FACULTY OF
INTER-DISCIPLINARY AND APPLIED SCIENCES (FIAS)

ADMISSION TO POST GRADUATE COURSES IN

Electronics

BULLETIN OF INFORMATION
2019-20

Department of Electronic Science
University of Delhi South Campus
Benito Juarez Road, Dhaula Kuan
New Delhi - 110021, India
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 organisations, 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 both FORTRAN 77 and 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 Kithley 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 stand alone 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 transceiver 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 Klyatron 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 best electromagnetic simulators: Ensamble from ANSOFT, IE3D and Empire. Hewlett-- Packard in recognizing the department as a major center of microwave education presented a work-station and one of the best software tools - EESOF’s advanced design software and Momentum. As part of the curriculum students design and simulate various planar microwave circuits like filters, couplers etc., get them fabricated and finally test them with measurements on the Network Analyzer.

**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 X-ray diffractometer, UV VIS NIR spectrophotometer and source meter has been procured and commissioned by the department.
ACADEMIC PROGRAMMES

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

1. M.Tech. (Microwave Electronics)
2. M.Sc. (Electronics)
3. Ph.D

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.

ENTRANCE TEST

The entrance test (of 2 or 3 hour duration) is conducted by the Department/University at various centres (list 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:


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 and South Campus Website. 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 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.

Examinations

There shall be following four Semester Examinations in the course:

**Semester I Examination:** On completion of the course of study for the period prescribed therein in November/December of first year of the course.
A student will be promoted to the second semester provided he/she has not failed in more than two theory papers and has obtained not less than 50% marks in the aggregate of theory and practicals taken together.
The student will have to essentially repeat (ER) and pass in those papers in which he/she has failed.
However, the student has to appear in the carried over papers only along with the regular students of the respective semesters in the course of reading which is prescribed for the fresh students, i.e., odd semester papers in odd semesters (I/III) and even semester papers in even semesters (II/IV).

**Semester II Examination:** On completion of the course of study for the period prescribed therein in April/May of the first year of the course.
A student will be promoted to the third Semester provided he/she has not failed in more than a total of two theory papers, inclusive of Semester I and Semester II, and has obtained not less than 50% marks in the aggregate of theory and practicals taken together in the Semester II examination. The student cannot carryover more than two papers for essential repeat at any stage.

**Semester III Examination:** On completion of the course of study for the period prescribed therein in November/December of the second year of the course.
A student will be promoted to the fourth Semester provided he/she has not failed in more than a total of two theory papers, inclusive of Semester I, Semester II and Semester III, and has obtained not less than 50% marks in the aggregate of theory and practicals taken together in the Semester III examination. The student cannot carryover more than two papers for essential repeat at any stage.

**Semester IV Examination:** At the end of the fourth semester in the month of July. The minimum marks required to pass the fourth Semester shall be 50% in project.

**IMPORTANT**
A. A student can appear in any theory paper only twice, i.e., once in the original attempt and once in a repeat attempt.
B. The minimum marks required to pass each theory paper shall be 40% in the University Semester Examination (30/75) and 40% in the total of the University Semester Examination and the Internal Assessment taken together.

**NOTE**
Out of 100 marks in each theory paper, 20 marks will be reserved for sessionals (internal assessment) and 5 marks will be reserved for attendance as per University guidelines.
Each theory paper shall be of three hours duration.
Each practical paper shall be of six hours duration in one day and shall carry 100 marks out of which 40 marks shall be reserved for laboratory record and 5 marks for attendance in the practical classes.
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.

**Classification of Successful Candidates**
At the end of final examination, the successful candidates shall be classified on the basis marks
obtained in the I, II, III and IV semester examinations taken together as follows:

**First Division with distinction:** 75% or more marks in the aggregate.

**First Division:** 60% or more marks but less than 75% marks in the aggregate.

**Second Division:** All others.

**If a student fails in any paper, he/she will not be eligible for a merit position.**

**Miscellaneous**

- a) The calendar for the academic year will be framed and declared at the beginning of the session.
- b) Scholarship will be discontinued if the student fails to score at least 60% marks in any examination.
- c) The span period for the M.Tech Degree will be four years.
- d) A candidate who fails in the I, II or III Semester Examination will be required to repeat that part of the course as a regular student only.
- e) There will be no provision of an ex-student.
- f) In the case of a student who repeats one or more theory papers, the internal assessment marks will be carried forward.
- g) 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 next six months. Such a candidate will be examined in January of that year.
- h) There will be no scope of improvement or revaluation.
- i) The medium of instruction and examination shall be English.
- j) 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.

