

NORTH LAKHIMPUR UNIVERSITY



(As recommended by Board of Studies in Electronics held on 20.06.2026 and Approved by Academic Council held on 25.06.2026)

Curriculum for M.Sc. in **ELECTRONICS As per NEP-2020**

(Semester: 1-4)

PG Course Structure as per NEP 2020 Guidelines
Department of Electronics

SEMESTER-I

Course	Course Title	Course Code	Credit	Marks	End Sem	IA
Core - I	Electromagnetics and Microwave	CC-4- MELE-101	4	80	56	24
Core - II	Communication Systems	CC-4- MELE -102	3+1	80	42 20	18
Core - III	Semiconductor Materials and Devices	CC-4- MELE-103	3+1	80	42 20	18
Elective-I	(A) Applied Machine Learning OR (B) Introduction to IC Design and Process OR (C) Programming in C and C++	EC-4- MELE -101	4	80	56	24
Other Course	Research Methodology	OC-4- MELE -101	4	80	56	24
Total			20	400	292	108

SEMESTER-II

Course	Course Title	Course Code	Credit	Marks	End Sem	IA
Core - IV	CMOS Circuits	CC-4-MELE-201	4	80	56	24
Core - V	Power Electronics and Control Systems	CC-4-MELE-202	4	80	56	24
Core - VI	Electronics Lab	CC-4-MELE-203	4	80	56	24
Elective-II	(A) Introduction to Statistics in Research OR (B) Optoelectronics	EC-4-MELE -201	4	80	42 20	18
Internship/ Community Engagement			4	80	80	
Total			20	400	310	90

SEMESTER-III

Course	Course Title	Course Code	Credit	Marks	End Sem	IA
Core - VII	Microprocessor and Embedded Systems	CC-4- MELE-301	4	80	56	24
Core - VIII	Digital Signal Processing	CC-4- MELE -302	4	80	56	24
Core - IX	Linear Electronic Circuits	CC-4- MELE-303	4	80	56	24
Elective-III	(A) Optical Communication OR (B) Antenna Theory OR (C) Semiconductor Device Fabrication Technology	EC-4-MELE -301	4	80	56	24
Project -I	Project (Phase-1)	EC-P4-MELE -302	4	80	56	24
Total			20	400	280	120

SEMESTER-IV

Course	Course Title	Course Code	Credit	Marks	End Sem	IA
Core - X	Communication Network	CC-4- MELE-401	4	80	56	24
Core - XI	Low Power VLSI Design	CC-4- MELE -402	4	80	56	24
Core - XII	Wireless and Mobile Communication Networks	CC-2- MELE-403	2	40	28	12
Elective-IV	(A) Instrumentation Systems and Applications OR (B) Sensor Technology & MEMS	EC-4- MELE -401	4	80	56	24
Project -II	Project (Phase-2)	EC-P6-MELE -402	6	120	84	36
Total			20	400	280	120

SEMESTER-I

Course Title : ELECTROMAGNETICS AND MICROWAVE
Course Code : CC-4-MELE-101
Nature of the Course : CORE
Total Credit assigned : 4
Components of the course : L-4, P-0, T- 0
Distribution of Marks : End Semester: 56 In Semester: 24

Unit	Contents	M	L	P	T
1	Fundamentals of electromagnetic theory: Formalism of Maxwell equations – differential & integral forms and their interpretations, boundary value problems based on Maxwell equations. Uniform plane waves: Uniform plane waves in time domain in free space, sinusoidal time-varying uniform plane waves in free space, wave equation and solution for material medium, uniform plane waves in Dielectrics and conductors, Poynting Vector.	12	15	0	0
2	Transmission lines-I (time domain analysis): TL equations and solutions, Determination of line parameters, line terminated by resistive load. Reactive and nonlinear resistive elements. Transmission lines-II (sinusoidal steady state analysis): Short circuited line, Line terminated by arbitrary load, TL line matching types, the smith chart and applications.	11	10	0	0
3	Metallic Waveguides and resonators: Uniform plane wave propagation in an arbitrary distinction, TE and TM waves in rectangular waveguide and cavity Resonator, Losses in Waveguides and Resonators.	8	8	0	1
4	Limitations of conventional tubes: Limitations of conventional vacuum tubes at VHF and UHF; Bandwidth limitation effects, Tube reactance effects and transit time effects; Remedies. Klystron amplifier: Introduction to Klystron amplifier, Velocity modulation and bunching of electrons; L-cavity Klystron amplifier; operation and analysis; power and efficiency; Multi- cavity Klystrons, Reflex Klystrons, operation and analysis: Electronic admittance	15	17		0
5	Magnetron: Principle of Magnetron, Linear and cylindrical magnetron, Hull cut-off voltage and Hull cut off frequency, Basic principle of inverted magnetron.	10	10		
		56	60	2	1

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Surprise Test		10
ii. Attendance		10
iii. Assignment		10
iv. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Sadiku, M. N. O. (2018), *Elements of Electromagnetics*, 7th Edition, Oxford University Press, New Delhi.
2. Kulkarni, S. V. (2015), *Microwave and Radar Engineering*, 4th Edition, Umesh Publications, New Delhi.
3. Liao, S. Y. (2007), *Microwave Devices and Circuits*, 3rd Edition, Pearson Education, New Delhi.

E-Learning Sources

1. NPTEL Course: *Electromagnetic Fields*, IIT Madras.
2. NPTEL Course: *Electromagnetic Waves*, IIT Kharagpur.
3. NPTEL Course: *Microwave Engineering*, IIT Kharagpur.
4. NPTEL Course: *Microwave Integrated Circuits*, IIT Delhi.
5. MIT OpenCourseWare: *Electromagnetic Fields and Energy*.
6. MIT OpenCourseWare: *Microwave Circuits and Devices*.

SEMESTER-I

Course Title	: COMMUNICATION SYSTEMS
Course Code	: CC-4-MELE-102
Nature of the Course	: CORE
Total Credit assigned	: 4
Components of the course	: L-3, P-1, T-3
Distribution of Marks	: End Semester: 42 In Semester: 18 Practical:20

Course Contents

Unit	Contents	M	L	P	T
I	Analog Communication: Elements of a communication system; Types of signals and communication channels; Need for modulation; Amplitude Modulation (AM) – generation, modulation index, spectrum and bandwidth; DSB-SC and SSB modulation; Frequency Modulation (FM) – generation, modulation index, spectrum and bandwidth; Demodulation of AM and FM signals; Noise in communication systems; Signal-to-noise ratio and performance of analog communication systems.	14	15		1
II	Digital Communication Fundamentals: Pulse modulation techniques: PAM, PWM and PPM; Sampling theorem; Pulse Code Modulation (PCM) – quantization, encoding and decoding; Delta Modulation (DM) and Adaptive Delta Modulation (ADM); Digital transmission of information; Baseband digital communication; Line coding techniques; Data rate and bandwidth requirements; Introduction to multiplexing techniques.	14	15		1
III	Digital Modulation and Communication Systems: Digital modulation techniques: ASK, FSK, PSK and QPSK; Bit error rate and noise performance; Digital communication receivers; Introduction to spread spectrum communication; Cellular communication concepts; Satellite communication systems; Optical fiber communication – basic principles, advantages and applications; Overview of modern digital communication systems and networks.	14	15		1
IV	PRACTICAL (Any 10) 1. Study the amplitude modulation (AM) waveform and determine the modulation index. 2. Generate and demodulate an AM signal using suitable modulation and detection circuits. 3. Study the frequency modulation (FM) waveform and determine the modulation parameters. 4. Generate and demodulate an FM signal. 5. Study Pulse Amplitude Modulation (PAM) and observe its waveform characteristics. 6. Study Pulse Width Modulation (PWM) and measure the variation in pulse width with the modulating signal. 7. Study Pulse Position Modulation (PPM) and observe its	20		30	

	waveform characteristics. 8. Verify the Sampling Theorem using a signal generator and oscilloscope. 9. Study Pulse Code Modulation (PCM) encoding and decoding. 10. Study Delta Modulation (DM) and observe slope overload and granular noise effects. 11. Generate and study digital modulation schemes such as ASK, FSK and PSK. 12. Study line coding techniques and compare the waveforms of NRZ, RZ and Manchester coding. Simulation-Based Experiments (MATLAB/Scilab) 13. Simulation of AM and FM modulation and demodulation. 14. Simulation of PCM and Delta Modulation systems. 15. Simulation of ASK, FSK, BPSK and QPSK communication systems. 16. Measurement of Bit Error Rate (BER) for digital modulation schemes under noise.				
		42+ 20	45	30	3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (18 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Seminar		10
ii. Assignment		10
iii. Attendance		10

In-semester Assessment: Marks 18

Textbooks

1. Haykin, S. (2014), *Communication Systems*, 5th Edition, Wiley India Pvt. Ltd., New Delhi.
2. Lathi, B. P. and Ding, Z. (2010), *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, New Delhi.
3. Sharma, S. K. (2017), *Analog and Digital Communication*, 3rd Edition, S. K. Kataria & Sons, New Delhi.

E-Learning Sources

1. NPTEL Course: *Analog Communication*, IIT Kanpur.
2. NPTEL Course: *Digital Communication*, IIT Kanpur.
3. NPTEL Course: *Principles of Communication Systems*, IIT Delhi.
4. SWAYAM-NPTEL: *Communication Engineering* courses.
5. MIT OpenCourseWare: *Principles of Digital Communication*.

