance and cut off frequency, microwave applications; Charge Coupled Devices (CCD); Transferred Electron Devices: Gunn Diode, LSA Diode, modes of operation, Microwave

Generation and Amplification; Avalanche Effect Devices: Read diode, carrier current and external current; IMPATT diodes.
Klystron: Velocity modulation process, bunching process, output power and beam loading; Reflex Klystron: power output and efficiency; Traveling Wave Tubes; Magnetron.

1.5 Microwave Measurements Laboratory

2.1 Microwave Passive Components and Circuits

The transmission line section as a basic component; Application of Thevenin's theorem to a transmission line; Transfer function of a transmission line section; T and PI representation of a transmission line section; Analysis of two ports and multiports network by using Z, Y and transmission matrix; S-parameter analysis of the microwave circuits; Conversion of Z, Y, transmission parameters and S-parameters; Matching networks: Reactive matching network using the lumped elements; Quarter wavelength transformer, multi section transformer matching section; Lumped planar components like capacitor, inductor and balun; Power divider, Branch line coupler, hybrid ring coupler, directional coupler; Analysis of these components using the S-parameters; Richard transformation and Kurda identities; Inverters, Design of microwave planar filters; Planar Non reciprocal devices: Circulator, delay lines and phase shifters; MEMS technology based microwave components like switches, filters, phase shifters and delay lines.

2.2 Antenna Theory and Techniques

Theory of electromagnetic radiation; Coordinate system and transformation of field quantities in different coordinate system; Basic concept and definition: Directive gain, side lobe, back lobe, polarization, co-polarization and cross polarization level, beam width, input impedance, bandwidth, efficiency; Various kind of antenna with applications; Formulation of radiation integrals and its application to analysis of wire, loop and helix type antenna; Theory of aperture antenna, including the Fourier transform method and application to slot, waveguide and horn antenna; Design consideration of parabolic reflector antenna; Microstrip antenna: Rectangular and circular patch; Feed to microstrip antenna: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch; Circularly polarized microstrip antenna; Theory of linear array: Two element and multi element array, isotropic and non-isotropic array, Binomial and Chebyshev distribution; Planar array, phased array and adaptive antenna; Feed network of microstrip antenna array; Antenna for mobile communication: handset antenna and base station antenna.

2.3 Communication Theory and Wave Propagation

Probability and random variables; Baye's theorem; Probability density and probability distribution functions, statistical expectation, moments and characteristic functions, various distributions, multiple random variables, transformation of PDFs; Random Processes: Basic concept, description of random process, correlation functions, Stationary and non-stationary process, ergodic process, power and energy;
Multiple random process; Random processes in frequency domain; Fourier transform of random processes, power spectrum of stochastic processes; Gaussian and White processes; Markov process; Various modulation systems and multiple access systems like FDMA, TDMA and CDMA.
Wave Propagation: Free space propagation model, ground reflection; Earth and its effect on propagation, terrain formation considerations and its effects on free transmission, Diffraction and scattering from obstacles; Atmospheric attenuation; Practical link budget; Troposphere propagation; Tropo system fading characteristics; Troposcatter loss calculations; Fading in LOS troposcatter; Statistical behavior of fading; Diversity techniques.

2.4 Computational Electromagnetics

Review of analytical methods; Green's function; Finite difference methods: Various finite difference schemes, finite differencing of PDEs, accuracy and stability of FD solutions; applications to guided structures such as transmission lines, waveguides; Finite Difference Time Domain Method (FDTD): Yee's FD algorithm, accuracy and stability, lattice truncation conditions, initial fields, programming aspects, absorbing boundary conditions for FDTD; Method of Moments: Introduction, Integral equations, Green's functions, applications to quasi- static problems, radiation problems, mutual impedance between linear elememts, mutual coupling in arrays, rectangular arrays, grating lobe considerations; Applications of FDTD and Method of Moments to wave guide, fin line, planar lines and planar antennas.

2.5 Computational Laboratory

3.1 Microwave Active Circuits

Introduction to RF and Microwave active circuits and its application to MMIC; Description of a complete system; Signal flow diagram; Equivalent circuit and models of microwave diode and transistor. S-parameter description of active devices; Classification of RF amplifiers for low noise, medium power and high power application; Biasing, stability and Noise consideration; Matching considerations for maximum power and minimum reflection; Design of microwave amplifier circuits: Narrow band amplifiers; broad band amplifiers, broadband matching; Classification and Design of microwave oscillators: characteristics and performance evaluation; Phase locked loop circuit; Basic mixer concept: Frequency domain characteristics, Single ended mixer design, Single and double balanced mixer. Design consideration and evaluation of a complete receiver and transmitter system.

3.2 Communication Systems

Introduction to Wireless Communication Systems; Global system for mobile(GSM): Cellular concept, System design, Transmission system; Receiving system; Frequency reuse; Channel interference and system capacity; Outdoor and indoor propagation models, small scale and multipath fading; practical link budget; Digital modulation with reference to wireless communication; Spread spectrum modulation; Modulation performances in fading and multipath channel; Multiple access techniques as applied to wireless communication; Pocket Radio system; Wireless networking: 1G, 2G, 3G wireless networks, traffic routing; wireless data service.

Introduction to Satellite Systems; Orbiting satellites, satellite frequency bands, communication satellite systems, satellite modulation and multiple access formats; Satellite systems in India; Satellite receiving systems, G/T ratio; Satellite uplink and downlink analyses in C, Ku and Ka bands; Spot beam, multiple beam, frequency reuse; Satellite transponder; Satellite front end. Introduction to Optical Communication Systems; Optical fibers, sources and detectors; Analog and Digital systems; Modulation and multiplexing; Power budget analysis; Synchronous optical networks (SONET/SDH); Fiber distributed data interface (FDDI).

3.3 Microwave Integrated Circuits

CAD of Microwave Integrated Circuits, fabrication and measurements.

4.1 Major Project (six months duration)

Course Outcomes and Program Specific Outcomes of M. Tech (Microwave Electronics)

Course Outcomes

COs for the course "Electromagnetic Theory and Transmission Lines"

CO1 Provides a good understanding of Electromagnetic Theory basics

CO2 allows detailed study of Transmission Line, with the use of EM Theory, Maxwell equations and Smith chart

CO3 helps to develop understanding in the propagation of EM waves

COs for the course "Microwave and MM-Wave Planar Transmission Lines"

CO1 gives introduction of Microwave planar transmission lines

CO2 describes the properties and behaviour of various transmission lines like microstrip line, strip line, coupled line and coplanar waveguide

COs for the course " Microwave Measurement Techniques and Industrial Microwaves"

CO1 describes the requirements of microwave parameters and their measurements using Microwave Instruments.

CO2 describes the exposure to Basic microwave measurement set up and helps to understand the propagation of microwaves and the role of each microwave components.

CO3 describes design and measurements for Electromagnetic Interference free environment.

COs for the course " Microwave Devices"

CO1 describes the basic construction details, working and operation of solid state devices, vacuum tubes based devices

CO2 helps to understand the non-linear applications in microwaves like amplifier, oscillator, mixer etc. using these devices

COs for the course "Microwave Measurements Laboratory"

CO1 supplements the learning developed by paper 1.1 - 1.4.

COs for the course " Microwave Passive Components and Circuits"

CO1 provides exposure to design microwave passive component, Transmission Line section basic component, microwave Filters, Non Reciprocal devices etc.

CO2 describes basics of MEMS Technology based Microwave Components.

COs for the course "Antenna Theory and Techniques"

CO1 describes working principle, parameters of antenna and antenna array

CO2 helps to understand the design aspect and application of different antennas like patch , horn antenna, array etc.

COs for the course "Communication Theory and Wave Propagation"

CO1 describes various Wave Propagation mechanism (Reflection, Diffraction, Scattering)

CO2 gives Concept of Random variables in Communication System Design

COs for the course "Computational Electromagnetics"

CO1 describes 2D and 3D Electromagnetic Solution Methods

CO2 provides the solution methods (FDTD, MOM, Green's Functions) used in various E-M solver software to solve different microwave structures.

COs for the course "Computational Laboratory"

CO1 provides an opportunity to design and analyze the various microwave passive components and use computational electromagnetic methods.

COs for the course "Microwave Active Circuits"

CO1 helps to learn the design techniques of active microwave circuits like amplifiers, oscillators, mixers.

CO2 develops understanding in deciding the features of such active components for certain applications

COs for the course "Communication Systems "

CO1 gives understanding in design requirement and types of various communication modes like Wireless Communications, Satellite Communications, Optical Fibre Communication.

COs for the course " Microwave Integrated Circuits (CAD, Fabrication and Measurements)"

CO1 provides design, fabricate and test the microwave components by the students

CO2 helps to develop various interpersonal skills like independent thinking, analytical, practical approach etc.

COs for the course " Major Project (six months duration)"

CO1 engages the students with external organization for their on-site training and exposure

CO2 exposes students to most advanced facility available in the Microwave field.

Program Specific Outcomes (PSO)

PSO1 Computer knowledge: computer facilities in the department can provide computational techniques, understanding of numerical techniques and efficient practices in programming languages.

PSO2 Engineering knowledge: The knowledge of mathematics, electronic engineering fundamentals, and modelling of electronic devices specialization to the solution of complex electronic problems.

PSO3 Analytical skills: The courses like engineering mathematics enhance the analytical skills which serve a useful background for other courses as well and is useful to those who wish to pursue higher studies in the areas of modeling and theoretical studies etc.

PSO4 Microwave Integrated Circuits: Design and simulation of passive components using 3D simulation tools.

Master of Science (ELECTRONICS) –Two year degree programme

The M.Sc. Electronics is a four semester programme initially started in 1984 with the aim to provide necessary theoretical background and practical experience in the field of Electronics.

About the M.Sc. (Electronics) Programme

The M.Sc. (Electronics) programme offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the programme are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars and assignments.

Three categories of courses are being offered in this programme: Core Courses (13 theory, 1 dissertation and 1 seminar courses offered by the Department), Elective Courses (students must opt for two out of six Elective Courses), and Open Elective (students may opt for any one Open Elective offered by either the Electronic Science Department or any other Department of the Faculty of Interdisciplinary and Applied Sciences). The Core Courses are of four/six/eight credits and include classroom as well as laboratory courses. A seminar on the recent topics of Electronics will presented by the students in Semester III and is worth two credits as a Core Course. A separate research- based course that leads to a dissertation and is worth eight credits is also one of the Core Courses. The Elective Courses are four credit courses and the Open Elective is a two credit course. The student is required to accumulate twenty-four credits each semester, a total of ninety-six credits, to fulfill the requirements for a Master of Science degree in Electronics.

Thirty percent of the total marks for each course will be awarded through Internal Assessment. Final examinations for two and four credit courses will be of two and three hours duration respectively while examinations for each laboratory-based course will be held over one day of six hours each for two credit courses respectively.

