UNIVERSITY OF CALCUTTA

Notification No. CSR/ 69 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus of Two-Year (Four-Semester) M.Sc. Course of Study in Electronic Sciences under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018

(Debabrata Manna)
Deputy Registrar (Acting)

Syllabus

M.Sc. in

Electronic Science

University

of

Calcutta

2018

Orientation of courses in four semesters for M. Sc in Electronic Science

1st Semester	**Marks**	**Credits**
EST 101: Mathematical & Computational Methods	50	4
EST 102: Quantum Mechanics	50	4
EST 103: Physics of Electronic Materials	50	4
EST 104: Semiconductor Devices	50	4
ESP 101: Material and Device Characterization Lab	25	2
ESP 102: Computer Application Lab	25	2
	200 (Theoretical) + 50 (Practical) = 250	16 (Theoretical) + 4 (Practical) = 20
2nd Semester	**Marks**	**Credits**
EST 201: Analog Circuits and Systems	50	4
EST 202: Digital Circuits, Microprocessors and Microcontrollers	50	4
EST 203: Electromagnetics, Antenna and Waves Propagation	50	4
EST 204: Communication	50	4
ESP 201: Analog Circuits and Systems Lab	25	2
ESP 202: Digital Circuits, Microprocessors and Microcontroller lab	25	2
	200 (Theoretical) + 50 (Practical) = 250	16 (Theoretical) + 4 (Practical) = 20
3rd Semester	**Marks**	**Credits**
EST 301: Microwave and Optoelectronics	50	4
EST 302: VLSI Technology	50	4
CBCC A	50	4
CBCC B	50	4
ESP 301: Device Fabrication and IC Technology Lab	25	2
ESP 302: Project: Stage-I	25	2
	200 (Theoretical) + 50 (Practical) = 250	16 (Theoretical) + 4 (Practical) = 20
4th Semester	**Marks**	**Credits**
EST 401: Control and Instrumentation	50	4
Elective I	50	4
Elective II	50	4
ESP 401: Electrical & Optical Communication Lab	25	2
ESP 402: Project Type Experiments	25	2
ESP 403: Project: Stage-II	50	4
	150 (Theoretical) + 100 (Practical) = 250	12 (Theoretical) + 8 (Practical) = 20
Total Marks/Credits	750 (Theoretical) + 250 (Practical) = 1000	60 (Theoretical) + 20 (Practical) = 80

List of Elective Papers (any two):

1. ESE 401: VLSI Design
2. ESE 402: Advanced VLSI Devices
3. ESE 403: Semiconductor Nanostructures and Characterization
4. ESE 404: DSP and Computer Networking

[ES: Electronic Science, T: Theory, P: Practical; E: Elective]
[E.g. EST 101 means Electronic Science Theory 1st semester paper one]
*List of experiments for the Practical papers will be in conformity with the respective theory course.

Semester I

EST 101: Mathematical and Computational Methods

Introduction to complex variables, integral transforms and application in signal processing, matrices, differential equations, special functions, computational algorithms, errors in numerical computation, interpolation, numerical differentiation and integration, numerical algorithms and methods to solve transcendental equations, linear and nonlinear ordinary and partial differential equations; optimization and curve fittings.
Familiarization with computers: programming languages, variables and constants, arrays, program structures, jump, loop, conditional branching, subroutines and functions.

EST 102: Quantum Mechanics

Review of classical mechanics and historical origin of quantum theory, operator method of solving quantum mechanical problems, hydrogen atom, perturbation method for non-degenerate and degenerate quantum system and applications, time dependent perturbation theory, harmonic and constant perturbation, variational method, WKB approximation and applications, angular momentum and spin, scattering theory, identical particles, interaction of radiation with matter, introduction to second quantization.