SEMESTER-I

Course Title : SEMICONDUCTOR MATERIALS AND DEVICES
Course Code : CC-4-MELE-103
Nature of the Course : CORE
Total Credit assigned : 4
Components of the course : L-3, P-1
Distribution of Marks : End Semester: 42 In Semester: 18 Practical:20

Course Contents

Unit	Contents	M	L	P	T
I	Semiconductor Devices: Principle of operation, Fabrication methods and doping profiles, Analysis of the ideal diffusion transistor, Real transistors, Static I-V characteristics, Charge control equations, diffusion transistor at high frequencies, the drift transistor, high frequency performance Junction and MOS Field Effect Transistors: Principle of operation, Static I-V characteristics of the idealized model, JFET structures, Semiconductor surfaces, C-V characteristics of the MOS capacitor, the Si-SiO ₂ system, Basic structures and the operating principle of MOSFET, Current-Voltage characteristics	16	15		3
II	Power Semiconductor Devices: Schockley diode, Thyristor, Light Activated Silicon Controlled Rectifier (LACSR), Silicon Controlled Switch, GTO, IGBT, MCT, ETO, RCT, DIAC, TRIAC.	14	14		1
III	Optoelectronic Devices: Solar Cells, Photovoltaic effect, GaAs solar cells, Thin film solar cells, Photo detectors, Photo diode, Avalanche photo diode, LEDs, LED materials and their structures, Semiconductor Lasers – p-n junction laser, Hetero junction laser, Laser diode materials, fabrication and structures.	12	13		1
IV	PRACTICAL 1. Study of the I-V Characteristics of the CE configuration of BJT and obtain r_i, r_o, β 2. Study of the I-V Characteristics of the CB configuration of BJT and obtain r_i, r_o, α 3. Study of the I-V Characteristics of the CB configuration of BJT and obtain r_i, r_o 4. Study of the I-V Characteristics of JFET 5. Study of the I-V Characteristics of MOSFET 6. Study of the I-V Characteristics of Thyristor 7. Study of Characteristics of Solar Cell 8. Study of the I-V Characteristics of Photo diode 9. To determine characteristics of LEDs and Photo - Detector 10. Study of Hall effect	20		30	

		42 + 20	45	30	5
--	--	------------	----	----	---

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (18 Marks)

A. Sessional Tests (1+2): **Marks:** **20+20**

B. Sessional Activity

i. Seminar **10**

ii. Assignment **10**

iii. Attendance **10**

In-semester Assessment: **Marks 18**

Textbooks

1. Sze, S. M. and Ng, K. K. (2007), *Physics of Semiconductor Devices*, 3rd Edition, John Wiley & Sons, Hoboken, New Jersey.
2. Sze, S. M. (2002), *Semiconductor Devices: Physics and Technology*, 2nd Edition, Wiley India Pvt. Ltd., New Delhi.
3. Streetman, B. G. and Banerjee, S. K. (2015), *Solid State Electronic Devices*, 7th Edition, Pearson Education, Noida.
4. M.S. Tyagi, "Introduction to Semiconductor Materials and Devices", John Wiley & Sons (Asia) Pte. Ltd., 2000

E-Learning Sources

1. NPTEL Course: *Semiconductor Devices*, IIT Bombay.
2. NPTEL Course: *Semiconductor Device Modeling*, IISc Bangalore.
3. NPTEL Course: *Optoelectronic Materials and Devices*, IISc Bangalore.
4. MIT OpenCourseWare: *Semiconductor Devices and Electronics*.
5. MIT OpenCourseWare: *Microelectronic Devices and Circuits*.
6. NPTEL YouTube Lectures on Semiconductor Devices, Power Semiconductor Devices and Optoelectronics.

SEMESTER-I

Course Title : (A) APPLIED MACHINE LEARNING

Course Code : MELE-EC-4-101(A)

Nature of the Course : Elective-I

Total Credit assigned : 4

Components of the course : L-4, P-0, T-0

Distribution of Marks : End Semester: 56 In Semester: 24 Practical:20

Course Contents

Unit	Contents	M	L	P	T
I	Introduction to Statistics and Machine learning: Statistical Inference, Types of Variables, Probability Distribution, Normality, Measures of Central Tendencies, Normal Distribution, Fundamentals of Machine Learning, Concepts and types, KNN methods, Predictive Models	10	10		2
II	Classification and Regression: Random Forest, Decision tree, Linear Regression, Gradient Descent, Polynomial Regression, Learning Curves, Regularized Linear Models, Logistic Regression, Ridge Regression. Clustering, Partitioning Clustering, Hierarchical Clustering, Grid based clustering, Clustering algorithms, K-means algorithm, Applications of Clustering in different fields	12	15		1
III	Advanced Machine Learning concepts and techniques: Multilayer Perceptron's: Introduction Perceptron, training a Perceptron: Learning Boolean Functions, Multilayer Perceptrons Back-propagation Learning: Supervised, unsupervised and reinforcement learning, types of unsupervised learning, KNN, regression models, Naive Bayes' classifier, decision trees, random forest classifier, SVM: linear, non-linear	18	20		1
IV	Introduction to Python: Python Basics, Variables and Data Types, Decision Making and Loops, Functions, Modules and Packages, Exception handling, File and Directories, Classes and objects, Regular expressions, Socket programming. Implementation of various ML algorithms using python	16	15		1
		56 + 20	60	30	8

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):

Marks:

20+20

B. Sessional Activity

i. Seminar

10

ii. Assignment

10

iii. Attendance

10

In-semester Assessment:

Marks 24

Textbooks

1. Alpaydin, E. (2021), *Introduction to Machine Learning*, 4th Edition, MIT Press, Cambridge, Massachusetts.
2. Mitchell, T. M. (1997), *Machine Learning*, McGraw-Hill Education, New York.
3. Burkov, A. (2019), *The Hundred-Page Machine Learning Book*, Andriy Burkov, Quebec, Canada.

E-Learning Sources

1. NPTEL Course: *Introduction to Machine Learning*, IIT Madras.
2. NPTEL Course: *Machine Learning*, IIT Kharagpur.
3. NPTEL Course: *Machine Learning for Engineering and Science Applications*, IIT Kharagpur.
4. SWAYAM-NPTEL: *Introduction to Machine Learning*.
5. Andrew Ng, *Machine Learning Specialization*, Stanford University and DeepLearning.AI, Coursera.
6. MIT OpenCourseWare: *Introduction to Machine Learning*.

SEMESTER-I

Course Title : (C) INTRODUCTION TO IC DESIGN AND PROCESS
Course Code : EC-4-MELE-101(B)
Nature of the Course : ELECTIVE-I
Total Credit assigned : 4
Components of the course : L-4, P-0, T-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	History and overview: History of Microelectronics, Components for logi, Integrated Circuit (IC) technology developments, Classification of IC. IC Design: IC design hierarchy, IC Technologies (CMOS, Bipolar, BiCMOS); CMOS Characteristics and Analysis: Review of MOS transistors, Characteristic and operation, MOS modes and regions of operations	10	12		2
II	Design Techniques: Static and dynamic logic design, Power consumption and speed considerations, Noise margins and signal integrity IC layout design: Stick diagram: Color code, Implied connection and crossover, Contacts and taps, Mask layout, Design rules and guidelines; Introduction to layout tools (e.g., Cadence, Mentor Graphics), nMOS layout, CMOS layout, Euler path, Multiple gates, Multiple-cell layout	14	15		1
III	Simulation and Design verification: Introduction to circuit simulation, AC, DC and transient analysis, CMOS component design procedures, Numerical integration, Convergence, Time step control, SPICE simulators Design Rule Check (DRC) and Layout Versus Schematic (LVS): Importance of DRC and LVS, Performing DRC and LVS checks, Interpreting DRC/LVS reports Testing methodologies: Fault modeling and fault simulation, Timing Analysis and Power Estimation: Static timing analysis, Power estimation techniques, Tools for timing and power analysis	18	18		1
IV	Fabrication and process technology: Semiconductor device fabrication process: Wafer preparation, Epitaxial growth, Oxidation, Photolithography, Diffusion, Ion implantation, Etching, Isolation, Metallization, Packaging	14	15		1
		56	60		5

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):

Marks:

20+20

B. Sessional Activity	
i. Seminar	10
ii. Assignment	10
iii. Attendance	10
In-semester Assessment:	Marks 24

Textbooks

1. Weste, N. H. E. and Harris, D. M. (2015), *CMOS VLSI Design: A Circuits and Systems Perspective*, 4th Edition, Pearson Education, Noida.
2. Kang, S. M. and Leblebici, Y. (2003), *CMOS Digital Integrated Circuits: Analysis and Design*, 3rd Edition, Tata McGraw-Hill Education, New Delhi.
3. Baker, R. J. (2019), *CMOS: Circuit Design, Layout and Simulation*, 4th Edition, Wiley-IEEE Press, Hoboken.

E-Learning Sources

1. NPTEL Course: *Digital VLSI Design*, IIT Kharagpur.
2. NPTEL Course: *CMOS Digital VLSI Design*, IIT Madras.
3. NPTEL Course: *VLSI Design Flow: RTL to GDS*, IIT Kharagpur.
4. NPTEL Course: *Analog IC Design*, IIT Madras.
5. SWAYAM-NPTEL: *VLSI Design*.
6. MIT OpenCourseWare: *VLSI System Design*.