ELIGIBILITY FOR THE M.Sc. COURSE

Admissions to this course will be in two categories: (I) 50% seats by direct merit on basis of marks obtained in B.Sc. (Hons.) Electronics, University of Delhi (II) 50% seats by entrance examination. Eligibility requirements are given below:

<u>Seat Distribution:– Total seats-:40</u>

Number of seats Offered (College wise Distribution) - Entrance Based					
Total Seats	UR	SC	ST	OBC	EWS
20	8	3	2	5	2

Number of seats Offered (College wise Distribution) - Merit Based					
Total Seats	UR	SC	ST	OBC	EWS
20	8	3	2	5	2

Category I (Admission on Merit Basis)

S.No	Course Requirements	Marks Requirements
1.	B.Sc. (Hons.) Electronics from University of Delhi	60% marks

Category II (Admission on Entrance exam Basis)

S.No	Course Requirements	Marks Requirements
1.	B.Sc. (Hons.) Electronics from University of Delhi	50% marks or above
2.	B.Sc. (Hons.) Electronics from other Universities	50% marks or above
3.	B.Sc. (Hons.) Electronics, Instrumentation from University of Delhi	50% or above
4.	B.Sc.. (Hons.) Electronics, Instrumentation from other Universities	50% marks or above
5.	B.Sc. (Hons.) Physics from University of Delhi	50% marks or above
6.	B.Sc. (Hons.) Physics from other Universities	50% or above
7.	B.Sc. Programme with Electronics from University of Delhi	60% or above
8.	B.Sc. Programme with Electronics from other Universities	60% or above
9.	B.Sc.(H) with atleast 04 courses / 04 Generic Elective courses of Electronics	Atleast 24 credits as per CBCS guidelines of University of Delhi

ENTRANCE TEST

The entrance test (of 2 or 3 hour duration) is conducted by the University or University appointed organization (details available during online application). In general, the test paper is of multiple choice objective type questions and further detail of the instructions will be available on the test paper.

Entrance test is based on the syllabus of eligibility courses of the University with emphasis on Electronics.

The merit list of the candidates for provisional admission to the M.Sc course is put up on the Notice Board of the Department, PG admission section of Delhi University website (http://du.ac.in) as well as Department website (http://electronics.du.ac.in).

The final admission list under Category II will be released along with the list for Category I. Candidates qualifying for admission under Category I on merit basis as well as through entrance test under Category II will be considered for admission under Category I only and the seats released will be offered to candidates included in the waiting list for Category II in order of merit as and when seats are available.

Examinations, Minimum Pass marks, Promotion and Classification of Successful Candidates

1. English shall be the medium of instructions and examination.
2. Assessment of students' performance shall consist of:

   2.1 : Each four credit theory course will carry 100 marks of which 30% marks shall be reserved for Internal Assessment (IA) based on class test, seminar/presentation and assignments. A two credit theory course will carry 50 marks of which 30% marks shall be reserved for Internal Assessment. The IA of every course will include at least two of the above components, and the weightage given to each of the components shall be decided and announced at the beginning of the semester by the individual teacher responsible for the course.
   2.2 Regarding ESCC403: Project work shall be carried out in Semester IV and will be worth eight credits. The candidate will submit a dissertation at the end of the semester. Total marks for dissertation shall be 200 and evaluation will be based on project work, report and presentation.
   2.3 There shall be FOUR Semester examinations comprised in the course. The minimum pass marks shall be 40% in each theory paper and 40% in practicals in each of the three semesters (I, II & III) and 40% in Seminar. In IV semester it will be 40% in each theory papers, 40% in Project/Dissertation.

Pass Percentage & Promotion Criteria:

Pass percentage: The student is required to pass separately both in theory and laboratory-based examinations. Minimum marks for passing the examination shall be 40% in aggregate in theory courses, 40% in laboratory courses and 40% marks in dissertation.
Pass percentage & Promotion criteria from semester to semester: Within the same Part, the candidate will be promoted from one semester to the next (Semester I to Semester II and Semester III to Semester IV), provided the candidate has passed at least two of the papers of the current semester by securing at least 40% marks in each paper.

Note: A candidate will not be allowed to reappear (even if he/she is absent) in the practical examination except in very special cases with approval of Head of the Department.

Part I to Part II Progression:

Admission to Part II of the progam shall be open to only those students who have fulfilled the following criteria:

1. Have scored at least 40% marks in the laboratory courses of both Semester I and II

2. Have passed at least 75% of the theory papers (6 papers) offered in courses of Part I comprising of Semester I and Semester II by securing at least 40% marks in each of these six papers and

3. Have secured at least 40% in aggregate of all theory papers of Part I.

   Note: The candidate however will have to clear the remaining papers while studying in Part II of the programme in order to qualify for the receipt of a Master's degree.

Conversion of Marks into Grades: As
per University Examination rule

Grade Points:
Grade point table as per University Examination rule

CGPA Calculation:
As per University Examination rule.

SGPA Calculation:
As per University Examination rule

Grand SGPA Calculation:
As per University Examination rule

Conversion of Grand CGPA into Marks
As notified by competent authority the formula for conversion of Grand CGPA into marks is: Final %age of marks = CGPA based on all four semesters × 9.5

Division of Degree into Classes:
Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.

Attendance Requirement:
Students will be required to show a minimum of 75% attendance in every course in order to appear for the examinations at the end of each semester. In addition, five marks of the Internal Assessment component for every course will be reserved for attendance.

Span Period:

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of four years from the date of admission to the Part-I/Semester-I of the M.Sc.(Electronics) Programme.

Guidelines for the Award of Internal Assessment Marks (Semester Wise)

Theory courses: A four credit course will be evaluated for a total of 100 marks while a two credit course will be evaluated for a total of 50 marks. 30% of the total marks of every theory course shall be reserved for Internal Assessment. Internal Assessment (IA) for a theory course will be based on written class test, seminar/presentation and assignment. The IA of a theory course will include at least two of the above components, and the weightage given to each component shall be decided and announced at the beginning of the semester by the teacher (s) responsible for the course. Five marks will be reserved for attendance.

Laboratory courses: A two credit laboratory course will be evaluated for a total of 50 marks. 30% of the total marks of every laboratory course shall be reserved for Internal Assessment. Internal Assessment will be based on performance of experiments, maintenance of records of data and results obtained, and viva-voce.

Project work/dissertation: The eight credit project- based course will be evaluated for a total of 200 marks. Internal Assessment will be based on continuous evaluation of the student. The student will be evaluated on ability to search, read and assimilate literature related to the project, regularity and perseverance at experiments and maintenance of data notebooks.

Programme Structure:

The M.Sc. (Electronics) programme is a two-year course divided into four-semester. A student is required to complete 96 credits for the completion of course and the award of degree.

		Semester	*Semester*
Part-I	First Year	Semester I	Semester II
Part-II	Second Year	Semester III	Semester IV

Course Credit Scheme

Semester	Core Courses			Elective Course			Open Elective Course			Total Credits
	No. of papers	Credits (L+T/P)	**Total Credits**	No. of papers	Credits (L+T/)	**Total Credits**	No. of papers	Credits (L+T/P)	**Total Credits**	
I	4	16 + 8	24							**24**
II	4	16 + 4	20				1	4	**4**	**24**
III	4	14 + 6	20	3	4					**24**
IV	3	16 + 4	20	3	4					**24**
Total Credits for the Course										**96**

*For each Core and Elective Course there will be 4 lecture hours of teaching per week.

*Open Electives to the maximum total of 8 credits.

*Duration of examination of each paper shall be 3 hours.

*Each paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment.

Semester wise Details of M.Sc.(Electronics) Course

Semester I				
Number of core courses	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
ESCC101:Network Analysis and Synthesis	4	2	-	6
ESCC102:Semiconductor Devices and Material	4	2	-	6
ESCC103:Digital Circuit Design	4	2	-	6
ESCC104: Mathematical and Computational Techniques	4	2	-	6
Core course ‘n’ (total number) = 4	16	8	-	24
Total credits in core course	**24**			
Number of elective courses	**Credits in each elective course**			
Course	Theory	Practical	Tutorial	Credits
Elective course 1	-	-	-	-
Elective course ‘n’ (total number) = 0	-	-	-	-
Total credits in elective course	**-**			

Number of open electives	**Credits in each open elective**			
Course	Theory	Practical	Tutorial	Credits
Open elective	-	-	-	-
Total credits in open elective	-			

Note: Each theory core paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment. Each core paper has practical laboratory of 50 marks which is equivalent to 2 credits.

Semester II				
Number of core courses	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
ESCC201:Signals & Systems	4	-	-	4
ESCC202:Electromagnetics, Antenna and Propagation	4	2	-	6
ESCC203:Analog Circuit Design	4	2	-	6
ESCC204:Control Systems	4	-	-	4
Core course ‘n’ (total number) = 4	16	4	-	20
Total credits in core course	**20**			
Number of elective courses	**Credits in each elective course**			
Course	Theory	Practical	Tutorial	Credits
Elective course 1	-	-	-	-
Elective course ‘n’ (total number) = 0	-	-	-	-
Total credits in elective course	**-**			
Number of open electives	**Credits in each open elective**			
	Theory			Credits
ESOE101: Data Acquisition Systems#	4	-	-	4
Total credits in open elective	**4**			
#Open to students of other departments of FIAS also.				

Note: Each theory core and elective paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment. Each core paper has practical laboratory of 50 marks which is equivalent to 2 credits. The Open Elective of four credits will be of 50 marks out of which 38 marks shall be allocated for semester examination and 12 marks for internal assessment.

Semester III				
Number of core courses	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
ESCC301:Digital and Data Communication Systems	4	2	-	6
ESCC302:Photonics: Principles and Applications	4	2	-	6

ESCC303:Embedded System Design	4	2	-	6
ESCC304:Seminar	2	-	-	2
Core course ‘n’ (total number) = 4	14	6	-	20
Total credits in core course	**20**			
Number of elective courses	**Credits in each elective course**			
Course	Theory	Practical	Tutorial	Credits
ESEC101: RF and Microwave Systems*	4	-	-	4
ESEC102:VLSI Technology*	4	-	-	4
ESEC103: MEMS Devices*	4	-	-	4
Elective course ‘n’ (total number) = 1	4	-	-	4
Total credits in elective course	**4**			
***Student must opt for anyone of the three elective courses.**				
Number of open electives	**Credits in each open elective**			
	Theory			Credits
Open elective	-	-	-	-
Total credits in open elective	-			

Note: Each theory core and elective paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment. Each core paper except ESCC304 has practical laboratory of 50 marks which is equivalent to 2 credits.

