ELECTRONIC SCIENCE

CORE AND DSE COURSES OFFERED BY DEPARTMENT OF ELECTRONIC SCIENCE

VIII Semester

Category I

Electronics Course for Undergraduate Programme of study with Electronics as a Single Core Discipline

(B.Sc. Honours in Electronics)

DISCIPLINE SPECIFIC CORE COURSE –20: Power 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		
Power Electronics	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course introduces the student to the fundamental understanding of power control in domestic and industrial applications through semiconductor devices. It also familiarise students with role and advantage of power semiconductor devices in automating the control of heavy machinery or power control circuits. This course forms the basis for bridging the knowledge of circuits, devices, embedded systems, machines and controls systems together, useful for the present era of e-control in every domain.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand the salient features and applicability of various types semiconductor devices through comparative study for power control
- Understand the construction, working and control of thyristors for power applications
- Develop understanding of various methods of conversion between DC and AC power
- Apply the learning for power control in real-life domestic applications

SYLLABUS OF ELDSC-20 **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)

Power Semiconductor Devices:

Definition and Applications of Power Electronics, Need and History of Power Semiconductor Devices, Introduction of various Power Semiconductor Devices (Power diodes, different types of Transistors and Thyristors), Vertical structure, Enhancement of voltage blocking and current carrying capability.

Power Transistors: Comparative study (structural, operational, functional, specifications) of Power BJT, Power MOSFET and IGBT as power switch: Vertical structure, Enhancement of voltage and current rating, IV characteristics, Safe Operating Area, switching characteristics/performance, equivalent structure

Second breakdown, saturation and quasi-saturation state in BJT, inversion in Insulated Gate Bipolar Transistor(IGBT), Latch-up in IGBT

Thyristors: Comparative Study of Silicon Controlled Rectifier(SCR), Diode for Alternating Current(DIAC), Triode for Alternating Current(TRIAC) and Gate Turn-Off Thyristor(GTO) as power switch: Structure, IV characteristics, utility

Comparative of specifications of Power BJT, Power Metal-Oxide-Semiconductor Field-Effect Transistor(MOSFET), IGBT, SCR and GTO

UNIT – II (10 Hours)

Semiconductor Controlled Rectifier (SCR):

Dynamic Turn-on and Turn-off characteristics, Turn-on methods, Gate triggering circuits (R, RC and Unijunction Transistor(UJT) triggering), Gate characteristics, Forced Commutation circuits, Voltage commutation, Current commutation, Load commutation, Two Transistor model, Internal regeneration, Factors affecting the characteristics/ratings of SCR, Protection of SCR, gate protection, di/dt and dv/dt protection using snubber circuit, series and parallel combination of SCRs

UNIT – III (13 Hours)

DC Power Control:

Single phase AC-DC converters: Phase-controlled rectifiers, half wave-controlled rectifier with resistive and inductive load, full wave-controlled rectifier using centre-tapped transformer and bridge configuration for resistive and inductive load, use of free-wheeling diode

DC-DC converters: Basic chopper circuit and classification, control strategies, step-up/down chopper (using both SCR and MOSFET), Class A-E choppers, Jones Chopper (load sensitive voltage commutation), Morgan's chopper

Applications of Phase-controlled rectifiers and choppers like DC motor speed control (in both directions), Light intensity of LED array, Variable DC power supply

UNIT – IV (11 Hours)

AC-AC converters: variable-voltage single phase AC power control, SCR and DIAC triggered TRIAC for half wave, full wave AC power control with inductive & non-inductive loads variable-frequency AC-AC Converters, introduction to single phase cycloconverters with resistive and inductive loads

DC-AC converters: Classification of inverters, Improved series inverter, limitations of series inverter, Parallel inverter with reactive feedback, single phase bridge inverter, introduction to McMurray Inverter, voltage control using PWM

Thyristor based control of domestic appliances like fan/others and Speed control of induction motors (block diagrams only)
Idea of Applicable IS/IEC Standards for Invertors and UPS.