SEMESTER-I

Course Title : (C) PROGRAMMING IN C AND C++
Course Code : EC-4-MELE-101(C)
Nature of the Course : ELECTIVE-I
Total Credit assigned : 4
Components of the course : L-4, P-0, T-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	C Programming Language: Introduction of C, Character set, Tokens, Keywords, Identifier, Constants, Basic data types in C, Concept of variables, Structure of C program. Arithmetic operators, Relational operators, Logical operators, Assignment operators, Increment and decrement operators, Conditional operators, Bit wise operators. Expressions and evaluation of expressions, Precedence of operators, Arrays: Concepts, Declaration, Accessing elements, Storing elements, Two-dimensional and multi-dimensional arrays	12	13		2
II	Object Oriented Programming (OOP): Introduction, Object oriented programming, Characteristics of an object oriented language, Basic concepts of object oriented programming language (OOP), Applications of OOPs C++ programming language: Basic structure of C++ program, Compiling and linking, Tokens, Data types, Arithmetic operators, Relational, Operators, Special operators, Expressions and evaluation of expressions, Scope Resolution operator, Derefencing operator. Decision making and control loop structures: If statement, if... else statement, switch statement, do... While, while statement, for loop statement	13	14		1
III	Functions in C++: The main function, Function prototyping Call by reference Classes and objects: Defining member functions, Nesting of member functions, Function overloading, Memory allocation for objects, Static and dynamic allocation Pointer and polymorphism: Polymorphism pointer to objects, Pointers to derived classes, Pointer to functions Managing console I/o operations: C++streams, Unformatted i/o operations, Structures: Declaration, Initialization, Nested of structure, Pointer to structures Inheritance: Extending classes, Derived classes	17	18		1

IV	Data Structures: Classification, Basic Operations Stacks: Representation of stack in C using Array, Operations of stack, Application of stack, Infix, Postfix & Prefix Expressions, Postfix expression evaluation Queue: Representation of Queue using Array, Operations on queue, Double ended and Circular queue Linked List: Advantages of linked list, Basic component of list, Representation of list, Basic operation of singly list, Types of list, Circular linked list, Doubly linked list Trees: Tree terminology, Classification & representation of tree, Binary tree, Tree traversal	14	15		1
		56	60		5

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Seminar		10
ii. Assignment		10
iii. Attendance		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Suggested Reading:

1. Yashavant Kanetkar, Let Us C, BPB Publications.
2. Programming in ANSI C, Balagurusamy, 2nd edition, TMH.
3. Byron S Gottfried, Programming with C, Schaum Series.
4. Brian W. Kernighan, Dennis M. Ritchie, The C Programming Language, Prentice Hall.

SEMESTER-I

Course Title : RESEARCH METHODOLOGY

Course Code : OC-4-MELE-101

Nature of the Course : OC

Total Credit assigned : 4

Components of the course : L-4, P-0, T-0

Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	Introduction to Research: Concept and characteristics of research; objectives and applications of research; types of research—basic research, applied research, action research, experimental research, and interdisciplinary research; research objectives and research questions; research problem—meaning, identification, and sources; research hypothesis; literature review and effective literature survey approaches. Research Design: Concept and importance of research design; features of a good research design; exploratory, descriptive, and experimental research designs; reliability and validity in research.	12	14		
II	Data Collection: Types and sources of data; methods of data collection; sampling concepts and sampling methods; characteristics of a good sample; probability and non-probability sampling techniques including simple random sampling, purposive sampling, convenience sampling, and snowball sampling. Data Presentation and Descriptive Analysis: Classification and organization of data; frequency distributions; graphical representation of data using histograms, frequency polygons, dot plots, stem-and-leaf plots, bar graphs, pie charts, scatter plots, and box plots; measures of central tendency; measures of dispersion; measures of relative standing; skewness and kurtosis.	13	14		
III	Scientific Writing: Principles of scientific writing; research reports and their structure; journal articles and their components; preparation of abstracts and keywords; theses and dissertations and their components; referencing styles, citations, bibliography, and reference management. Project Proposal: Components of a research proposal—title, abstract, introduction and rationale, objectives, methodology, work plan and timeline, budget and justification, expected outcomes, and references.	13	10		

IV	Intellectual Property Rights: Concept and significance of intellectual property rights; patents, copyrights, trademarks, industrial designs, and geographical indications; patent rights and scope of protection; patenting and development process; Patent Cooperation Treaty (PCT) procedure; administration of patent systems; patent information and databases; technology licensing and commercialization.	10	12		
V	Research Ethics: Principles of research ethics; ethical review committees/Institutional Review Boards (IRB); responsible conduct of research; citation and acknowledgement; plagiarism. authorship and publication ethics.	8	10		
		56+ 24	60	0	

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (18 Marks)

A. Sessional Tests (1+2):

Marks: 20+20

B. Sessional Activity

i. Seminar

10

ii. Assignment

10

iii. Attendance

10

In-semester Assessment:

Marks 24

Textbooks

1. Kothari, C. R. and Garg, G. (2019), *Research Methodology: Methods and Techniques*, 4th Edition, New Age International Publishers, New Delhi.
2. Kumar, R. (2019), *Research Methodology: A Step-by-Step Guide for Beginners*, 5th Edition, SAGE Publications India Pvt. Ltd., New Delhi.
3. Creswell, J. W. and Creswell, J. D. (2018), *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, 5th Edition, SAGE Publications, Thousand Oaks, California.

E-Learning Sources

1. **Research Methodology**, NPTEL, Prof. Dipankar Deb, IIT Kharagpur.
2. **Research Methodology**, SWAYAM-NPTEL.
3. **Research Methods**, Open University (OpenLearn).

4. **Research Design and Methods**, SAGE Research Methods Video Collection.
5. **Introduction to Research**, SWAYAM MOOCs.
6. **Research Ethics and Publication Ethics (RPE)**, UGC Human Resource Development

SEMESTER-II

Course Title : CMOS CIRCUITS
Course Code : CC-4-MELE-201
Nature of the Course : CORE-IV
Total Credit assigned : 4
Components of the course : L-4, P-0, T-0
Distribution of Marks : End Semester: 56 In Semester: 24 PRACTICAL: 00

Course Contents

Unit	Contents	M	L	P	T
I	Review of MOS device, discrete biasing of MOS amplifier, small signal analysis of amplifier in CS, CG & CD configurations; Multistage amplifiers, cascade and cascode amplifiers, effect of feedback in amplifier, frequency response, stability and noise, oscillators	8	10		
II	Different types of Current mirrors, their design and analysis, bandgap references, MOS amplifiers with active load; Design and analysis of MOS differential amplifier, two and three stage MOS Operational amplifiers, frequency compensation, non-ideal characteristics of operational amplifier.	14	15		
III	Sample and hold circuit, data converters (ADC, DAC), switch capacitor filters, Phase Lock Loop (PLL). MOS layout and fabrication, MOS scaling theory, recent advances in MOS transistors, SPICE model of MOS transistors and simulation	10	12		
IV	Review of logic families, TTL versus CMOS logic, Transient and static behavior of MOS device, design and analysis of logic gates in CMOS, pseudo n-MOS, BiCMOS logic, Power dissipation	10	8		
V	Clocked and dynamic CMOS, tristate circuits, transmission gates, dual rail logic, design and analysis of combinational & Sequential logic circuits and arithmetic circuits	14	15		
		56	60		

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Weste, N. H. E. and Harris, D. M. (2015), *CMOS VLSI Design: A Circuits and Systems Perspective*, 4th Edition, Pearson Education, Noida.
2. Kang, S. M. and Leblebici, Y. (2003), *CMOS Digital Integrated Circuits: Analysis and Design*, 3rd Edition, Tata McGraw-Hill Education, New Delhi.
3. Baker, R. J. (2019), *CMOS: Circuit Design, Layout and Simulation*, 4th Edition, Wiley-IEEE Press, Hoboken.

E-Learning Sources

1. **CMOS Digital VLSI Design**, NPTEL, IIT Madras.
2. **Digital VLSI Design**, NPTEL, IIT Kharagpur.
3. **VLSI Design Flow: RTL to GDS**, NPTEL, IIT Kharagpur.
4. **Integrated Circuits, MOSFETs, Op-Amps and their Applications**, NPTEL, IIT Madras.
5. **VLSI System Design**, MIT OpenCourseWare, Massachusetts Institute of Technology.
6. **CMOS VLSI Design**, NPTEL Video Courses and SWAYAM-NPTEL Archive.

