UNIVERSITY OF DELHI

MASTER OF SCIENCE (ELECTRONICS)

based on

NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 17-02-2026, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 23-02-2026, and meeting of 'Standing Committee' held on _____________

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Historical Background of Department

The Department of Electronic Science was established in 1985 and is widely recognised as one of the most prestigious Electronic Science Departments in the country.

The Department is conducting courses leading to M.Tech. in Microwave Electronics and M.Sc. in Electronics. The aim of these programmes is to provide the necessary theoretical background and practical experience in order to meet the requirements of the R&D Organizations and Industries. In addition, the M.Tech. students work for 6 months on projects in collaboration with Industry and R&D Organisations and the M.Sc. students do in-house six months projects in the final semester. The curriculum of these courses is updated regularly to keep it in consonance with the changing industrial environment. Workshops/ seminars and hands-on workshops are organized on a regular basis to bridge the gap between academia and industry, and to provide requisite exposure to the students about the latest technological developments taking place in varied areas related to microelectronics, microwaves, communication, photonics etc. The interface with industry is further enhanced by an annual seminar under the Visitors' Programme in which professionals from industry, R&D organizations and academics are invited. Our alumni, now spread over a large number of government and private organisations, facilitate these interactions.

A full range of resources and facilities are available to the students. The Department has a wellequipped computer laboratory with various circuit simulation and microwave design software for students. In addition, there are well equipped laboratories for experimental work in the following areas: Microwave Measurements, Communication Electronics, Circuit Design, Electronic Materials and Semiconductor Devices, Microprocessors and Digital Signal Processing, Optical Electronics, Anechoic chamber and Microwave Component Fabrication. An assessment of students' performance is made through continuous series of tests and presentations in addition to semester end examinations to ensure highest standards.

The Department is actively helping the students in their placement through Campus interviews. Students graduating from the Department have found positions in both government and private organizations working in the areas of Semiconductors, Information Technology, Telecommunications, Defence and Space Applications, etc. The students graduating from the programs have the necessary theoretical and practical skills to take on any R&D and Production responsibilities in today's complex and challenging environment. This is evident from the contributions and achievements of our alumni in organizations like ST Microelectronics, Cadence, HFCL, Aricent, Transwitch, SAMEER, ISRO, Keysight Technologies, VVDN Technologies, DRDO laboratories like DEAL, LRDE and many more.

Department Highlights:

The Department is well established with thirteen faculty members. Extramural grants from DST, CSIR, DRDO, ISRO, etc as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department was also funded under the DST-FIST, UGC 12th plan and DUDST PURSE programs. The Department has well-equipped teaching and research laboratories with state-of-the-art equipment for fabrication, characterization and measurement in the areas of microwave measurement, electronic materials and semiconductor devices, communication electronics, photonics etc. A large number of TCAD and EDA tools are also available that further enhances and strengthens teaching and research. The students graduating from these programmes acquire the necessary theoretical and practical skills to take up roles in R&D organizations, academia as well as industry. Since the inception of these programmes, the Department has witnessed several success stories and our students have done exceptionally well and are placed in some of the most reputed government as well as private organizations such as SSPL, NPL, DEAL, IRDE, BEL, SAMEER, ISRO, Keysight technologies, VVDN Technologies, ST Microelectronics, cadence, NXP ARM, etc.

About the Program

The M.Sc. Electronics program offered by University of Delhi is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments. Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ techniques of research writing, and Dissertation/Problem based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester i.e. a total of eighty-eight credits over four semesters to fulfil the requirements for a Master of Science degree in Electronics (two-year program), and forty-four credits over two semesters to fulfil the requirements for a Master of Science degree in Electronics (one year *program).*

About Post-Graduate Attributes:

The curriculum is designed to train the students in basic and advanced areas of Electronics, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Electronics. This enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they undertake in their final year.

The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential electronics as well as the most recent advances in varied specialized areas. Thus, the program will prepare students for various opportunities in academia or industry, and equip them to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in varied areas of Electronics. Through the stimulus of scholarly progression and intellectual development, the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multidimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will gain requisite exposure in different branches of Electronics such as Microelectronics, RF & Microwaves, Communication and Photonics, Digital Signal Processing, Terahertz Technology etc. They will be able to design and execute experiments related to advanced Analog and Digital Circuits, Signal Processing, Embedded Systems, RF& Microwave Systems, and Optical Communication. They will also be able to execute a research projects in varied areas under supervision. The student will be equipped to take up a suitable position in academia or industry, and pursue a career in research if desired.

About Program Structure:

The M.Sc. Electronics program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020. Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement course (SEC) in each semester of the first year. In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Structure-1: (PG with only coursework) (Level 6.5)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2: (PG with coursework and research) (Level 6.5)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3: (PG with research) (Level 6.5)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. ELECTRONICS COURSE (NEP-PGCF)

Second-Year
Structure-1: (PG with only coursework)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Advanced Digital and Data Communication	3	1	0	4
DSC-08: Processing of Semiconducting Materials and Devices	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4
Generic Elective courses*				
GE-03: Science of Microwave Heating	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SBC-03: Software Defined Radio Techniques for Modern Wireless Systems	1	1	0	2
Total credits				22

*** (a student can opt for either three DSE courses, or two DSE with one GE)**

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-10: Advanced Digital Signal Processing	3	1	0	4
DSC-11: Principles of VLSI Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-14: Artificial Intelligence & Robotics	3	1	0	4
DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication	3	1	0	4

DSE-18: Modern Antennas	3	1	0	4
Generic Elective Courses*				
GE-04: Consumer Electronics	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SBC-04: Electronic Materials and Device Fabrication	1	1	0	2
Total credits				22

*** (a student can opt for either three DSE courses, or two DSE with one GE)**

Second-Year
Structure-2: (PG with coursework and Research)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Advanced Digital and Data Communication	3	1	0	4
DSC-08: Processing of Semiconducting Materials and Devices	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4
Generic Elective Courses*				
GE-03: Science of Microwave Heating	3	0	1	4
Dissertation/Academic Project/Entrepreneurship				6
Total credits				22

*** (a student can opt for either two DSE courses, or one DSE with one GE)**

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-10: Advanced Digital Signal Processing	3	1	0	4
DSC-11: Principles of VLSI Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-14: Artificial Intelligence & Robotics	3	1	0	4

DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication Systems	3	1	0	4
DSE-18: Modern Antennas	3	1	0	4
Generic Elective Courses*				
GE-04: Consumer Electronics	3	0	1	4
Dissertation/Academic Project/Entrepreneurship				6
Total credits				22

*** (a student can opt for either two DSE courses, or one DSE with one GE)**

Second-Year
Structure-3: (PG with only Research)

Part-II Semester-III

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Emerging Materials and Technologies for Next-Generation Electronics	3	1	0	4
Discipline Specific Elective (DSE) courses **(a student can opt one DSE course from any of the research stream)**				
Credits in each course	Theory	Practical	Tutorial	Credits
DSE-09: Advanced Driver Assistance Systems (ADAS)	3	1	0	4
DSE-10: Biomedical Signal Processing	3	1	0	4
DSE-11: Fiber Optics	3	1	0	4
DSE-12: Microwave Devices and Measurements	3	1	0	4
DSE-13: Modelling and Simulation of Semiconductor Devices	3	1	0	4

Stream A	Stream B	Stream C
Electronic Materials/ Semiconductor Devices & Circuits	**Meta-Materials/ Microwave/ Antennas**	**Communication/Signal Processing /AI&ML**
DSE-11 DSE-13	DSE-11 DSE-12	DSE-09 DSE-10 DSE-11

Research Methods/ Tools/ Writing				
RMT-01: Research Methodology and Practices	2	0	0	2
RMT-02: Tools for Research	2	0	0	2
One intensive research-based problem				10
Total credits				22

Part-II Semester-IV

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline specific Elective (DSE) courses* **(a student can opt one DSE course from any of the research stream)**				
Credits in each course	Theory	Practical	Tutorial	Credits
DSE-14: Artificial Intelligence & Robotics	3	1	0	4
DSE-15: Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)	3	1	0	4
DSE-16: Fundamentals of MEMS Technologies	3	1	0	4
DSE-17: Modern Communication Systems	3	1	0	4
DSE-18: Modern Antennas	3	1	0	4

Stream A	**Stream B**	**Stream C**
Electronic Materials/ Semiconductor Devices & Circuits	**Meta-Materials/ Microwave/ Antennas**	**Communication/Signal Processing /AI&ML**
DSE-15 DSE-16	DSE-15 DSE-18	DSE-14 DSE-17 DSE-18

Research Methods/ Tools/ Writing				
RMT-03: Techniques of Research Writing	2	0	0	2
One intensive research-based problem				16
Total credits				22

DISCIPLINE SPECIFIC CORE COURSE – DSC 07

Advanced Digital and Data Communication Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-07: Advanced Digital and Data Communication Systems	4	3	-	1	Entry level	Basics of Communication System.

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamental and modern concepts of analog and digital communication systems.
2. To learn the principles of information theory, source encoding, and error control coding.
3. To study multiplexing and multiple access techniques including OFDM and MIMO used in modern wireless systems.
4. To analyze the behavior of random variables and random processes in communication systems.
5. To understand the basics of data communication and networking protocols in wireless systems.

Learning Outcomes

At the end of this course, students will be able

1. Explain and compare analog and digital communication techniques.
2. Apply concepts of information theory and error correction coding in communication system design.
3. Describe multiplexing, OFDM, and MIMO techniques used in modern wireless standards.
4. Analyze and model communication systems using random processes and probability theory.
5. Demonstrate understanding of data communication fundamentals and wireless networking protocols.

SYLLABUS OF DSC-07 — Total Hours: 45h

UNIT -I (10 Lectures)

Random process and Random variables:

Probability and random variables; Baye's theorem; Probability density and probability distribution functions, statistical expectation, and characteristic functions, various continuous and discrete distributions, multiple random variables, transformation of PDFs; Random Processes, Classification of Random Processes, Power spectral density, Power spectrum of stochastic processes; Markov process.

UNIT – II (10 Lectures)

Introduction to Digital Modulation Transmitters:

Overview of digital transmitter architecture and signal flow, and principles and implementation of BPSK, QPSK, and QAM transmitters. Coherent Receivers for Digital Carrier Modulations, General Expression for Error Probability of optimum receivers. Information Theory: Measure of Information, Source Encoding, Entropy, Channel capacity, Error Correcting codes: Hamming code, linear block codes, cyclic codes, Huffman coding, Shannon-Fano coding, code tree & Trellis diagram.

UNIT – III (15 Lectures)

Multiplexing and Modern Communication Techniques:

Distortion less transmission Multiplexing: Frequency division Multiplexing, Time division Multiplexing, Multiplexing applications, Introduction to multiple access techniques, Spread Spectrum, Frequency Hopping in Bluetooth (IEEE 802.15), Code Division Multiple Access (CDMA). Introduction to Orthogonal Frequency Division Multiplexing (OFDM); Advantages and challenges of OFDM; OFDM Transmitter and Receiver Design, Serial-to-parallel conversion, Cyclic Prefix (CP); OFDM in Modern Wireless Standards, OFDM in Wi-Fi (IEEE 802.11x), OFDM in LTE and 5G/6G; MIMO Systems: Basic principles, spatial multiplexing, diversity gain.

