BSc. (H) Instrumentation
Category-I

DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1) –: Analog Electronics (INDSC1A)

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		
Analog Electronics (INDSC1A)	04	03	-	01	Course Admission Eligibility	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To impart in-depth knowledge of semiconductor devices & circuits focusing on many aspects of design & analysis
- To design various biasing configurations for transistor circuits
- To provide knowledge of amplifiers and their design
- To introduce the concept of feedback for designing oscillators

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the working of the diode circuits
- Analyze analog circuits and their applications using active devices
- Understand the design of feedback circuits and use them in amplifiers and Oscillators
- Explain the operation of various oscillator circuits

SYLLABUS OF DSC-1

UNIT – I **(12 Hours)**

Diode and its application: Introduction to semiconductor materials, intrinsic & extrinsic semiconductors. PN junction diode: Depletion region, Junction capacitance, Construction, and Working, Diode equation, Effect of temperature on reverse saturation current, Ideal diode. Diode applications: clipper circuits, clamping circuits, Half wave rectifier, center-tapped, and bridge full-wave rectifiers, calculation of efficiency and ripple factor. DC power supply: Block diagram of regulated power supply, Zener diode as a voltage regulator.

UNIT – II **(12 Hours)**

Bipolar Junction Transistor (BJT): NPN and PNP transistors, current components in BJT, Transistor amplifying action, Input and Output characteristics of BJT for CE, CB, CC

configurations (cut-off, active, and saturation regions), CE configuration as a two- port network: h-parameters, h- parameter equivalent circuit.

UNIT – III **(12 Hours)**

BJT Biasing: Fixed bias, collector to base bias, emitter bias, and voltage divider bias circuits.
CE amplifier and frequency response: dc and ac load line analysis, Hybrid equivalent of CE, the frequency response of CE amplifier.
Introduction to Power Amplifiers: Class A, Class B, Class AB, and Class C

UNIT – IV **(9 Hours)**

Feedback Amplifiers and Oscillators: Concept of feedback, negative and positive feedback, Negative feedback: advantages and disadvantages of negative feedback, voltage (series and shunt), current (series and shunt) feedback amplifiers, derivation of gain, input and output impedances for feedback amplifiers. Oscillators: Barkhausen criteria for sustained oscillations, Study of phase shift oscillator, Colpitt's oscillator, and Crystal oscillator.

Practical component- **(30 Hours)**

1. To study I-V characteristics of PN junction and Zener diodes in forward and reverse bias configurations.
2. To study clipping and clamping circuits.
3. To study the Half wave rectifier and full-wave rectifier.
4. To design the power supply with capacitor filter
5. To study input and output I-V characteristics of common base and common emitter transistor configurations.
6. To study Fixed Bias and Voltage divider bias configurations of BJT.
7. To design a Single Stage CE amplifier for a given gain.
8. To study the frequency response of a single stage CE Amplifier
9. To study the Colpitt's Oscillator.
10. To study the Phase Shift Oscillator.
11. To study Class A, Class B and Class AB power amplifier

Essential/recommended readings

1. R. L. Boylestad, L. Nashelsky, K. L. Kishore, Electronic Devices and Circuit Theory, Pearson Education (2006).
2. N Bhargava, D C Kulshreshtha and S C Gupta, Basic Electronics and linear circuits, Tata Mc Graw Hill (2007).
3. J. Millman and C. Halkias, Integrated Electronics, Tata McGraw Hill (2001).
4. David A. Bell, Electronic Devices & Circuits, Oxford University Press, Fifth edition.
5. Mottershed, Electronic Devices, PHI Publication, 1stEdition.
6. D. L. Schilling and C. Belove, Electronic Circuits: Discrete and Integrated, Tata McGraw Hill(2002).

Suggestive readings:

1. J. R. C. Jaegar and T. N. Blalock, Microelectronic Circuit Design, Tata McGraw Hill(2010).
2. Donald A. Neamen, Electronic Circuit Analysis and Design, Tata McGraw Hill(2002).

3. J.Cathey, 2000 Solved Problems in Electronics, Schaum"s outline Series, Tata Mc Graw Hill (1991).

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

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-2): Basic Circuit theory (INDSC1B)

Credit distribution, Eligibility and Prerequisites 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		
Basic Circuit theory (INDSC1B)	04	03	-	01	Course Admission Eligibility	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop an understanding of the fundamental laws and elements of electric circuits.
- To learn the energy properties of electric elements and techniques to measure current and voltage.
- To develop the ability to apply circuit analysis to AC and DC circuits.
- To understand signals, waveforms and transient & steady state responses of RLC circuits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the current-voltage characteristics of basic fundamental elements
- Design and analyze the electronic circuits using various network theorems
- Understand frequency response and behavior of ac circuits
- Understand the concept of two port network and overall response for interconnection of two port networks

SYLLABUS OF DSC- 2

UNIT – I **(12 Hours)**

Basic Circuit Concepts: Voltage and Current Sources including their types, Resistors: types and color coding, Capacitor: types and color coding, Inductor: types and color coding, star-delta conversion & delta-star conversion. Sinusoidal voltage and current: Definition of instantaneous, peak to peak, average and rms value.