**The M.Tech. Programme**

<table>
<thead>
<tr>
<th>Semester I</th>
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<tbody>
<tr>
<td>1.1 Electromagnetic Theory and Transmission Lines</td>
<td>100</td>
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<tr>
<td>1.2 Microwave and MM-Wave Planar Transmission Lines</td>
<td>100</td>
</tr>
<tr>
<td>1.3 Microwave Measurement Techniques and Industrial Microwaves</td>
<td>100</td>
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<td>1.4 Microwave Devices</td>
<td>100</td>
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<tr>
<td>1.5 Microwave Measurements Laboratory</td>
<td>100</td>
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<td><strong>TOTAL</strong></td>
<td><strong>500</strong></td>
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<th>Semester II</th>
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<tr>
<td>2.1 Microwave Passive Components</td>
<td>100</td>
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<td>2.2 Antenna Theory and Techniques</td>
<td>100</td>
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<tr>
<td>2.3 Communication Theory and Wave Propagation</td>
<td>100</td>
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<td>2.4 Computational Electromagnetics</td>
<td>100</td>
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<tr>
<td>2.5 Computational Laboratory</td>
<td>100</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>500</strong></td>
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<th>Semester III</th>
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<tbody>
<tr>
<td>3.1 Microwave Active Circuits</td>
<td>100</td>
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<td>3.2 Communication Systems</td>
<td>100</td>
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<tr>
<td>3.3 Microwave Integrated Circuits</td>
<td></td>
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<tr>
<td>(CAD, Fabrication and Measurements)</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>400</strong></td>
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Number of Seats

The total numbers of seats (including reserved seats) for M.Tech. are 26 *

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of seats</th>
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<tr>
<td>Gen</td>
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<td>OBC</td>
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<td>SC</td>
<td>4</td>
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<td>ST</td>
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| Sponsored seats for candidates sponsored by Government R&D Laboratories like DRDO, ISRO, CSIR etc. and Defence. | 4  
| Total                                 | 30              |

*The seats for PWD/Foreign Students/Sports Category are supernumerary and as per the University Guidelines.

# 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 admission & pay fees.

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; Varactor 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 multiple transmission line sections; 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 array antenna; 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 elements, 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).
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"**

CO 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.

**PO4 Microwave Integrated Circuits:** Design and simulation of passive components using 3D simulation tools
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.

**ELEGIBILITY 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:

**Eligibility Requirements for the M.Sc. Course**

**Category I (Admission on Merit Basis)**
1. B.Sc. (Hons.) Electronics from University of Delhi

**Category II**

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<thead>
<tr>
<th>Category II</th>
<th>Percentage</th>
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<tr>
<td>1. B.Sc. (Hons.) Electronics from University of Delhi</td>
<td>50% or above</td>
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<tr>
<td>2. B.Sc. (Hons.) Electronics from other Universities</td>
<td>50% or above</td>
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<tr>
<td>3. B.Sc. (Hons.) Instrumentation from University of Delhi</td>
<td>50% or above</td>
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<tr>
<td>4. B.Sc. (Hons.) Instrumentation from other Universities</td>
<td>50% or above</td>
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<tr>
<td>5. B.Sc. (Hons.) Physics from University of Delhi</td>
<td>50% or above</td>
</tr>
<tr>
<td>6. B.Sc. (Hons.) Physics from other Universities</td>
<td>50% or above</td>
</tr>
<tr>
<td>7. B.Sc. (Gen.) Physics, Maths, Electronics from University of Delhi</td>
<td>60% or above</td>
</tr>
<tr>
<td>8. B.Sc. (Gen.) Physics, Maths, Electronics from other Universities</td>
<td>60% or above</td>
</tr>
</tbody>
</table>

All Course Requirements after 10+2+3

**ENTRANCE TEST**

The entrance test (of 2 or 3 hour duration) is conducted by the Department/University at various centres (list 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. Syllabus for these B.Sc courses are available at the Delhi University website at the following link: (http://www.du.ac.in/du/index.php?page=old-undergraduate-courses)

For Example, The syllabus for B.Sc. (Hons.) Electronics is available at: (http://www.du.ac.in/du/uploads/old-ug-courses/04082010_electronics.pdf)

The merit list of the candidates based on the entrance test for admission to the M.Sc. course is put up on the Notice Board of the Department on the announced date. Candidates are required to see the Notice Board of the Department for this purpose.