UNIT – IV (10 Lectures)

Introduction to Data Communication and Networking:

Introduction to Data communication, Wireless protocols: IEEE 802.xx, Network layers; Routing, mobility management, Transport layer protocols for wireless networks; Types of transmission media: Guided Media, Unguided Media, Transmission Impairments, Circuit and packet switching.

List of Experiments: 30h

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

Essential/recommended readings:

1. Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson. (Unit-II, and Unit-III)
2. Palaniammal, S. (2019). Probability and Random Processes. PHI. (Unit-I)
3. Lathi, B. P., & Ding, Z. (2019). Modern digital and analog communication systems, Oxford university press. (Unit-II, and Unit-III)

Reference Books:

1. Rappaport, T. S. (2024). *Wireless communications: principles and practice*. Cambridge University Press. (Unit III, and Unit IV)
2. Forouzan, B. A. (2007). *Data communications and networking*. Huga Media. (Unit-IV)
3. Montgomery, D. C., & Runger, G. C. (2020). *Applied statistics and probability for engineers*. John wiley & sons. (Unit-I)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 08

Processing of Semiconducting Materials and Devices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 08 Processing of Semiconducting Materials and Devices	4	3		1	Entry Level	Basics of Semiconductor Materials and Devices

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspect of semiconductor process technologies.
2. This course will create the foundation of Fabrication Techniques for Semiconductor Materials and Devices.
3. The course educates the students with the understanding science behind fabrication techniques of micro/nano electronic devices.
4. The main objective is to train the manpower/students in the field of semiconductor science and technology relevant to modern electronic industry/technology

Learning Outcomes

At the end of this course, students will be able

1. To understanding role of Semiconductor Devices in duality human life.
2. To ability to use vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
3. To skills over Device Isolation, Contacts and Metallization for CMOS Applications.
4. To trained with various processes and instruments to fabricate the electronic materials and devices.

SYLLABUS OF DSC-08 — Total Hours: 45 h

UNIT I: (10 Lectures)

Introduction:

Semiconductor Devices in Microelectronic Industry. Key concepts of Semiconductor Technologies: clean room specifications and safety requirements, Wafer cleaning processes, Semiconductor substrates processing technologies.

UNIT II: (13 Lectures)

Thin films and Pattern Transfer:

Key concepts of thin film deposition, High Vacuum and Ultra High vacuum Systems: thermal and e-beam evaporation, sputtering, MBE etc. Atomic layer deposition, Electrodeposition, Spray pyrolysis, Spin coating. Etching: Photoresists, Dry etching, Chemical etching, sputter etching, control of etch rate and selectivity, control of edge profile. Lithography: Optical, e-beam lithography, lift off, dip pen nanolithography. Micro/Nano fabrication on flexible substrates. Solution processes.

UNIT III: (12 Lectures)

Doping and Implantation of Semiconductors:

Doping: Fick's Diffusion Equation, Atomistic models of Diffusion, Analytic solutions of Fick's law, Diffusion Coefficients for common Dopants etc. Thermal Oxidation: The linear and parabolic coefficients, Effect of Dopants during Oxidation, Oxidation induced Stacking Fault, Alternative Gate Insulator for MOSFET applications. Ion Implantation: Coulomb Scattering, Channeling and lateral Projected Rang, Implantation Damage, Shadow junction formation, Buried Dielectrics etc. Rapid Thermal Processing: Thermoplastic Stress, Activation of Impurities, Processing of Dielectrics etc.

UNIT IV: (10 Lectures)

Device Isolation, Contacts and Metallization:

Junction and Oxidation Isolation, LOCOS Methods, Trench Isolation, Silicon-on-Insulator Isolation Techniques, Semi-insulating substrates, Schottky and Ohmic contacts, Alloyed Contacts, Multilevel Metallization, Planarization and advanced interconnects. CMOS Technologies.

List of Experiments: 30h

1. To study the process of high vacuum creation in a bell jar system using vacuum pumps.
2. To remove of conducting ITO film from glass substrate by heating techniques.
3. Analysis/estimation of Lattice parameters of semiconductors from X-ray diffraction pattern.
4. To estimate the optical band gap of semiconductor thin film/nano structures absorption/reflection method.
5. Structural analysis of Semiconductors using FE-SEM/TEM characteristics images.
6. Wire boding techniques for Microelectronic Devices Integration (Case Studies).

Essential/recommended readings

1. G. S. May and S. M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley India, 2004 (Unit-I, and Unit-II)
2. M. J. Madou, *Fundamentals of Microfabrication*, 2nd Edition, CRC Press, 2011. (Unit-II, and Unit-III)
3. Stephen A. Campbell, Fabrication engineering at the micro-and nanoscale, 4th Edition, Oxford University Press, 2008. (Unit-I, Unit-II, and Unit-III)
4. Fundamentals of Device and Systems Packaging: Technologies and Applications by Rao R. Tummala, McGraw-Hill Publications (Unit-IV)

Reference Books:

1. Microelectronics Packaging Handbook by Rao R. Tummala, Eugene J. Rymaszewski, and Alan G. Klopfenstein
2. Robert F. Pierret, Semiconductor device fundamentals. Pearson Education India, 1996
3. Sunipa Roy, Solid State & Microelectronics Technology. Bentham Science Publishers, 2023

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

(Structure – III -Research Track)

DISCIPLINE SPECIFIC CORE COURSE – DSC 09

Emerging Materials and Technologies for Next-Generation Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-09: Emerging Materials and Technologies for Next-Generation Electronics	4	3	0	1	Entry level	Electronics

Learning Objectives

Students will learn to:

1. Analyze the unique physical and electrical properties of low-dimensional nanomaterials.
2. Investigate the design and simulation of electromagnetic metamaterials, focusing on S-parameter analysis.
3. Examine the architecture and operation of advanced transistor technologies.
4. To demonstrate the field of AI in the design of an electronic System and study the brain-inspired computing and quantum computing.

Learning Outcomes

At the end of this course, students will be able to

1. Evaluate and select specific nanomaterials and 2D structures for sensors and energy storage applications.
2. Design and characterize metasurfaces and Frequency Selective Surfaces
3. Assess the trade-offs between high-speed performance and low-power consumption in modern semiconductor nodes
4. Apply deep learning for the understanding of electronic phenomena and demonstrate brain-inspired computing and quantum computing.

SYLLABUS OF – DSC-09 (Research Track) Total Hours: 45h

UNIT -I (11 Lectures)

Nano-materials and Applications:

Properties of Nano-materials relevant to Electronics, Carbon Nanotubes (CNTs); 2D materials: Graphene, MXene, h-BN etc,; Transition Metal Dichalcogenides (TMDs); Metal Oxide nanoparticles; Quantum Dots; Nanowire; Applications: Optoelectronic Devices, Energy Storage, Sensors; Challenges and Future Directions.

UNIT -II (11 Lectures)

Metamaterials and their Applications:

Introduction of metamaterials, Split Ring Resonator (SRR); structure, and equivalent circuit, Double Negative (DNG) materials, propagation constant, permittivity, permeability, refractive index, boundary conditions, Unit Cell and its S-parameter analysis, Metasurfaces, Frequency Selective Surface (FSS), Polarization Convertor, Microwave Absorber, Metalenses, Intelligent Reflecting Surfaces (IRS), Fabrication and testing of metamaterial and metasurfaces.

UNIT -III (12 Lectures)

Advanced Semiconductor Devices and Technologies

High-speed and low-power devices: Silicon-on-Insulator (SOI) technology; Fin Field-Effect Transistors (FinFETs); Gate-All-Around (GAA) FETs; Carbon Nanotube Field-Effect Transistors (CNTFETs); nanosheet FETs; High-k/Metal Gate (HKMG) technology; junctionless transistors. High-frequency and power devices: Gallium Nitride (GaN) High Electron Mobility Transistors (HEMTs)—design, working, and applications; Power MOSFETs; Heterojunction Bipolar Transistors (HBTs).

UNIT -IV (11 Lectures)

Large Language Model:

Machine Learning, Deep Machine Learning, and their scope in the fields of Electronics, AI, edge AI, and AI-aided Electronic design, Quantum Computing, and Neuromorphic Computing.

List of Experiments **30h**

1. Synthesis of Nanostructures by bottom to top approach.
2. Design and simulation of periodic structure and study of reflection phase and dispersion diagram of metamaterial unit cell.
3. Computation of permittivity and permeability of metamaterial unit cell.
4. Implement ML algorithm/Convolutional Neural Network (CNN) in MATLAB/Python.
5. Develop a Generative Adversarial Network (GAN) in MATLAB/Python.
6. Simulation of Spiking Neuron Model (LIF Model) in MATLAB/Python.
7. Implement Quantum Gates using IBM Quantum Experience.
8. To study and plot the Surface Potential and Subthreshold Characteristics of Non-classical Semiconductor device (MOSFET)
9. To study and plot the I-V and threshold voltage of MOSFET.

Essential/recommended readings

1. Michael F. Ashby, Paulo J. Ferreira and Danel L. Schodek, Nanomaterials Nanotechnologies and Design. An Introduction for Engineers and Architects, Published by Elsevier. (Unit-1, and Unit-2)
2. 2D Materials Fundamentals, Fabrication and Applications by Editors: Rekha Sharma, Sapna Raghav
3. Fundamentals of modern vlsi devices by Yuan Taur, Tak H. Ning, Cambridge University Press, 3rd Edition, 2021. (Unit-3)
4. Y. P. Tsividis, "Mixed Analog-digital VLSI Devices and Technology", World Scientific Publishing Co Pte Ltd, 2002 (Unit-3)
5. Narain Arora, "MOSFET Models for VLSI Circuit Simulation: Theory and Practice" World Sintific, 2007. (Unit-3)
6. Elishai Ezra Tsur: Neuromorphic Engineering: The Scientists', Algorithm Designers and Computer Architects' Perspectives on Brain-Inspired Computing, CRC Press, 2022. (Unit-IV)
7. Amit Kumar Tyagi, Shrikant Tiwari, S. V. Nagaraj: Quantum Computing; The Future of Information Processing, CRC Press, 2025. (Unit-IV)

Suggested Readings/Books

1. C. Caloz, and T. Itoh, "Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications", Hoboken, New Jersey: John Wiley & Sons Inc. 2006. (Unit-II).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 09

Advanced Driver Assistance Systems (ADAS)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE 09: Advanced Driver Assistance Systems (ADAS)	4	3	0	1	Entry level	Electromagnetic Theory

Learning Objectives

The Learning objectives of this course are as follows:

1. To provide an in-depth exploration of advanced automation application in the field of electronics.
2. To covers the fundamentals, design, and implementation of Advanced Driver Assistance Systems (ADAS).
3. To explores key technologies, sensors, algorithms, and the future of autonomous driving.
4. To fulfil the requirements of industries by providing knowledge of electronic sensors, and IoT.

Learning Outcomes

At the end of this course, students will be able to

1. Gain knowledge of ADAS, V2X, V2V, and V2I systems.
2. Understand the mechanism of all the components of ADAS.
3. Gain knowledge about sensor fusion and core functions of ADAS.
4. Develop the knowledge of machine learning and artificial intelligence in ADAS.