SEMESTER-II

Course Title	: POWER ELECTRONICS AND CONTROL SYSTEM
Course Code	: CC-4-MELE-202
Nature of the Course	: CORE
Total Credit assigned	: 4
Components of the course	: L-4, P-0, T-3
Distribution of Marks	: End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	Introduction to power electronics: Basic terminologies, definitions, comparison of conventional and power electronics, calculation of power, power factor, single/three phase, star and delta connections, heating effect, noise factors, shielding, protections, circuit breakers, ground leakage detection, Single phasing preventers. Power electronics circuits: Controlled rectifiers and filters: Single phase half wave and full wave-Semi-converter and full converter, Dual converter, three phase half wave, semi and full wave converter, three phase dual converter. Inverters: Principle of operation, voltage driven inverters, current driven inverters; Choppers: Basic principles, Type A, B and C choppers Series and parallel turn- off choppers, Morgan choppers and Jones choppers. Triggering and protection circuit: Thyristor firing, circuit- using transistor, UJT etc. thyristor gate protection circuit, di/dt and dv/dt protection for thyristors.	20	22		1 1
II	AC power supply systems: CVTs, Stabilizers, tap changers, UPS types (on-line and off line). Special application DC power supplies: CVCC, voltage mode and current mode SMPS, Tracking and fold back systems, Low voltage, low current, high voltage and high current power supplies, SMPS for computers.	8	8		
III	Concepts of closed -loop and open-loop systems: Importance and Application of Control System; Conceptual Block diagram of a control system and types- open loop and closed loop, Continuous and discrete data systems, Feedback theory Remedies. Representation of feedback control system: Block diagram, signal flow graphs, Mason's gain formula; Transfer function concept- Time and frequency domain analysis of first and second order systems to step, ramp and other inputs; error analysis, Types of systems.	16	18		1

IV	System Stability: Routh Hurwitz stability criteria, Root locus, Nyquist criteria, Relative and absolute stability; Polar and Bode Plot, Gain and phase margins. State Space Analysis: Definitions of state, state variables, state space, representation of systems Controllers: Response with P, PI and PID Controllers, Effects of proportional, integral and derivative control	12	13		
		56	60		3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):

Marks: 20+20

B. Sessional Activity

i. Attendance	10
ii. Assignment	10
iii. Seminar	10

In-semester Assessment:

Marks 24

Textbooks

Power Electronics

1. Power Electronics –Rashid, PHI
2. Power Electronics-P.C. Sen, TMH Ltd.
3. Thyristor engineering-M.S. Bedi, Khanna publications.
4. Thyristors and their applications- N. Rammurthy

Control systems:

1. Control Systems Engineering - I.G. Nagrath, M. Gopal; Wiley Eastern Ltd.
2. Automatic Control Systems- B.C. Kuo, Prentice-Hall of India.
3. Modern Control Engineering- K. Ogata, Prentice-Hall of India
4. Control System – S. Ghosh, Pearson Education
5. Control System Engineering- Bhattacharjya- Pearson Education

E-Learning Sources

1. **Control Engineering**, NPTEL, IIT Kharagpur.
2. **Control Systems**, NPTEL, IIT Madras.
3. **Modern Control System Design**, NPTEL, IIT Madras.
4. **Feedback Control Systems**, NPTEL, IIT Roorkee.
5. **Control of Mobile Robots**, Coursera, Georgia Institute of Technology.
6. **Control Systems**, MIT OpenCourseWare, Massachusetts Institute of Technology.

SEMESTER-II

Course Title : ELECTRONICS LAB
Course Code : CC-4-MELE-203
Nature of the Course : CORE-VI
Total Credit assigned : 4
Components of the course : L-0, P-4, T-0
Distribution of Marks : PRACTICAL: 80

A Student will have to perform at least 30 experiments (10 each from group A, B, and 10 from group C or D based on the opted DSE)

Course Contents

Unit	Contents	M	L	P	T
A	CMOS Circuit: List of Experiments for SPICE simulation: 1 Plot I-V characteristic curves of MOSFET. 2 Design and simulation of single stage MOS amplifier. 3 Design and simulation of MOS current mirror circuit. 4 Design and simulation of MOS differential amplifier. 5 Design and simulation of switch capacitor LP filter 6 Design and simulation of switch capacitor HP filter 7 Design and simulation of sample and hold circuit. 8 Design and simulation of cascode MOS amplifier. 9 Design and simulation of MOS voltage follower. 10 Plot switching characteristic curves of p-MOS and n-MOS. 11 Design and simulation of CMOS inverter. 12 Design and simulation of pseudo n-MOS NAND gate 13 Design and simulation of CMOS NOR gate 14 Design and simulation of tristate CMOS inverter. 15 Design and simulation of pseudo n-MOS SR Flip flop 16 Design and simulation of pseudo n-MOS D Flip flop 17 Design and simulation of CMOS 2:1 MUX 18 Estimation of propagation delay in CMOS logic gates			80	
B	Power Electronics and Control Systems (By using experimental set-up/Simulation tools): 1. Study of I-V characteristics of DIAC				

	2. Study of I-V characteristics of SCR 3. Study of I-V characteristics of TRIAC 4. Study of I-V characteristics OF UJT 5. SCR as a half wave rectifier with R and RL loads 6. SCR as a full wave rectifier with R and RL loads 7. Study of chopper circuits 8. Design of snubber circuit 9. To plot poles and zeros of a system by using its transfer function 10. Study of rise time, peak time and settling time of a second order system 11. Study of the performance of PID control system 12. Study of the stability of a given system by using its transfer function				
C	Statistics in Research 1. Calculate measures of central tendency (mean, median, mode) and dispersion (range, variance, standard deviation) for given datasets. 2. Construct frequency distributions and histograms to represent data. 3. Use z-scores to standardize and find probabilities for normal distribution. 4. Construct confidence intervals for population parameters (mean, proportion) using sample data. 5. Perform hypothesis tests for means and proportions using both z-tests and t-tests. 6. Calculate correlation coefficients to measure the strength and direction of linear relationships between variables. 7. Perform simple linear regression analysis to model the relationship between two variables. 8. Utilize statistical software (e.g., R, SPSS, Excel) to conduct various analyses and interpret the results. Mandatory Assignment: • Work on real-world research datasets to apply statistical concepts learned in class. • Present findings and interpretations of statistical analyses in written reports or presentations.				
D	Optoelectronics 1. To study the I-V characteristics and luminous intensity of a homo-junction LED. 2. To compare radiation patterns of surface-emitting and edge-emitting LEDs. 3. To calculate internal and external quantum efficiency of an LED from experimental data.				

4. To study the spectral response and thermal effects on LED output.				
5. To measure the modulation bandwidth of an LED using a square wave input.				
6. To study the electroluminescent behavior of an OLED and its response to input voltage.				
7. To demonstrate stimulated and spontaneous emission using a laser diode setup.				
8. To study the threshold current and output power characteristics of a pn-junction laser diode.				
9. To compare homo-junction and hetero-junction laser diode performance.				
10. To measure the responsivity and dark current of a p-i-n photodiode.				
11. To determine the response time and bandwidth of an avalanche photodiode.				
12. To study the angular response and noise equivalent power of a photodetector.				
To obtain the I-V characteristics and calculate the efficiency of a silicon-based solar cell under illumination				
	50		120	

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (30 Marks)

A. Sessional Activity

i. Continuous Evaluation	20
ii. Attendance	10
iii. Notebook record	10

In-semester Assessment:

Marks 30

Suggested Reading:

1. Electronics Lab Manual, Volume I, fifth edition, K. A. Navas.
2. Electronics Laboratory Primer, Chandra S. Poorna and Sasikala B, S. Chand Publications, 2005.

SEMESTER-II

Course Title : INTRODUCTION TO STATISTICS IN RESEARCH
Course Code : EC-4-MELE-201(A)
Nature of the Course : Elective
Total Credit assigned : 4
Components of the course : L-4
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	Introduction to Statistics and Data Presentation: Overview of statistics and its role in research; Types of data and scales of measurement; Classification and organization of data; Frequency distributions; Measures of central tendency (mean, median, mode); Measures of variability (range, variance, standard deviation); Measures of relative standing; Skewness and kurtosis; Data visualization using tables, bar charts, histograms, boxplots, and scatter plots.	12	15		1
II	Probability and Statistical Inference: Basic concepts of probability; Random variables and probability distributions; Normal distribution; Sampling and sampling distributions; Estimation and confidence intervals; Null and alternative hypotheses; Significance levels and p-values; Type I and Type II errors; Introduction to hypothesis testing.	14	16		1
III	Statistical Tests and Modelling: One-sample, independent-sample and paired-sample t-tests; Assumptions and interpretation of t-tests; One-way ANOVA; Pearson and Spearman correlation coefficients; Simple linear regression; Multiple regression; Chi-square tests; Interpretation of statistical results in research.	18	20		1
IV	Statistical Software and Applications: Overview of commonly used statistical software (e.g., SPSS, R, Excel), Basic functions and commands, Data input and manipulation, performing descriptive and inferential statistical analyses, Presenting statistical findings in research	12	9		
		56	60		3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2): **Marks:** **20+20**

B. Sessional Activity

i. Seminar	10
ii. Assignment	10
iii. Attendance	10

In-semester Assessment: **Marks 24**

Suggested Reading:

Textbooks

1. Gupta, S. C. and Kapoor, V. K. (2020), *Fundamentals of Applied Statistics*, 4th Revised Edition, Sultan Chand & Sons, New Delhi.
2. Montgomery, D. C. and Runger, G. C. (2018), *Applied Statistics and Probability for Engineers*, 7th Edition, John Wiley & Sons, Hoboken.
3. Triola, M. F. (2018), *Elementary Statistics*, 13th Edition, Pearson Education, New York.