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
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). In IV semester it will be 40% in each theory papers, 40% in Project/Thesis and 40% in Seminar. Minimum pass marks in Summer Training will also be 40%.

Examination

I Semester Examination: On completion of the study for the period prescribed therein November December of the first year of the course. At the end of the first semester a student will be promoted to second semester provided he has not failed in more than two theory papers and has obtained not less than 40% marks in the aggregate of theory and practicals taken separately. The student will have to essentially repeat and pass in those theory papers in which he has failed along with the papers of the second semester. A student who is not promoted to the second semester will have to repeat the first semester as a regular student as and when it runs in the following July-December session.

II Semester Examination: On completion of the course of study for the period prescribed therein April/May of the first year of the course. At the end of the second semester a student will be promoted to the third semester provided he has passed in all the first semester papers and has not failed in more than two theory papers of the second semester and has obtained not less than 40% marks in the aggregate of theory and practicals taken separately. The student will have to essentially repeat and pass in those second semester theory papers in which he has failed along with the third semester. A student who has not passed in all the first semester theory papers at the end of the second semester will be deemed failed in the first semester and will have to join back in the first semester as a regular student in the following month of July and repeat both first and second semesters in sequence. A student who is not promoted to the third semester, but has passed in all the theory papers of the first semester will be considered pass in the first semester and will have to repeat the second semester as and when it runs in the following January-May session.

III Semester Examination: On completion of the course of study for the period prescribed therein November/December of the second year of the course. At the end of third semester a student will be promoted to the fourth semester provided he has passed in all the second semester papers and has not failed in more than two theory papers of the third semester and has obtained not less than 40% marks in the aggregate of theory papers and has not failed in more than two theory papers of the third semester and has obtained not less than 40% marks in the aggregate of theory and practicals taken separately. The student will have to essentially repeat and pass in those third semester theory papers which he was failed along with the papers of the fourth semester. A student who has not passed in all the second semester theory papers at the end of the third semester will be deemed failed in the second semester and will have to join back in the second semester as a regular student in the following month of January and repeat both second and third semesters in sequence. A student who is not promoted to the fourth semester, but has passed in all the theory papers of the second semester will be considered pass in the second semester and will have to repeat the third semester as and when it runs in the following July-December session.

IV Semester Examination: On completion of the course of study for the period prescribed therein in April/May of the second year of the course. At the end of the fourth semester a student will be declared successful provided he has passed in all the third semester papers and has obtained not less than 40% marks in the aggregate of theory, project/thesis and seminar taken separately.
If at end of the fourth semester a student will be declared successful provided he has passed in all the third semester papers and has obtained not less than 40% marks in the aggregate of theory, project/thesis and seminar taken separately.
If at the end of the fourth semester a student has passed in all the third semester papers and has not failed in more than two theory papers of the fourth semester and has obtained not less than 40% marks in the aggregate of theory, project/thesis and semester taken separately, the student will have to essentially repeat and pass in those fourth semester theory papers in which he has failed during the semester exams held in the following November/December.

A student who has not passed in all the third semester theory papers at the end of the fourth semester will be deemed failed in the third semester and will have to join back in the third semester as a regular student in the following month of July and repeat both third and fourth semesters in sequence.

A student who has not passed the fourth semester, but has passed in all the theory papers of the third semester will be considered pass in the third semester and will have to repeat the fourth semester as and when it runs in the following January-May session.

At the end of the fourth semester the successful candidates shall be classified on the basis of marks obtained as I, II and III division; 60% and above I division, 50% to less than 60% II division, 40% to less than 50% III division.