Practical component (if any) – Power Electronics Lab
(Hardware and Software Simulation using Multisim/MATLAB/Other Electronics Simulation Software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Functioning and control of different types of transistors and thyristors
- Working of DC Power control circuits
- Working of AC Power control circuits
- To design and develop a small power control system

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Study of IV characteristics of SCR/TRIAC, MOSFET/IGBT (Familiarity with use of commercially available Data-Sheet)
2. SCR based phase-controlled rectifier with (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
3. SCR/MOSFET based chopper (DC-DC converter)
4. AC-AC voltage controller using SCR/TRIAC (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
5. Study of series, parallel and bridge inverter
6. Study of single phase cycloconverter
7. Micro-projects based on power electronics (at least one)
    a. DC motor control using SCR/IGBT based rectifier (AC-DC converter)
    b. Battery eliminator with 0-12V, 1A rating
    c. AC motor (Fan) speed control using DIAC triggered TRIAC
    d. AC voltage controller using TRIAC with UJT triggering

e. SCR based temperature controller using thermistor
f. Light intensity controller in an LED array
g. Any other similar circuit

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than five and one micro-project.

Essential/recommended readings

1. Principles of Electric Machines and Power Electronics, P.C. Sen, John Wiley & Sons, 3rd Edition, 2013
2. Power Electronics Circuits, Devices and Applications, M.H. Rashid, Pearson Education, 4th Edition, 2024
3. Power Electronics, P.S. Bimbhra, Khanna Publishers, 7th Edition, 2024
4. Power Electronics, M.D. Singh & K.B. Khanchandani, McGraw Hill Education, 2nd Edition, 2014

Suggestive readings

1. Power Electronics: Devices, Circuits and Industrial Applications, V.R. Moorthi, Oxford University Press
2. Power Electronics, K. Hari Babu, Scitech Publishing
3. An Introduction to Thyristors and their applications, M. Ramamoorty, Palgrave Macmillan/East West Press

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

DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES OFFERED BY THE DEPARTMENT

DISCIPLINE SPECIFIC ELECTIVES (DSE-1)

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		
Natural Language Processing ELDSE8A	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course introduces the student to the fundamental understanding of Natural Language Processing (NLP) which is a rapidly developing field with broad applicability throughout the hard sciences, social sciences, and the humanities. This course is intended as a theoretical and methodological introduction to the most widely used and effective current techniques, strategies and toolkits for natural language processing, with a primary focus on those available in the Python programming language.

Learning outcomes

On successful completion of this course, student will be able to:

CO1 Analyze the natural language text.

CO2 Define the importance of natural language.
CO3 Understand the concepts of Text mining.
CO4 Illustrate information retrieval techniques.
CO5 Analyze the natural language text.

SYLLABUS OF ELDSE-8A **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

Unit I: (11 Hours)
Overview and Language Modeling:
Origins and challenges of NLP-Language, Phases and components of NLP, Applications-Information Retrieval, Unigram Language Model, Bigram, Trigram, N-gram, Advanced smoothing for language modelling, Empirical comparison of smoothing techniques, Applications of Language Modelling.

Unit II: (12 Hours)
Part of Speech and Word Form:
Natural Language Generation, Parts of Speech Tagging, Morphology, Named Entity Recognition, Rule-base and Stochastic POS tagger, Markov Model, Maximum Entropy model, Bag-of-Words, skip-gram, Continuous Bag-of-Words, Embedding representations for words Lexical Semantics, Word Sense Disambiguation, Knowledge-Based and Supervised Word Sense Disambiguation.

Unit III: (11 Hours)
Text Analysis, Summarization and Extraction:
Text Summarization – Extraction and Abstraction, Information Extraction - Tokenization, Named Entity Recognition, Relation Extraction, Information Retrieval, Stop-Word, Stemming, Term weighting, Term Frequency, Document Frequency, Document Frequency Weighting (TFIDF), Text Classification (TF-IDF/Term Frequency Technique), Sentiment Mining.

Unit IV: (11 Hours)
Machine Translation:
Need of MT, Problems of Machine Translation, MT Approaches, Direct Machine Translations, Rule-Based Machine Translation, Knowledge Based MT System, Statistical Machine Translation (SMT), Parameter learning in SMT (IBM models) using EM), Encoder-decoder architecture, Neural Machine Translation.