E-Learning Sources

1. Introduction to Probability and Statistics, NPTEL, Prof. H. S. Mohana, IIT Roorkee.
2. Probability and Statistics, NPTEL, Prof. Soma Gupta, IIT Kharagpur.
3. Statistical Inference, NPTEL, IIT Kanpur.
4. Basic Statistics, SWAYAM-NPTEL.
5. Statistics and Data Science MicroMasters, Massachusetts Institute of Technology (MITx), edX.
6. Statistics for Applications, Coursera, Stanford University.

SEMESTER-II

Course Title : (B) OPTOELECTRONICS
Course Code : EC-4-MELE-201(B)
Nature of the Course : Elective
Total Credit assigned : 4
Components of the course : L-4
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Review of semiconductor physics: Direct and indirect band gap semiconductors, energy band diagrams and optical processes in semiconductors - optical absorption and carrier transitions; carrier recombination and generations.	10	10		
II	Light emitting diode (LED): LED materials, physics of homo-junction and hetero-junction LEDs, Radiation patterns of LED: surface and edge emitting diodes, LED characteristics: internal and external quantum efficiency, spectral width, thermal effects, modulation bandwidth. Basics of OLED and organic materials for OLED. Photodetectors: PD materials, pn junction PD, p-i-n PD, avalanche PD, PD characteristics- Dark current, responsivity, response times, electrical and optical bandwidth, angular response of PD, noise, noise equivalent power. Quantum limit, basics of photomultiplier tubes; Solar cells: I-V characteristics and spectral response, materials and fabrication of solar cells.	18	20		
III	Laser: stimulated emission and spontaneous emission, population inversion, active medium, optical cavity and optical feedback, pn-junction laser diodes – homo-junction and hetero-junction lasers, DFB laser. Optical Fibres: Theory of dielectric waveguide, light coupling to fibers and propagation principle, Total internal reflection, fiber classifications based on mode and refractive index profile, Numerical aperture, acceptance angle, light coupling to optical fibers, power loss inside the fibers, pulse dispersion, dispersion compensated fiber, polarization maintain fiber, fiber amplifier, fiber splicing, optical power budgeting in fiber links.	16	18		
IV	Luminescence: Luminescent materials: fluorescence & phosphorescence phenomena, Stokes shift, luminescent display devices based on CRT, LED, LCD, plasma and OLED	12	12		
		56	60		

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2): **Marks:** **20+20**

B. Sessional Activity

i. Seminar **10**

ii. Assignment **10**

iii. Attendance **10**

In-semester Assessment: **Marks 24**

Textbooks

1. Wilson, J. and Hawkes, J. F. B. (1998), *Optoelectronics: An Introduction*, 3rd Edition, Prentice Hall, London.
2. Bhattacharya, P. (2017), *Semiconductor Optoelectronic Devices*, 2nd Edition, Pearson Education, Noida.
3. Chuang, S. L. (2012), *Physics of Photonic Devices*, 2nd Edition, Wiley India Pvt. Ltd., New Delhi.

E-Learning Sources

1. **Optoelectronic Materials and Devices**, NPTEL, Indian Institute of Science (IISc) Bangalore.
2. **Optical Communication**, NPTEL, IIT Delhi.
3. **Fiber Optic Communication Technology**, NPTEL, IIT Kharagpur.
4. **Photonics and Optoelectronics**, NPTEL Course Archive.
5. **Optics**, MIT OpenCourseWare, Massachusetts Institute of Technology.

SEMESTER-III

Course Title : MICROPROCESSOR AND EMBEDDED SYSTEMS
Course Code : CC- 4-MELE-301
Nature of the Course : CORE
Total Credit assigned : 4
Components of the Course : L– 4, P-0, T - 0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	8086 Processor-Architecture, Pin Diagrams and Timing Diagrams: Van Neumann and Harvard Architecture, CISC and RISC Processors, Architectural block diagram of 8086 Microprocessor, Register Organization- General purpose registers, segment registers, PSW, index and pointers registers, Pin diagram and signal Descriptions, Physical Memory Organization, General Bus operation, I/O Addressing capability, Minimum Mode 8086 system and Timings, Maximum mode 8086 system and Timings.	10	11		1
II	Instruction Set and Addressing Modes of 8086: Instruction set of 8086 – Classification of 8086 Instructions - Data transfer instructions – Arithmetic Instructions –Logical instructions – Branching instructions – Bit Manipulation Instructions, Different addressing modes of 8086, Assembling and running an 8086 program – Structure of Assembly Language –Assembler directives.	10	11		1
III	8051Architecture: Introduction to MCU -51 Family microcontrollers, Architectural block Diagram, Comparison of Microprocessor and microcontroller, Pin diagram and Pin functions, General purpose and special purpose registers, Oscillators and clock circuit, Reset Circuit, I/O Port Circuits, Memory Organizations, Program memory and data memory. Addressing modes, data transfer instructions, Arithmetic and Logical instructions, Bit level instructions, branching instructions (Jump and loop Jump and call), Concept of stack, subroutine and related instructions, writing programs (like time delay using loop, Programming model of 8051, I/O Port programming, data conversions HEX to ASCII, BCD to ASCII, use of look up table, etc.) in assembly language 8051.	18	19		1
IV	External Memory Interfacing & Timer/Counter and Programming: Memory address decoding, interfacing 8031/8051 with ROM/EPROM, RAM; Introduction and function of Timer/Counters, Timer/Counters and associated registers, various modes of timer/counter operations	18	19		

	8051 Interrupts: Concept of interrupts, polling versus interrupts, Types of interrupts in 8051, Interrupts control and associated registers, interrupt vectors, Interrupt execution, RETI Instruction, software and hardware generated interrupt, interrupt handler subroutine for timer/counter and serial data transmission/reception in assembly language/ embedded c.				
		56	60		3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):

Marks: 20+20

B. Sessional Activity

i. Attendance

10

ii. Assignment

10

iii. Seminar

10

In-semester Assessment:

Marks 24

Suggested Reading:

Textbooks

1. Gaonkar, R. S. (2014), *Microprocessor Architecture, Programming and Applications with the 8085*, 6th Edition, Penram International Publishing (India) Pvt. Ltd., Mumbai.
2. Mazidi, M. A., Mazidi, J. G. and McKinlay, R. D. (2007), *The 8051 Microcontroller and Embedded Systems: Using Assembly and C*, 2nd Edition, Pearson Education, Noida.
3. Krishna Kant (2010), *Microprocessors and Microcontrollers: Architecture, Programming and System Design using 8085, 8086 and 8051*, PHI Learning Pvt. Ltd., New Delhi.
4. Ray, A. K. and Bhurchandi, K. M. (2019), *Advanced Microprocessors and Peripherals*, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., Noida

E-Learning Sources

1. **Microprocessors and Microcontrollers**, NPTEL, IIT Kharagpur.
2. **Microprocessor and Interfacing**, NPTEL, IIT Kharagpur.
3. **Embedded Systems Design**, NPTEL, IIT Kharagpur.
4. **Introduction to Embedded System Design**, NPTEL, IIT Bombay.
5. **Embedded Systems - Shape the World: Microcontroller Input/Output**, University of Texas at Austin, edX.
6. **Microprocessor and Microcontroller Virtual Laboratory**, Virtual Labs, Ministry of Education, Government of India.

SEMESTER-III

Course Title : DIGITAL SIGNAL PROCESSING
Course Code : CC- 4-MELE-302
Nature of the Course : CORE-VIII
Total Credit assigned : 4
Components of the Course : L– 4, P-0, T - 0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Signal and System classification: Definition of Signals and types: random and deterministic, continuous and discrete, Periodic, aperiodic; even-odd; exponential, sinusoidal; unit impulse & unit step functions; Definition of System and types- linear, causal, time-variant, stable, with memory and related types; Sampling theorem-review only. Linear time invariant [LTI] system: Representation of discrete time signals in terms of impulses; convolution; convolution sum representation of LTI systems; properties of LTI (commutative, distributive, associative); LTI systems with & without memory, causality, linearity, stability of LTI systems; Unit impulse response of an LTI system;	18	17		2
II	Z-Transform: Definition and properties, Inverse Z Transform and stability. Parsevals Theorem and applications. System Function: signal flow graph, its use in representation and analysis of Discrete Time Systems. Techniques of representations. Matrix generation and solution for DTS evaluations.	14	16		1
III	Discrete Fourier Transform: DFT assumptions and Inverse DFT. Matrix relations, relationship with FT and its inverse, circular convolution, DFT theorems, Computation of DFT. FFT Algorithms and processing gain, Discrimination, interpolation and extrapolation. Gibbs phenomena. FFT of real functions interleaving and resolution improvement.	12	13		1
IV	Digital Filters: Analog filter review. System function for IIR and FIR filters, network representation. IIR filter realization methods and their limitations. FIR filter realization techniques. Discrete correlation and convolution; Properties and limitations.	12	14		1
		56	60		

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:

Marks 24

Textbooks

1. Oppenheim, A. V. and Schafer, R. W. (2010), *Discrete-Time Signal Processing*, 3rd Edition, Pearson Education, Noida.
2. Proakis, J. G. and Manolakis, D. G. (2007), *Digital Signal Processing: Principles, Algorithms and Applications*, 4th Edition, Pearson Education, Noida.
3. Nagoor Kani, A. (2017), *Digital Signal Processing*, 2nd Edition, McGraw Hill Education (India) Pvt. Ltd., Noida.