**NOTE:** A student who is deemed failed in any semester will join as a regular student over and above the allocated seats for the course. Attendance in two-thirds of the theory classes and three fourths of the practical classes is compulsory, failing which the student will not be allowed to appear in the examination.

Each Semester calendar will ensure a minimum of 40 lectures in each theory course of study. In each theory paper 20 percent of marks are reserved for Sessional Tests, which will be awarded as the average of two best of three tests conducted by the teacher.

Students will be required to go for Industrial Training for two months in Summer Vacation between IInd and IIIrd Semester.

The total span period for the course will be four years.

**The M.Sc. Programme**

<table>
<thead>
<tr>
<th>Semester I</th>
<th></th>
<th>Semester II</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.1 High-level Computer Language and Operating System</td>
<td>50</td>
<td>2.1 Electromagnetics, Antenna and Propagation</td>
<td>50</td>
</tr>
<tr>
<td>1.2 Engineering Mathematics</td>
<td>50</td>
<td>2.2 Semiconductor Devices and Materials</td>
<td>50</td>
</tr>
<tr>
<td>1.3 Network Analysis and Synthesis</td>
<td>50</td>
<td>2.3 Microprocessors</td>
<td>50</td>
</tr>
<tr>
<td>1.4 Advanced Analog and Digital Circuit Design</td>
<td>50</td>
<td>2.4 Signal Systems and Control</td>
<td>50</td>
</tr>
<tr>
<td>1.5 Practical I : High level Computer Languages and Operating Systems</td>
<td>25</td>
<td>2.5 Practical I : Electromagnetics</td>
<td>25</td>
</tr>
<tr>
<td>1.6 Practical II : Electronic Circuits</td>
<td>25</td>
<td>2.6 Practical II : Materials and Semiconductor Devices</td>
<td>25</td>
</tr>
<tr>
<td>1.7 Practical III : Microprocessors</td>
<td>25</td>
<td>2.7 Practical III : Circuit Design and Simulation</td>
<td>25</td>
</tr>
<tr>
<td>1.8 Practical IV : Computational Techniques</td>
<td>25</td>
<td>2.8 Practical IV : Electrical Machines and Control Systems</td>
<td>25</td>
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<tr>
<td><strong>Semester I total</strong></td>
<td><strong>300</strong></td>
<td><strong>Semester II total</strong></td>
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**Summer Training (8 weeks)** | **50**
<table>
<thead>
<tr>
<th>Semester III</th>
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<tbody>
<tr>
<td>3.1 Optical Electronics</td>
<td>50</td>
</tr>
<tr>
<td>3.2 Integrated Circuit Technology</td>
<td>50</td>
</tr>
<tr>
<td>3.3 Digital Signal Processing</td>
<td>50</td>
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<tr>
<td>3.4 Communication Systems</td>
<td>50</td>
</tr>
<tr>
<td>3.5 Practical I : Optical Electronics</td>
<td>25</td>
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<tr>
<td>3.6 Practical II : Science and Technology of Semiconductor Devices</td>
<td>25</td>
</tr>
<tr>
<td>3.7 Practical III : Digital Signal Processing</td>
<td>25</td>
</tr>
<tr>
<td>3.8 Practical IV : Communication Systems</td>
<td>25</td>
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<tr>
<td>Semester III total</td>
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</table>

<table>
<thead>
<tr>
<th>Semester IV</th>
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<tr>
<td>4.1 Quantum Electronics</td>
<td>50</td>
</tr>
<tr>
<td>4.2 VLSI Circuit Design and Device Modeling</td>
<td>50</td>
</tr>
<tr>
<td>4.3 Modern Communication Systems</td>
<td>50</td>
</tr>
<tr>
<td>4.4 Microwave Electronics</td>
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</tr>
<tr>
<td>4.5 Seminar</td>
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<tr>
<td>4.6 Lectures from Industry</td>
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<tr>
<td>4.7 Project</td>
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<td>Semester IV total</td>
<td>450</td>
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<tr>
<td>Grand Total</td>
<td>1400</td>
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</table>