UNIT – II **(12 Hours)**

Concepts of Circuit Analysis: Ohms Law, Kirchhoff's Current Law (KCL), Kirchhoff's
Concepts of Circuit Analysis: Ohms Law, Kirchhoff's Current Law (KCL), Kirchhoff's
Voltage Law (KVL), Node Analysis, Mesh Analysis.
Network Theorem (DC Circuits): Principal of Duality, Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Reciprocity Theorem, Millman's Theorem, Maximum Power Transfer Theorem. Voltage Law (KVL), Node Analysis, Mesh Analysis.
Network Theorem (DC Circuits): Principal of Duality, Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Reciprocity Theorem, Millman's Theorem, Maximum Power Transfer Theorem.

UNIT – III **(12 Hours)**

DC Transient Analysis: Time Constant, Response of RC, RL and RLC circuit to dc source(s), Response of source free RC, RL and RLC circuit.
AC Circuit Analysis: Voltage-Current relationship in Resistor, Inductor and Capacitor, Phasor, Complex Impedance. Mesh Analysis, Node Analysis and Network Theorems for AC Circuits. Frequency Response of Series and Parallel RLC Circuits, Resonance, Quality (Q) Factor and Bandwidth. Fundamentals of passive Filters: Low Pass, High Pass, Band Pass and Band Stop.

UNIT – IV **(9 Hours)**

Power in AC Circuits: Instantaneous Power, Average Power, Reactive Power, Complex Power and Power Triangle, Power Factor.
Two Port Networks: Introduction to two port networks, Impedance (Z) Parameters, Admittance (Y) Parameters, hybrid (h) parameters and Transmission (ABCD) Parameters.

Practical component- **(30 Hours)**

1. Verification of Kirchoff's Law.
2. Verification of Norton's Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Reciprocity Theorem.
5. Verification of Superposition Theorem.
6. Verification of the Maximum Power Transfer Theorem.
7. Designing of RC Integrator circuit.
8. Designing of RC differentiator circuit.
9. Designing of a RC Low Pass Filter and study of its Frequency Response.
10. Designing of a RC High Pass Filter and study of its Frequency Response.

Essential/recommended readings

1. S. A. Nasar, Electric Circuits, Schaum"s outline series, Tata McGraw Hill (2004).
2. Electrical Circuits, M. Nahvi and J. Edminister, Schaum"s Outline Series, Tata McGraw-Hill (2005).
3. Robert L. Boylestad, Essentials of Circuit Analysis, Pearson Education (2004).

Suggestive readings: Nil

1. W. H. Hayt, J. E. Kemmerly, S. M. Durbin, Engineering Circuit Analysis, Tata McGraw Hill (2005).
2. Alexander and M. Sadiku, Fundamentals of Electric Circuits, McGraw Hill (2008).

DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC-3): Testing and Measurement (INDSC1C)

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		
Testing and Measurement (INDSC1C)	04	02	-	02	Course Admission Eligibility	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To describe the units of measure and the various instruments used in various measurement parameters.
- To teach the various methods in power measurement.
- To make them understand about the error in measurement systems.
- To explain the various components of a testing and calibration system.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the basic concept of measurements and calibration
- Perform error measurement concepts correctly and present final values with the correct units/symbols
- Analyze various standardization techniques in Production Plants
- Familiarize with various testing and calibration procedures in measurement

SYLLABUS OF DSC-3

UNIT – I **(12 Hours)**

Introduction to Measurement System, Significance of Measurement, Methods of measurement, Elements of a generalized measurement system.

Performance characteristics of measurement system: Static Characteristics -Accuracy, Sensitivity, Linearity, Precision, Resolution, Threshold, Range, Hysteresis, Dead Band, Backlash, Drift, Impedance Matching and Loading.

Dynamic Characteristics- Types, Fidelity, Speed of Response, Dynamic Error.

UNIT – II **(12 Hours)**

Measuring Instruments: Introduction to Voltmeters, Ammeters, Ohmmeters, Digital Multimeters, Clamp Meter, Lux meter, Flux Meter, Tester, Function Generator, Bolometer, B-Dot and D-Dot Sensors.

Errors in measurement systems:

Definition of Errors: Systematic Errors, Instrumental Errors, Environmental Errors, Randoin Errors, Loading Errors, Limiting Errors. Source of Errors in Measuring Instruments.

UNIT – III **(9 Hours)**

Introduction to Testing, Fault, Types of Faults, Methods used for localizing faults, Methods used for ground and short circuit faults, Murray loop test, Varley loop test, location of open circuit faults in cable, types of Probes and Connectors.

UNIT – IV **(12 Hours)**

Standardization and Calibration Modelling: Standardization in Production Plants and manufacturing houses, Reliability studies and inspection, Product Standardization techniques, Calibration: Calibration of measuring instruments, Theory and Principles (absolute and secondary or comparison method), Setup, Modelling.