SYLLABUS OF DSE-09 — Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to Advanced Driver Assistance Systems (ADAS):

Importance and Benefits of ADAS, Evolution of ADAS, Levels of Automation (SAE Levels 0–5), Regulatory and Safety Standards (NCAP, ISO 26262, etc.). Vehicle-to-Everything (V2X) Communication; Basics of V2X Technology, Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). Communication, Cybersecurity in V2X Networks. Autonomous Driving and Future Trends; Path Planning and Motion Control, Ethics and Challenges in Autonomous Vehicles, Trends in AI-Driven ADAS Development, Regulations and Future Roadmaps.

UNIT – II (10 Lectures)

Components of ADAS:

Cameras; Function, Types, Image Processing, Object Detection. Radar; Working Principles, Short-Range Radar, Long-Range Radar, functions of short range and long-range RADAR in ADAS, RADAR Range equation, speed detection through Radar. Lidar; Function and mechanism, Scanning, Point Cloud Processing, Use Cases. Ultrasonic Sensors; Parking Assistance and Close-Range Detection. Sensor Fusion; Combining Multiple Sensor Data.

UNIT – III (15 Lectures)

Sensor Fusion and Data Processing and Core ADAS Functions:

Kalman Filters and Sensor Fusion Algorithms, Multi-Sensor Data Processing Techniques, Localization and Mapping in ADAS.

Adaptive Cruise Control (ACC), Lane Departure Warning (LDW) and Lane Keeping Assist (LKA), Blind Spot Detection (BSD), Automatic Emergency Braking (AEB), Parking Assistance Systems, Traffic Sign Recognition (TSR).

UNIT – IV (10 Lectures)

Machine Learning & Artificial Intelligence (AI) in ADAS:

Role of AI and Deep Learning in ADAS, Convolutional Neural Networks (CNNs) for Object Detection, AI-based Decision Making in ADAS, Real-time Data Processing. Embedded Systems & Software for ADAS; Electronic Control Units (ECUs) in ADAS, Real-time Operating Systems (RTOS), Functional Safety and ISO 26262 Compliance, Middleware and Communication Protocols (CAN, LIN, Ethernet).

List of Experiments **30h**

1. Study the architecture, safety, and configuration of FMCW automotive radar development kit.
2. Configure FMCW chirp parameters and acquire raw IQ radar data using the radar SDK or capture board.
3. Perform 1-D FFT processing on acquired radar data to estimate target range and visualize the range spectrum.
4. Analyze the effect of chirp bandwidth on range resolution and measurement accuracy using experimental data.
5. Implement 2-D FFT processing to generate range–Doppler maps and detect moving targets.
6. Practice applications- automatic emergency braking (AEB), adaptive cruise control (ACC).
7. Practice applications- blind spot detection (BSD).
8. Practice applications- lane change assist (LCA).
9. Practice applications- parking assist.

Essential/recommended readings:

1. Lentin Joseph, Amit Kumar Mondal, (2021). Autonomous Driving and Advanced Driver-Assistance Systems (ADAS): Applications, development, Legal Issues, and Testing. CRC Press. (Unit-III, and Unit-IV)
2. Plato Pathrose, (2024), ADAS and Automated Driving - Systems Engineering, SAE International. (Unit-I, and Unit-II)
3. John Ball, Bo Tang, (2019), Machine Learning and Embedded Computing in Advanced Driver Assistance Systems (ADAS), MDPI. (Unit-IV)
4. Yan Li, Hualiang Shi, (2022), Advanced Driver Assistance Systems and Autonomous Vehicles: From Fundamentals to Applications, Springer. (Unit-I, Unit-II, Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 10

Biomedical Signal Processing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-10: Biomedical Signal Processing	4	3	--	1		**Instrumentation, Signals and Systems & Soft Computing**

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the concepts of biomedical signal processing and its related terminology.
2. Elaborate on the Biomedical Signal Measurement.
3. Distinguish between Single-channel and Multichannel Signal Processing and their roles.
4. How can the signal be analyzed if it is corrupted with noise?
5. Understand the role of biomedical signal processing in developing a BCI inference system.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the Human Brain and the physics of various Bio signal generation.
2. Measure the biomedical signal and its representation.
3. Describe the multichannel Signal processing tools and their role.
4. Denoising of biomedical Signals and artefact reduction.
5. Design of BCI inference system.

SYLLABUS OF DSE-10 **Total Hours: 45h**

UNIT -I (12 Lectures)

Brain Structures and Scalp Potentials: Structure of the human brain, biomedical instrumentation, Physiological Signals, origin of Bio signals, Action potential, Electroencephalography, magnetoencephalography (EEG), electromyography (EMG), electrocardiography (ECG), Neural Activities, Bio signal Measurement Systems, 10-20 electrode placement system, electrodes for bio signal measurement, Measuring Electric Activity in the Brain, EEG, MEG, Event-Related Potentials (SSVEP and P300 Signals), Wearable and Wireless EEG Monitoring.

UNIT – II (10 Lectures)

Bio signal representation and artefact reduction: Classification of signals and noise, Time Series physiological

signals and their representation, rhythm of brain signals, Single/ Multi-channel EEG Time series Data, Modelling of EEG signal, Artefact identification from EEG and MEG, Digital Filters, Spatial filter: Laplacian Referencing, Common Average Referencing, Noise removal, EEG Source Localisation.

UNIT – III (10 Lectures)

Single/Multichannel Signal Processing and Pattern classification: Signal decomposition technique: Blind Source Separation, Principal Component Analysis (PCA), Independent Component Analysis (ICA), empirical mode decomposition, Filtering and Denoising, Spectral Analysis: Classical Methods, Multivariant Autoregressive (MVAR) Modelling and Coherency Maps**,** Feature Extraction (Time domain and Frequency domain), Pattern classification–supervised and unsupervised classification, Neural networks, Statistical Classifier**,** Bayes classifier.

UNIT – IV (13 Lectures)

Application of Biomedical Signal Processing: Epileptic Seizure detection, sleep disorder detection, development of user interface using bio signals for neurorehabilitation, event-related desynchronization (ERD) and event-related synchronization (ERS), Brain computer interface (BCI), BCI Paradigms, performance evaluation parameters, Different neural models and their implementation at the device level, Introduction to Neuromorphic Computing.

List of Experiments: **30h**

1. Study of biomedical signal characteristics.
2. Study signal acquisition using sensors.
3. Study Signal smoothing & denoising, Noise removal using digital filters.
4. Analysis of EMG Muscle activity.
5. Analysis of EEG band power.
6. Signal classification using machine learning.
7. Develop a real-time biomedical signal monitoring system.
8. Decomposition of single-channel and multi-channel EEG time series data and its representation in the time and frequency domains.
9. Develop a patient health monitoring system.

Essential/recommended readings:

1. W. J. Tompkins, "Biomedical Digital Signal Processing", Prentice Hall, 1993. (Unit-I, and Unit-II)
2. Eugene N Bruce, "Biomedical Signal Processing and Signal Modelling", John Wiley & Sons publication, 2001. (Unit-I, and Unit-III)
3. Saied Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd., 2007. (Unit-II, and Unit-IV)

Suggested Reading:

1. Leif Sornmo, Pablo Laguna: Bioelectrical Signal Processing in Cardiac and Neurological Applications, Academic Press, 2005

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11

Fiber Optics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-11: Fiber Optics	**4**	**3**	**--**	**1**	**Basics of Electronics**	**Basics of Optics**

Learning Objectives

The Learning Objectives of this course are as follows:

1. To study the fundamentals of Optical Fibers and its Electromagnetic theory
2. To get a comprehensive understanding and hands-on exposure to the various processes, industrial tools, protocols
3. To study the different types of Fibers, sources, detectors
4. To study the link budget as applicable to the Optical Fiber Communication System

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Student will learn Familiarization of the various types of Optical Fibers and its components
2. Understanding of the Optical Fiber components, their characteristics and their applications.
3. Student will learn pre-requisite knowledge to perform design of link budget of the Optical Fiber Communication System
4. Understand the current trends, scope and future trends of the Optical Fiber Communication System.

SYLLABUS OF DSE-11 — Total Hours: 45h

UNIT -I (10 Lectures)

EM Spectrum and Optical Frequencies; Introduction to OFC, Optical Spectral bands; Basic Optical Laws and definitions, Mode Theory of Circular Dielectric Waveguides, Optical Fiber modes and configurations; Cut off wavelength and V-number of Fibers; Single mode and multi-mode fibers, Step index and graded index fibers, structure of the graded index fibers, fiber materials, Fiber fabrication, Fiber optic cables; Attenuation, Signal Dispersion in Fibers, Intermodal and Intramodal dispersion, chromatic and waveguide dispersion, group delay, polarization mode dispersion.

UNIT – II (10 Lectures)

Optical Sources, Semiconductor physics for optical sources, direct and indirect band gap semiconductors, Energy momentum diagrams; Light emitting Diodes (LEDs), Physical Structures of LEDs; Lasing actions, Different types of Lasers, Laser Diodes, Structure of Laser Diodes, Fabry Perot Cavity in Laser Diodes; Light Source Linearity. Reliability Considerations; OFC transmitter considerations, source to fiber power launching, lensing schemes for coupling improvement, fiber splicing and optical fiber connectors.

UNIT – III (10 Lectures)

Optical Detectors, Physical Principles of photodiodes, Photodetector noise, Detector response time; Avalanche and Zener breakdown, Avalanche multiplication noise; Structure of InGaAs Avalanche Photodetectors (APDs), temperature effect on Avalanche Gain, Comparison of Photodetectors; Optical receiver system, Fundamental of receiver operation, Digital Receiver performance, Eye diagrams.

UNIT – IV (15 Lectures)

Digital Links, Point to Point links, Power penalties, error control, codes for error control; Coherent detection; Analog links and its overview, Carrier to noise ratio, multi-channel transmission techniques; Microwave Photonics; Wavelength Division Multiplexing (WDM) and Dense Wavelength Division Multiplexing (DWDM); Diffraction gratings, tunable light sources. Basic applications and types of Optical Amplifiers, Semiconductor Optical Amplifiers; Erbium-Doped Fiber Amplifiers, Optical SNR, Raman Amplifiers; General Overview of non-linearities in optical fiber communication, Stimulated Raman and Brillouin Scattering; Optical Networks and Topologies, SONET/SDH; Optical Time domain reflectometry (OTDR).