Semester IV				
Number of core courses	**Credits in each core course**			
Course	Theory	Practical	Tutorial	Credits
ESCC401:Digital Signal Processing	4	2	-	6
ESCC402:Fabrication and Characterization Techniques for Electronics Devices	4	2	-	6
ESCC403: Dissertation	8	-	-	8
Core course ‘n’ (total number) = 3	16	4	-	20
Total credits in core course	**20**			
Number of elective courses	**Credits in each elective course**			
Course	Theory	Practical	Tutorial	Credits
ESEC104: Photonic Devices & Optical Communication*	4	-	-	4
ESEC105:Modern Communication Systems*	4	-	-	4
ESEC106: EMI & EMC*	4	-	-	4

Elective course ‘n’ (total number) = 1	4	-	-	4
Total credits in elective course	**4**			
***Student must opt for anyone of the three elective courses.**				
Number of open electives	**Credits in each open elective**			
	Theory			Credits
Open elective	-	-	-	-
Total credits in open elective	-			

Note: Each theory core and elective paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment. Each core paper except ESCC403 has practical laboratory of 50 marks which is equivalent to 2 credits. Dissertation (ESCC403) will be of 200 marks.

Selection of Elective Courses:

There should be a minimum 10 students opting for any elective course to run. ESEC101, ESEC102 and ESEC103 are being offered in Semester III. The student would choose any one of these three courses that would be worth four credits. ESEC104, ESEC105 and ESEC106 are being offered in Semester IV. The student would choose any one of these two courses that would be worth four credits. ESOE101 is an Open Elective being offered in Semester II. This course is open to students of other Departments of the Faculty of Interdisciplinary and Applied Sciences also. The students of the M.Sc. Electronics programme can also take up an Open Elective being offered by any of the other Departments of FIAS.

Course Wise Content Details for M.Sc.(Electronics) Programme

Detailed Syllabus

Semester I Course Code: ESCC101
Course Name: Network Analysis and Synthesis (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

To equip the students with rigorous theoretical and practical knowledge to analyze and synthesize networks.

Course Outcomes:

- Apply the knowledge of basic circuital law and simplify the network using reduction technique.
- Analyze the circuit using Kirchoff's law and network theorem.
- Infer and evaluate transient response, steady state response, network functions. • Equip with network synthesis study.

Unit I: Network Theorems: Applications of Thevenin and Norton's theorem, Reciprocity theorem, Compensation theorem, Superposition theorem & Tellegen's theorem.

Unit II: Time Domain Analysis of Networks: Differential equation approach (first and higher order differential equations), initial conditions in networks. Laplace Transformation: Introduction to the Laplace transform approach, partial fraction expansion, Heaviside's expansion theorem, transform impedance and transform circuits, network functions, poles and zeroes of network functions and restrictions on pole and zero locations for driving-point functions and transfer function, stability of active network .

Unit III: Two Port Network Parameters: Transmission and inverse transmission parameters, hybrid and inverse hybrid parameters, relation between parameter sets, and interconnection of two port network. Graph Theory: graph tree, link branches, basic tie and cut set, matrices for planar networks, loop and nodal method of analysis

Unit IV: Network Synthesis: Properties of Hurwitz polynomial and positive real function, synthesis of LC, RC and RL network, Foster form and Cauer form.

List Of Experiments (Marks 50):

Experiments will be based on the above syllabus.

Course Code: ESCC102 Course Name: Semiconductor Devices and Material (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective: To provide basic knowledge and concepts of Semiconductor materials and devices.

Course Outcomes:

- Ability to apply basic concepts of Inorganic and Organic Semiconductor materials for electronic device application in modern electronic industry.
- Detailed knowledge of various classifications and applications to VLSI, LEDs and solar cells.
- Holistic view of the latest progress in two-dimensional (2D)-one-dimensional (1D) and nano materials.
- Emphasis on nano-electronic applications such as Schottky barrier transistors, flexible Electronics.

Unit I: Inorganic and Organic Semiconductor: Energy bands, carrier transport, mobility, drift-diffusivity, excess carrier, injection and recombination of the excess carriers, carrier statistics; High field effects: velocity saturation, hot carriers and avalanche breakdown.

Unit II: Majority carrier Devices: MS contacts rectifier and non-rectifier, MIS structures, MESFET, hetero-junction, HEMT and band diagrams, I-V and C-V characteristics.

Unit III: MOS structures: Semiconductor surfaces; The ideal and non-ideal MOS capacitor band diagrams and CVs; Effects of oxide charges, defects and interface states. MOSFET: Structures and Device Characteristics, Short-Channel effects. Charge coupled Devices (CCDs), application to VLSI.

Unit IV: Nonvolatile Memory Device. Optoelectronic Devices: solar cell, photo detectors, LEDs, laser diodes. **Nano structures and concepts:** quantum wells, supper lattice structures, nanorod, quantum dot, CNTs, 2D materials: grapheme, BN, MoS_2 etc, matamaterials.

<u>List Of Experiments (Marks 50):</u>

1. To study the Hall Effect: determine the Hall coefficient, type of semiconductor and carrier concentration in the given semiconductor sample.
2. To study the four probe method: calculate the resistivity and energy band gap of given semiconductor sample.
3. To determine the resistivity of the given semiconductor specimen using Vander Pauw method.
4. To design a MOSFET as switching regulator for given duty cycle and plot the current-voltage (I-V) characteristic of MOSFET using Keithley.
5. To design a phase controlled rectifier using SCR and plot the I-V characteristic of SCR using Keithley.
6. To design a relaxation oscillator using UJT and plot the I-V characteristic of UJT using Keithley.
7. I-V characteristics measurement of a p-n diode/LEDs using Keithley - calculate its ideality factor.

Course Code: ESCC103

Course Name: Digital Circuit Design (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:

The course offers students to learn how to minimize the Boolean expression by advanced digital design techniques, programmable logic devices; to understand analysis, designing and reduction techniques for sequential circuits by using Algorithmic state machine and asynchronous sequential circuit design by using transition table. Also course explains concept of fault diagnosis; VHDL programming language and digital designing tools like FPGA, ASIC.

Course Outcomes:

- To learn how to design digital systems, from specification and simulation to construction and debugging.

- To learn techniques and tools for programmable logic design.
- To understand the limitations and difficulties in modern digital design, including wiring constraints, high-speed, etc.
- To design, construct, test, and debug a moderate-scale digital circuit.
- Familiarity with the latest state-of-the-art system on chip (SoC) design methods using FPGAs and ASIC design chips.
- Through the practical assignments, experience will be achieved from both using tools as well as designing their own system.

Unit I: Introduction to Computer-aided design tools for digital systems: SIMO, MIMO. The tabulation method(Quin Mc-clusky), Determination of Prime implicants, Selection of Essential Prime implicants, Iterative Consensus, Generalized Consensus method, Map-entered variables method of Multiple output minimization.
Analysis and Design of combinational System: Multiplexers, ROMs, PLAs, PALs, SPLDs, SRAM.

Unit II: Sequential Circuit Design: Analysis of clocked synchronous sequential circuits and modelling-State diagram, state table, state table assignment and reduction-Design of synchronous sequential circuit design of iterative circuits-ASM chart and realization using ASM.

Unit III: Asynchronous Sequential Circuit Design: Analysis of asynchronous sequential circuit, flow table reduction, races-state assignment, transition table and problems in transition table, design of asynchronous sequential circuit-Static, dynamic and essential hazards, data synchronizers, mixed operating mode asynchronous circuits, Clock skew, set up and hold time of a flip-flop. Behavioral models of combinational and sequential logics.

Unit IV: Fault Diagnosis and Introduction To VHDL: Introduction to testing and fault diagnosis in digital circuits: fault modeling, test generation and fault simulation, fault diagnosis, design for testability and built-in self-test.
Introduction to VHDL Programming language, data objects, classes and data types, Operators, Overloading, and logical operators. Types of delays Entity and Architecture declaration, Introduction to behavioral, dataflow and structural models Application of Functions and Procedures, Structural Modelling, component declaration, structural layout and generics
Introduction to FPGAs, ASIC Programming Technology for designing and its device Architecture.

Digital Circuit Design Lab List of Experiments (Marks 50):

Experiments based on above the theory course.

Course Code: ESCC104 Course Name: Mathematical and Computational Techniques (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

To improve and summarized the mathematical and computational techniques among the students.

Course Outcomes: On completion of this course, student able

- To apply various techniques to solve homogenous and non-homogenous differential equations to describe various physical phenomenon.
- To apply partial differential techniques to solve the physical engineering problems.
- To implement transform techniques to designing electrical circuits, solving differential and integral equations.

- This course also provides a theoretical and practical knowledge of working with MATLAB and helps to get jobs in software industry which also helpful for those who go for higher studies.

Unit-I

Ordinary Differential Equations: Introduction to first order, second order, homogeneous, non-homogeneous equations, system of equations.

Orthogonal Functions in Mathematical Physics and Engineering: Bessel Functions, Spherical Bessel Functions, Legendre Polynomials, Associated Legendre Polynomials, Hermite Polynomials, Laguerre Polynomials, Associated Laguerre Polynomials, Chebyshev Polynomials – corresponding differential equations, graphical representation and orthogonality.

Sturm-Liouville's problem: applications and examples. Green's function technique and its application. Calculus of variations with examples.

Unit-I

Laplace Transform: Definition and Properties, Laplace Transform derivatives and integrals, Evaluation of differential equations using Inverse Laplace Transform, Applications of Laplace Transform to Integral Equations and ODEs. **Fourier Series & Transform**: Definition and Properties, Fourier Series in the Interval, Uses of Fourier Series, Physical Examples of Fourier Series, Fourier sine and cosine transform of Derivatives, Finite Fourier Transform, Applications of Fourier Transform.

Unit II:

Partial differential equations: Homogeneous and non-homogeneous boundary conditions, Solutions by separation of variables and series expansion methods. Laplace, wave and diffusion equations in various coordinate systems. **Integral equations:** methods and solutions,

Unit IV:

MATLAB environment: Managing the workspace, Matrix and Vectors, Matrix and Array operations, Arithmetic and Logical operations. Creating simple plots, MATLAB scripts and functions (m-files), Control structures (if, if-else, else-if, switch, for, while etc).

Computational Techniques using MATLAB: Numerical Integration & Differentiation, Linear system of equations, Fourier and Laplace transform. Plotting of data: contour plot, surface plot, mesh plot, 3-D plot etc.

<u>List of Experiments(Marks 50):</u>

Experiments based on above theory course.

Semester II Course Code: ESCC201 Course Name: Signals & Systems (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

- The concepts and theories of signals and systems form the foundation for further studies in areas such as analog and digital communication, analog and digital signal processing, control systems and circuit analysis and synthesis.
- The aim of building complex systems that perform sophisticated tasks imposes on students a need to enhance their knowledge of signals and systems so that they are able to effectively use the rich variety of analysis and synthesis techniques in an application-specific manner.

Course Outcomes:

- By the end of course, students will be able to understand mathematical description and representation of both continuous-time and discrete-time signals and systems and their properties.

- Further, the fundamental input-output relationship for LTI systems and the concept of correlation of energy and power signals will be discussed.
- Through this unit, students will learn about the concept of frequency domain representations and how to decompose periodic signals into their frequency components.
- Through this course, students will learn about sampling of continuous-time and discrete-time lowpass and bandpass signals.
- This course will discuss block diagram representation of a system, and methods of realization of a given system H (z) through different realization structures.
- Students will be able to correlate the Laplace and Z-transforms of sample signals and understand mapping of s-plane into the z-plane.