Practical component (if any) – Natural Language Processing Lab
(Python/MATLAB)

Learning outcomes

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

CO1 To experiment with the concepts introduced in the course Natural Language Processing.
CO2 Ability to program various techniques of NLP.
CO3 Design and develop applications for text or information extraction/summarization/classification

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Perform sentence tokenization to break a text paragraph into individual sentences.
2. Perform word tokenization to break a text paragraph into individual words.
3. For the text selected in Practical 1, remove stop words and punctuation marks.
4. Apply the stemming technique to the text document selected in Practical 1 to obtain root words.
5. Perform different forms of lemmatization on the text document selected in Practical 1 to obtain base forms of words.
6. Extract the top 10 most common words in the selected text, excluding stop words.
7. Extract nouns and pronouns from the text and calculate similarities between any two words using a suitable method.
8. Case Study – Sentiment Analysis: Students will preprocess a text dataset (e.g., movie reviews or tweets) using tokenization, stemming, and feature extraction (TF-IDF or word embeddings). They will build and evaluate a sentiment classification model (e.g., Logistic Regression or Naive Bayes) and analyze its performance using metrics - Accuracy and F1-score.
9. Case Study - Language identification: Students will work with a multilingual dataset to preprocess text and extract features using character or word-level n-grams. They will train a language classification model (e.g., Naive Bayes or Random Forest) to identify the language of text samples and evaluate it with a confusion matrix and accuracy metrics.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than eight.

Essential/recommended readings

1. Daniel Jurafsky and James H Martin, “Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition”, 2nd Edition, Prentice Hall, 2013.
2. James Allen, “Natural Language Understanding”, 2nd edition, Benjamin/Cummings publishing company, 1995.
3. Eisenstein, J. (2019). Introduction to Natural Language Processing, MIT Press.

Suggestive readings

1. Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit, Steven Bird, Ewan Klein, and Edward Loper.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-2)

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		
Mobile and Satellite Communication ELDSE8B	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

The course will introduce the fundamental concepts of communication systems in the field of wireless communication. It will discuss the fundamental operation and design problems of wireless communication systems and thus help gain an understanding over the applications of communication in day-to-day real world.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand fundamentals of Wireless Communication System
- Comprehend the Protocols and Technologies in the Wireless Environment
- Understand the working of a Cellular Communication System.
- Understand the working of Satellite Communication.

SYLLABUS OF ELDSE-8B **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)

Introduction to Wireless Communication: Principle of Wireless Communication: advantages, disadvantages and applications. Cellular Revolution, Spread Spectrum: The Concept of Spread Spectrum, Frequency Hopping Spread Spectrum, Direct Sequence Spread Spectrum, Code Division Multiple Access, Generation of Spreading Sequences, Coding and Error Control: Block Error Correction Codes (Hamming Code and Cyclic Codes), Automatic Repeat request (Flow and Error Control)

UNIT – II (11 Hours)

Wireless LAN Technologies and Protocols: Network Topologies, LAN, MAN, WAN and PAN. Wireless LAN: Applications, Requirements and Technology, Infrared LANs, Spread Spectrum LANs and Narrow Band LANs
Wireless LANs: IEEE 802.11 Protocol Stack,
Broadband Wireless: IEEE 802.16 Protocol Stack,
Bluetooth: Architecture, Applications and Protocol Stack

UNIT – III (11 Hours)

Satellite Communication: Satellite Orbits, Kepler Laws, Satellite Communication Systems, Repeaters and Transponders, Communication Subsystems, Power Subsystem, Telemetry, Command and Control Subsystems, Ground Stations.
Applications: Communication Satellites, Digital Satellite, Surveillance Satellites, Navigation Satellite, GPS.

UNIT – IV (11 Hours)

Cell Phone Technologies: Evolution of Mobile Radio Communication, Paging System, Cordless Telephones Systems, Internet Telephony.
Cellular Telephone Systems: Cellular Concepts, Frequency Allocation, Multiple Access, AMPS, Digital Cell Phone Systems, Advanced Cell Phones, Personal Satellite Communication System.