List of Experiments: **30h**

1. a. Measurement of Fiber Optic Numerical Aperture
   b. Measurement of Fiber Optic using Optical Power Meter
2. a. Setting up Fiber Optical Analog Link
   b. Setting up Fiber Optical Digital Link
3. a. Study of Intensity Modulation Technique using Analog Input Signal
   b. Study of Intensity Modulation Technique using Digital Input Signal
4. a. Study of VI Characteristics of three different LED
   b. Study of Gaussian Illumination profile of three different LED
5. a. Study of Visual inspection and fault locating using OTDR
   b. Study of Variable optical attenuator (VOA)
6. a. Study of Optical fiber isolator
   b. Study of Fiber-based optical switch
7. a. Measurement of Wavelength division multiplexing (WDM) principle
   b. Study of Principle of EDFA (Erbium-doped fiber amplifier)
8. Study of Transmission of video signal through an optic fiber cable

Essential readings:

1. Keiser, G., Optical Fiber Communications, Tata Mc Graw Hills, 4th edition, 2008. (Unit-I, and Unit-II)
2. Ghatak, A., Thayarajan, K., Introduction to Fiber Optics, Cambridge University Press, 1999. (Unit-II, and Unit-III)
3. Senior, J. M., Optical Fiber Communications: Principles and Practice, Pearson education Ltd., 2009. (Unit-IV)

Suggested Readings:

1. G. Agrawal, Fiber Optic communication systems, John Wiley and Sons, 1992 (Unit-I, and Unit-II)
2. R. Singh, A. V. Agarwal, Textbook of Optical Fiber Communication, Heritage Publishers, 2019 (Unit-III, and Unit-IV)
3. S. Katiyar, A Textbook of Optical Fiber Communication Systems, S. K. Kataria & Sons, 2023 Reprint edition (Unit-IV)

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 12

Microwave Devices and Measurements

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE 12: Microwave Devices and Measurements	4	3	0	1	Entry level	Electromagnetics and Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To provide knowledge of various microwave devices to the students.
2. To have detailed knowledge of conventional as well as latest devices of RF and microwave engineering.
3. To attain the knowledge of microwave semiconductor devices & their related applications.
4. To gain knowledge of microwave sources and the integration of microwave devices with microwave-integrated circuits (MIC) and Monolithic Microwave Circuits (MMIC).

Learning Outcomes

At the end of this course, students will be able

1. To understand about the microwave devices, MIC & MMIC technologies, and related industrial requirements.
2. To have knowledge of unipolar and bipolar microwave devices including various microwave diodes and Transferred Electron devices.
3. To attain the knowledge of three terminal microwave devices and their advancement in accordance with the latest technology.
4. To gain knowledge of microwave sources and their applications and advancement.

SYLLABUS OF DSE-12 — Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to RF and Microwaves:

Guided and Unguided Medium, Frequency Spectrum, Need of High Frequency, Different Modern Applications of RF and Microwave. Active and Passive RF Components/Devices. Introduction to Microwave integrated circuits (MIC), Technology of hybrid MICs, and Monolithic Microwave Circuits (MMIC), Surface Mount Devices (SMD) & through-hole components, Integration of microwave devices with MIC and MMIC structures, Electronic packaging, Basics of RF device packaging and thermal management.

UNIT – II (15 Lectures)

Microwave Solid State Devices:

Unipolar and Bipolar Devices, Tunnel Diode, Varactor Diode, Schottky diode, Avalanche Transit Time Devices: Read, IMPATT, TRAPATT, BARITT. Transferred electron devices (TED); Gunn Diode; Gunn effect, Ridley–Watkins–Hilsum theory, Modes of operation. Microwave Transistors, Concept of Hetero-junction, Hetero-junction Bipolar Transistor (HBT), Comparison among Junction Field Effect Transistor (JFET), metal-oxide-semiconductor field-effect transistor (MOSFET), Metal-Semiconductor Field-Effect Transistor (MESFET), High

Electron Mobility Transistor (HEMT); Structure and Mechanism. Applications of Microwave Solid State Devices.

UNIT – III (10 Lectures)
Microwave Sources:
Microwave Triodes, Introduction to vacuum tubes, Linear and O-Type Tubes, Klystron; two cavity and multi-cavity, velocity modulation process, bunching process, output power and beam loading, Reflex Klystron; Power Output and efficiency, Traveling wave tubes (TWT), Slow wave structures, Magnetron; Construction & operation, Conventional tube design, Hull or single-anode magnetron, Split-anode magnetron, Cavity magnetron.

UNIT – IV (10 Lectures)
Microwave Measurements:
The Microwave Bench, detailing its modular architecture and its constituent blocks, sources, isolators, and tuners. Application of Waveguide Attenuators, Resistive Card and their types, Phase Shifter and Mode Converters. Microwave Power Measurement using the Bolometer Method, calibration of thermistors and barretters within bridge circuits. Measurement of Attenuation, Frequency (via cavity wavemeters), and Impedance, and dielectric measurement. S-parameters measurements.

List of Experiments **30h**

1. To study the VI characteristics of Tunnel Diode. And study of Tunnel Diode Amplifier and Oscillator Circuits.
2. To study the VI characteristics and capacitance of Varactor diode.
3. To study the characteristics of pin, and Schottky diodes.
4. To study the Gunn Diode and microwave Bench.
5. To study the Vector Network Analyzer (VNA) and calibration.
6. To measure the S-parameters of single-port RF device and calculation of percentage bandwidth.
7. To measure the S-parameters of dual-port RF devices and study of return loss and insertion loss.
8. To measure the dielectric constant of a material.

Essential/recommended readings:

1. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012. (Unit-II, and Unit-IV)
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012. (Unit-I, Unit-III and Unit-IV)
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003. (Unit-II, Unit-III and Unit-IV)

Reference Books:

1. George Kennedy & Bernard Davis, Electronic Communication system, 4th ed, Tata McGraw Hill Education Private Limited, 1999.
2. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 13

Modelling and Simulation of Semiconductor Devices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE- 13: Modelling and Simulation of Semiconductor Devices	4	3	--	1		Basic semiconductor physics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand Analytical modelling of MOSFETs
2. To derive and understand the mathematical equations for DC drain current in different regions of operation (cutoff, linear, and saturation).
3. To analyze the small-signal capacitances (gate capacitance, junction capacitances) and their dependence on biasing.
4. To develop the ability to model the non-classical MOS devices
5. To understand the basics of TCAD tools.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. To develop TCAD Simulation and Practical Skills
2. To create 2D/3D device structures, define doping profiles, and simulate electrical characteristics (transfer and output curves)
3. To validate analytical models by comparing them with TCAD simulation results
4. To relate device-level modeling to circuit specifications, enabling the design of efficient analog and digital circuits.

SYLLABUS OF DSE – 13 — Total Hours: 45h

UNIT -I (09 Lectures)

MOS Theory & Operation:

Two-Terminal MOS Structure: band diagram, charge distribution, accumulation, depletion, inversion, weak & strong inversion, Capacitance-Voltage (C–V) characteristics. Four Terminal MOSFET: Structure and operation, channel potential, threshold voltage, drain current, gains, DC biasing and small-signal analysis, short channel Effects (SCEs)

UNIT – II (14 Lectures)

Analytical Modeling Techniques:

Poisson's equation (cartesian and cylindrical coordinates), surface potential formulation, threshold voltage formulation, drain current formulation: derivation of drain current (I_D-V_G & I_D-V_D) using the gradual channel approximation in linear and saturation regions, full range drain current modelling, impact of short channel parameters, compact analytical modeling.

UNIT – III (12 Lectures)

Advanced MOSFET Architectures:

Transition from planar to 3D architectures: Silicon on Insulator (SOI) FETs, FinFETs, Gate-All-Around FET, High Electron Mobility Transistors (HEMT), Junctionless transistor, High-k & strained-semiconductor MOSFETs, Introduction to Process Design Kit (PDK): design rules, models and applications.

UNIT – IV (10 Lectures)

Fabrication, Foundry and Numerical Simulation:

Advanced Semiconductor Fabrication Technologies, Deposition Techniques, Twin-tub CMOS fabrication, Chemical Mechanical Planarization (CMP), Foundry Overview: IDMs (Integrated Device Manufacturers), fabless, wafer fab vs. OSAT (Outsourced Assembly and Test), Cleanroom Technology: Classes of cleanrooms (ISO standards), contamination control, HEPA filters, safety protocols, and gowning procedures.

Introduction to Technology computer aided design (TCAD) tools: device simulation and process simulation. Introduction to Advanced Models: SPICE and History of SPICE modelling, types of SPICE: SPICE2, SPICE3 and HSPICE, BSIM models.

List of Experiments: **30h**

1. Plot the C-V and I-V characteristics of MOS capacitor.
2. To study the channel surface potential and electric field of MOSFET using analytical models.
3. To study and plot transfer characteristics (I_D-V_G) & output characteristics (I_D-V_D) of MOSFET.
4. Plot and analyze the impact of short channel parameters on (I_D-V_D) and (I_D-V_G) characteristics of MOSFET.
5. To study the analytical threshold voltage of MOSFET.
6. To study the impact of short channel effects, DIBL, SS of MOSFET.
7. Design and implementation of MOS devices in circuits.

Essential/recommended readings:

1. T. A. Fjeldly, T. Yetterdal, and M. Shur, “Introduction to Device Modeling and Circuit Simulation”, John Wiley, 1998. (Unit-I)
2. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 1998. (Unit-I)
3. Y. P. Tsividis, “Mixed Analog-digital VLSI Devices and Technology”, World Scientific Publishing Co Pte Ltd, 2002 (Unit-I, and Unit-II)
4. Narain Arora, “MOSFET Models for VLSI Circuit Simulation: Theory and Practice” World Scientific, 2007. (Unit-I & Unit-II, and Unit-III)
5. C K Sarkar, “Technology Computer Aided Design: Simulation for VLSI MOSFET”, CRC Press, 1st Edition, 2013, ISBN: 978-1466512658. (Unit-III, and Unit-IV)
6. J.-P. Colinge, “FinFETs and Other Multi-Gate Transistors”, Springer, 2008, ISBN: 978- 0-387- 71751-7 (Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – GE 03

Science of Microwave Heating

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE 03: Science of Microwave Heating	4	3	1	0	Entry level	Basic Knowledge of Physics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamentals of microwave technology, including electromagnetic waves, microwave theory, and wave interaction with conductors and dielectrics.
2. To learn about key microwave components like waveguides, cavity resonators, stub tuners, and directional couplers.
3. To explore microwave heating principles and dielectric and magnetic loss types and compare them with conventional heating, focusing on thermal and non-thermal effects.
4. To study the applications of microwave heating in various fields like food processing and chemistry, including specialized equipment and advanced techniques.

Learning Outcomes

At the end of this course, students will be able

1. To understand the fundamental properties of microwaves and their interaction with materials.
2. To differentiate between microwave heating and conventional thermal heating.
3. To learn to analyze the dielectric properties of materials relevant to microwave heating.
4. To gain knowledge of the principles and applications of microwave heating in various processes like extraction and digestion.
5. To evaluate different microwave processing techniques and equipment used in material processing and chemistry.

SYLLABUS OF GE-03 — Total Hours: 45h

UNIT -I (11 Lectures)

Concept of Microwave:

Basics of Electromagnetic Waves, Concept of Microwave Theory, Conductor versus Dielectric materials. Waves and their polarisation, Reflection, Refraction, or Transmission. Waveguides, Modes, Cavity Resonator, Stub Tuner, and Direction Coupler Basics.

UNIT – II (12 Lectures)

Introduction of Microwave Heating:

Types of Microwave Heating, Microwave Radiation, Microwave Dielectric Heating. Basics of Dielectric Properties, Microwave versus Conventional Thermal Heating and Microwave Effects. Temperature Monitoring in Microwave Chemistry, Thermal Effects (Kinetics), Specific Microwave Effects, and Nonthermal Microwave Effects.