**Number of Seats**

The total numbers of seats (including reserved seats) for M. Sc. are 32*

<table>
<thead>
<tr>
<th></th>
<th>Cat. I</th>
<th>Cat. II</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Scheduled caste</td>
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<td>3</td>
</tr>
<tr>
<td>Scheduled tribes</td>
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<td>1</td>
</tr>
<tr>
<td>OBC</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total No. of seats</strong></td>
<td><strong>16</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

*The seats for **PWD/Foreign Students/Sports Category** are supernumerary and as per the University Guidelines.
Detailed Syllabus

1.1 High-level Computer Languages and Operating Systems

Operating Systems: familiarity with various operating systems like DOS, OSII, GUI like Windows, UNIX & LINUX. Details of one operating system such as UNIX: introduction, multitasking, multiuser capabilities, UNIX basis, files and directories, understanding the UNIX shell, text processing in the UNIX environment, editors like VI, EMAC, SED. Programming languages (one high level language such as C++): introduction to C++ and object oriented programming, development environment, compiling and linking the source code, brief look at cout, comments, variable and constants, expressions and statements, functions, classes, pointers, references, overloading, arrays, inheritance, special classes and functions, streams and files, the preprocessor, object-oriented analysis and design, templates, exceptions & error handling, standard libraries and bit manipulation.

1.2 Engineering Mathematics


1.3 Network Analysis and Synthesis


1.4 Advanced Analog and Digital Circuit Design

Practical Analog and Digital Circuit Design of amplifiers (single and multistage, audio and RF range) and power amplifiers. Design process as a troubleshooting tool. Oscillators, Mixers and PLL. Review of Logic families tabular and computer aides minimisation procedures. Programmable Logic Array. Clock mode sequential machines, incompletely specified sequential machines and fundamental mode sequential machines.

1.5 Practical I: High Level Computer Languages and Operating Systems

1.6 Practical II: Electronic Circuits

1.7 Practical III: Microprocessors

1.8 Practical IV: Computational Techniques
2.1 **Electromagnetics, Antenna and Propagation**
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. Maxwell’s equations, constitutive relations, wave equation, plane wave functions, rectangular waveguide, circular waveguide, dielectric slab waveguide surface guide waves. 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.

2.2 **Semiconductor Devices and Materials**

2.3 **Microprocessors**
Microprocessor based design, design constraints, microprocessor selection, hardware implementation, software implementation, hardware debugging, software debugging. Introduction to 8086, 8088, 80186, 80188, 6800, 68000 and other latest chips of Intel/Motorala microprocessors. 8086 Internal architecture, introduction to programmable parallel ports and hand-shake, input-output, interfacing the microprocessor to keyboards, alphanumeric displays and high power devices. The 8086 Maximum code, DMA data transfer interfacing and refreshing dynamic RAM, processors with integrated peripherals, the 80186, the 8087 math coprocessor. Multiple bus microcomputer system.

2.4 **Signal Systems and Control**
Introduction with examples of. various kinds of continuous and discrete time signals and their mathematical representation. Signal energy and power. Even and odd signals. Periodic, exponential and sinusoidal signals. Unit impulse and unit step functions for both discrete and continuous time signals. Examples and mathematical representation of continuous and discrete time systems. Difference equation. Basic vector matrix form of state equation. Basic system properties. Discrete time Linear Time Invariant (LTI) systems with convolution sum. Continuous time LTI system with convolution integral. Fourier series and transform application to analysis of signals and systems.

Introduction to control with examples of feedback control systems from several fields. Block diagram, transfer function and signal flow graph. Mathematical modelling of physical systems. Time domain and frequency domain analysis of control systems. Stability criteria, root locus techniques.

2.5 **Practical I :** Electromagnetics
2.6 **Practical II :** Electronic Materials and Semiconductor Devices
2.7 **Practical III :** Circuit Design and Simulation
2.8 **Practical IV :** Electrical Machines and Control Systems
3.1 Optical Electronics


3.2 Integrated Circuit Technology

Material purification. Epitaxial growth: LPE, VPE, MBE. Clean room specifications and requirements. Vacuum technology, sputtering, oxidation, growth mechanism and kinetics (thin and ultrathin oxides), oxidation techniques, redistribution of dopants at the interface and oxidation induced defects. Diffusion: Fick’s law, diffusion mechanism, measurement techniques, diffusion in SiO₂. Ion Implantation: systems and dose control, ion range, ion stopping, knock on ranges, metalization choices. Etching: dry etching, pattern transfer, plasma etching, sputter etching, control of etch rate and selectivity, control of edge profile. Process simulation and process integration. Lithography: optical, electron beam, ion beam, X-ray lithography, lift off, dip pen. Pattern generation. Fabrication of few devices like MMIC, laser diode etc.