EST 103: Physics of Electronic Materials

Crystal structure and symmetries, determination of crystal structure by X-ray diffraction, crystal binding, lattice vibration, concept of phonons, defects in solids.
Free electron theory of metals, energy band in solids, Bloch theorem, Kronig Penny model, E-k diagram, concept of effective mass, electrons in weak periodic potential, tight binding model.
F-D statistics, density of states, carrier concentration, carrier transport in semiconductor, SRH recombination model, continuity equation, Boltzmann transport equation and transport coefficients. Electron dynamics under electric and magnetic fields, Hall effect.
Dielectric aand magnetic properties of materials: polarization and dielectric constant, Clasius-Mossotti relation, electronic and ionic polarizability, dielectric loss, ferroelectric materials, domain theory, piezoelectricity and pyroelectricity, applications of ferroelectric materials.
Organic semiconductor and conducting polymers, liquid crystals, introductory concepts of nano-materials.

EST 104: Semiconductor Devices

Elements of semiconductor physics: Electron and hole concentrations in the bands for degenerate and nondegerate semiconductors**,** effective density of states in the conduction and valence band, distinction between shallow and deep impurities, charge neutrality condition, calculation of Fermi level, features of SRH processes.

Basic equations for device operations: Basic carrier transport mechanisms in semiconductors, electron and hole current densities, continuity equations; Poisson's equation and distribution of electric field and potential.

Metal-semiconductor diode: Device structure and energy band diagram, Schottky effect, barrier height, voltage dependence of semiconductor surface potential, current transport mechanisms, device capacitance, series resistance effect, ohmic contact.

P-N junction diode: Recapitulation of basic features for abrupt and linearly graded junctions, concept of quasi Fermi level and derivation of Shockley equation, generation and recombination currents, diffusion capacitance, breakdown mechanisms: thermal instability, tunneling and avalanche multiplication, transient and noise behavior, device performance as rectifier, voltage regulator, varistor, varactor, application of P-N junction as solar cell.

Semiconductor hetero junction diode: Device structure and energy band diagram, concept of band discontinuities, built-in potential, device capacitance, current transport mechanism.

Bipolar Junction Transistor: Device structure, band diagrams, current components, amplification, Ebers-Moll relations, microwave BJT.

Field-Effect Transistors: **JFET:** Device structure and operation, gradual channel approximation, pinch-off and saturation, I-V characteristics, normally-on and -off FET; **MESFET:** Device structure and operation, energy band diagram and operation.

MOS capacitors: Energy band diagram, accumulation, depletion and inversion mode of operation, threshold voltage, flat band voltage, defects in MOS system, capacitance-voltage characteristics, M**OSFET**: Device structure and operation, band diagram, I-V characteristics, subthreshold current and other performance parameters, parasitic effects.

Power Electronic Devices: Basic Characteristics of SCR, reverse and forward blocking, two transistor analogy, constructions and the basic characteristics of DIAC, TRIAC, IGBT and UJT, and their applications.

Semester II

EST 201: Analog Circuits and Systems

Network theorems, transient analysis, applications of transform methods in network analysis, passive filters, properties and synthesis of passive and active networks, positive real function, Cauer's and Foster's reactance theorems, single and double terminated LC ladders, poles and zeros of network functions.

Small-signal model and equivalent circuit for diodes, BJTs and MOSFETs. Analyses of various active circuits at different frequency ranges. Feedback amplifiers, power amplifiers and tuned amplifier.

Operational amplifier: characteristics, architecture, differential amplifiers, current mirror and active load. Linear and nonlinear applications of OP AMP. Active filters, switched capacitor filters.

Wave form generation and timer: sinusoidal feedback oscillators, relaxation oscillators, 555 timer, VCO and PLL.

EST 202: Digital Circuits, Microprocessors and Micro-controllers

Combinational logic circuits: multiplexers, decoders, demultiplexers, parity generator/checker, arithmetic circuits. Sequential circuits: flip-flops, asynchronous and synchronous circuits, flow tables, state tables and state diagrams, timing diagram. Shift-registers and counters. Data converters: ADCs and DACs. Display and display drivers: LED, 7-segment display. Semiconductor memories: memory organization, address decoding, access times, SRAM, DRAM, ROM, PROM, EPROM, flash memory.

Introduction to HDL. Digital system design using HDL, FPGA

Introduction to microprocessors (8085), block diagram, address and data bus, assembly language programming, interrupts. Introduction to 8086 and advanced microprocessors. Interfacing of memory, I/O devices and supporting ICs. Analog interfacing and industrial control.