UNIT – III (11 Lectures)

Microwave Heating:

Fundamental principles and applications of microwave heating. Dielectric properties, permeability, and the measurement of these properties. Concept of conduction loss and dielectric and magnetic loss heating. Penetration depth and skin depth. Basics of Microwave oven, Microwave extraction and Digestion.

UNIT – IV (11 Lectures)

Material Processing and Its Equipment:

Microwave materials processing, microwave-assisted chemistry, and the potential future of microwave technology in food processing. Dedicated Microwave Reactors for Organic Synthesis. Single-Mode Instruments and Multimode Instruments. Microwave Processing Techniques - Solvent-Free Reactions, Open- versus Closed-Vessel Conditions, Pre-pressurized Reaction Vessels, Nonclassical Solvents, Passive Heating Elements.

Tutorials: 15h

1. Electromagnetic Foundations & Wave Interaction
2. Dielectric Properties & Loss Mechanisms
3. Penetration Depth and Heat Distribution
4. The "Microwave Effect" Debate
5. Instrument Architecture for Single-mode vs. Multimode
6. Safety, Industrial Scaling, and Future Trends
7. Case Studies on Microwave Industrial Heating

Essential/recommended readings:

1. Pozar DM. *Microwave Engineering*. John Wiley & Sons; 2021. (Unit-I)
2. S. Horikoshi, R. F. Schiffmann, J. Fukushima, and N. Serpone, *Microwave Chemical and Materials Processing*. Springer, 2017. (Unit-II, Unit-III, and Unit-IV)

Reference Books:

1. G. B. Awuah, H. S. Ramaswamy, and J. Tang, *Radio-Frequency Heating in Food Processing*. CRC Press, 2014. (Unit-II, and Unit-IV)
2. Kappe CO, Stadler A, Dallinger D. *Microwaves in Organic and Medicinal Chemistry*. John Wiley & Sons; 2013. (Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL BASED COURSE – SBC 03

Software Defined Radio Techniques for Modern Wireless Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-03: Software Defined Radio Techniques for Modern Wireless Systems	**2**	**1**	**0**	**1**	**Entry level**	**Basics of analog and digital communication.**

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the basic concepts and architecture of Software Defined Radio (SDR).
2. To develop familiarity with Linux-based environments and LabView/MATLAB/Python programming for SDR applications.
3. To learn to use open-source SDR software frameworks such as GNU Radio.
4. To simulate digital communication systems and visualize signal processing chains.

Learning Outcomes

At the end of this course, students will be able to

1. Describe SDR architecture and compare it with traditional radio systems.
2. Implement basic signal processing tasks using LabView/MATLAB/Python and GNU Radio.
3. Analyze and visualize signals in time and frequency domains.
4. Build and test simple digital communication links in simulation and on real SDR hardware.

SYLLABUS OF SBC-03 — Total Hours: 60h

UNIT -I (20 Lectures)

Introduction to Linux environment and programming tools for signal processing, including basic Python/MATLAB/LabVIEW usage. Basics of Software Defined Radio (SDR) architecture. Fundamentals of GNU Radio and GNU Radio Companion (GRC), block-based signal flow, sources, sinks, flowgraph creation, parameter settings, and simulation workflow. Signal generation and visualization in time and frequency domains using FFT. Introduction to USRP hardware, RF signal transmission and reception, FM broadcast reception.

UNIT -2 (40 Lectures)

List of Experiments

A. Without Hardware (Simulation-based)

1. Basics of Linux environment: Basic terminal commands, installing packages, creating and running Python scripts.
2. LabView/Python/MATLAB for signal processing: Generating and plotting sine, square, and noise signals.
3. Time and frequency domain analysis   FFT implementation and visualization of signals.
4. Introduction to GNU Radio Companion (GRC): Create first flowgraph using signal source, throttle, and scope sink blocks.

5. Signal modulation using GRC, Implement AM and FM modulation and demodulation.
6. Digital modulation simulation: Implement and visualize BPSK, QPSK, and QAM in GNU Radio or Python.
7. Noise and SNR analysis: Add AWGN noise to modulated signal and observe effect on BER and constellation.
8. Basic spectrum analyzer using simulated signals, Plot spectrum using FFT Sink in GNU Radio.

B. With Hardware (USRP)

1. Introduction to SDR hardware (USRP): Device setup, connection, and verification in GNU Radio.
2. FM receiver implementation: Receive live FM broadcast and play audio output.
3. Spectrum sensing / scanning: Capture live RF signals and display spectrum (FM, Wi-Fi, GSM bands etc).
4. Transmit amplitude and frequency modulated signals using SDR hardware and observe waveforms at the receiver.
5. Real-time digital modulation: Transmit and receive BPSK/QPSK/QAM signals between two SDRs. Capture received symbols and analyze constellation under various SNRs.
6. Bit error rate (BER) measurement: Implement a digital link and compute BER vs. SNR using simulated or real noise.
7. OFDM Transmission and Reception: Implement basic OFDM link using GNU Radio OFDM blocks and observe subcarrier structure.
8. Design and Implementation of an SDR-based Wireless Data (image, text or voice sample) Transmission System.

Essential/ Recommended readings:

1. Wyglinski, A. M., Getz, R., Collins, T., & Pu, D. (2018). *Software-defined radio for engineers*. Artech House. (Unit-1)
2. David Clark, Paul Clark, (2025). *Practical SDR: Getting Started with Software-Defined Radio*, No Starch Press, Inc. (Unit-2)
3. Marc Lichtman (Online) - PySDR: A Guide to SDR and DSP using Python, https://pysdr.org/ (Unit-1 and Unit-2)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 01

Research Methodology and Practices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-01: Research Methodology and Practices	2	2	-	--	Entry Level	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the fundamental practices of Research.
2. To conceptualize various research tools.
3. To Illustrate and outline the software needed for research.

4. To understand various research practices.
5. To understand the scientific writing practices

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Understanding the basics of various research practices being followed.
2. Implement the research tools learned in their research work.
3. Determine the optimum software requirements for one's research.
4. Comprehension of various sources of errors.
5. Understand the various scientific writing practices.

SYLLABUS OF RMT-01 — Total Hours: 30h

UNIT -I Various Types of Research (5 Lectures)

Introduction to Research, Types of Research: Theoretical and Experimental; Methodology with Direct and Indirect Observation and Analysis; Qualitative and Quantitative Tools; Problem identification, Literature Survey; Types of Indexing of the journals, Case Studies based on the above unit.

UNIT – II Research Methodology (10 Lectures)

Research Methodology: Top-Down approach, Inverted Pyramid, Bottom Up; Concepts of Highlighting any Text, Font size; Key Performance Indicator (KPI); Feedback System; Execution of Task: Goal Identification, Asses tools to solve, Decide Option, Implement Option; Introduction to Design thinking.

UNIT – III Design of Experiment and Error Analysis (7 Lectures)

Design of experiment, Measurement and analysis, error analysis, different types of errors, Statistical Treatment: Mean, Median, Mode, Standard Deviation, etc.; Different types of pictorial representation of data: Bar Graphs, Histograms, plots, etc.

UNIT – IV Scientific Writing and IPR (8 Lectures)

Writing scientific articles, plagiarism, research practices and ethics, referencing and styles; Intellectual Property (IP) and Intellectual Property Rights (IPR), different types of patents, Indian Patent pedagogy; presentation skills; software tools: MATLAB and its programming.

Essential readings:

1. Mishra B., Satapatty A. K., Mishra S., Consumer Electronics, Chaukhambha Orientalia, Varanasi, 2018 edition (Unit I, and Unit-II)
2. Kothari C. R., Garg G., Research Methodology: Methods and Techniques, New Age International Publishers, 2023 latest edition (Unit III, and Unit-IV)
3. Pratap R., Getting Started with MATLAB 7, Oxford University Press, 2006 edition. (Unit IV)

Suggested Readings:

1. Aguinis H., Research Methodology: Best Practices for Rigorous, Credible, and Impactful Research, Sage, 2024, latest edition (Unit I, and Unit-II)
2. Jain R. K., Research Methodology: Methods and Techniques, Vayu Education of India, 2021, latest edition (Unit III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 02

Tools for Research

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-02: Tools for Research	2	2	-	--	Entry Level	Software programming, Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand computational, simulation, and experimental tools used in electronics research.
2. Apply numerical computing and data analysis for modeling and measurements.
3. Use laboratory instrumentation and characterization techniques effectively.
4. Develop skills in scientific analysis, documentation, and research reporting.

Learning Outcomes

After completing the course, students will be able to:

1. The Learning Outcomes of this course are as follows:
2. Apply computational and simulation tools to analyze research problems.
3. Perform experimental measurements and interpret characterization data.
4. Validate results using statistical and error analysis methods.
5. Prepare professional scientific documents with proper visualization and references.

SYLLABUS OF RMT-02 — Total Hours: 30h

Unit I: (7 Lectures)
Computational Tools:
Role and significance of computational tools in electronics research; numerical computing environments including MATLAB, GNU Octave, and Python (NumPy, SciPy); matrix operations, numerical methods, and scientific scripting for modeling and data analysis; use of Jupyter Notebook for research and documentation.

Unit II: (7 Lectures)
Computer Simulation and Design Tools:
Classification and application of simulation and design software across electronics domains; comparison of open-source and commercial research tools with licensing and cost considerations; criteria for selection, validation, benchmarking, and verification of simulation results; introductory concepts of Multiphysics simulation and co-simulation in advanced electronics research.

Unit III: (8 Lectures)
Experimental and Measurement Tools:
Laboratory instrumentation used in electronics research; data acquisition methods, sensor interfacing,

calibration procedures; overview of basic microfabrication and PCB prototyping technologies; fundamentals of automated measurements using software-controlled instrumentation. Tools for Electrical, Structural and Optical Characterization: C-V, I-V, X-Ray Diffraction, SEM, TEM, AFM, UV-visible-NIR Spectroscopy, PL, Raman Spectroscopy.

Unit IV: (8 Lectures)
Data Analysis and Technical Documentation:
Scientific data processing, visualization, and statistical interpretation; error analysis, uncertainty estimation, and validation of experimental results; reference and citation management using Mendeley, Zotero, and EndNote;-preparation of technical documents using LaTeX for research papers, theses, and reports; creation of scientific diagrams and plots using Origin, Visio, and Python libraries.