3.3 Digital Signal Processing


3.4 Communication Systems

Frequency allocation and standards. Analog Transmission: AM, FM and PM (modulation, demodulation techniques and noise Analysis), AM and FM transmitters and receivers. Digital transmission: sampling and digital multiplexing techniques, PAM, PWM, PPM, PCM, DM, line codes, Information theory, ASK, FSK, PSK and QAM.

3.5 Practical I: Optical Electronics

3.6 Practical II: Science and Technology of Semiconductor Devices

3.7 Practical III: Digital Signal Processing

3.8 Practical IV: Communication Systems
4.1 Quantum Electronics


4.2 VLSI Circuit Design and Device Modeling

Passive elements design, design of silicon integrated circuits. Basic MOS inverter design, transfer characteristics, logic threshold, NAND & NOR logic, transit time and inverter time delay, depletion and enhancement modes, CMOS inverter, inverting and non-inverting type super buffers. Optimization of NMOS and CMOS inverters, noise margins MOS design rules. MOS layers, Stick diagrams, NMOS design layout diagrams, CMOS design, design rules and layout. Lamda bases design rules. Scaling of MOS Circuits. Functional Limitations to scafHng, scaling of wires and interconnections. MOS memories and programmable logic arrays, non-volatile semiconductor memories with MOS technology. General considerations associated with VLSI design. Design of a four-bit shifter, design of an ALU sybsystem. Physical model for Si VLSf, MOSFET modeling, short channel structures, scaled down MOS performance. Packaging of VLSI devices, packaging types. Packaging design consideration, VLSI assembly technology and fabrication technologies. Mechanism of yield loss in VLSI, modeling of yield loss mechanism, reliability requirements for VLSI. Failure mechanism in VLSI. Fault finding in VLSI chips.

4.3 Modern Communication Systems

Data transfer and computer networking: packet switching, ISDN, ATM, LAN, WAN, Internet and WAP. Digital Radio Communication Systems; Transmission media, sampling, multiplexing, digital modulation and multiple access techniques. Satellite Communication Systems: principles of satellite communication, modulation, multiplexing and; multiple access techniques; satellite services like DBS, VSAT etc. Mobile communication: specifications, design approach and details. Optical Communication Systems: network topologies, Fiber Distributed Data Interface (FDDI) network, Synchronous Optical Network (SONET/SDH), Asynchronous Transfer Mode (ATM), Wavelength Division Multiplexing (WDM) and its network implementation.
4.4 **Microwave Electronics**
Introduction to microwaves and their publications; Klystron amplifiers: operation and analysis, power and efficiency, multi cavity klystron. Reflex klystrons: operation and analysis, electronic admittance, electronic tuning, power output and deficiency. Magnetrons: operation and analysis. Travelling Wave Tubes: operation, gain bandwidth, coupling and focusing methods, applications. Avalanche Diode, Gunn effect and Gunn diode oscillators. Solid state microwave amplifiers, oscillators and mixers. Microwave components: attenuator, phase shifter, slotted lines, frequency meter, directional couplers, E-plane Tee, Magic Tee and Ferrite devices basic measurements of frequency, SWR, impedance and power at microwave frequencies. Principles of microwave LOS communication. Introduction to RADAR.

4.5 **Seminar**

4.6 **Lectures from Industry**

4.7 **Project**
M. Sc (Electronics)

Course Outcomes

COs of the course “High-level Computer Language and Operating System”

CO1 The emphasis is to provide a rigorous theoretical background in high level computer language and operating system.

CO2 Helps students to get jobs in software industry, in telecom industry etc and to pursue higher studies in this field.

COs of the course “Engineering Mathematics”

CO1 The course provides a theoretical background in advanced engineering mathematics which provides a good background for other theoretical courses.

CO2 It is aimed at honing the analytical skills which are helpful to those which join industry or go for higher studies.