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

Unit II: Introduction to Fourier Transform: Fourier analysis, continuous and discrete time Fourier series and its properties, Fourier Transform for continuous and discrete time signals. Magnitude and phase spectra of continuous and discrete time signal, response of LTI system using Fourier transform. Applications of Fourier transform.

Unit III: **Sampling:** Sampling theorem for low-pass signals, aliasing, sampling techniques, Impulse sampling, Natural sampling, Flat-top sampling, Aperture effect.

Unit IV: **The Laplace Transform:** The Region of Convergence for Laplace Transforms. The Inverse Laplace Transform. Geometric Evaluation of the Fourier Transform from the Pole-Zero Plot. Properties of the Laplace Transform. Some Laplace Transform Pairs. The Unilateral Laplace Transform.

Unit V: **The z- Transform:** Basic principles of z-transform, z-transform definition, Unilateral and Bilateral Z-Transform, Relationship between z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of z-transform, Poles and Zeros, Inverse z-transform using Contour integration, Power Series expansion and Partial fraction expansion.

Course Code: ESCC202 Course Name: Electromagnetics, Antenna and Propagation (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:

The student learns the fundamental solutions of time-varying Maxwell's equations, and applies them to design antennas. The student understands radio wave propagation phenomena in modern communication systems, and fundamentals of electromagnetic radiation with application to antenna theory and design.

Course Outcomes:

- Use of electromagnetics, physics, and mathematics to understand fundamentals of antennas.
- Understand important and fundamental antenna engineering parameters and terminology,
- Learn the basic concepts of electromagnetic wave radiation and reception,
- Develop the basic skills necessary for designing a wide variety of practical antennas and antenna arrays.

Unit I: Maxwell's equations and Electromagnetic Wave Propagation: Maxwell's equations, constitutive relations, wave equation, plane wave functions, wave propagation in lossy dielectric, plane waves in lossless dielectrics, power and Poynting vector.
Unit II: Transmission lines: transmission line equation in time and frequency domain, losses and dispersion, reflection from an unknown load; quarter wavelength, single stub and double stub matching; Smith Chart and its applications.
Unit III: Waveguides: Rectangular waveguide, circular waveguide, dielectric slab waveguide surface guided waves, TE and TM modes, waveguide components.
Unit IV: Antennas: Antenna parameters, radiation from simple dipole and aperture, concept of antenna arrays, end fire and broadside arrays, horn antenna, microstrip antenna, parabolic disc antenna. Ground wave, space wave and ionospheric propagation. Communication link budget for ground transmission

List of Experiments (Marks 50):
Experiments will be based on this syllabus.

Course Code: ESCC203
Course Name: Analog Circuit Design (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:
- To develop the ability design and analyze MOS based Analog VLSI circuits to draw the equivalent circuits of MOS based Analog VLSI and analyze their performance.
- To develop the skills to design analog VLSI circuits for a given specification.

Course Outcomes:
At the end of the course student will be able
- To draw the equivalent circuits of MOS based analog circuits and analyze their performance.
- To analyze the frequency response of the different configurations of an amplifier.
- To understand the feedback topologies involved in the amplifier design. • To appreciate the design features of the differential amplifiers.

Unit I: Basic MOS device Physics: MOS I/V characteristics, Second order effects, MOS device models, Short channel effects and device models.
Single-stage amplifiers: Basic concepts, Common source stage, Source follower, Common gate stage, Cascode stage.

Unit II: Differential amplifiers: Single ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS loads, Gilbert cell.
Passive and active current mirrors*:* Basic current mirrors, Cascode current mirrors, Active current mirrors.

Unit III: Frequency response of amplifiers: Common source stage, Source followers, Common gate stage, cascode stage, Differential pair.
Noise: Types of noise, Representation of noise in circuits, Noise in single stage amplifiers, Noise in differential pairs.

Unit IV: Feedback amplifiers: Feedback topologies, Effect of loading.

Operational Amplifiers: One stage OP Amps, two stage OP Amps, Gain boosting, Common-mode feedback, Input range limitations, Slew rate, Power supply rejection, Noise in Op Amps, Stability and frequency compensation.
Bandgap references, Introduction to switched capacitor circuits, Nonlinearity and mismatch.

List Of Experiments (Advanced Analog Design**) (Marks 50):** Experiments will be based on above syllabus.

Course Code: ESCC204 Course Name: Control Systems (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Course Objective:
This course is to develop an understanding of the fundamentals of control theory, determine and use models of physical systems in forms suitable for use in the analysis and design of control systems. In particular understand: the concept of feedback and its properties; stability analysis of a feedback system; the concept of stability and stability margins; the different tools that can be used to analyze the properties of control system and the steady state error in control system.

Course Outcome: This course is to develop an understanding of the elements of classical control theory as applied to the control of real life applications such as spacecraft, car etc. In particular understand: the concept of feedback and its properties; the concept of stability and stability margins; and the different tools that can be used to analyze the properties of control system.
Unit I: Introduction to Control systems: Necessity and examples of control systems, feedback control systems. Mathematical modeling of: electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-spacemodelling of dynamical systems, Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, Time-invariance versus nonlinearity and time-variance Linearization, Distributed parameter systems

Unit II: Mathematical models: Obtaining solutions from mathematical models, Poles and zeros and their effects on solutions, Transient response of second order system, Time domain specifications for unit step response, Steady state error-linear continuous data control system. Generalized error coefficient and its evaluation, Correlation between static and dynamic error coefficients.

Unit III: Feedback control systems: Basic idea of feedback control systems, Definition of stability. Routh-Hurwitz test.Lyapunov theory.Bode plot, Nyquist plot, Nyquist stability criterion, gain and phase margins, and robustness. The root-locus technique, steps in obtaining a root-locus. Design of controllers using root-locus,Error analysis,

Unit IV: P, PI, PD and PID controllers: Proportional (P), Proportional Integrator(PI), Proportional Derivative(PD), Proportional Integrator Derivative(PID) controllers, Pole placement with state feedback, controllability. Pole placement with output feedback, observability, Luenberger observer LQR controlLead compensator, lag compensator, lead-lag/lag-lead compensators, and their design.

Course Code: ESOE101 Course Name: Data Acquisition Systems (Credits: 04)

Marks: 100 **Duration: 60 Hrs**

Course Objective:

In essence, the objective of this course is to reliably and accurately acquire and record data from a variety of sensors and external devices.

Course Outcomes:

- Understanding the concepts of acquiring the data from transducers/input devices, their interfacing and instrumentation system design.
- After the successful completion of the course the students will be able to elucidate the elements of data acquisition techniques.
- The course aims at developing the understanding of design and simulation of signal conditioning circuits.
- To develop and specialize the applications of a data acquisition, compose and organize new applications and to evaluate the system performance.

Unit I: Data Acquisition Techniques: Analog and digital data acquisition, Sensor/Transducer interfacing, unipolar and bipolar transducers, Sample and hold circuits, Interference, Grounding and Shielding.

Unit II: Data Acquisition with Op-Amps: Operational Amplifiers, CMRR, Slew Rate, Gain, Band-width. Zero crossing detector, Peak detector, Window detector. Difference Amplifier, Instrumentation Amplifier AD 620, Interfacing of IA with sensors and transducer, Basic Bridge amplifier and its use with strain gauge and temperature sensors, Filters in instrumentation circuits

Unit III: Data Transfer Techniques: Serial data transmission methods and standards RS 232-C: specifications connection and timing, 4 - 20 mA current loop, GPIB/IEEE - 488, LAN, Universal serial bus, HART protocol, Foundation -Fieldbus, ModBus, Zigbee and Bluetooth.

Unit IV: Data Acquisition System using computers (DAS):Single channel and multichannel, Graphical Interface (GUI) Software for DAS, RTUs, PC - Based data acquisition system

Semester III Course Code: ESCC301
Course Name: Digital and Data Communication Systems (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:
At the end of this course students will be able to visualize how analog signals are converted to digital signals for voice and data transmission; the concept of multiplexing to fulfill the demand of high speed digital transmission across the globe; the various methods of generation of digital signals (ASK,FSK,PSK,QAM) according to the application requirements; implement optimization techniques, data coding, channel requirements, signal to noise ratio, bandwidth, error finding within the received information and information theory.

Course Outcomes:

- With advent of areas such as GSM, GPS, Bluetooth, RFID, DTMF, Mobile, Ethernet, RF, XBEE, Networking, Data Acquisition, Smart city and Smart Card, Internet of things the knowledge of the subject is an essential need.
- Today multiplexing have become an extremely important asset to telecommunication processes and has greatly improved the way that we transmit and receive independent signals over AM and FM radio, telephone lines, and optical fibers.
- Digital communication has become ubiquitous for success in the workplace. It helps in networking, demonstrates efficiency, stable foundation for documentation etc.
- The most important part in transmission is noise immunity. So after understanding the above topics the students will be able to implement optimization techniques and will have a better understanding of data coding, channel requirements, signal to noise ratio, bandwidth, error finding within the received information

Unit I: Digital Transmission: Sampling and quantization, Low pass sampling – Aliasing, Signal Reconstruction, Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding of speech signal.PCM, DPCM, DM, ADM Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ – Manchester, ISI – Nyquist criterion for distortionless transmission Multiplexing**:** Many to one/one to Many, Frequency division Multiplexing, Time division Multiplexing, Multiplexing applications, introduction to multiple access techniques

Unit II: **Digital Modulation Scheme:** Random Processes and Spectral Analysis: Concept of Probability, Random variable, Random Process, Classification of Random Processes, Power spectral density **,** Method of generation and detection of coherent & non-coherent binary ASK, FSK & PSK, DPSK quadrature modulation/demodulation techniques.(QPSK and MSK),M-ary Digital carrier Modulation/demodulation, QAM

Unit III: Performance Analysis Of Digital Communication System: General Binary Signaling, Coherent Receivers for Digital Carrier Modulations, General Expression for Error Probability of optimum receivers.
Information Theory**:** Measure of Information, Source Encoding, Entropy, Channel capacity, Error Correcting codes: Hamming code, linear block codes, cyclic codes, Huffman coding, Shannon-Fano coding, code tree & Trellis diagram

Unit IV: Introduction To Data Communication and Networking: Data Communication, network architecture, Networks, Protocols and Standards, data link layer Standards Organizations. Line Configuration, Topology, Transmission Modes

Types of transmission media: Guided Media, Unguided Media, Transmission Impairments, Circuit switching

List Of Experiments (Digital Communication Lab) (Marks 50):

1. To analyze a PCM system and interpret the modulated and demodulated waveforms for a sampling frequency
2. To analyze a Delta modulation-demodulation and observe effect of slope overload
3. To analyze a FSK modulation system and interpret the modulated and demodulated waveforms
4. To analyze a PSK modulation system and interpret the modulated and demodulated waveforms
5. To demonstrate Time Division Multiplexing and De-multiplexing process using Pulse amplitude modulation signals
6. To simulate Binary Amplitude shift keying technique using MATLAB software
7. To simulate Binary Frequency shift keying technique using MATLAB software
8. To simulate Binary Phase shift keying technique using MATLAB software
9. To simulate Quadrature Phase shift keying technique using MATLAB software
10. To simulate Differential Phase shift keying technique using MATLAB software
11. Study of single bit error detection and correction using Hamming code

Course Code: ESCC302 Course Name: Photonics: Principles and Applications (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:

- Photonics is a key technology of the 21st century. It forms, for example, the basis for today's optical communications, environmental sensing, biomedical diagnostics in the life sciences, energy efficient lighting and solar energy harvesting.
- Upon completion of this course, students should understand the basic principles of modern physical optics and photonics. They should be able understand the principle of operation of modern photonic devices and optical communication.