Practical component (if any) – Mobile and Satellite Communication Lab
(Hardware/Software) The practical needs to be performed on MATLAB/Packet Tracer/VLabs or any other equivalent software/supporting hardware

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the basic elements of a wireless communication system.
- Build and understand the various network topologies.
- Understand the concept of various important parameters related to wireless communication systems.
- Prepare the technical report on the experiments carried.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

S.No.	Category	Title of Experiment
1	Wireless Communication	Simulate TDMA, FDMA and CDMA for wireless communication using MATLAB or equivalent.
2	Simulation of network topologies	Implement MESH/STAR/RING/BUS topology in Packet Tracer.
3	Tracing across Networks	Connect two different networks using a router in Packet Tracer and show movement of packets from one network to the other.
4	Bluetooth Simulation	Connect two Bluetooth devices-Portable Music Player & Bluetooth speaker and Configure to play music using Packet Tracer.
5	Frequency Reuse	Find the co-channel cells for a particular cell. http://vlabs.iitkgp.ac.in/fcmc/exp6A/index.html
6	Frequency Reuse	Find the cell clusters within certain geographic area. http://vlabs.iitkgp.ac.in/fcmc/exp6B/index.html
7	Sectoring	The aim of the experiment is to understand the impact of many different parameters which influence the downlink C/I ratio. http://vlabs.iitkgp.ac.in/fcmc/exp7/index.html#
8	Handoff	To study the effect of handover threshold and margin on SINR and call drop probability and handoff probability. http://vlabs.iitkgp.ac.in/fcmc/exp8/index.html
9	Calculation of Boundary Coverage Probability	To calculate the probability that the received signal level crosses a certain sensitivity level. http://vlabs.iitkgp.ac.in/fcmc/exp4/index.html
10	Calculation of SINR including Beam Tilt	To understand the concept of co-channel interference and hence Signal to Interference and Noise Ratio. http://vlabs.iitkgp.ac.in/fcmc/exp5/index.html
11	Satellite Network	Simulation of a Satellite Network http://vlabs.iitkgp.ac.in/ant/4/theory/

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than ten.

Essential/recommended readings

1. Wireless Communications and Networks by William Stallings, Pearson Education, 2nd Edition, 2004
2. Principles of Electronic Communication Systems, Louis E. Frenzel, McGraw-Hill Education, 5th Edition, 2022

Suggestive readings

1. Electronic Communication Systems, Fifth Edition by Wayne Tomasi (Pearson Education)
2. Data Communication and Networking, Fourth Edition by Behrouz Forouzan (Tata McGraw Hill)
3. Wireless Communications Principles and Practice, Third Edition by Theodore Rappaport (Pearson Education)
4. Satellite Communications, Third Edition by Dennis Roddy (Tata McGraw Hill)

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-3)

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		
CMOS Analog VLSI Design ELDSE8C	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	Digital Electronics, Analog Electronics-I & II, Basic VLSI Design

Learning Objectives

This course introduces the student to the fundamental understanding of Analog Circuits, Switched Capacitor Circuits, Phase locked loops, Converters and Filters.

Learning outcomes

On successful completion of this course, student will be able to:

- Extend the mixed signal design to different applications
- Comprehend the concept of Switched Capacitor Circuits
- Understand different types of Phase Locked Loops
- Build Mixed Signal Circuits and understand different Continuous Time Filters
- Analyze the Data Converter architecture and choose the most appropriate Data Converter for the specified applications

SYLLABUS OF ELDSE-8C **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (09 Hours)

CMOS Analog Circuits: Current Sources and Sinks, Current Mirror, Differential Amplifiers, Operational Amplifiers-Basic CMOS Op-Amp design, Operational Transconductance Amplifiers, CMOS Instrumentation Amplifier.