8051 microcontroller architecture and programming, interfacing of I/O devices, 8051 based system design.

EST 203: Electromagnetics, Antenna and Wave Propagation

Transmission Lines: various types, line parameters, line equations, loss less, distortion less line and low loss line, terminated line, power flow on line, impedance matching techniques, Smith chart, non-uniform lines, transients on transmission lines, planar transmission lines, waveguides, power transmission and attenuation, excitations, cavity resonators, dielectric, Fabry-Perot and microstrip resonators, excitation, tuning and coupling of cavities, design of resonators.

Antennas: electromagnetic radiation, retarded potentials, antenna characteristics and parameters, reciprocity theorem, radiation fields of Hertzian dipole (alternating current element), radiated power and radiation resistance, wire antennas, antenna array, binomial array, Babinet's principle, method of moments, travelling wave antennas, microwave antennas, antenna temperature and signal to noise ratio.

Radio Wave Propagation: Propagation characteristics, ground and surface wave, tropospheric and space waves, ionosphric and sky wave, structure and characteristics of ionosphere, plasma frequency, characteristics parameters, sun spot cycle, effect of earth's magnetic field.

Satellite Communication: Active and passive satellites, satellite orbits, structure of satellite communication, attitude and orbit control system (AOCS), telemetry, tracking and command (TT&C), power system, communication subsystems, satellite link design or Friis' transmission equation, system noise temperature, C/N and G/T ratio, uplink and downlink design.

EST 204: Communication

Analog Communication:

Basic signal theory: Introduction to communication systems, difference between analog and digital communication process.

Amplitude modulation: Basic principles of DSB, SSB, and VSB amplitude modulation systems, modulation and demodulation principles, modulators and demodulators, quadrature amplitude modulation (QAM).

Frequency and phase modulation: Modulators and demodulators, frequency discriminators and phase locked loops, receivers, noise in FM and PM systems, comparison of the effect of noise in different processes.

Noise and noise analysis.

Pulse Modulation: Sampling, PAM, PWM, PPM, delta modulation, ADM.

Digital Communication:
Quantization: Uniform and non-uniform, pulse code modulation, basic idea of digital compression of speech signals, echo control, ASK, FSK, PSK, BPSK and QPSK.

Principle of data transmission; Data transmission in presence of noise, fundamentals of digital signal processing, operations on discrete signals, correlations and autocorrelations, discrete time random processes, strength of discrete time signals, uncertainty principle and notion of aliasing.

General communication applications: Principles of telephony, television fundamentals, radar principles, mobile and cellular telephony, satellite communications.

Fiber Optic Communication.

Semester III

EST 301: Microwave and Optoelectronics

Microwave and millimeter wave frequency spectrum, need for microwave devices, microwave networks, signal flow graph, microwave components, directional couplers, microwave linear beam tubes (O-Type), microwave crossed field tubes (M-Type), microwave diodes, microwave transistors, microwave field-effect transistors, transferred electron devices, avalanche transit time devices, monolithic microwave integrated circuits and fabrication.
Optoelectronic Devices: Basic principle of operation of light emitting diodes, semiconductor lasers, applications of lasers, photodiodes, white LED, solar cells.

EST 302: VLSI Technology

Clean room and its usage, crystal growth (Czchrosky & floating zone), epitaxial growth, wafer cleaning.
Thermal oxidation: uses of oxides, dry and wet oxidation, oxidation kinetics, ultrathin oxides, oxinitrides, oxidation systems.

Diffusion: Fick's law, constant-source and constant-dose diffusion, diffusion systems, diffusion mechanisms.
Ion-implantation: mechanism, system, advantages, implant damage, damage annealing.
Annealing: furnace annealing, rapid thermal annealing, rapid thermal oxidation (RTO), damage annealing.
Chemical vapor deposition: deposition of oxide, nitride and poly-silicon, metals.
Physical vapor deposition: thermal evaporation, e-beam evaporation, sputtering, junction spiking, electromigration, step coverage.
Lithography: Photolithography and photoresist, steps, pattern transfer, resist stripping, introduction to e-beam and x-ray lithography.
Etching: wet and dry etching, plasma etching, reactive ion etching (RIE).
Process integration: n-MOS, CMOS, BiCMOS, SOI and FinFET technology.
High and low-k gate dielectrics, multi level metallization, materials for local and global interconnects, silicide and SALICIDE, CMP.