Course Outcomes:

- Students will be able to understand the need for an electromagnetic description of propagation and properties of light waves.
- Students should understand the basic principles of light propagation and diffraction. They should be able to read the specifications of commercial optical instruments such as a scanner for a laser printer, or a spectrometer, and determine how these specifications impact the intended application.
- Students should understand the basic principles of various devices used in modern optical devices used in manipulation of optical signals and optical communication.
- Students will understand guided wave propagation, suface plasmon waves at metal interfaces and propagation through optical fibers in context to optical communication**,** the operation of lasers and optical fiber amplifiers which form the backbone of photonics technology*.*

Unit I: Light as electromagnetic wave: Review of Maxwell's equations and propagation of electromagnetic waves, various states of polarization, reflection and refraction of electromagnetic waves, Brewster angle, total internal reflection and evanescent waves, optics of metals.

Unit II: **Diffraction and Fourier Optics:** Fraunhofer Diffraction of optical waves propagating through apertures, the effects on the resolution of imaging systems and the spreading and focusing of optical beams, Gaussian beams, introduction to Fourier analysis for treating diffraction. Fourier Optics, basics of Fourier transformation, spatial frequency, Fourier transform by diffraction and a lens, spatial frequency filtering.

Unit III: Anisotropic Media and Crystal Optics: Plane waves in anisotropic media, wave refractive index, uniaxial and biaxial media, wave plates and analysis of polarized light, electro-optic effect andacousto-optic effect, application to modulators. Faraday effect, optical isolators.Sagnac effect, gyroscopes. Nonlinear optics and applications.

Unit IV: Guided Waves and Optical Fibers: Planar optical waveguides, Guided modes in symmetric dielectric waveguides, surface plasmon modes at dielectric metal interface, Step- and graded-index optical fibers, Multimode and single mode fibers, attenuation, material and modal dispersion, broadening of optical pulses in fibers. Introduction to guided wave integrated optical devices.

Unit V: Lasers: Interaction of radiation and matter, Einstein's coefficients, line shape function, condition for amplification. Optical resonators, resonator losses and Q-factor, condition for laser oscillations. Longitudinal and transverse modes. Some laser systems including fiber amplifiers and fiber lasers.

List Of Experiments (Marks 50):

Experiments based on the above theory course.

Course Code: ESCC303 Course Name: Embedded Systems (Credits: Theory-04, Practicals-02)

Marks: 100 **Duration: 60 Hrs**

Course Objective:

- Products using microprocessors generally fall into two categories-the first category uses high-performance microprocessors such as the Pentium in applications where system performance is critical.
- In the second category, performance is secondary while issues of space, power and rapid development are more critical than raw processing power.
- From this knowledge, the design and interfacing of microcontroller-based embedded systems can be explored.
- This course is especially important for practicing technicians, hardware engineers, computer scientists and hobbyists for building projects in which data is collected and fed into a PC for distribution on a network.

Course Outcomes:

- Students will be able to understand the general concept of embedded systems.
- Students will learn to compare and contrast microprocessors and microcontrollers, and the advantages of microcontrollers for specific applications.
- This unit will also elaborate on the history, architecture and instruction set of 8051 microcontroller.
- By the end of this unit, students will understand the variations of speed, packaging, memory and cost per unit and how these affect choosing a microcontroller
- To assemble and run an 8051 program, detailing the execution of assembly language instructions.
- Through this unit, students will be able to contrast and compare serial versus parallel communication.

- To assemble and run an 8051 program, detailing the execution of assembly language instructions.
- Through this unit, students will be able to contrast and compare serial versus parallel communication.

Unit I: Introduction to Embedded Systems: Sensors and Actuators, Examples and Real world applications of Embedded Systems, Recent trends in Embedded Systems, Requirements of Embedded Systems.

Unit II: Introduction to Microcontrollers: Overview of Microcontroller 8051, Architecture, Register Banks, Special purpose registers and Stack, On-chip RAM Space, Addressing Modes, Instruction Set.

Unit III: 8051 Microcontroller programming: Assembly language programming of 8051, Timer Programming in Assembly, 8051 Serial communication using USART protocol and Programming.

Unit IV: AVR Microcontroller: Integrated Development Environment (IDE) for Embedded Systems, Introduction to AVR family of Microcontrollers, AVR CPU, System Clock and Clock option.

Suggested Reading:

1. P.H. Dave, H.B. Dave,"Embedded Systems- Concepts Design and Programming", Pearson Publication.
2. Shibu KV,"Introduction to Embedded Systems", Tata McGraw Hill Publication.
3. M.A. Mazidi, J. G. Mazidi, R.D. McKinlay,"The 8051 Microcontroller and Embedded Systems", Pearson Publication.
4. M.A. Mazidi, S.Naimi, S.Naimi,"The AVR Microcontroller and Embedded Systems", Pearson Publication.

<u>List of Experiments (Marks 50):</u>

Experiments based on the above theory course.

Course Code: ESCC304
Course Name: Seminar (Credits: -02)

Marks: 100 **Duration: .... Hrs**

Students will give presentations on current and emerging topics of Electronics.

Semester III Course Code: ESEC101 Course Name: RF & Microwave Systems (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Pre-requisites: Maxwell's equations, Electromagnetic theory, basics of transmission lines, TEM, TE and TM modes of propagation, Electromagnetic Wave Propagation in waveguide.

Course Objectives:

Knowledge of microwave technology is essential in developing the systems for mobile communication, satellite and RADAR. Such systems consist of microwave active and passive components. A design concept for RF and microwave systems will enable students to use their expertise in industry as well as R & D institutions.

Course outcomes:

- To understand the basic concepts of microwaves and propagation through the transmission lines, microwave components
- To learn the requirement of impedance matching and techniques
- To understand the generation of microwaves through the vacuum-based tubes
- To understand the working of microwave active circuits and study of various microwave semiconductor devices.
- To learn the test methods at the microwave frequencies
- To understand the design and concepts of microwave communication
- To understand the working of RADAR and its types.

Unit I: Introduction to microwave transmission- applications and limitations: Review of transmission lines and their properties, Microwave components: Directional coupler, E&H plane Tee, Magic Tee, Circulator, Isolator, Frequency meter, Attenuator and Phase Shifter

Unit II: Impedance matching techniques: LC network, single and double stub tuning using the Smith chart, Tube based devices: klystron amplifiers, Reflex klystron oscillators, Magnetron oscillators, TWT amplifiers.

Unit III: Principles of Microwave amplifiers, oscillators and mixer: GUNN, IMPATT, TRAPATT, BARITT devices, PIN diode and TUNNEL diode.

Microwave Measurements: Power, Frequency, Impedance, VSWR, Network analyzer and spectrum analyzer.

Unit IV: Microwave LOS Communicatio: Microwave Transmitter and receiver systems, Introduction to RADAR, range equation, Continuous wave and Pulse radar, Synthetic aperture radar.

Course Code: ESEC102
Course Name: VLSI Technology (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

- To provide students with rigorous foundation in MOS and CMOS devices and circuits.
- To provide exposure to students and to equip them for semiconductor and VLSI industry, R & D organization in the area of microElectronics.

Course Outcomes:

- Implement the logic circuits using MOS and CMOS technology.
- Acquire the knowledge about various CMOS fabrication process and its modeling.
- Infer about the second order effects of MOS transistor characteristics.
- Analyse various circuit configurations and their applications.
- Analyse the merits of circuits according to the technology and applications.
  Understand the rapid advances in CMOS Technology.

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Unit I: Passive element and integrated circuit design: Semiconductor resistors, design of diffused semiconductor resistors, thin-film resistors, resistor tolerances, monolithic and MOS capacitors, Complementary MOS structures, pattern generation, mask-alignment tolerance, minimum layout spacings, layout of silicon integrated circuits.

Unit II: Basic MOS device physics and MOSFET operation: Enhancement and Depletion mode MOSFETs, MOS I-V characteristics, second order effects, MOS device layout, MOS device capacitances, scaling, short channel effects, fundamental limit to scaling, MOS Spice model, Spice level 1 model, level-2 model (including parasitic S/D resistance), Introduction to BSIM models.

Unit III: Basic MOS Inverter design: voltage transfer characteristics, logic threshold, NAND/NOR logic, inverter with resistive, enhancement and depletion loads, noise margin, transit time and inverter delay, CMOS inverter: complete analysis, pass transistor, switch level RC delay model.

Unit IV: MOS design rules: Combinational and sequential CMOS logic design, MOS memories and programmable logic arrays, non-volatile semiconductor memories with MOS technology, MOS layers, Stick diagrams, CMOS design rules and layout, Lambda and micron design rules, DRC, layout *vs* schematic checks.

Unit V: VLSI assembly technology and fabrication technologies: mechanism of yield loss in VLSI, modeling of yield loss mechanism, reliability requirements for VLSI: basic ideas of time dependent dielectric breakdown, antenna effect, IR drop and other reliability issues, Failure mechanism in VLSI, fault finding in VLSI chips, packaging of VLSI device, packaging type, packaging design consideration.

Course Code: ESEC103 Course Name: MEMS Devices (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Pre-requisites: Semiconductor theory, Electronics principles, Passive components, IC fabrication, Electromagnetic theory and measurements.

Course Objectives:

The objective of this course is to make students to gain basic knowledge on overview of MEMS (Micro Electro Mechanical System) and various fabrication techniques. This enables them to design, analysis, fabrication and testing the MEMS based components. And to introduce the students various opportunities in the emerging field of MEMS. In addition, students will learn how to design MEMS transducers and to explore design tradeoffs, circuit/system issues, device performance, and manufacturing of microsystems.

Course outcomes:

- To understand the definition of micromachining and MEMS as well as an historical perspective of this emerging field.
- To understand the fundamental properties of materials used for MEMS devices
- To gain a comprehensive perspective of various physical mechanisms for MEMS design
- To understand the fundamental principle of piezoresistive sensing, piezoelectric sensing, magnetostatic actuation and methods for fabricating
- To understand the principle and design of Polymer based MEMS, Optical MEMS, RF MEMS.

Unit-I Introduction to MEMS and microfabrication: History of MEMS development, characteristics of MEMS-miniaturization - micro Electronics integration -Mass fabrication with precision. Micro fabrication - microElectronics fabrication process- silicon based MEMS processes- new material and fabrication processing- points of consideration for processing.