UNIT – II (12 Hours)

Switched Capacitor Circuits: Overview of Switched Capacitor circuits, Basic building blocks, Operation and Analysis, Non-ideal effects in Switched Capacitor Circuits, Switched Capacitor Integrators, First Order Filters

UNIT – III (09 Hours)

Continuous Time Filters: Overview of gm-C (Transconductor-C) filter, CMOS Transconductance Amplifier using Triode and active transistors, MOSFET-C filters

UNIT – IV (15 Hours)

Phased Locked Loop (PLL): Simple PLL, Basic PLL topology, Dynamics of Simple PLL, Overview of Charge Pump PLLs, Applications: Frequency Multiplication and Synthesis and Skew reduction.

Data Converter Fundamentals: Sample and Hold Circuit, Ideal D/A and A/D converter, Quantization Noise, Performance limitations. Types of A/D and D/A converters (overview of any one or two)

Practical component (if any) – CMOS Analog VLSI Design Lab

(Practicals to be performed using Ngspcie/LTspice/QUCS, CADENCE/MENTOR GRAPHICS)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply VLSI design methodologies to analyze and design the Analog Circuits
- Comprehend the design and working of Mixed Signal Circuits
- Get familiarized with the VLSI design Simulation Tools

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Implement a Current Mirror Circuit
2. Implement an Operational-Transconductor Amplifier
3. Implement a Sample and Hold Circuit for a given sampling rate.
4. Implement a First order Switch Capacitor Filter
5. Implement a Simple Phase Locked Loop Circuit
6. Implement a Single-ended First Order Gm-C Filter
7. Implement an A/D converter or D/A converter

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, Wiley Interscience, 2nd Edition, 2008, ISBN-10 0470290269, ISBN-13 9780470290262
2. Tony Chan Carusone, David Johns, Kenneth Martin, Analog Integrated Circuit Design, Wiley Student Edition, 2013, ISBN-10 9788126543939, ISBN-13 978-8126543939
3. Behzad Razavi, Design of Analog CMOS Integrated Circuits, TMH Edition, 2nd Edition, 2017, ISBN-10 938706784X, ISBN-13 978-9325983274

Suggestive readings

1. Philip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, International Second Edition/Indian Edition, 2016, ISBN-10 0199765073, ISBN-13 978-0199765072

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-4)

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		
Nanomaterials and their Applications ELDSE8D	**4**	**4**	**-**	**-**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course builds the basic background of nanomaterials, nanostructures and their properties. Classification of nanomaterials and its chemistry is explained and in addition to this, they are made aware of the various applications of nanomaterials.

Learning outcomes

On successful completion of this course, student will be able to:

- To understand classification of nanomaterials.
- To have a broad idea of applications of nanoscience in various fields.
- To understand carbon technology in nanoscience and nanotechnology.
- To have an idea of nano devices and sensors

SYLLABUS OF ELDSE-8D **Total Hours- Theory: 60 Hours**

UNIT – I (14 Hours)
Nanomaterials:
Classification of nanomaterials: Nanosized metals and alloys, semiconductor, Ceramics- a comparison with respective bulk materials, Organic compounds and polymers, carbon age-new form of carbon (CNT to Graphene), Nanocomposites.

Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nanopolymers: Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Applications of Nanopolymers in Catalysis.

Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers.

UNIT – II (16 Hours)
Applications of Nanomaterials for Sustainable Environment:
Nanomaterials in Energy Technology- Introduction: Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion, use of nanoscale catalysts to save energy and increase the productivity in industry.

Electrochemical Energy Storage Systems: Batteries: Primary, Secondary, Lithium, solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium batteries; Advanced batteries.

Nanomaterials in Energy Storage: Nano-electrochemical systems, nanomaterials for rechargeable batteries, nanomaterials for fuel cells.

Environmental applications of nanomaterials: Mechanism for remediation of aqueous contaminants, photocatalyst; membranes incorporating nanomaterials, transport processes in membrane technology; nanomaterial-based adsorbents for water and wastewater treatment – adsorption at metal oxide surfaces, hybrid adsorbents.