Semester IV

EST 401: Control and Instrumentation

Introduction to control system, open loop and closed loop control system, system sensitivities, error amplifier, on-off controller, Proportional (P), Proportional-Integral (PI), Proportional-Derivative (PD), and PID controllers, transfer function, block diagram and signal flow graph, stability analysis, root locus techniques, polar plot, Nyquist analysis, Bode analysis, Nichol's chart design, state variable analysis, introduction to nonlinear control system analysis.
Characteristics of instruments and measuring systems, errors in measurements, dynamic characteristics of instruments and measurement systems, galvanometers, ammeter, voltmeter, potentiometers, AC bridges, watt meter, optoelectronic measurements. Oscilloscopes: CRT, CRO, storage and digital storage oscilloscope. Wave analyzer and spectrum analyzer. Transducers. Interfacing: RS 232 serial, parallel, IEEE 488, introduction to interfacing softwares.

ESE 401: **VLSI Design**

Overview of VLSI design: design flow, design hierarchy and design styles.
CMOS processing technology: process flow, concept of masks, stick diagram, design rules and layout.
CMOS inverter design issues: circuit characterization and performance estimation, voltage transfer characteristics, noise margins, switching characteristics and gate delay, power dissipation.
Combinational and sequential circuit design: design of logic circuits, complex circuits, Euler's rule. Design of latches and flip-flops, clocking strategies. Pseudo-nMOS circuits, switch-logic based design, BiCMOS technology and circuits, I/O structures.
Dynamic logic circuit design: charge storage and leakage. Precharge-evaluate, domino and zipper logic. Dynamic shift register design.

Chip design options: custom and semicustom design, gate array, standard cell and programmable logics.
Semiconductor memories: memory organization, sense amplifier, drivers and buffers. Design of SRAM, DRAM, and non-volatile memory devices.
Analog CMOS design: MOSFET capacitances and small signal models. MOS resistor, MOS current source, current mirror circuits. MOS voltage source. CMOS OPAMP design: differential amplifier, output stage and compensation techniques.

ESE 402: Advanced VLSI Devices

Physics of surfaces and interfaces; intrinsic, extrinsic and mixed interface states; interface states effects in metal-semiconductor devices and semiconductor heterojunctions; Carrier transport mechanism in thin insulators; Interface state admittance model: Application to metal-insulator-semiconductor systems; Majority and minority carrier MOS tunnel devices; Interface degradation and aging behavior of MOS structures; Spectroscopic methods for the characterization of MOS structures; Physical models on practical metal-semiconductor and optical field effect transistors.
Introduction to nanoelectronics, quantized structures, band structures of different semiconductors in the presence of 1D, 2D and 3D quantization of the wave vector space, magnetic quantization, quantum size effects, band engineering with quantum size effects.
Quantum effects in MOS and layered semiconductor structures: concept of electric sub-band and electron localization. Calculation of electric sub band: triangular well approximation and variational method. Resonant tunneling in double barrier diodes.
Moore's law, CMOS scaling, scaling principles, limitations of scaling, short-channel effects (SCEs), CMOS scaling and power dissipation issues, SCE reduction techniques, FinFET, SOI devices, advantages and limitations, power management and performance enhancement techniques. Nano-devices: nanowire FETs, quantum wire FETs, carbon nanotube FET, quantum dot array for memory, single electron transistor (SET).
Non-volatile memory devices, FAMOS, flash memory devices, memristors, switching resistor and PRAM.