Unit-II Electrical and Mechanical properties of MEMS materials: Conductivity of semiconductors, crystal plane and orientation, stress and stain – definition – relationship between tensile stress and stain- mechanical properties of silicon and thin films, flexural beam bending analysis under single loading condition- types of beam- deflection of beam-longitudinal stain under pure bending spring-constant, torsional deflection, intrinsic stress, resonance and quality factor.

Unit-III Sensing and actuation: Electrostatic sensing and actuation-parallel plate capacitor and its application and tactile sensor parallel Plate actuator- comb drive.
Thermal sensing and actuations-thermal sensors-actuators and its applications.
Piezoresistive sensors- piezoresistive sensor material- stress in flexural cantilever and membrane and its application.
Piezoelectric sensing and actuation- piezoelectric material properties-quartz-PZT-PVDF –ZnO and its applications.
Magnetic actuation- micro magnetic actuation principle- deposition of magnetic materials-design and fabrication of magnetic coil.

Unit-IV Polymer, RF and Optical MEMS: Polymers in MEMS- polymide-su-8 liquid
Crystal polymer(LCP)-PDMS-PMMA-parylene- flurocorbon, application-acceleration, pressure, flow and tactile sensors.
RF MEMS- Impedance tuners, Tunable filters, Phase shifters, Reconfigurable antennas
Optical MEMS-passive MEMS
Optical components-lenses-mirrors-actuation for active optical MEMS.

Semester-IV

Course Code: ESCC401
Course Name: Digital signal Processing (Credits: Theory-04, Practical-02)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

The field of digital signal processing has grown enormously in the past decade to encompass and provide firm theoretical backgrounds for a large number of applications such as communication and speech, seismology, Radar and Sonar theory, etc. The importance of digital signal processing will eventually surpass that of analog signal processing for the same reasons that digital computers have surpassed analog computers.Since digital signal processing, for the most part, relies on the theory of discrete-time linear time-invariant systems, this will be studied as a major unifying influence for the entire field.

Course Outcomes:

- This course will explain the methods of windowing, frequency sampling design and minimum peak error design used in algorithms for designing digital filters.
- Through this unit, students will learn the techniques of mapping of differentials, impulse invariant transformation, bilinear transformation and matching poles and zeros.
- The course will also enable students to design filters using modern optimization algorithms such as minimum mean square method, minimum absolute error method, equiripple methods and time domain optimization to match a prescribed time response.
  Students will be able to understand tradeoffs in complexities between the two classes of filters-FIR and IIR.

- By the end of this course, students will be able to understand the effect of quantization on digital filters and alsotwo-dimensional signal processing techniques.
- This course will also elaborate the application of DSP in Speech and RADAR.
- The course provides a comprehensive summary of the major areas of digital signal processing, including a powerful tool for analyzing discrete-time signals with the help of Z-transforms.

Unit I: Introduction to DSP: An overview of Digital Signal Processing (DSP), Theory of Discrete time Linear System (Representation of sequences, arbitrary sequences, LTI Systems, Causality, Stability, Difference Equations, Frequency response of 1^{st}& 2^{nd} Order Systems, Discrete Fourier series), Z-Transform(Unilateral & Bilateral Z-transform), Inverse Z-Transform, Properties of Z-Transforms, Convolution of Sequences (Infinite, Finite), Sectioned Convolution.

Unit II: **FIR Filters:** The Theory and Approximation of Finite duration Impulse Response Digital Filters (Issues in Filter Design), Characteristics of FIR filter with Linear phase and its frequency response, Positions of Zeros of linear phase FIR filters, Design techniques-windowing, Rectangular window, Generalized Heming window, Kaiser window, Examples of Window Low-Pass Filter, Issues with windowing and Solution for optimization.

Unit III: **IIR Filters:** Theory and Approximation of Infinite response Digital Filter, Some Elementary properties of IIR filters-Magnitude squared Response, Phase Response, Grouped Delay, Impulse invariant Transformation, Bilinear Transformation, Matched Z-Transformation, optimization method for designing IIR Filter.

Unit IV: Finite word length effects in digital filters, Spectrum Analysis and Fast Fourier Transformation, An Introduction to the theory of Two-dimensional Signal Processing, Applications of Digital Signal Processing to Speech, RADAR.

<u>List of Experiments (Marks 50):</u>

Experiments based on above theory course.

Course Code: ESCC402 Course Name: Fabrication and Characterization Techniques for Electronic Devices (Credits: Theory-04, Practical-02)

Marks: 100 **Duration: 60 Hrs**

Objective:

- The main objective is to train the manpower/students in the field of semiconductor science and technology relevant to modern electronic industry/technology.

Course Outcomes:

- Understanding the fabrication and characterization technology for electronic (micro & nano) and opto-electronic devices based on Inorganic and Organic materials
- Knowledge and skills necessary for device fabrication. This includes developing the ability to use clean room and vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
- Trained manpower will be conversant with various processes and instruments to characterize the electronic materials and devices at different level for real time application.

Unit I: Vacuum Science and thin film technology: Kinetic theory of gases, Production of Vacuum: Mechanical pumps, Diffusion pump, Getter and Ion Pumps. High Vacuum and Ultra High vacuum Systems: thermal and e-beam evaporation, sputtering, MBE etc. Atomic layer deposition, Electrodeposition, Spray pyrolysis, Spin coating.

Unit II: Surface modification of materials: thermal treatment, thermomechanical treatment, ion beam irradiation. Etching: dry etching, plasma etching, sputter etching, control of etch rate and selectivity, control of edge profile. **Lithography:** optical, electron beam, ion beam, X-ray lithography, lift off, dip pen nanolithography. Pattern generation. Fabrication of few devices like MMIC, laser diode etc.

Unit III: Spectroscopic Techniques: UV-visible-NIR Spectroscopy, Photoluminescence (PL), Raman Spectroscopy, X-ray photoelectron spectroscopy (XPS) and Transform Spectroscopy (FTIR).
Electrical Characterization: current-voltage (I-V) and capacitance-voltage (C-V), Deep Level Transient Spectroscopy (DLTS).

Unit IV: X-Ray Diffraction (XRD): The Bragg's condition, Laue method, Rotating crystal method, powder method, Determination of lattice type and crystal structure.

Electron Microscope: Scanning electron microscope (SEM), Transmission electron microscopy (TEM), Field Emission SEM.
Scanning probe microscopy: Atomic Force microscopy (AFM), Scanning tunneling microscopy (STM).

List Of Experiments (Fabrication and Characterization Techniques for Electronic Devices**) (Marks 50):**

1. To study the process of etching using ITO coated glass and design different shapes and copper cladded sheets for PCB design..
2. To determine the crystallinity of given semiconductor sample and crystallite size using Scherer formula using XRD technique.
3. To deposit the thin of MEHPPV on glass substrate using spin coating technique.
4. To calculate the band gap of thin film using UV-VIS absorption spectroscopy.
5. To study the photoluminescence in the deposited thin film.
6. To study the process of vacuum generation in a bell jar system and to deposit Aluminum thin film on glass substrate using thermal evaporation method. 7. Fabrication of Metal/Semiconductor contact and their characterization.

Course Code: ESCC403
Course Name: Dissertation (Credits: 08)

Marks: 100 **Duration: 60 Hrs**

Students will undertake projects to enhance their understanding in various emerging areas. This will help to equip students with the current trends and will instill in them a spirit of enquiry and scientific temperament.

Semester IV Course Code: ESEC104 Course Name: Photonic Devices and Optical Communication (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Course Objectives:

- Photonic Devices have emerged as the key technology for optical communications, environmental sensing, biomedical diagnostics in the life sciences, energy efficient lighting and solar energy harvesting.
- Upon completion of this course, students should understand the functioning and design of most photonic devices in use.

Course Outcomes:

- At the end of the Course students will be able to understand the basic components and devices of photonic integrated circuits.
- At the end of the Course, students should understand propagation in optical fiber couplers, fiber Bragg grating and long period fiber gratings and their applications
- At the end of Course, students should understand the area of silicon photonics which is an upcoming area of photonic integration with Electronics.
- At the end of Course students will understand the operation of optical communication systems, the limitations of photodiodes and avalanche photodiodes, understand direct optical amplification. explain the basics of optical modulation and multiplexing, design a fiber link of given length operating at a given wavelength, and at a prescribed bit error rate by use of optical repeaters and relate an integrated view of engineering by explaining the fundamental analogies between electrical and optical communication systems.

Unit I: Guide Wave Integrated Optic Devices: Planar and channel waveguides,Waveguide platforms on various materials and their fabrication techniques. Waveguide directional couplers,tapered waveguides and *Y*-junction splitters/combiners, Ring resonators, Mach-Zehnder interferometers/modulators.Sagnac interferometer/gyroscope. Coupling in and out of Photonic Integrated Circuits: Optical mode converters, prism and grating couplers.Wavelength-division multiplexing components: Mulitplexers, Demultiplexers, Multimode interferometers, Arrayed-waveguide gratings.

Unit II: **Fiber Optic Devices:** Splitters and combiners in optical fibers, fiber directional couplers as WDM component. Coupled mode analysis optical fiber Bragg and long period gratings, applications of fiber gratings as WDM components in add-drop multiplexers/circulators and fiber sensors.

Unit III: Silicon Photonics: Motivation towards silicon photonics, Silicon on Insulator (SOI) waveguides or nanowires.Optical fiber to silicon waveguide: edge, grating, evanescent coupling, spot-size converters.III-V integration with silicon photonics.Photonic modulators: electro-optical and thermo-optical effects. Phase and amplitude modulators.Thermal phase shifter, thermo-optic switch.Franz-Keldysh effect and FK electro-optical modulators.

Unit IV: Computational Photonics: Concepts of eigenmodesapproach, finite difference and finite element methods, finite difference timedomain(FDTD) methods and beam propagation methods. Identification of method that is amenable to a specific class of photonic structures, and themethod that should be avoided except in special circumstances and developand use basic computational codes for a variety of realistic applications inintegrated photonic structures.

Unit V: Solar Photovoltaics: Solar cell materials and their properties. Solar cell research: technology (silicon, organic, Dye sensitized, peroviakites), applications and limitations.Characterization and analysis: ideal cell under illumination- solar cell parameters,optical losses; electrical losses, surface recombination velocity, quantum efficiency - measurements of solar cell parameters; I-V curve & L-I-V characteristics, internal quantum yield measurements – effects of seriesand parallel resistance and temperature - loss analysis.Solar photovoltaic(PV) modules from solar cells, series and parallel connections, design and structure of PV modules.