Essential/recommended readings:

1. Heath, M. T. (2018). Scientific computing: An introductory survey (2nd ed.). McGraw-Hill. (Unit I, and Unit IV)
2. Chapra, S. C., & Canale, R. P. (2020). Numerical methods for engineers (8th ed.). McGraw-Hill Education. (Unit I, and Unit II)
3. Horowitz, P., & Hill, W. (2015). The art of electronics (3rd ed.). Cambridge University Press. (Unit III)
4. Taylor, J. R. (1997). An introduction to error analysis: The study of uncertainties in physical measurements (2nd ed.). University Science Books. (Unit III, and Unit IV)

Suggested Books:

1. Chapra, S. C. (2024). Applied Numerical Methods with Python for Engineers and Scientists. McGraw-Hill Education. (Unit I, and Unit II)
2. McKinney, W. (2022). Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter (3rd ed.). O'Reilly Media.(Unit I, and Unit IV)
3. Verma, M. (2021). Practical Numerical Computing Using Python: Scientific & Engineering Applications. (Self-published/academic).(Unit I, and Unit IV)
4. Dinov, I. D. (2023). Data Science and Predictive Analytics: Biomedical and Health Applications using R (2nd ed.). Springer. (Unit IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 10

Advanced Digital Signal Processing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-10: Advanced Digital Signal Processing	4	3	--	1		Signals and Systems, Digital Signal Processing

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the concepts of Advanced signal processing and its related terminology.
2. Elaborate on the time frequency analysis.
3. Distinguish between Parametric and Non-parametric Power Spectrum estimation
4. Implement the Weiner and Kalman filter for a real-time application.
5. Understand the programming model of the Digital Signal Processor.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the concept of Time frequency analysis and its scope.
2. Describe the Multi-rate Digital Signal Processing.
3. Implement Optimum linear filters for noise cancellation.
4. Represent the Spectrum of real-time series data using Parametric and non-parametric methods of Spectrum Estimation.
5. Understand the programming model of the DSP processor and its real-time implementation.

SYLLABUS OF DSC-10 **Total Hours: 45h**

UNIT -I (12 Lectures)

Introduction to Digital Signal Processor, Architecture of DSP Processor, Programming Model, Time-Frequency Analysis: Introduction to time frequency analysis, Windowed Fourier transforms (STFT), Signal representation with continuous and discrete STFT, Wavelet Transform, Stockwell transform, Wigner-Ville transform, Cohen's Class distribution. Chirp Z Algorithm, Goertzel's Algorithm**.**

UNIT – II (10 Lectures)

Discrete sine and cosine transform, Discrete Hartley transform, Multi-rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, polyphase filters, QMF, digital filter banks, Multi-resolution signal analysis, wavelet decomposition, DWT, Wavelet Packet,
Applications in sub-band coding.

UNIT – III (10 Lectures)

Linear prediction and Optimum Linear Filters: Random signals and power spectra, Forward and backward Linear prediction, solutions of the normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters and Kalman Filter. Adaptive filter.

UNIT – IV (13 Lectures)
Power spectrum estimation: Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenvalue decomposition-based Spectrum Estimation.

List of Experiments **30h**

1. Write a program to implement time frequency analysis in MATLAB.
2. Write a program to implement power spectrum estimation methods in MATLAB.
3. Write MATLAB code to implement the Weiner and Kalman filter to denoise the noisy signal.
4. Develop an adaptive filter algorithm for sinusoidal Noise Cancellation using TMS320C6748 - Fixed/ Floating Point Digital Signal Processor. [Code Composer Studio (CCS)]
5. Generation of the Frequency Response of the DAC Reconstruction Filter using a Pseudorandom Binary Sequence with the help of the TMS320C6748 processor. [CCS]
6. Develop a fourth-order Elliptic low-pass IIR Filter Designed Using FDA tool.
7. Develop the code for the implementation of four different filters: Low pass, High Pass, Band Pass and Band Stop using the TMS320C6748 processor. [CCS]
8. Implementation of an IIR filter using a cascade second-order filter. [CCS]
9. DFT of a Sequence of Real Numbers with Outputs in the CCS graphical display window. [CCS]

Essential/recommended readings:

1. J.G.Proakis and D.G.Manolakis "Digital signal processing: Principles, Algorithm and Applications", 5th Edition, Pearson, 2021. (Unit I, and Unit III)
2. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999. (Unit-I, and Unit-II)
3. D. G. Manolokis, V. K. Ingle and S. M. Kogar, "Statistical and Adaptive Signal Processing", Mc Graw Hill International Edition, 2000. (Unit-III)
4. S. Haykin and T. Kailath, Adaptive Filter Theory, Pearson Education, 4th Edition, 2005. (Unit-III, and Unit-IV)

Suggested Reading:

1. Discrete Wavelet Transform: A Signal Processing Approach, by D. Sundararajan, John Wiley and Sons Inc., 2015 (Unit-I)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 11

Principles of VLSI Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-11: Principles of VLSI Design	4	3	--	1		Basics of analog and digital electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To introduce the VLSI design hierarchy, abstraction levels, and overall design flow.
2. To develop understanding of CMOS logic circuits and common combinational and sequential building blocks.
3. To enable analysis of timing, power, and performance trade-offs in VLSI systems.
4. To familiarize students with physical design concepts and verification methodologies.
5. To build a foundation for advanced study or industry applications in VLSI design.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Explain the VLSI design hierarchy, abstraction levels, and end-to-end design flow.
2. Design and analyze basic CMOS combinational and sequential circuits using appropriate logic styles.
3. Evaluate timing and power characteristics of VLSI circuits and identify critical design trade-offs.
4. Apply physical design concepts such as floor planning, placement, routing, and verification at a conceptual level.
5. Relate VLSI design methodologies to practical implementation and further studies in integrated circuit design.

SYLLABUS OF DSC -11 — Total Hours: 45h

UNIT -I (10 Lectures)

VLSI Design Flow and Abstraction:

VLSI system hierarchy, design complexity, and need for abstraction at system, architectural, logic, circuit, and layout levels. Top-down and bottom-up design approaches and representations at each abstraction level. Overview of ASIC design flow from specification to fabrication, including design entry using HDL and verification. Standard-cell based design methodology, IP blocks, and comparison of ASIC and FPGA design flows.

UNIT – II (12 Lectures)

CMOS Logic Circuits and Building Blocks:

CMOS implementation of basic combinational logic gates and arithmetic circuits. Multiplexers, encoders, decoders, and XOR/XNOR circuits. Pass transistor logic and transmission gate logic: operation, advantages, and limitations with logic realization. Sequential elements (latches and flip-flops) and design considerations in terms of speed, power, and area.

UNIT – III (11 Lectures)

Timing and Power Considerations in VLSI:

Propagation delay, rise/fall times, critical path, and timing constraints in synchronous systems. RC delay models, interconnect delay, setup/hold time, and clock skew effects. Dynamic and leakage power dissipation in CMOS circuits and influencing factors. Power–delay trade-off and low-power design considerations.

UNIT – IV (12 Lectures)

Physical Design Concepts:

Physical design flow and its role in VLSI implementation. Floor planning, area estimation, placement, and routing concepts. Impact of interconnect and parasitic effects on timing and performance. Physical verification techniques including DRC, LVS, and parasitic extraction.

List of Experiments: 30h

1. Study of VLSI Design Flow and Abstraction Levels.
2. Design and Simulation of CMOS Inverter
3. Design of Basic CMOS Logic Gates (NAND, NOR, XOR)
4. Design of Combinational Circuits (Multiplexers, Encoders, Decoders)
5. Design and Analysis of Pass Transistor and Transmission Gate Logic Circuits
6. Design of Sequential Circuits (Latches and Flip-Flops)
7. Timing Analysis of Digital Circuits
8. Power Analysis of CMOS Circuits.

Essential/recommended readings:

1. Rabaey, J. M., Chandrakasan, A., Nikolić, B Digital Integrated Circuits: A Design Perspective, 3rd Edition, Pearson Education, 2019. (Units-I, Unit-II and Unit-III)
2. Weste, N. H. E., Harris, D. CMOS VLSI Design: A Circuits and Systems Perspective, 4th Edition, Pearson Education, 2011. (Units-I, Unit-II, Unit-III, and Unit-IV)
3. Kang, S. M., Leblebici, Y. CMOS Digital Integrated Circuits: Analysis and Design, 4th Edition, McGraw-Hill Education, 2015. (Units II, Unit-III and Unit-IV)

Suggested / Supplementary Readings

1. Wolf, W. Modern VLSI Design: Systems on Silicon, 4th Edition, Pearson Education, 2008. (Units I, and Unit-IV)
2. Uyemura, J. P. Introduction to VLSI Circuits and Systems, Wiley, 2002. (Units I, and Unit-II)
3. Pedram, M., Rabaey, J. (Eds.) Power Aware Design Methodologies, Springer, 2002. (Unit-III)
4. Baker, R. J. CMOS: Circuit Design, Layout, and Simulation, 3rd Edition, Wiley-IEEE Press, 2019. (Units II, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 14

Artificial Intelligence & Robotics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-14: Artificial Intelligence & Robotics	**4**	**3**	**--**	**1**		**Biology, Mathematics & Embedded Systems**

Learning Objectives

The Learning Objectives of this course are as follows:

1. Understand the importance, applicability and strength of AI.
2. Elaborate search and knowledge representation schemes for intelligent systems
3. Understand the logics and knowledge representation techniques.
4. Understand the basics of logical programming PROLOG.
5. Explain the design of the robot.

Learning Outcomes

At the end of this course, students will be able to

1. Implement the AI techniques in the field of Electronics.
2. Apply various search and knowledge representation schemes for intelligent systems.
3. Explain the logic and knowledge representation techniques.
4. Demonstrate the various phases involved in the development of the Expert system.
5. Design and development of a robot.

SYLLABUS OF DSE-14 — Total Hours: 45h

UNIT -I (12 Lectures)
Introduction to AI:
Definition and history of AI, Domains and Applications of AI, advantages and disadvantages of AI, Subsets of AI, Intelligent agents in AI and their types, Agent Environment in AI, Turing Test.

UNIT – II (10 Lectures)
Searching techniques:
Search Algorithm Terminologies, Properties of search algorithms, types of search algorithms, Breadth-first search, Uniform cost search, Depth-first search, Best-first search, A* search, Hill climbing algorithm.

UNIT – III (10 Lectures)
Knowledge Representation:
Knowledge-Based Agent and its architecture**,** types of knowledge, Techniques of knowledge representation, Propositional logic, Syntax & semantics for Propositional logic, rules of inference, First-order logic (FOL) and

syntax, Inference rules for FOL. Introduction to logical programming, PROLOG. Machine learning.

UNIT – IV (13 Lectures)

Introduction to Robotics:

Basic: Robot-Basic concepts, Need, Robot configurations-cartesian, cylinder, polar and articulate. Robot wrist mechanism, Precision and accuracy of the robot, and safety standards.

Sensors and Actuators in robotics: Touch sensors, Tactile sensors, proximity and range sensors, Pressure sensors, Actuators: DC Motor, Servo Motor and Stepper Motor.

Applications: Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defence, and Disaster management.

List of Experiments **30h**

1. Understanding of the programming model of STM32CubeIDE, NanoEdge AI Studio, and development tools. Programming for TinyML and Edge AI.
2. Multi-sensor data fusion and on-device AI decision making.
3. Write a PRO LOG program for Family Relationships.
4. Human activity recognition using motion sensors.
5. Motion and Vibration Sensor Interfacing.
6. To display real-time sensor data on OLED.
7. Forward kinematics and validate using any software (Robo analyzer or other).
8. Demonstration of a robot with 2 DOF, 3 DOF, 4 DOF using any software (Robo analyzer or other).
9. Design a Robotic Arm using Arduino.