ESE 403: Semiconductor Nanostructures and Characterization

Introduction to semiconductor nanostructures, difference of nano- and bulk semiconductors.
Growth and Fabrication of nano-materials and nanoscale devices (top-down and bottom-up): Focused Ion Beam (FIB), Reactive Ion Etching (RIE), Chemical Bath Deposition (CBD), Vapor Liquid Solid (VLS), Metal Organic Vapor Phase Epitaxy (MOVPE), Metal Organic Chemical Vapor Deposition (MOCVD), Molecular Beam Epitaxy (MBE).

Nanostructure imaging: Scanning Tunneling Microscopy (STM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM).

Nano-Patterning: Electron Beam Lithography (EBL) and Ion Beam Lithography (IBL).

Semiconductor nanostructure characterization: FESEM: EDX, cathodoluminescence, electrical probing to nanostructures, lattice mapping by EBSD. TEM: Lattice planes mapping by SAED, EDX. AFM: Local I-V and C-V measurement.

Theory: Basics of quantum mechanics, band structure estimation, LCAO, basics of DFT. Quantum confinement, energy eigenstates and DOS.

Applications: 1D materials, 2D materials, nanowire diode and nanowire MOS, NWFETs, nano-photodetector, nanostructure solar cell, LASER, biosensor.

ESE 404: DSP and Computer Networking

Analysis of Signals and Systems: Discrete time signal analysis and linear systems. Sampling of continuous time signals. Z-transform, inverse z-transform.
Digital Filters: signal flow graph representation, basic structures for IIR and FIR filters, noise in digital filters, filter design techniques,
Transforms: Discrete Fourier Transform (DFT) and Fast Fourier Transforms (FFT).
DSP Algorithm Implementation Considerations: basic issues software implementation, computation of the DFT, tunable digital filters, concept of multirate digital signal processing.
O.S.I. reference model and LAN: OSI reference model, TCP/IP model, circuit switching , packet switching, various transmission media, LAN Topologies, LAN components- NIC, hubs, switches, MAN and WAN- routers, repeaters, gateways.
Data Link Layer: error control and flow control techniques, MAC layer.
Internet Protocol and Routing: addressing scheme, subnet and supernetting, routing schemes.
Transport layer: reliability of transmission, ports, connections and endpoints, concept of sliding windows, TCP segment format, establishing, closing and resetting a TCP connection, TCP port numbers.
Introduction to Wireless Networks: GSM, MANET and bluetooth.

CBCC offered by Department of Electronic Science

Electronics

Module – 1: Introduction to Semiconductor Physics & Device Fabrication Technology
Introduction, concept of energy bands, Fermi level, intrinsic and extrinsic semiconductors, P-type and N-type semiconductors, energy band diagram, effective mass, carrier transport, mobility, drift and diffusion, carrier recombination, introduction to device fabrication technology.

Module – 2: Junction Diodes:
Formation of P-N junction, energy band diagram, depletion region, forward and reverse biased P-N junction diode, I-V characteristics, breakdown mechanisms, Zener breakdown, Avalanche breakdown, Zener diode and its characteristics, junction capacitance and Varactor diode, diode rectifier circuits and Zener voltage regulators.

Module – 3: Bipolar Junction Transistors:
PNP and NPN transistors, energy band diagram, working principle of transistor, cut-off, active and saturation, current components in active mode, transistor characteristics, CE, CB, CC configurations, transistor as an amplifier and a switch, biasing and bias stability, CE h-parameter model, analyses of amplifiers using h-parameter model.

Module – 4: Field Effect Transistors:
JFET, construction, working principle, I-V characteristics, small signal equivalent circuit of JFET, MOS devices, concept of depletion and inversion in MOS capacitor, MOSFET, construction, working principle, characteristics, depletion and enhancement type, introduction to CMOS.

Module – 5: Analog Circuits:
Concept of positive and negative feedback, feedback topologies, effects of negative feedback (qualitative), Barkhausen criteria, condition of oscillation, operational amplifier and its characteristics, applications of Op-Amp.

Module – 6: Digital Electronics:
Introduction to number systems, Boolean algebra, logic gates, k-map minimization, half and full adder, subtractor, parity checker, comparator, multiplexer, demultiplexer, encoder, decoder, SR, JK, D and T flip-flops, shift registers, counters.