E-Learning Sources

1. Digital Signal Processing, NPTEL, IIT Delhi.
2. Digital Signal Processing, NPTEL, IIT Bombay.
3. Digital Signal Processing, NPTEL, IIT Madras.
4. Discrete-Time Signal Processing, Massachusetts Institute of Technology (MIT OpenCourseWare).
5. Digital Signal Processing, EPFL (École Polytechnique Fédérale de Lausanne), Coursera.
6. Digital Signal Processing Virtual Laboratory, Virtual Labs, Indian Institute of Technology Kharagpur, Ministry of Education, Government of India.

SEMESTER-III

Course Title : LINEAR ELECTRONIC CIRCUITS
Course Code : CC- 4-MELE-303
Nature of the Course : CORE
Total Credit assigned : 4
Components of the Course : L– 4, T – 0, P-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	Diode circuits: Review of pn diode junction operation, diode biasing, load line analysis, rectifier circuits & zener diode-based voltage regulator, clipper and clamper circuits, Logic gates design with diodes. BJT circuits: Review of BJT operation, CE, CB and CC configurations and Q point, stability factor, BJT biasing techniques, BJT modeling: re -model, h-parameter model, determination of input impedance, voltage gain, current gain and output impedance, Darlington pair and feedback pair, BJT amplifiers; multistage BJT amplifiers, tune amplifiers.	15	15		1
II	JFET and MOSFET circuits: Review of JFET & MOSFET operation, device specifications; JFET & MOSFET biasing techniques, Trans-conductance model of JFET and MOSFET; small signal analysis of JFET & MOSFET amplifiers at low and high frequencies – determination of input impedance, voltage gain, current gain and output impedance of the amplifiers in CS, CG and CD configurations; multistage JFET & MOSFET amplifiers	14	15		1
III	Power amplifiers: Classification of power amplifiers; design and analysis of class A, B, AB, C amplifiers – determination of conversion efficiency, signal distortions in power amplifier; heat sink requirement and power transistor specifications. Feedback and oscillator circuits: Types of feedback, Feedback topologies, Barkhausen conditions for sustain oscillation, types of oscillator circuits – sinusoidal and non-sinusoidal oscillators; BJT based multivibrators, design of RC-phase-shift oscillator, Colpitt and Hartly oscillators with transistors and OP-AMP. Tune oscillators and crystal oscillators.	16	18		1
IV	Differential amplifier and OP-AMP: Differential amplifier terms and terminologies, design and analysis of differential amplifier with BJT, JFET & MOSFET, Current mirror circuits and their role inside OP-AMP circuitry, Op-AMP: review of ideal and real characteristics of OP-AMP, case studies of OP-	11	12		

	AMP 741; OP-AMP circuits – analog computation, logarithmic and anti-logarithm amplifier, Schmitt trigger, voltage to frequency converter, instrumentation amplifier.				
		56	60		3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):

Marks: 20+20

B. Sessional Activity

i. Attendance

10

ii. Assignment

10

iii. Seminar

10

In-semester Assessment:

Marks 24

Textbooks

1. Boylestad, R. L. and Nashelsky, L. (2019), *Electronic Devices and Circuit Theory*, 11th Edition, Pearson Education, Noida.
2. Millman, J. and Halkias, C. C. (2015 Reprint), *Electronic Devices and Circuits*, Tata McGraw-Hill Education, New Delhi.
3. Sedra, A. S. and Smith, K. C. (2020), *Microelectronic Circuits*, 8th Edition, Oxford University Press.
4. Rashid, M. H. (2017), *Microelectronic Circuits: Analysis and Design*, Cengage Learning.

E-Learning Sources

1. **Analog Electronic Circuits**, NPTEL, IIT Madras.
2. **Electronic Circuits**, NPTEL, IIT Delhi.
3. **Integrated Circuits, MOSFETs, Op-Amps and their Applications**, NPTEL, IIT Madras.
4. **Circuits and Electronics**, MIT OpenCourseWare, Massachusetts Institute of Technology.
5. **Analog Electronics Laboratory**, Virtual Labs, IIT Kharagpur, Ministry of Education, Government of India.
6. **Electronic Devices and Circuits**, SWAYAM-NPTEL

SEMESTER-III

Course Title : OPTICAL COMMUNICATION (A)
Course Code : EC-4-MELE-301(A)
Nature of the Course : Elective - III
Total Credit assigned : 4
Components of the Course : L– 4, T – 0, P-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Introduction to Optical Fibers: Introduction to general optical fiber communication system, electromagnetic spectrum, advantages of optical fiber communication, basic optical laws and definitions, elements of optical fiber transmission, optical modes and configurations, ray theory transmission, total internal reflection, Optical fiber waveguides, cylindrical fiber modes, mode coupling, losses in optical fiber.	17	20		1
II	Transmission Characteristic of Optical Fiber: Attenuation, absorption, scattering losses, bending losses, core and cladding losses, signal dispersion, inter symbol interference and bandwidth, intra model dispersion, material dispersion, waveguide dispersion, polarization mode dispersion, intermodal dispersion. dispersion optimization of single mode fiber, characteristics of single mode fiber, R-I Profile, cutoff wave length, dispersion calculation, mode field diameter.	12	16		
III	Optical Sources and Detectors: Types of dispersion, Optical fiber connectors, Optical sources, light emitting diodes (LEDs) – structures, materials, properties; surface and edge emitting LED, figure of merit, quantum efficiency, power modulation; LASER diodes, modes and threshold conditions, rate equations; PIN photo detector, Photo detector noise, Avalanche photo diodes.	16	18		1
IV	Optical Receiver, Measurements and Coupling: Optical system design, fundamental receiver operation, preamplifiers, digital signal transmission, error sources, receiver configuration, optical power measurement, attenuation& dispersion measurement, fiber to fiber joints, LED coupling to single mode fibers, fiber splicing, optical fiber connectors	11	12		1
		56	60		3

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Gerd Keiser (2021), *Optical Fiber Communications*, 6th Edition, McGraw Hill Education, New York.
2. John M. Senior and M. Yousif Jamro (2009), *Optical Fiber Communications: Principles and Practice*, 3rd Edition, Pearson Education, Noida.
3. Ghatak, A. and Thyagarajan, K. (2012), *Introduction to Fiber Optics*, Cambridge University Press, New Delhi.

E-Learning Sources

1. **Optical Communication**, NPTEL, IIT Delhi.
2. **Fiber Optic Communication Technology**, NPTEL, IIT Kharagpur.
3. **Optical Networks**, NPTEL, IIT Madras.
4. **Fiber Optics**, MIT OpenCourseWare, Massachusetts Institute of Technology.
5. **Fiber Optics Virtual Laboratory**, Virtual Labs, IIT Kharagpur, Ministry of Education, Government of India.
6. **Optical Communication Systems**, SWAYAM-NPTEL.

SEMESTER-III

Course Title : ANTENNA THEORY
Course Code : EC-4-MELE-301(B)
Nature of the Course : Elective - III
Total Credit assigned : 4
Components of the Course : L- 4, T – 0, P-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Antennas Basics: Introduction, Basic Antenna Parameters, Patterns, Beam Area (or Beam Solid Angle) Ω_A , Radiation Intensity, Beam Efficiency, Directivity D and Gain G, Directivity and Resolution, Antenna Apertures, Effective Height, The radio Communication link, Fields from Oscillating Dipole, Single-to-Noise Ratio (SNR), Antenna Temperature, Antenna Impedance.	16	18		1
II	Application to an Isotropic Source, Radiation Intensity, Arrays of Two Isotropic Point Sources, Non-isotropic but Similar Point Sources and the Principle of Pattern Multiplication, Pattern Synthesis by Pattern Multiplication, Linear Arrays of n Isotropic Point Sources of Equal Amplitude and Spacing.	14	15		1
III	Electric Dipoles: Thin Linear Antennas and Arrays of Dipoles and Apertures: The Short Electric Dipole, The Fields of a Short Dipole, Radiation Resistance of Short Electric Dipole, Thin Linear Antenna, Radiation Resistance of $\lambda/2$ Antenna, Horizontal Antennas Above a Plane Ground, Vertical Antennas Above a Plane Ground, Yagi-Uda Antenna Design, Long Wire Antennas, folded Dipole Antennas.	14	15		1
IV	Loop Antenna: Design and its Characteristic Properties, Application of Loop Antennas, Slot Antennas, Horn Antennas, Helical Antennas, The Log-Periodic Antenna, Micro strip Antennas. Reflector Antennas: Flat Sheet Reflectors, Corner Reflectors, The Parabola-General Properties, A Comparison Between Parabolic and Corner Reflectors, Reflector Types (summarized).	12	12		
		56	60		3

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:

Marks 24

Textbooks

1. Balanis, C. A. (2016), *Antenna Theory: Analysis and Design*, 4th Edition, John Wiley & Sons, Hoboken.
2. Kraus, J. D. and Marhefka, R. J. (2002), *Antennas for All Applications*, 3rd Edition, Tata McGraw-Hill Education, New Delhi.
3. Harish, A. R. and Sachidananda, M. (2007), *Antennas and Wave Propagation*, Oxford University Press, New Delhi.