Essential/recommended readings:

1. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 4e , 2022. (Units-I, and Unit-II)
2. Vinod Chandra S.S., and Anand Hareendran S. Artificial Intelligence and Machine Learning 1st Edition., PHI, 2014. (Units-I, and Unit-II)
3. Dan W. Patterson, Introduction to artificial intelligence and expert systems, 1st edn, Pearson, 2015. (Units-I, and Unit-III)
4. John Craig, Introduction to Robotics, Pearson, 2022. (Unit-IV)
5. S.K Saha, Introduction to Robotics, Magraw Hill, 2024. (Unit-IV)

Suggested reading:

1. Saroj Kaushik: Artificial Intelligence, Cengage, 2nd Edition, 2022.
2. Peter J. Bentley : Artificial Intelligence and Robotics: Ten Short Lessons (Pocket Einstein Series), Johns Hopkins University Press,2020.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 15

Electromagnetic Interference and Electromagnetic Compatibility (EMI & EMC)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-15: EMI & EMC	4	3	-	1	Entry level	Basics of Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

1. To understand the significance of EMI/EMC in the design of electrical and electronic products.
2. To learn about EMI sources, coupling mechanisms, and their impact on system performance.
3. To gain knowledge of international EMI/EMC standards and test procedures.
4. To explore various EMI control techniques such as grounding, shielding, and filtering.
5. To develop good design practices for achieving EMC compliance at circuit and PCB levels.

Learning Outcomes

At the end of this course, students will be able to

1. Explain the concepts and importance of EMI and EMC in product design.
2. Identify EMI sources and apply suitable control and mitigation techniques.
3. Interpret and follow relevant EMI/EMC standards and testing methods.
4. Design circuits and PCBs with improved EMC performance.
5. Apply good design practices to ensure reliable and compliant electronic systems

SYLLABUS OF DSE-15 — Total Hours: 45h

UNIT -I (12 Lectures)

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

UNIT – II (11 Lectures)

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

UNIT – III (11 Lectures)

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

UNIT – IV (11 Lectures)

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

List of Experiments: **30h**

1. To study the noise coupling between twisted and untwisted wires using an oscilloscope.
2. To study the conducted EMI from a DC power supply or motor circuit.
3. To study the radiated EMI from a digital circuit or switching power supply.
4. To measure the electromagnetic radiation emitted by a device using spectrum analyzer
5. To study the effect of metallic and non-metallic enclosures on EMI.
6. To evaluate the effectiveness of various shielding materials in preventing electromagnetic interference.
7. To study the crosstalk between parallel PCB traces or cables by measuring the induced noise at varying separation distances.
8. To study the EMI/EMC test using a GTEM cell.

Essential/recommended readings:

1. Kumar, L. A., & Maheswari, Y. U. (2024). Electromagnetic interference and electromagnetic compatibility: Principles, design, simulation, and applications. 1st Edition, CRC Press. (Unit I, II, III and IV).
2. Mardiguian, M. (2025). Electromagnetic compatibility: Understanding, design, and testing with practical solutions. 1st Edition, Springer. (Unit I, II, and III).
3. Ott, H. W. (2011). Electromagnetic Compatibility Engineering. John Wiley & Sons. (Unit I, II, III and IV).

Suggested Books:

1. Archambeault, B., & Drewniak, J. (2013). PCB design for real-world EMI control. Springer. (Unit I, III, and IV)
2. Nguyen, K. (2025). Grounding, shielding & EMC for builders: Quiet circuits: Practical grounding, shielding & EMC for projects,1st ed. Independently Published. (Unit III and IV)
3. Paul, C. R., Scully, R. C., & Steffka, M. A. (2022). Introduction To Electromagnetic Compatibility. John Wiley & Sons. (Unit I- IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 16

Fundamentals of MEMS Technologies

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course
		Lecture	Tutorials	Practical/ Practice		
DSE-16 Fundamentals of MEMS Technologies	4	3		1	Entry Level	Electromagnetics

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspects of MEMS technologies.
2. Basic knowledge of Essential Materials for MEMS fabrication.
3. The course educates the students on the understanding mechanism behind Actuators and Sensors.
4. The course educates the students on the working principles of MEMS-based RF and Optical Technologies.

Learning Outcomes

At the end of this course, students will be able

1. To understand basic principle of MEMS operation.
2. To design the various MEMS structures
3. To acquire a knowledge on Actuators and Sensors and operational principle.
4. To design requirements for RF MEMS components

SYLLABUS OF DSE-16 Total Hours: 45h

UNIT -I (11 Lectures)
Introduction:
History of MEMS Development, Intrinsic characteristics of MEMS, Electrical and Mechanical Properties of Materials for MEMS, Electrical and Mechanical Properties, Miniaturization, Scaling issues, Micromachining: bulk, surface and dry micromachining, Microelectronics Integration, Transduction Principles: Electrostatic and Capacitive, Electromagnetic, Piezoelectric and Thermal Transductions. Mass fabrication with precision. Micro fabrication - microelectronics fabrication process- silicon based MEMS processes and fabrication processing.

UNIT -II (12 Lectures)
Sensors and Transducers:
Principles, Classifications, Characteristics; Recent Trends in Sensor Technologies, Electromechanical transducers: Piezoelectric transducers, Electrostatic sensing and actuation-parallel plate capacitor, Tactile sensor parallel Plate actuator- comb drive. Thermal sensing and actuations-thermal sensors-actuators. Smart Sensors, Sensors and their Applications.

UNIT -III (12 Lectures)
RF Technologies:
Need for RF MEMS components in communications, space and defense applications, Materials and fabrication technologies, Actuation methods in MEMS, Special considerations in RF MEMS design. RF MEMS components: Micro-switches, Planar, on-chip components, Transmission lines and other components, Micromachined antennas, Micromachined phase shifters.

UNIT -IV (10 Lectures)
Optical Technologies:
Optical MEMS and Optofluids, Optical materials for MEMS, Challenges in optical MEMS fabrication, MEMS scanning micromirror, MEMS based endoscopy, Microlens, Microcamera.

List of Experiments: 30h

1. Design and Simulation of Cantilever Beam Sensor.
2. Design and Simulation of Pressure Sensor.
3. Design and Simulation of a Fluid-Filled RF-based MEMS Switch.
4. Design and Simulation of MEMS-based Surface Acoustic Wave Gas Sensor.
5. Design and Simulation of an RF-based MEMS planar component.
6. Design and Simulation of an Optical-based MEMS component.

Essential/recommended readings

1. Eun Sok. Kim, Fundamentals of Microelectromechanical Systems (MEMS). 1st ed. New York: McGraw Hill, 2021 for Unit-I, III and IV D. Patranabis, Sensors and Transducers, 2nd Edition. (UNIT-II)
2. V. K.Varadan, K. J. Vinoy, and K.J. Jose, RF MEMS and their Applications, John Wiley & Sons. 2002. (Unit – III, and Unit-IV)

3. H. J. De Los Santos, RF MEMS Circuit Design for Wireless Communications, Artech House. 1999. (Unit – III)
4. Hongrui Jiang, Optical MEMS for Chemical Analysis and Biomedicine, Institution of Engineering and Technology, London, United Kingdom, first edition, 2016. (Unit – IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 17

Modern Communication Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-17: Modern Communication Systems	4	3	0	1	Entry level	Analog and Digital Communication.

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning Outcomes

At the end of this course, students will be able

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

SYLLABUS OF DSE-17 — Total Hours: 45h

UNIT -I (10 Lectures)

Satellite Communication:

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

UNIT – II (10 Lectures)
Wireless Communication:
Fundamental concepts in wireless, Basic Terminologies, cellular technology, GSM, GPRS, 3G, 4G, 5G, Standards evolved, Mobile Radio Propagation, Mobile System and Network Architectures, Advanced Wireless IP network Architectures, Wireless Standards.

UNIT – III (15 Lectures)
Data transfer and Computer Networking:
Packet switching, ISDN, ATM, LAN, WAN, Internet and WAP, Digital Radio Communication Systems; Multiple Access Techniques: Frequency Hopping Spread Spectrum (FHSS) systems, Direct Sequence Spread Spectrum, Code Division Multiple Access of DSSS.

UNIT – IV (10 Lectures)
Internet of Things:
Introduction, Fundamental IoT Mechanisms and Key Technologies, Radio Frequency Identification Technology, Resource management in IoT, IoT Privacy, Security and Governance, Business models for IoT.

List of Experiments **30h**

1. To Establish a voice/video link between an uplink transmitter and a downlink receiver.
2. To Study Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS) techniques.
3. To calculate carrier-to-noise ratio (SNR) for uplink and downlink.
4. To study Minimum Shift Keying (MSK) modulation and demodulation.
5. Use software (MATLAB) to determine satellite position, velocity, and visibility, including Keplerian elements.
6. To determine longitude, latitude, and altitude using a GPS receiver.
7. Functional study and block diagram study of mobile communication through mobile trainer kit.
8. Signal analysis and measurement of mobile communication.
9. Study of automation through I.O.T.

Essential/recommended readings:

1. Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J. (2017). IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press. (Unit-IV)
2. Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson. (Unit-II)
3. T. Pratt, C. Bostain & J. Allnutt. (2003). Satellite Communication, Wiley. (Unit-I)

Reference Books:

1. Rappaport, T. S. (2024). Wireless communications: principles and practice. Cambridge University Press. (Unit-II)
2. Forouzan, B. A. (2007). Data communications and networking. Huga Media. (Unit-III)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE 18
Modern Antennas

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-18: Modern Antennas	4	3	--	1		Basics of Electromagnetics and transmission lines

Learning Objectives

1. To understand the fundamentals of antenna theory and electromagnetic radiation principles.
2. To analyze key antenna parameters such as gain, polarization, beamwidth, directivity, and efficiency.
3. To derive and evaluate the radiation fields of various antennas, including wire, aperture, and microstrip antennas, along with appropriate feeding techniques and circular polarization concepts.
4. To apply the principles of antenna arrays, including beam steering, null steering, and adaptive/smart antenna techniques.
5. To design and analyze modern antenna systems such as reconfigurable, fractal, metamaterial/metasurface, holographic, wearable, biomedical, IoT, and millimeter-wave antennas for practical applications.

Learning Outcomes

At the end of this course, students will be able to:

1. Explain the radiation mechanism of antennas and evaluate key antenna parameters such as gain, directivity, polarization, beamwidth, and efficiency.
2. Derive and analyze the field components of wire antennas including dipole, loop, helix, and Yagi–Uda antennas.
3. Compute and evaluate the field components and radiation characteristics of various aperture antennas.
4. Analyze and design linear and planar antenna arrays, and implement beam scanning techniques using Binomial and Chebyshev distributions.
5. Design and assess modern antenna systems such as reconfigurable, fractal, metamaterial/metasurface, holographic, wearable, biomedical, and IoT antennas for contemporary applications.

SYLLABUS OF DSE-18 — Total Hours: 45h

UNIT -I (10 Lectures)

Antenna fundamentals and parameters:

Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Maximum Directivity and Maximum Effective Area, and Antenna Polarization, Antenna Apertures, and near-field and far-field concepts. Types of Antennas, Radiation Mechanism and Current Distribution on a Thin Wire Antenna. Radiation integrals and vector potential.