Unit VI: Optical Fiber Communication: The fiber as a communication link, Step- and graded-index optical fibers. Multimode and single mode fibers, attenuation and dispersion, broadening of optical pulses in fibers.Transmitters and receivers, interaction of light with semiconductor materials: absorption and electroluminescence. Semiconductor light sources (Light emitting diodes and laser diodes) and photodetectors (PIN photodiodesand avalanche photodiodes), Semiconductor and fiber optical amplifiers. Optical Link Design: System Considerations, Photoreceiver noise, Bit error rates for attenuation and dispersion limited systems, Link Power Budget, Rise-Time Budget, Line Coding. Optical Networking and Switching: General Network Concepts, SONET/SDH, Optical Ethernet, Network Management, WDM light wave systems and WDM components.

List Of Experiments (Marks 50):

Experiments based on the above theory course.

Semester IV Course Code: ESEC105 Course Name: Modern Communication Systems (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Pre-requisites: Signals and systems, Fourier Transforms, concept of multiplexing and various modulation techniques, channel requirements, signal-to noise ratio and bandwidth.

Course Objective:

This course enables students to attain successful professional careers by applying their engineering skills in communication system design to meet out the challenges in industries and academia. The course develops a strong foundation in the field of Satellite Communication, earth and space subsystems involved and their importance; multiple access techniques, recent technological developments in Mobile communication systems; Understand what Internet of Things is, RFID Technology, Sensor Technology and Satellite Technology.

Course Outcomes:

- To provide students with strong fundamental concepts and also advanced techniques and tools to build various communication systems.
- To enable students to attain successful professional careers by applying their engineering skills in communication system design to meet out the challenges in industries and academia.
- To engage students in lifelong learning, adapt emerging technology and pursue research for the development of innovative products.

Unit I: Satellite Communication: Radiation and propagation of waves**:** fundamental of EM waves and their effects ground, sky and space waves propagation, Orbits and Launching Methods, Space Link Budget, Space and Earth Segment, Satellite Services;

Unit II: Wireless Communication: Fundamental concepts in wireless, Basic Terminologies, cellular technology, Standards evolved, Mobile Radio Propagation, Mobile System and Network Architectures, Advanced Wireless IP network Architectures, Wireless Standards.
Unit III: Data transfer and Computer Networking: Packet switching, ISDN, ATM, LAN, WAN, Internet and WAP, Digital Radio Communication Systems; Multiple Access Techniques: Frequency Hopping Spread Spectrum (FHSS) systems, Direct Sequence Spread Spectrum, Code Division Multiple Access of DSSS;

Unit IV: Internet of Things: Introduction, Fundamental IoT Mechanisms and Key Technologies, Radio Frequency Identification Technology, Resource management in IoT, IoT Privacy, Security and Governance, Business models for IoT

Semester IV Course Code: ESEC106 Course Name: Electromagnetic Interference and Compatibility (EMI & EMC) (Credits: Theory-04)

Marks: 100 **Duration: 60 Hrs**

Pre-requisites: Maxwell's equations, Electromagnetic theory, basics of transmission lines, microwave parameters and measurements.

Course Objectives:
Importance of product marking like CE is essential for widely acceptance for the electrical and electronic products. Knowledge of EMI generation and its reduction methods is integral part for designing any product at initial stage. A good design practice for compliance will make the students to incorporate their skills in the commercial world.

Course outcomes:

- To understand the EMI and EMC concepts and their importance for the electrical and electronic products
- To understand EMC standards and various test methods for EMI/EMC
- To learn the control techniques for EMI
- To understand the design process for EMC systems

Unit I: Introduction to EMI/EMC: EMI scenarios, EMI sources, coupling mechanism & modes- common and differential modes, EMI victims, classification of disturbance phenomena, Time & frequency domain analysis, Emission and Susceptibility.

Unit II: EMI/EMC Standards & Measurements: Standard making bodies, commercial & MIL Standards (FCC, CISPR etc.), Emission and Immunity tests, Test instrumentation, compliance & diagnostic testing.

Unit III: EMI Control Techniques: Grounding & Cabling, Filtering & Shielding, Transient suppression & ESD Control.

Unit IV: Design for EMC (Emission & Susceptibility control at PCB level): Components & Circuit selection, Circuit layout, Partitioning, Chassis bonding, Grounding, PCB stack-up, Transmission line termination, Decoupling, PSU design.

Ph.D in Electronic Science

Key Research Areas: Modeling and Simulation Studies of Microelectronic Devices and Materials, Thin films, Nano-materials & nanostructures (Electronic/semiconductor materials & Devices) for various applications, Material Science: Nano science/ Nano composites/ Nano technology, Microwave passive components and circuits, Microwave Antennas for advanced communications, Plasmonic waveguides and devices, Robotics and Artificial Intelligence, Embedded Systems and Automation, Integrated Optics, Cyber Physical Systems and Machine learning, Biophotovoltaics

ENTRANCE TEST

The entrance test (of 2 or 3 hour duration) is conducted by the University or University appointed organization (details available during online application) In general, the test paper is of multiple choice objective type questions and further detail of the instructions will be available on the test paper.

The test is based on the syllabus consisting following topics upto PG level:

Research Methodology: Vectors; Matrices; Special Functions; Complex variables; Differential Equations; Integral Equations; Numerical Techniques; Laplace and Fourier Transforms; MATLAB; Basic Computer Programming (C, C++).

Semiconductor Materials & Devices; Analog and Digital Circuits; Electromagnetic Theory; Microwaves: wave guides & transmission lines; Analog and Digital communication; Optoelectronics; Microprocessors and Microcontrollers

Note: 50% questions of entrance question paper from "*Research Methodology*"

ELIGIBILITY FOR Ph.D.

As per Ordinance VI-B of the University, after Ph.D registration, student has to complete the Ph.D course work and the syllabus for same has been given below.

All requisite details about the programme are available at the following link

http://electronics.du.ac.in/

Ph.D. COURSE WORK PREAMBLE

The Department of Electronic Science is offering the following **six courses** (each of 4 credits) as Ph.D. Course work for students admitted to the Ph.D. Programme in Department of Electronic Science:

1. **Research Methodology (ES-1)**
2. **Fabrication, Characterization Techniques for Electronic Materials (ES-2)**
3. **Mathematical and Computational Techniques (ES-3)**
4. **Modeling and Simulation of Semiconductor Devices (ES-4)**
5. **Microwave Antennas (ES-5)**
6. **Robotics and Artificial Intelligence (ES-6)**
7. **Research and Publication Ethics**

These are advanced level courses specifically designed for the doctoral programme and cater to the requirements of all research areas offered by the Department. As per UGC Regulations 2016 and Ordinance VI of University of Delhi the credits assigned to Ph.D. Course work shall be a minimum of 08 credits and maximum of 16 credits. Course No. ES-I on Research Methodology which covers quantitative methods, computer applications, research ethics and review of published research in the relevant field is compulsory for all students. In addition the research scholars have to take atleast one additional course from the Ph.D. courses offered by the Department or by other Departments of the Faculty of Interdisciplinary Science. However, on recommendation of the Research Advisory Committee the research scholar may be required to take additional courses.

The Course work is a prerequisite for PhD. Preparation.

ES – 1 Research Methodology
(Credits: 04)

Lecture -60

Unit-I **Lecture -15**

Introduction: Introduction and definition of Research. Classification of research- Experimental and Theoretical, Fundamental and Applied, Quantitative and Qualitative.Motivation for research. Research Methodology - definition of Problem, aim and objectives, historical background of investigation, issues and concerns related to scientific investigation.

Literature Review: Introduction to Peer-reviewed and Open access Journals, e-Journals and e-books, Reviews and Monographs. Impact factor of a Journal, h-index, i10-index.

Various tools for Literature review: Idea about print and digital resources, Common E-search engines for literature, Scopus, HEP-spires, Google Scholar, Scirus, SciFinder. Search for publications related to institutes/society (APS, AIP, IOP, IEEE, OSA, IEE etc.) or publishers (Elsevier-Science direct, etc.).

Unit -II **Lecture -10**

Measurements and Analysis: Designing an experiment, generation and recording of data. Numbers, units, abbreviations and nomenclature used in scientific writing. Accuracy and precision. Significant figures.

Error and uncertainty analysis: Types of errors: Gross error, systematic error, and random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square).Correlation and regression. Least square curve fitting, spline fitting, Gaussian distribution.

Graphical Representation: Introduction to software for drawing and analysis of graphical representation of data like MS-Excel, ORIGIN, etc. Incorporation of error bars in graphs.

Unit –III **Lecture -20**

Scientific Writing: Art of scientific writing and presentation. Writing references. Research and scientific writing ethics- Importance, basic principle, issues of authorship (in a group or collaborative work), plagiarism, conflict of interest, research misconduct.

Intellectual Property: Introduction to intellectual property, patent, copyright, definition of invention and discovery, idea about patentability, importance of academia-industry interaction, marketing of research outcome.

Presentation: Preparation of Power point scientific presentation and Poster presentation.

Unit –IV **Lecture -15**

MATLAB or other related software: Problem solving based on MATLAB or any other related Software.

MATLAB problems to be decided by the faculty involved in the course.

Examination mode: Internal Assessment : 20 Marks Final
Examination : 50 Marks
Presentations : 30 Marks

Suggested Reading:

1. Research Methodology: Methods and Techniques, C. R. Kothari and G. Gaurav, New Age International (2014).
2. Getting Started with MATLAB 7, RudraPratap, Oxford University Press (2006)

ES-2 Fabrication, Characterization Techniques for Electronic Materials
(Credits: 04)

Lecture-60

Unit-I **Lecture-15**

Introduction of Electronic materials: Organic and Inorganic Semiconductor Materials.

Basic Parameters: Miller Index, Energy Bands, Resistivity, Carrier Doping Density, Mobility, Carrier Lifetime, Contact Resistance, Series Resistance. Defects: Surface Defects, Deep Defects, Oxides and Interface traps.

Elementary ideas of Material Synthesis: Physical Vapor deposition, Chemical Vapor Deposition, Spin Coating etc. With idea on Vacuum units/ pumps (Rotary, Diffusion, Turbo molecular, Getter, Cryogenic and Ion pumps), Vacuum measurement system. Doping methods.

Heterojunctions and Nanostructures: Heterojunctions in devices, Quantum well and Superlattice structures, Quantum dots, Nano-tubes and Nano-rods etc.

Unit-II **Lecture-15**

Structural/Morphological Characterization: X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), Scanning Tunnelling Microscope (STM).

Spectral Characterization Techniques: UV-Vis Spectroscopy, Fourier Transform Spectroscopy (FTIR), Photoluminescence (PL), Raman Spectroscopy.

Electrical Characterization: Four-Point Probe, I-V characteristics of devices, C-V plots, Hall Effect.

Unit-III **Lecture-15**

XRD data analysis: Crystal orientation, texture factor, grain size and stress evaluation.

Evaluation of Optical Spectroscopy Data: Direct and In-direct band-gap, Urbach tail, refractive index and Defects analysis.

Electron Microscopy and XPS data inference: Grain size, morphology, orientation, Laue pattern, chemical composition and stoichiometry.