UNIT – III (14 Hours)
Carbon Nanotechnology:
Introduction to carbon nanotubes and their applications in various industries, supercapacitors, hydrogen storage; Nanomaterials for solar power: Solar energy materials, Solar energy devices, silicon solar technology for clean energy, Light Emitting Diodes, LED displays.

UNIT – IV (16 Hours)

Nano Devices and Sensors:

Introduction to Gas sensors; Characteristics of Gas sensors; Types of Gas sensors; Solid State Gas sensors: Chemiresistive Gas sensors (Semiconducting Metal Oxide based sensors, Carbon Nano Tube based nano sensors).

Miscellaneous applications: Microfluidics and Microsystems, Micro-electromechanical systems, ChemFET (NEMs and MEMS based sensors), Optic Gas sensors, Spectroscopic Gas sensors, Chemical Sensors: Electrochemical Gas Sensors.

Nano magnetism

Magnetism and Magnetic Materials, Basics of Magnetism, Magnetic Domains and Anisotropy, Magnetic Nanostructures, Magnetism of Nanosized Materials, Spintronics technology and the challenges, Electron and nuclear spin devices

Practical component (if any) – None

Essential/recommended readings

1. Introduction to Nanomaterials and Devices , Omar Manasreh, Wiley, 1st Edition, 2011
2. Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath, James Murday, 2013, Springer, e-ISBN 978-3-642-28030-6
3. Nano: The Essentials - Understanding Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw-Hill (TMH) Education, 1st Edition, 2007
4. Linden's Handbook of Batteries (and Fuel Cells), Thomas B. Reddy (original: David Linden, Thomas Reddy), McGraw-Hill Education, 5th Edition, 2019
5. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill, 2nd Edition, 2016

Suggestive readings

1. Diallo, M., Duncan, J., Savage, N., Street, A., and Sustich, R. (Eds). "Nanotechnology Applications for Clean Water" William Andrew. 2008
2. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, (1981).
3. Nanosensors: Physical, Chemical, and Biological by Vinod Kumar Khanna, Publisher: CRC Press.
4. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-5)

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		
Nanomaterials Characterization ELDSE8E	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

The course will teach various existing techniques used in nanotechnology; their Physical principles/concepts involved in fabrication of the materials at nano scale. The students will study various advanced characterization equipment used to characterize different types of materials including advanced optical and magnetic characterization techniques.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand the concept of Top-down and Bottom-UP approaches for synthesis and processing of nanomaterials
- Understand structural and optical characterization of nanoparticles
- Understand electrical and magnetic characterization of nanoparticles

SYLLABUS OF ELDSE-8E **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (11 Hours)
Introduction to Synthesis Approaches:
Concept of bulk versus nanomaterials and dependence of properties on size. Introduction to 'Top down' vs. 'Bottom up' approaches for synthesis of nanostructures (with suitable examples.), Physical, chemical and biological synthesis mechanism. Advantages and disadvantages of top down. Advantages and disadvantages of bottom up

UNIT – II (12 Hours)
Characterization and Data Analysis: Scattering & Imaging techniques:
Structural: X-Ray Diffraction, Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy, Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM).

UNIT – III (11 Hours)
Characterization and Data Analysis using Spectroscopic techniques:
Optical: Ultraviolet-Visible-Infrared Absorption, Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence

UNIT – IV (11 Hours)
Characterization and Data Analysis: Electrical and Magnetic
Electrical: Electrochemical techniques (Cyclic Voltammetry), resistivity, Four Probe Method
Magnetic: Magneto-Resistance, Vibrating Sample Magnetometer, , Magneto Optical Kerr Effect, Magnetic Force Microscopy.

Practical component (if any) – Nanomaterials Characterization Lab
(Use any relevant software(s))

Learning outcomes

The Learning Outcomes of this course are as follows:

- Calculate the material parameters of nanomaterials using suitable characterization techniques using secondary data.
- Visit to Research laboratories/ Instrumentation Centre and use advanced tools/techniques for synthesis and characterization of nanomaterials.
- Prepare technical reports of the experiments carried out.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. XRD analysis of the given XRD spectra using secondary data and thus determine the particle size and other parameters of nanomaterial.