COs of the course “Network Analysis and Synthesis”

CO1 This is a rigorous course which focuses both on analysis and synthesis.

CO2 Provides a good background to students who wish to join industry or those who want to go for higher studies as the course forms an important background for other electronics courses as well.

CO3 It is particularly useful for students who wish to join industry as analog or digital layout engineers.

COs of the course “Advanced Analog and Digital Circuit Design”

CO1 The course focuses on theoretical skills in the area of analog and digital circuit design.

CO2 It is in keeping with the current trends and is particularly useful for students who wish to join industry as analog or digital layout engineers.

COs of the course “Practical I : High level Computer Languages and Operating Systems”

CO This course provides practical knowledge to supplement paper High level Computer Languages and Operating Systems.

COs of the course “Practical II : Electronic Circuits”
CO This course provides practical knowledge to supplement paper 1.3 and 1.4 and provides rigorous training to students in circuit design and simulation of analog and digital circuits.

**COs of the course “Practical III : Microprocessors”**

CO1 The laboratory course provides a system level understanding of the 8086 microprocessor involved in the design of microprocessor based electronic equipment.

CO2 It involves in depth studies of software architecture, instruction set and assembly level programming with PC interfacing

**COs of the course “Practical IV : Computational Techniques”**

CO This supplements paper Engineering Mathematics

**COs of the course “Electromagnetics, Antenna and Propagation”**

CO1 This provides a good theoretical background for basic electromagnetics and transmission lines.
CO2 Is particularly useful for students planning to join photonics and microwave industry

**COs of the course “Semiconductor Devices and Materials”**

CO1 The course provides an understanding of electronic materials and devices used in the semiconductor industry.

CO2 Equips students with understanding of devices used in the semiconductor industry.

**COs of the course “Microprocessors”**

CO1 This course provides rigorous background in microprocessors and microcontrollers.

CO2 Enhances understanding of concepts useful in Embedded systems.

**COs of the course “Signal Systems and Control”**

CO1 This paper develop understanding of various kinds of signals

CO2 Explains how these are useful in describing the electronic power and energy.

**COs of the course “Practical I - Electromagnetics”**

CO This supplements paper Electromagnetics, Antenna and Propagation

**COs of the course “Practical II - Materials and Semiconductor Devices”**

CO This supplements paper Semiconductor Devices and Materials

**COs of the course “Practical III - Circuit Design and Simulation”**
CO This hones the practical knowledge in the areas of circuit design and simulation tools used for analog/digital applications

**COs of the course “Practical IV : Electrical Machines and Control Systems”**

CO This supplements paper Semiconductor Devices and Materials

**COs of “Summer Training”**

CO1 Students undergo 2 months training in industry and R&D organizations CO2 This provides the necessary exposure to the current trends in industry and R&D

**COs of the course “Optical Electronics”**

CO1 This paper covers various optical effects and the design, operation of optical devices

**COs of the course “Integrated Circuit Technology”**

CO1 This course provides necessary background in the IC technology

CO2 This course provides the required exposure which is useful to students looking forward to join the semiconductor or fabrication industry.

**COs of the course “Digital Signal Processing”**

CO1 Signal and System as well DSP is backbone of modern electronics.

CO2 In this course students are trained rigorously in transforming discrete time domain signal into frequency domain signal using Z-transform.

CO3 Students are exposed to various structures of both infinite impulse response as well as FIR (finite impulse response), Digital filters which are the ultimate base of this course.

CO4 Since we in an era where fast computation is mandatory the students are also exposed to digital Fourier transform, which is backbone of FFT algorithm.

**COs of the course “Communication Systems”**

CO1 This provides background for students who wish to join communication, telecom, space industry

**COs of the course “Practical I : Optical Electronics”**

CO1 This supplements paper Optical Electronics

**COs of the course “Practical II : Science and Technology of Semiconductor Devices”**

CO1 This supplements paper Integrated Circuit Technology

**COs of the course “Practical III : Digital Signal Processing”**
CO This supplements paper Digital Signal Processing

**COs of the course “Practical IV : Communication Systems”**

CO This supplements paper Communication Systems

**COs of the course “Quantum Electronics”**

CO1 This course provides a rigorous study of quantum phenomena taking place in devices at nanoscale regime

CO2 This paper enhances understanding of devices operating in this regime.