E-Learning Sources

1. **Antennas**, NPTEL, IIT Kharagpur.
2. **Antennas and Propagation**, NPTEL, IIT Bombay.
3. **Electromagnetic Waves and Antennas**, NPTEL, IIT Madras.
4. **Antenna Engineering**, SWAYAM-NPTEL.
5. **Electromagnetics and Applications**, MIT OpenCourseWare, Massachusetts Institute of Technology.
6. **Antenna Virtual Laboratory**, Virtual Labs, Ministry of Education, Government of India.

SEMESTER-III

Course Title : Semiconductor Device Fabrication Technology
Course Code : EC-4-MELE-301(C)
Nature of the Course : Elective - III
Total Credit assigned : 4
Components of the Course : L– 4, T – 0, P-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Introduction of Semiconductor Process Technology (Line width – 10 nm technology), Semiconductor materials, single crystal, polycrystalline and amorphous, Crystal growth techniques: Si from the Czochralski technique, starting material, Distribution of dopants, Effective Segregation Coefficient. Silicon Float Zone Process. Epitaxy Deposition: Epitaxial growth by vapor phase epitaxy (VPE) and molecular beam epitaxy (MBE). Characterization: Various characterization methods for structural, electrical and optical properties. Basic idea of X-ray diffractometer, Scanning electron microscope, Transmission electron microscope and UV-VIS-NIR spectrophotometer.	19	20		1
II	Oxidation: Thermal Oxidation Process: Dry and Wet oxidation. Effects of high pressure and impurities, Impurity Redistribution during Oxidation, Masking property of Silicon Oxide, Oxide Quality, Chemical vapour deposition of silicon oxide, properties of silicon oxide, step coverage. Diffusion: Basic Diffusion Process: Diffusion Equation, Diffusion Profiles. Extrinsic Diffusion Concentration Dependent Diffusivity, Lateral Diffusion, Doping through Ion Implantation and its comparison with diffusion.	13	14		1
III	Lithographic Processes: Clean room, Optical lithography, exposure tools, masks, Photoresist, Pattern Transfer, Electron Beam Lithography, X-ray Lithography and Ion Beam Lithography. Comparison between various lithographic techniques. Etching: Wet Chemical Etching-basic process and few examples of etchants for semiconductors, insulators and conductors; Dry etching using plasma etching technique. Metallization: Uses of Physical Vapor Deposition and Chemical Vapor Deposition technique for Aluminum and Copper Metallization.	14	15		1

IV	Process Integration: Passive components- Integrated Circuit Resistor, Integrated Circuit Inductor, Integrated Circuit Capacitor. Bipolar Technology: Basic fabrication process, Isolation techniques. MOSFET Technology: Basic fabrication process of NMOS, PMOS and CMOS technology.	10	11		1
		56	60		3

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance	10	
ii. Assignment	10	
iii. Seminar	10	

In-semester Assessment:

Marks 24

Textbooks

1. Sze, S. M. and Ng, K. K. (2007), *Physics of Semiconductor Devices*, 3rd Edition, John Wiley & Sons, Hoboken.
2. Plummer, J. D., Deal, M. D. and Griffin, P. B. (2000), *Silicon VLSI Technology: Fundamentals, Practice and Modeling*, Prentice Hall, New Jersey.
3. Jaeger, R. C. and Blalock, T. N. (2016), *Microelectronic Circuit Design*, 5th Edition, McGraw-Hill Education (for fabrication-process overview and device technology).

E-Learning Sources

1. **Semiconductor Devices and Circuits**, NPTEL, IIT Madras.
2. **Semiconductor Device Modeling and Simulation**, NPTEL, IIT Bombay.
3. **VLSI Design Flow: RTL to GDS**, NPTEL, IIT Kharagpur.
4. **Microfabrication / Semiconductor Processing**, Massachusetts Institute of Technology (MIT OpenCourseWare).
5. **Nanotechnology, Science and Applications**, NPTEL.
6. **Semiconductor Device Fabrication Laboratory**, Virtual Labs, Ministry of Education, Government of India.
7. **Semiconductor Manufacturing**, Coursera, University of Colorado Boulder.
8. **Introduction to Semiconductor Devices**, SWAYAM-NPTEL.

SEMESTER-IV

Course Title : COMMUNICATION NETWORK
Course Code : CC-4-MELE-401
Nature of the Course : CORE-X
Total Credit assigned : 4
Components of the Course : L– 4, T – 0, P-0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Computer Network: Definition, basic types – LAN, MAN, WAN, Wireless networks, Reference Models: OSI Reference model, description of TCP/ IP reference model, comparison of OSI & TCP/ IP reference models. Physical Layer: Transmission Models: Serial/Parallel, Synchronous/Asynchronous, Full Duplex, Multiplexing: FDM, TDM, Statistical TDM, WDM WANs: Circuit, Packet & Message Switching, LANs: Architecture, Configurations Mobile Telephone systems: From 1G, 2G, 3G,4G and 5G	16	18		1
II	Data link Layer: Data Link Control – Flow Control; Error Detection, Correction & Control. Elementary Data Link protocols, Sliding Window Protocols – One-bit Sliding window protocol, protocol using go back n. Medium Access Sub layer: Channel Access Control – ALOHA, Carrier Sense Multiple Access Protocol, WDMA Protocols, Wire Less LAN protocols, CDMA.IEEE Standard Protocols IEEE standard 802 for LAN. Ethernet, Bluetooth and RFID.	16	15		1
III	Network Layer Services: Design issues, Routing algorithms – optimality principle, shortest path algorithm, flooding, distance vector routing. Congestion control algorithms, Network layer in the Internet. Transport Layer: Transport service, transport protocols, Internet transport protocol (TCP & UDP).	14	15		1
IV	ATM and Wireless Networks: Main features of ATM – addressing, signaling and routing. ATM cell header structure-Adaptation layer, Management and Control. BISDN, Interworking with ATM, Wireless Channel, link level design, Channel access.	10	12		
		56	60		3

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Forouzan, B. A. (2017), *Data Communications and Networking*, 5th Edition, McGraw Hill Education, New York.
2. Kurose, J. F. and Ross, K. W. (2021), *Computer Networking: A Top-Down Approach*, 8th Edition, Pearson Education, Noida.
3. Tanenbaum, A. S. and Wetherall, D. J. (2011), *Computer Networks*, 5th Edition, Pearson Education, Noida.

E-Learning Sources

1. **Computer Networks and Internet Protocol**, NPTEL, IIT Kharagpur.
2. **Computer Networks**, NPTEL, IIT Kharagpur.
3. **Data Communication**, NPTEL, IIT Bombay.
4. **Computer Networking**, Massachusetts Institute of Technology (MIT OpenCourseWare).
5. **Computer Networks Laboratory**, Virtual Labs, IIT Kharagpur, Ministry of Education, Government of India.
6. **Computer Networks**, SWAYAM-NPTEL.
7. **Computer Communications**, Coursera, University of Colorado System.
8. **Computer Networking**, Stanford Online

SEMESTER-IV

Course Title : LOW POWER VLSI DESIGN
Course Code : CC- 4-MELE-402
Nature of the Course : CORE
Total Credit assigned : 4
Components of the Course : L- 4, P-0, T - 0
Distribution of Marks : End Semester: 56 In Semester: 24

Course Contents:

Unit	Contents	M	L	P	T
I	Introduction to low power integrated circuit, sources of power dissipation- switching power dissipation, short circuit power dissipation, leakage power dissipation, glitching power dissipation, speed – area trade off, overview of low power design methods, Hot electron effect.	12	13		1
II	Modelling of low voltage transistors - Bipolar and MOS transistors characteristics, threshold voltage scaling, short channel effect, subthreshold conduction and leakage mechanism, DIBL and velocity saturation, CMOS device scaling, low power transistor models, process variations and reliability issues; low voltage device fabrication and process technology.	13	12		1
III	Design and analysis of Low power CMOS combinational (adders and multipliers) and sequential logic circuits, low power memory design. BiCMOS structure, operation and application in high-speed low power circuits, designs of BiCMOS logic gates, delay and noise margin analysis, low power combinational circuits (adders, multipliers), sequential circuits (flip -flops, registers, and clock gating circuits)	17	19		1
IV	Low power design through Voltage scaling-VTCMOS circuits, MTCMOS circuits, gate level, architectural level (pipelining and parallel processing approach), algorithmic level; Power estimation techniques. Low-Voltage-Low-Power Memories: Basics of Rom, Low-power ROM Technology, Basics of SRAM, Memory Cell, Low-power SRAM technologies, Basics of DRAM, self-refresh circuit.	14	16		
		56	60		3

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Chandrakasan, A. P. and Brodersen, R. W. (1995), *Low Power Digital CMOS Design*, Kluwer Academic Publishers, Boston.
2. Rabaey, J. M., Chandrakasan, A. and Nikolic, B. (2003), *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, Pearson Education, Noida.
3. Weste, N. H. E. and Harris, D. M. (2015), *CMOS VLSI Design: A Circuits and Systems Perspective*, 4th Edition, Pearson Education, Noida.

E-Learning Sources

1. **Low Power VLSI Circuits and Systems**, NPTEL, IIT Kharagpur.
2. **CMOS Digital VLSI Design**, NPTEL, IIT Madras.
3. **Digital VLSI Design**, NPTEL, IIT Kharagpur.
4. **VLSI Design Flow: RTL to GDS**, NPTEL, IIT Kharagpur.
5. **VLSI CAD: Logic to Layout**, NPTEL, IIT Bombay.
6. **VLSI System Design**, Massachusetts Institute of Technology (MIT OpenCourseWare).
7. **VLSI Design Virtual Laboratory**, Virtual Labs, Ministry of Education, Government of India.
8. **CMOS VLSI Design**, SWAYAM-NPTEL.