2. To analyze chemical properties of a nanomaterial using UV-Visible spectroscopy secondary data
3. Find out the optical band gap of a nanomaterial using UV-Visible spectroscopy secondary data.
4. Software like ImageJ based structural analysis from secondary data (SEM/TEM).
5. To identify the presence of functional groups in nanomaterials using FTIR secondary data.
6. Report writing and presentation of the Lab Visit

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than five.

Essential/recommended readings

1. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 1st Edition, 2003.
2. Nanotechnology: Principles & Practices, S.K. Kulkarni, Capital Publishing Company (India), 2024, ISBN 9789381891810
3. Nanotechnology Synthesis to Applications, Sunipa Roy, Chandan Kumar Ghosh, Chandan Kumar Sarkar, CRC Press (Routledge), 1st Edition, 2020

Suggestive readings

1. Nanostructures and Nanomaterials Synthesis, Properties, and Applications, Guozhong Gao, Imperial College Press, 2004

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-6)

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		
Digital Control System ELDSE8F	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course introduces the students to fundamental concepts, principles and application of digital control system analysis and design. The topics cover classical control design as well as the modern control design methods

Learning outcomes

On successful completion of this course, student will be able to:

- Familiarize basic concepts for analysis of discrete-time domain systems.
- Use of pulse transfer function in discrete time systems.
- Stability analysis of digital control systems
- Design of compensators and controllers for desired time/frequency response.
- Design of estimators and observers

SYLLABUS OF ELDSE-8F **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (11 Hours)
Digital Control System:
Overview of control systems (open-loop vs closed-loop), Introduction to digital control systems, Continuous-time vs discrete-time control systems, Sampling theory: Sampling theorem and Nyquist rate, Aliasing and anti-aliasing filters, Reconstruction using zero-order hold (ZOH), Quantization effects, Discrete-time signals and systems, Z-transform and pulse transfer functions

UNIT – II (11 Hours)
Stability Analysis:
Stability analysis of discrete-time systems: Jury's stability criterion, Stability analysis using bi-linear transformation, Time response of discrete-time systems-Transient and steady-state responses, Design of sampled data control system-Discrete Root locus analysis, Frequency domain analysis: Bode and Nyquist plots (for sampled systems), Concept of Lyapunov stability

UNIT – III (11 Hours)
Discrete State-space Analysis:
State variable model, State-space representations for discrete-time systems, canonical forms, the solution to discrete-time state-space equation, state transition matrix (STM), controllability, observability and stability of discrete state space models

UNIT – IV (12 Hours)
Design and Analysis of Discrete-time Control System*:
Design of digital control based on the frequency response method Bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators, and digital PID controllers, Deadbeat control design. Design of state feedback controller through pole placement – Necessary and sufficient conditions

*Note: Controllers like digital PID, state-feedback controllers are to be designed in the discrete-time domain to work with sampled data. Software tools like MATLAB/Simulink to simulate and optimize digital controllers.

Practical component (if any) – Digital Control System Lab
(Software Platform: MATLAB/Simulink or similar software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Perform experiments involving concepts of Digital Control for Automation
- Simulate different types of Digital Filters
- Perform the stability analysis of a system

- Design and simulate controllers using different techniques studied in theory paper
- Prepare the technical report on the experiments carried

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Simulate the step response of a sampled-data (digital) control system
2. Stability analysis of a system using bode plot, root locus, and pole-zero gain representation
3. To obtain closed loop step and impulse response of a first order unity feedback system
4. Simulate a PD, PI and PID control design with a discrete-time controller. Compare the steady state response.
5. Simulate a frequency-domain controller to transform a continuous-time control design to a discrete-time control design
6. Design and simulate a Frequency-response controller or a State-feedback controller
7. Design of lead-lag compensator

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. Katsuhiko Ogata, "Discrete-Time Control Systems", 2nd Edition, Pearson, 1995, ISBN 9780130342812 (International), 9789332549661 (India).
2. M. Gopal, "Digital Control and State Variable Methods", 4th Edition, McGraw Hill Education, 2022, ISBN 9780071333276.
3. Benjamin C. Kuo, "Digital Control Systems", 2nd, Oxford University Press /Saunders College Publishing, 1995, ISBN 9780195104377/ 9780132111720.