UNIT -II (11 Lectures)

Conventional Antennas:

Dipole, monopole, loop and helical antennas, Yagi-Uda, and horn antennas, Reflector antennas: parabolic reflectors, Cassegrain feed, Microstrip patch antenna: types, analysis, feeding techniques, Design parameters: bandwidth, substrate effects, impedance matching, Circularly polarized and broadband patch designs.

UNIT -III (12 Lectures)

Antenna Arrays and Beamforming:

Two Element Array, N-Element Linear Array- Uniform amplitude and Spacing, Broadside Array, Ordinary End-Fire Array, Phased Array, Array factor and pattern multiplication, Beam steering and null steering techniques, Adaptive and smart antenna concepts, Introduction to MIMO and beamforming for 5G.

UNIT -IV (12 Lectures)

Modern and Emerging Antennas:

Reconfigurable antennas (frequency, pattern, and polarization reconfigurability), Fractal antennas and miniaturization techniques, Metamaterial and metasurface antennas, Holographic Antenna, Wearable, biomedical, and implantable antennas, Antennas for IoT.

List of Experiments: **30h**

1. To study and design of Dipole antenna and analysis of its various parameters.
2. Study the Effect of a Perfect Electric Conductor (PEC) and a Perfect Magnetic Conductor on dipole antenna performance.
3. To study and design of microstrip Rectangular and Square patch antenna
4. To study and design of microstrip Circular Patch Antenna
5. To study the effect of various feeds in the microstrip Patch antenna.
6. To study and design of circularly polarized microstrip antenna.
7. To study and design of planar microstrip array antenna (1×2)
8. To study and design of MIMO antenna and analyse its various parameters.
9. To study and design of Aperture antenna (rectangular slot)
10. Measurement of a radiation pattern of dipole and Yafi-Uda antenna. Analysis of co-polarization and cross-polarization.

Essential/recommended readings:

1. C. A. Balanis, Antenna Theory: Analysis and Design, Wiley. (Unit-I, Unit-II, Unit-III, and Unit-IV)
2. W. L. Stutzman and G. A. Thiele, Antenna Theory and Design. (Unit-I, and Unit-II)
3. R. S. Elliott, Antenna Theory and Design, Wiley. (Unit-II)
4. K. F. Lee and K. M. Luk, Microstrip Patch Antennas. (Unit-II)
5. Y. Lo and S. Lee, Antenna Handbook. (Unit-III)
6. Constantine A. Balanis, Modern Antenna Handbook, Wiley. (Unit-III, and Unit-IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – GE-04

Consumer Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-04: Consumer Electronics	**4**	**3**	**1**	**--**	**Entry Level**	**Basic Electronics**

Learning Objectives

The Learning Objectives of this course are as follows:

1. To discuss the concepts of audio and video system fundamentals.
2. To conceptualize the analogous system and their work mechanism.
3. To illustrate and outline the Television system.
4. To understand various electronic devices of popular use.
5. To explain the component level understanding of the devices.

Learning Outcomes

The Learning Outcomes of this course are as follows:

1. Student will Understand the component and system level understanding of the electronic devices.
2. Student will learn to describe the interconnections of components to achieve the system in device electronics.
3. Student will determine the response of system.
4. Synthesize the electronic device with the help of Electrical Elements.
5. Student will learn the description of modern TV systems and other devices

SYLLABUS OF GE-04 — Total Hours: 45h

UNIT -I (12 Lectures)

Audio Fundamentals and Devices:

Basic characteristics of sound signal: level and loudness, pitch, frequency response, fidelity and linearity, Reverberation; Audio level metering, decibel level in acoustic measurement; Microphone: working principle, sensitivity, nature of response, directional characteristics; Types: carbon, condenser, crystal, electrets, tie- clip, wireless; Loud speaker: working principle, characteristic impedance, watt

Capacity; Types: electrostatic, dynamic, permanent magnet etc , woofers, and tweeters; Sound recording: Optical recording, stereophony and multichannel sound, MP3 standard.

UNIT – II (10 Lectures)

Audio Systems:

Audio system: CD player, home theatre sound system, surround sound; Digital console: block diagram, working principle, applications; FM tuner: concepts of digital tuning, ICs used in FM tuner TDA 7021T; PA address system: planning, speaker impedance matching, Characteristics, power amplifier, Specification.

UNIT – III (13 Lectures)
Television Systems:
Picture resolution; Composite video signal: horizontal and vertical sync details, scanning sequence; Colour TV standards, colour theory, hue, brightness, saturation, luminance and chrominance; Different types of TV camera; Television Receivers and Video Systems: block diagram, Precision IN Line colour picture tube; Digital TVs:- LCD, LED ,PLASMA, HDTV, 3-D TV, projection TV, DTH receiver; Video interface: Composite, Component, Separate Video, Digital Video, SDI, HDMI Multimedia Interface) , Digital Video Interface; USB stick: working principles, interfaces.

UNIT – IV (10 Lectures)
Home/Office Appliances:
Scanner; Microwave Oven: types, single chip controllers, wiring and safety instructions, technical specifications; Washing Machine: wiring diagram, electronic controller for washing machine, technical specifications, types of washing machine, fuzzy logic; Air conditioner and Refrigerators: Components features, applications, and technical specification; Digital camera and cam coder: pick up devices, picture processing, picture storage**.**

Tutorials: 15h
List of Activities under Tutorials:
1. Case Study on Audio system specifications and applications, fidelity factor, etc.
2. Comparison between various loudspeakers and microphones
3. Understanding the features of various types of Smart TVs and smart gadgets
4. Seminar on emerging consumer electronics gadgets to be integrated with 5G, 6G technologies
5. Case studies on IoT based Smart Home systems

Essential/Recommended Readings:
1. Gupta B. R., Singhal V., Consumer Electronics, S. K. Kataria & Sons India, 2023 edition (Unit I, and Unit-II)
2. Hetrelezis P., Consumer Electronics: Repair, Reuse and Recylcing, Elektor Publishing, 2024 latest edition (Unit III, and Unit-IV)
3. Gulati R.R., Modern Television practices, New Age International Publication (P) Ltd. New Delhi Year 2023, latest edition. (Unit III)

Suggested Readings:
1. Whitaker Jerry & Benson Blair, Mastering Digital Television, McGraw-Hill Professional, 2023, latest edition
2. Whitaker Jerry & Benson Blair, Standard handbook of Audio engineering, McGraw-Hill Professional, 2023, latest edition
3. Latest User Manuals from Philips, Dell and HP for the new generation devices.

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SKILL BASED COURSE – SBC-04

Electronic Materials and Devices Fabrication

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course
		Lecture	Tutorials	Practical/ Practice		
SBC – 04 Electronic Materials and Devices Fabrication	**2**	**1**	**0**	**1**		**Basic Electronic Materials**

Learning Objectives

The Learning Objectives of this course are as follows:

1. This course will provide important aspect of semiconductor process technologies.
2. This course will create the foundation of Fabrication Techniques for Semiconductor Materials and Devices.
3. The course educates the students with the understanding science behind fabrication techniques of micro/nano electronic devices.
4. The main objective is to train the manpower/students in the field of semiconductor science and technology relevant to modern electronic industry/technology.

Learning Outcomes

At the end of this course, students will be able

1. To understanding role of Semiconductor Devices in duality human life.
2. To able to use vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
3. To skilled over Device Isolation, Contacts and Metallization for CMOS Applications.
4. To trained manpower will be conversant with various processes and instruments to fabricate the electronic materials and devices.

SYLLABUS OF SBC-04 — Total Hours: 60h

Unit 1:

Over view of semiconductor wafer and electronic devices processing, clean room specifications and importance; Isolation: mesa isolation, Oxide isolation; Self-Alignment; Local oxidation: Trech Technique; Planarization: Chemical and mechanical Polishing; Metallization; Planar and Mesa structures; Device packing basics: System on chip (SOC) and System on packing (SOP) wire bonding techniques for IC fabrication.

Unit 2: List of Experiments

1. Demonstrate Semiconductor thin films fabrication by Physical/chemical vapor deposition techniques.
2. Doping (n- or p-type) of intrinsic semiconductors.
3. Polymer thin film depositions: Spin coating techniques.
4. Semiconductor thin film characterization and analysis: crystalline quality, optical defects, bandgap identification etc.
5. Thin film deposition on flexible substrates using screen-printing technique for flexible electronic device applications.
6. Device characterization and analysis: Semiconductor parameter analyzer.

Essential/recommended readings

1. Sorab K. Ghandhi, VLSI Fabrication Principles, 2nd Edition, Wiley
2. Fundamentals of Device and Systems Packaging: Technologies and Applications by Rao R. Tummala, McGraw-Hill Publications

Reference Books:

1. G. S. May and S. M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley India, 2004
2. Stephen A. Campbell, Fabrication engineering at the micro-and nanoscale, 4th Edition, Oxford University Press, 2008
3. M. J. Madou, *Fundamentals of Microfabrication*, 2nd Edition, CRC Press, 2011.

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RESEARCH METHODS/ TOOLS/ WRITING COURSE – RMT 03

Techniques of Research Writing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RMT-03: Techniques of Research Writing	**2**	**2**	**0**	**0**	**Entry level**	**N.A.**

Learning Objectives

Students will learn to:

1. Produce structured academic papers (paragraphs, essays, reports).
2. Use academic language effectively and appropriately.
3. Properly document sources to maintain academic integrity.
4. Critically read and analyze academic texts.

Learning Outcomes

At the end of this course, students will be able to

1. Write a technical paper.
2. Understand academic language.
3. Have knowledge of references, and citation.
4. Develop the knowledge of machine learning and artificial intelligence in ADAS.

SYLLABUS OF RMT-03 — Total Hours: 30h

UNIT -I (7 Lectures)

Introduction to Academic Writing:

Purpose, audience, tone, and features (objectivity, precision, formality).

The Writing Process:

Brainstorming, outlining, drafting, revising, and proofreading.

UNIT – II (8 Lectures)
Paragraph & Sentence Structure:
Topic sentences, coherence, cohesion, and paragraph development (descriptive, opinion, comparison).
Essay Types:
Expository, argumentative, and compare/contrast essays.

UNIT – III (8 Lectures)
Working with Sources:
Paraphrasing, summarizing, quoting, and avoiding plagiarism.
Referencing & Citations:
Understanding citation styles (e.g., MLA, APA, Chicago, IEEE Style).
Research Skills:
Using the library, internet, and organizing research materials.

UNIT – IV (7 Lectures)
Critical Analysis:
Developing arguments, evaluating sources, and reviewing literature.
Drafting and revising manuscript, addressing reviewers' queries, Annotated bibliographies or literature reviews, Final research paper.

Essential/recommended readings:

1. Birkenstein, C., & Graff, G. (2018). *They say / I say: The moves that matter in academic writing* (4th ed.). W.W. Norton & Company. (Unit-1, Unit-2, Unit-III, and Unit -IV)
2. Hayot, E. (2014). *The elements of academic style: Writing for the humanities*. Columbia University Press. (Unit-1, Unit-2, Unit-III, and Unit -IV)
3. Alred, G. J., Oliu, W. E., & Brusaw, C. T. (2019). The handbook of technical writing (12th ed.). (Unit-1, Unit-2, Unit-III, and Unit -IV)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.