SEMESTER-IV

Course Title : Wireless and Mobile Communication Networks
Course Code : CC- 2-MELE-403
Nature of the Course : CORE
Total Credit assigned : 2
Components of the Course : L-2, T - 0
Distribution of Marks : End Semester: 28 In Semester: 12

Course Contents:

Unit	Contents	M	L	P	T
I	Wireless and Mobile Communication Networks: Review of cellular communication concepts; Evolution of mobile communication systems from 2G to 5G; LTE and 5G network architecture; Multiple access techniques – FDMA, TDMA, CDMA and OFDMA; MIMO systems and diversity techniques; Wireless Local Area Networks (WLAN), Bluetooth and ZigBee; Internet of Things (IoT) communication networks	14	15		
II	Modern Communication Systems and Applications: Optical communication networks: WDM concepts and optical network architecture; Satellite communication networks and applications; Network performance measures – throughput, latency, bandwidth and Quality of Service (QoS); Software Defined Radio (SDR) and Cognitive Radio concepts; Emerging trends in communication systems including 5G applications, machine-to-machine communication and future communication networks.	14	15		
		28	30		0

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (12 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:

Marks 12

Textbooks

1. Kurose, J. F. and Ross, K. W. (2021), *Computer Networking: A Top-Down Approach*, 8th Edition, Pearson Education, Noida.
2. Forouzan, B. A. (2017), *Data Communications and Networking*, 5th Edition, McGraw Hill Education, New York.

3. Stallings, W. (2017), *Data and Computer Communications*, 10th Edition, Pearson Education, Noida.

E-Learning Sources

1. **Computer Networks and Internet Protocol**, NPTEL, IIT Kharagpur.
2. **Computer Networks**, NPTEL, IIT Kharagpur.
3. **Wireless Communication**, NPTEL, IIT Kanpur.
4. **Introduction to Industry 4.0 and Industrial Internet of Things**, NPTEL, IIT Kharagpur.
5. **Computer Networking**, Massachusetts Institute of Technology (MIT OpenCourseWare).
6. **Computer Networks Laboratory**, Virtual Labs, IIT Kharagpur, Ministry of Education, Government of India.
7. **Computer Networks**, SWAYAM-NPTEL.
8. **Introduction to 5G Technologies**, Coursera, Yonsei University

SEMESTER-IV

Course Title	:	Instrumentation Systems and Applications
Course Code	:	EC- 4-MELE-401(A)
Nature of the Course	:	ELECTIVE-IV
Total Credit assigned	:	4
Components of the Course	:	L-4, T – 0, P-0
Distribution of Marks	:	End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Sensors and Systems Temperature Measurement: Units of Temperature Measurement / Temp Measurement Scales; Broad Classification of Temperature Transducers, RTD, Thermocouple, Thermistors, Optical Fiber Sensors. (Basic Principle of Working, Selection Criteria); IR Temperature Sensor: MLX90614 ESF Non- Contact Human Body Infrared Temperature Measurement Module. Humidity: Hygrometer, Soil Humidity Sensor Pressure sensor: Strain gauge (Load Cell using Strain gauge), Piezoelectric Transducer, Solid State Pressure Sensors, Pneumatic sensors (bellows, diaphragm), Ultrasonic and Hall effect Sensors for flow Measurement Displacement: Potentiometer, Strain-gauged element, Capacitive element, Differential transformers, Inductive and Capacitive Proximity switch, Optical encoders.	18	19		1
II	Biomedical signals & Physiological transducer Source of biomedical signal, Origin of bioelectric signals, recording electrodes, Electrodes for ECG, EMG & EEG. Physiological transducers: Pressure, Temperature, ultrasound Transducers. Measurement in Respiratory system: Physiology of respiratory system, Measurement of breathing mechanics, Spiro meter, Respiratory therapy equipments.	11	13		1
III	Patient Monitoring systems: Cardiac monitor, Bedside patient monitor, measurement of heart rate, blood pressure, temperature, respiration rate, Arrhythmia monitor, Methods of monitoring fatal heart rate.	09	11		1

IV	Instrumentation applications Basic Concept of Data Acquisition Systems (Block Diagram Understanding); Basic Concept of IoT, Sensor Interface in IoT systems Case Study 1: IoT based Agriculture/Greenhouse systems (Block Diagram) consisting of Optical Sensors, Electro-Chemical Sensors, Mechanical Sensors Dielectric Soil Moisture Sensors, Air Flow Sensors etc. Case Study 2: IoT based Healthcare Systems (Block Diagram consisting of ECG Module, Temperature, Accelerometer, Oxygen Level, Heart Rate sensors	18	17		
		56	60		3

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment: Marks 24

Textbooks

1. Morris, A. S. and Langari, R. (2016), *Measurement and Instrumentation: Theory and Application*, 2nd Edition, Academic Press, Elsevier.
2. Patranabis, D. (2017), *Sensors and Transducers*, 3rd Edition, PHI Learning Pvt. Ltd., New Delhi.
3. Sawhney, A. K. and Sawhney, P. (2023), *A Course in Electrical and Electronic Measurements and Instrumentation*, 21st Edition, Dhanpat Rai & Co., New Delhi.

E-Learning Sources

1. **Industrial Instrumentation**, NPTEL, IIT Kharagpur.
2. **Sensors and Actuators**, NPTEL, IIT Kharagpur.
3. **Biomedical Instrumentation**, NPTEL, IIT Madras.
4. **Electronic Instrumentation Laboratory**, Virtual Labs, IIT Kharagpur, Ministry of Education, Government of India.
5. **Biomedical and Signal Processing Laboratory**, Virtual Labs, Ministry of Education, Government of India.
6. **Instrumentation and Process Control**, SWAYAM-NPTEL.

SEMESTER-IV

Course Title	:	SENSOR TECHNOLOGY & MEMS
Course Code	:	EC- 4-MELE-401(B)
Nature of the Course	:	ELECTIVE-IV
Total Credit assigned	:	4
Components of the Course	:	L-4, T – 0, P-0
Distribution of Marks	:	End Semester: 56 In Semester: 24

Course Contents

Unit	Contents	M	L	P	T
I	Sensors: Basics of Sensors, Sensor Classification, Performance and Types, Sensor Characteristics, Error Analysis characteristics, Displacement, position and proximity sensors, Velocity and motion sensors, Strain gauge, load cell, Fluid pressure sensors, Piezoelectric sensors, Ultrasonic sensors, Temperature sensors, Smart sensors, Basics of biomedical sensors: ECG sensor, EEG sensor, PPG sensor	12	15		2
II	Electronic and Optical properties of Sensors: semiconductor as sensors, LED, Semiconductor lasers, Fiber optic sensors, photoconductive detectors, Photo diodes, Avalanche photodiodes	15	15		1
III	Signal conditioning and processing: Data acquisition systems, block diagram of DAQ, signal conditioning, Digital to Analog converters, Analog to digital converters.	10	12		1
IV	MEMS and Microsystems: Structural and Sacrificial Materials, Properties of Materials, Basic Modelling of Elements in Electrical and Mechanical systems, Sensors/transducers, Sensors Characterization and Classifications, Microactuators, Applications of MEMS, Modelling of different types of MEMS sensor for real life application	19	18		1
		56	60		8

(L: Lecture T: Tutorial P: Practical)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Tests (1+2):	Marks:	20+20
B. Sessional Activity		
i. Attendance		10
ii. Assignment		10
iii. Seminar		10

In-semester Assessment:	Marks 24
--------------------------------	-----------------

Textbooks

1. Bhattacharyya, T. K. and Pal, S. (2019), *MEMS and Microsystems: Design, Manufacture and Nanoscale Engineering*, CRC Press, Boca Raton.
2. Hsu, T. R. (2008), *MEMS and Microsystems: Design and Manufacture*, 2nd Edition, McGraw-Hill Education, New York.
3. Fraden, J. (2016), *Handbook of Modern Sensors: Physics, Designs and Applications*, 5th Edition, Springer International Publishing.

SEMESTER-IV

Course Title	:	PROJECT WORK
Course Code	:	EC- 6-MELE-402
Nature of the Course	:	ELECTIVE-V
Total Credit assigned	:	6
Components of the Course	:	L-0, T – 0, P-6
Distribution of Marks	:	PRACTICAL-120

Course Contents

Unit	Contents	M	L	P	T
I	PROJECT: The project is an essential component of the Masters courses. It is a substantial piece of fulltime independent work which occupies the final months of the course. Students may also be required by their project markers to demonstrate any system that arose from the project. The project involves both the application of skills learned in the past and the acquisition of new skills. It allows the students to demonstrate their ability to organize and carry out a major piece of work according to sound scientific and engineering principles. The types of activity involved in each project will vary but all will typically share the following features: 1. Research the literature and gather background information 2. Analyze the requirements, compare alternatives and specify a solution 3. Design and implement the solution 4. Experiment and evaluate the solution 5. Develop written and oral presentation skills			120	
				120	

(L: Lecture T: Tutorial P: Practical)