Suggestive readings

1. C. Phillips, H. Nagle, A. Chakrabortty, "Digital Control System Analysis & Design", Pearson
2. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison Wesley, Pearson

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

ANNEXURE-2

Structure of B.Sc. (Hons) Instrumentation

6.1 Credit and Paper Distribution for B.Sc. (Hons) Instrumentation

Papers	Semester	Credits (L-T-P)	Name of the Paper	Papers	Semester	Credits (L-T-P)	Name of the Paper
FIRST YEAR							
DSC-1	I	3-0-1	Analog Electronics (INDSC1A)	DSC-4	II	3-0-1	Fundamentals of Digital circuits (INDSC2A)
DSC-2	I	3-0-1	Basic circuit theory (INDSC1B)	DSC-5	II	2-0-2	Sensors and Actuators (INDSC2B)
DSC-3	I	2-0-2	Testing and Measurement (INDSC1C)	DSC-6	II	3-0-1	Electronic Instrumentation (INDSC2C)
GE-1	I	4 credits	Choose one from pool of GE courses	GE-2	II	4 credits	Choose one from pool of GE courses
AEC-1	I	2 credits	Choose one from pool of AEC courses	AEC-2	II	2 credits	Choose one from pool of AEC courses
VAC-1	I	2 credits	Choose one from pool of VAC courses	VAC-2	II	2 credits	Choose one from pool of VAC courses
SEC-1 **One paper is to be selected out of the given two options**				SEC-2 **One paper is to be selected out of the given two options**			
SEC-1	I	0-0-2	Programming using Python (INSEC1A)	SEC-2	II	0-0-2	Applied Cryptography (INSEC2A)
SEC-1	I	0-0-2	Quantum computation (INSEC1B)	SEC-2	II	0-0-2	Big data Analytics (INSEC2B)
Semester I – Total Credits- 22				**Semester II – Total Credits- 22**			
Students on exit shall be awarded Undergraduate Certificate in Instrumentation after securing the requisite 44 credits in Semesters I and II							
SECOND YEAR							
DSC-7	III	2-0-2	Analytical Instrumentation-I (INDSC3A)	DSC - 10	IV	3-0-1	Biomedical Instrumentation (INDSC4A)
DSC-8	III	3-0-1	Operational Amplifiers and Applications (INDSC3B)	DSC - 11	IV	2-0-2	Machine Learning (INDSC4B)
DSC-9	III	3-0-1	Mathematical techniques for Instrumentation (INDSC3C)	DSC - 12	IV	3-0-1	Optical Instrumentation (INDSC4C)
AEC-3	III	2 credits	Choose one from pool of AEC courses	AEC-4	IV	2 credits	Choose one from pool of AEC courses
VAC-3	III	2 credits	Choose one from pool of VAC courses	VAC-4	IV	2 credits	Choose one from pool of VAC courses
DSE-1 One paper is to be selected out of the given three options OR GE-3				**DSE-2 One paper is to be selected out of the given three options OR GE-4**			
DSE-1	III	3-0-1	Signals and Systems (INDSE3A)	DSE-2	IV	3-0-1	Linear Integrated Circuits (INDSE4A)
DSE-1	III	2-0-2	VHDL Programming (INDSE3B)	DSE-2	IV	3-0-1	Statistical Tools and Techniques (INDSE4B)
DSE-1	III	2-0-2	Programming Using MATLAB (INDSE3C)	DSE-2	IV	2-0-2	Virtual Instrumentation (INDSE4C)
SEC-3 **One paper is to be selected out of the given two options**				SEC-4 **One paper is to be selected out of the given two options**			
SEC-3	III	0-0-2	Simulation tools & techniques(INSEC3A)	SEC-4	IV	0-0-2	PCB designing(INSEC4A)
SEC-3	III	0-0-2	Testing & Calibration(INSEC3B)	SEC-4	IV	0-0-2	PLC & SCADA(INSEC4B)