Unit-IV **Lecture-15**

Probability Density Distributions: Binomial, Poisson, Gaussian, Uniform, Landau and Multi-Dimensional Distribution

Errors: Gaussian errors, Combinarion of errors and Systematic Errors

Estimators: Likelihood Function, Maximum Likelihood and Least Squares

Method of Least Squares: Linear Regression, Fitting Binned Data, chi square distribution and Non-linear Least squares

Examination mode: Internal Assessment: 50 Marks
Final Examination : 50 Marks

Suggested Reading:

1. Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng, Wiley (2013).
2. Semiconductor Material and Device Characterization, Dieter K. Schroder, John Wiley & Sons inc. (1998)
3. Modern Spectroscopy, MichealHollas, Wiley (2004).
4. Preparation of Thin Films, Joy George, Marcel Dekkar (1992).
5. Statistical Data Analysis, G. Cowan, Clarendon, (1998)
6. Statistics, A Guide to the Use of Statistical in the Physical Sciences, R.J. Barlow, Wiley (1989)
7. Statistical Methods in Experimental Physics (2nd ed.), F. James, World Scientific (2007)
8. Statistical and Computational Methods in Data Analysis, S. Brandt, Springer (1998)

ES – 3 Mathematical and Computational Techniques
(Credits: 04)

Lecture-60

Unit-I **Lecture-15 Numerical Methods in General:** Introduction, Floating-Point form of numbers, Round-off, Stability of algorithms, Errors.

Solutions of Equations f(x)=0 by Iteration: Fixed point iteration, Bisection method, Newton-Raphson method, Secant method.

Interpolation: Lagrange interpolation, Newton's divided differences interpolation.

Numerical Integration and Differentiation: Trapezoidal rule, Simpson's rule, Gauss integration formulas, Numerical differentiation formulas.

Unit-II **Lecture-15**

Ordinary Differential Equations: Introduction to first order, second order, homogeneous, non-homogeneous equations, system of equations.

Orthogonal Functions in Mathematical Physics and Engineering: Bessel Functions, Spherical Bessel Functions, Legendre Polynomials, Associated Legendre Polynomials, Hermite Polynomials, Laguerre Polynomials, Associated Laguerre Polynomials, Chebyshev Polynomials – corresponding differential equations, graphical representation andorthogonality.

Numerical Methods for Differential Equations: First order equations – Euler-Cauchy method, RungaKutta methods, Methods for higher order equations and system of equations.

Unit-III **Lecture-15**

Solution of linear system of equations: Elimination methods – Gauss' method, Cholesky method. Iterative methods – Jacobi's method, Gauss Seidel method, Relaxation, Over-Relaxation method. Curve fitting.

Matrix Eigenvalue Problems: Power Method, Jacobi's method.

Unit-IV **Lecture-15**

Partial Differential Equations: Classification of partial differential equations. Homogeneous and non-homogeneous boundary conditions. Solutions by separation of variables and series expansion methods

Finite Difference Methods for Partial Differential Equations: Finite difference schemes in rectangular coordinates, Finite differencing of Parabolic partial differential equations – Diffusion equation, Finite differencing of Hyperbolic partial differential equations – Wave equation, Finite differencing for nonrectangular systems – cylindrical and spherical coordinates.

Examination mode: Internal Assessment: 50 Marks
Final Examination : 50 Marks

Suggested Reading:

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley (2010).
2. Numerical Techniques in Electromagnetics, Mattew N. O. Sadiku, CRC Press (2009)

ES-4 Modeling and Simulation of Semiconductor Devices
(Credits -04)

Lecture-60

Unit I **Lecture-15**

MOSFET Device Physics and Operation, MOS capacitor – Interface charges, threshold voltage, MOS capacitance, Basic MOSFET operation, Scaling and Short channel effects, Introduction to non-classical MOSFET architectures – Silicon on Nothing (SON) MOSFET, Gate Electrode Engineered MOSFET, Dielectric Pocket (DP) MOSFET, Recessed channel MOSFET, Gate All Around (GAA) MOSFET and Junctionless (JL) Transistor

Unit-II **Lecture-15**

MOSFET modeling – simple charge control model, Meyer model, capacitance models, small signal modeling, non-ideal effects, short channel effects, gate leakage and effective oxide thickness, Unified MOSFET CV model, MOSFET long channel approximation, drain current in linear region & saturation region, channel length modulation, dynamic elements – high frequency figure of merits, operation in subthreshold region, MOS device physics in short channel, effect of velocity saturation, threshold reduction, body effect, mobility degradation, transit time effect, SPICE Models.

Unit-III **Lecture-15**

Introduction to HEMT: Material Properties, Device Structure, Device operation, Spontaneous and Piezoelectric Polarization, Surface States, Electron Mobility, Breakdown Voltage, DC and RF Characteristics, Homoepitaxy and Heteroepitaxy of GaN HEMT (Comparison of Electrical Properties). GaN Device Scaling technologies.

Unit-IV (Lab session) **Lecture-15**

Introduction to TCAD tools, ATLAS device simulation software. Online Simulation resources–NANOHUB. Simulation of n-channel MOSFET; Silicon on Insulator.

Suggested Reading:

Unit-II - http://homepages.rpi.edu/~sawyes/Models_review.pdf
http://people.seas.harvard.edu/~jones/es154/lectures/lecture_4/pdfs/MOS_review.pdf
http://web.stanford.edu/class/archive/ee/ee214/ee214.1032/Handouts/HO2.pdf
Research papers to be provided for each device architectures other than course material

Unit-III- Gallium Nitride (GaN) Physics, Devices, and Technology, Edited By : FaridMedjdoub, CRC Press, Taylor & Francis Group.
Fundamentals of III-V Devices, HBTs, MESFETs, and HFETs/HEMTs, William Liu, Wiley-Inter Science Publication.

Unit-IV - https://nanohub.org/resources/tools https://www.silvaco.com/content/kbase/device.pdf
https://www.silvaco.com/examples/windows/GuidetoTCAD_PC.pdf Simulation Standard -
https://www.silvaco.com/tech_lib_TCAD/simulationstandard/latest.html

Examination mode: Internal Assessment: 50 Marks
Final Examination : 50 Marks

ES-5 Microwave Antennas
(Credits-04)

Lecture-60

Unit-I **Lecture -15**

Electromagnetic Waves: Maxwell equations**,** Electromagnetic spectrum**,** RF and Microwave region and band designations, RF and Microwaves applications.

Basic Transmission Line parameters: Lumped and distributed circuits, Transmission lines - propagation characteristics, reflection coefficient, VSWR, power, return loss, insertion loss, scattering parameters and Smith chart applications to RF and Microwave characterization.

Introduction of various transmission lines like two conductor line, coaxial line, microstrip line, coplanar waveguide (CPW), slotline, rectangular and circular waveguides.

Unit-II **Lecture-15**

Antenna fundamentals and parameters:

Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Maximum Directivity and Maximum Effective Area, and Antenna Polarization, Antenna Apertures, and near-field and far-field concepts.

Types of Antennas, Radiation Mechanism and Current Distribution on a Thin Wire Antenna.

Antenna Measurement: Basics of Antenna measurement techniques, Antenna ranges, Radiation pattern, Gain, directivity and return loss measurement, Anechoic chamber.

Unit-III **Lecture-15**

Radiation Integrals, Auxiliary Potential Functions and dipole:

Vector Potential A for an Electric Current Source, Vector Potential F for a Magnetic Current Source M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources, Solution of the Vector Potential Wave Equation, Far-Field Radiation, Duality Theorem, Reciprocity Theorem. Infinitesimal Dipole, Small Dipole, Region Separation, Half-Wavelength Dipole.

Introduction to Broadband Dipoles: Biconical Antenna, Bow-Tie, and Folded Dipole.

Unit-IV **Lecture-15**

Antennas Arrays: Two Element Array, N-Element Linear Array- Uniform amplitude and Spacing, Broadside Array, Ordinary End-Fire Array, Phased Array.

Microstrip antenna – Definition, advantages and disadvantages of microstrip antennas, applications, Radiation mechanism and Radiation fields of microstrip antennas, Feeding Methods. Method of analysis: Transmission line model and cavity model for rectangular patch antenna.

Introduction to modern antennas: Inverted F Antenna, MIMO antenna, UWB antenna, Circularly polarized antenna, Reconfigurable antennas and Mobile antennas.

Examination mode:

Internal Assessment : 50 Marks
Final Examination : 50 Marks

Suggested Reading:

1. Pozar D M, Microwave Engineering, Wiley
2. Collin R E, Foundations for Microwave Engineering, McGraw Hill International
3. Balanis C A, Antenna Theory: design and applications, Wiley
4. Kraus, John D. &Mashefka, Ronald J, Antennas: For All Applications, Tata McGraw Hill, 3rd Ed
5. Hohnson R C and H Jasik, Antenna Engineering Handbooks, McGraw Hill

ES-6 Robotics and Artificial Intelligence (Credits-04)

Lecture-60

Unit - 1: **Lectures- 15**

Kinematic Models

Introduction to robotics, Kinematic Models and Constraints (Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints), Mobile Robot Maneuverability (Degree of mobility, Degree of steerability, Robot maneuverability), Mobile Robot Workspace, Motion Control

Unit - 2:

Robot Perception and Image Processing **Lectures- 15**

Sensors for Mobile Robots (Sensor classification, Characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Vision-based sensors), Data Uncertainty, Feature Extraction

Unit - 3:

Localization, Mapping and Planning **Lectures- 15**

The Challenge of Localization: Noise and Aliasing (Sensor noise, Sensor aliasing, Effector noise), Localization-Based Navigation, Map Representation, Probabilistic Map-Based Localization (Markov localization, Kalman filter localization), Path Planning.

Unit - 4:

Laboratory Session **Lectures- 15**

1. To determine the footprint, i.e., the intersection of the field of view with the ground for a camera with given pixel dimensions and HFOV & VFOV
2. To determine location of the object of interest in robot coordinates for RADAR sensor
3. To determine the position of the object based on uncertain information about the initial position of the object as well as measurements of the position provided by a laser rangefinder for a simple object under freefall using Kalman Filter.
4. To develop a model for a four-wheeled robot that is steered via front wheels and powered by rear wheels and simulate the robot for straight line motion
5. To simulate a differential – drive robot for straight line motion
6. To simulate a differential – drive robot for circular path motion
7. To implement lossy and lossless image compression techniques Course will be taught by group

   of faculty

Mode of Examination

Internal Examination : 50 Marks
Final Examination : 50 Marks

Suggested Reading:

1. 'Mobile robots: navigation, control and remote sensing', Gerald Cook, Wiley-IEEE Press, 2011
2. 'Introduction to Autonomous Mobile Robots', Roland Siegwart and Illah R Nourbakhsh, The MIT Press, 2004
3. 'Introduction to AI Robotics', Robin R. Murphy, The MIT Press, 2000

4. ‘Mobile Robotics’, Luc Jaulin, ISTE Press - Elsevier, 2015
5. ‘Digital Image Processing using MATLAB’, Rafael C Gonzalez, Richard E Woods, Steven L Eddins, Pearson Education, 2004