**COs of the course “VLSI Circuit Design and Device Modelling”**

CO1 This course provides a rigorous theoretical background in the areas of VLSI device and circuit technology

CO2 Is extremely helpful to students who wish to join the semiconductor, VLSI industry.

**COs of the course “Modern Communication Systems”**

CO1 This provides background for students who wish to join communication, telecom, space industry

**COs of the course “Microwave Electronics”**

CO1 This provides background for students who wish to join microwave and space industry

**COs of “Seminar”**

CO1 Students are required to give presentations in current trends in industry and R&D.

**COs of “Lectures from Industry”**

CO Department invites experts from Industry and R&D organizations to give lectures and seminars to provide exposure to students to the current trends and an exam is held at the end of the semester

**COs of “Project”**

CO As a part of Curriculum, students perform projects with their respective mentors in order to enhance their understanding in the electronics and practical problems
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 Electronic Material Fabrication and Characterizations:** The material laboratory provides experimental set ups to fabricate/develop electronic materials and facilities for characterization.

**PSO5 Network Analysis & Synthesis and Analog/Digital Circuit Design** The course provides rigorous theoretical and practical background in the areas of network analysis and synthesis and analog/digital circuit design which is extremely useful to students who wish to join industry, R&D organizations or want to pursue higher studies.

**PSO6 VLSI Circuit Design & Device Modeling** The course provides rigorous theoretical and practical background in the area of semiconductor devices, circuits etc which is extremely important and helpful to students who wish to join semiconductor industry, R&D organizations or want to pursue higher studies. The course enhances the knowledge which is useful for application in these areas and also updates about the current technological trends in industry.
Ph.D in Electronics

**Key Research Areas:** Micro Electronics Device Simulation, Photovoltaic, Opto Electronics, Semiconductor Materials and Devices Characterization, Photonics Simulation Design and Applications, Microwave Electronics.

**ENTRANCE TEST**
The entrance test (of 2 or 3 hour duration) is conducted by the Department/University at various centres (list 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:
**Engineering Mathematics, Numerical Techniques, Semiconductor Devices, Optoelectronics, Electromagnetics, Transmission Lines and Basics of Microwaves.**

**ELIGIBILITY**
As per Ordinance VI-B of the University. After Ph.D registration, students has to complete the Ph.D course work and the syllabus for same has been given below.
Ph.D. COURSE WORK

PREAMBLE

The Department of Electronic Science is offering the following five 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)

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)

Unit-I Lecture -60  
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.


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, 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:


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.


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.

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.

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

Suggested Reading:
Unit-I

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


Unit-III

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

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


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

Suggested Reading:
ES-4 Modeling and Simulation of Semiconductor Devices
Credits -04)

Lecture-60

Unit I
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
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

Unit-IV (Lab session)
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
Research papers to be provided for each device architectures other than course material

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

Examination mode:
Internal Assessment: 50 Marks
Final Examination : 50 Marks
Unit-I

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

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

Radiation Integrals, Auxiliary Potential Functions and dipole:

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

Unit-IV

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


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 Books
1. Pozar D M, Microwave Engineering, Wiley
2. Collin R E, Foundations for Microwave Engineering, McGraw Hill International
FACULTY

**Professors:**

*Professor Avinashi Kapoor (Head of the Department)*  
Specialization: Opto-electronics and Photovoltaics

*Professor Enakshi Khular Sharma*  
Specialization: Fiber and Integrated Optics, Photonics, Microwave Photonics

*Professor Mridula Gupta*  
Specialization: Communication, Microwaves and Microelectronics

**Assistant Professors:**

*Dr. Harsupreet Kaur*  
Specialization: Microelectronics, Semiconductor Device Modeling

*Dr. Kamlesh Patel*  
Specialization: Microwave Components and Characterization

*Dr. P. Koteswara Rao*  
Specialization: Semiconductor Materials and Devices

*Mr. Amit Birwal*  
Specialization: Communication, Microwaves

**UGC BSR Fellow:** *Professor P.K. Bhatnagar*  
Specialization: Semiconductor and Nanomaterials, Solid State Devices

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