Various Testing and Calibration Systems: Sensor calibration and testing, Analytical methods in calibrating, Automated test and calibration systems.

Practical component - **(30 Hours)**

1. Testing of Active and Passive Components.
2. Testing of all basic components.
3. Calculation and verification of Resistance.
4. Calculation and verification of Voltage and Current.
5. Testing of Faulty equipment.
6. Fault diagnosis of Lab. Instruments.
7. Measurement of Temperature.
8. Measurement of Pressure.
9. Measurement of Power.
10. Measurement of Energy using Energy meter.
11. Study of Electrical and Mechanical parameters standards used in testing and calibration.
12. Calibration of Instruments.
13. Testing of Electrical Components.
14. Testing of Various Instruments.
15. Murray Loop test
16. Varley loop test
17. B-Dot sensor, D-Dot sensor
18. Study of Lux meter
19. Study of Flux meter
20. Study of Multimeter

Essential/recommended readings

1. Electrical measurement and measuring Instruments by Golding and Widdis.
2. Electrical and Electronic measurements and Instruments By A.K.Sawhney.

Suggestive readings

1. Electrical measurements and Measuring instruments By Rajendra Prasad.

GENERIC ELECTIVES (GE-1): Fundamentals of Instrumentation (INGE1A)

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	Department offering the course
		Lecture	Tutorial	Practical / Practice			
Fundamentals of Instruments (INGE1A)	**04**	**03**	**-**	**01**	**Class XII pass**	**Physics and Mathematics in 10+2**	**Instrumentation**

Learning Objectives

The Learning Objectives of this course are as follows:

- To learn about basic concepts of Instrumentation.
- To understand the basic concept of errors and study different types of errors present in measurement systems.
- To study different characteristics of measurement systems.
- To study different types of transducers – resistive, capacitive and inductive
- To study signal conditioning.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the basics of concepts of Instrumentation and measurement systems
- Identify and comprehend various sensors used in the real-life applications and paraphrase their importance
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, and light
- Be conversant in construction and working of signal conditioning circuits

SYLLABUS OF GE-1

UNIT – I **(12 Hours)**

Basic concepts of Instrumentation: Generalized instrumentation systems block diagram representation, Error in measurement- Gross Errors, Systematic Errors and Random Errors. Statistical analysis of error in measurement-Arithmetic mean, Deviation, standard deviation

UNIT – II **(9 Hours)**

Measurement systems: static characteristics (accuracy, sensitivity, linearity, precision, resolution, threshold, range, hysteresis, dead band, backlash, drift), dynamic characteristics (types, fidelity, speed of response, dynamic error)

UNIT – III **(12 Hours)**

Transducers: Classification, Active and Passive. Principle and working of following types: Resistive (Strain Gauge) Capacitive, Inductive (LVDT), Piezoelectric, Light (LDR),

Temperature (RTD, Thermocouple, Thermistor)

UNIT – IV **(12 Hours)**

Signal Conditioning: Introduction to Op-Amp, Basic Instrumentation Amplifier, Application of Instrumentation Amplifiers

Practical component- 30 Hours

1. Measurement of strain using strain gauge/load cells.
2. Measuring change in resistance using LDR
3. Measurement of displacement using LVDT.
4. Measurement using capacitive transducer.
5. Measurement of Temperature using Temperature Sensors.
6. Design and study basic circuit of Op-Amp.

Essential/recommended readings

1. Doeblin&Manek, Measurement Systems, McGraw Hill, New York, 1992, 5th edition.
2. Nakra& Choudhary, Instrumentation Measurements and Analysis, Tata McGraw-Hill, 2nd edition.
3. A.K. Sawhney, Electrical & Electronic Measurements & Instrumentation, 19th revised edition.
4. Rangan, Sarma, and Mani, Instrumentation- Devices and Systems, Tata-McGraw Hill, 2nd edition.
5. H.S Kalsi, Electronic Instrumentation, McGraw Hill, 4th edition.
6. DVS Murthy, Measurement & Instrumentation, PHI, 2nd edition.

Suggestive readings:

1. D. Patranabis, Sensors and Transducers, PHI, 2nd edition.
2. A Course in Electrical and Electronic Measurements and Instrumentation, (2005), A.K. Sawhney, DhanpatRai& Co.
3. Mechanical and Industrial Measurements, 3rd Edition, Tenth Edition (1996), R.K. Jain, Khanna Publishers.

GENERIC ELECTIVES (GE-2): Engineering Physics (INGE1B)

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	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Engineering Physics (INGE1B)	04	03	-	01	Class XII pass with Mathematics	Mathematics in 10+2	Instrumentation

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop an intuitive understanding of semiconductor physics
- To provide the students a thorough understanding of the fundamentals of optics
- To introduce fundamental aspects of photonics

Learning outcomes

The Learning Outcomes of this course are as follows:

- Gain in-depth knowledge about basic concepts of semiconductor physics
- Understand the physics behind various phenomena in optics
- Understand the photonics

SYLLABUS OF GE-2

UNIT – I **(12 Hours)**

Semiconductor physics: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, the temperature dependence of carrier concentration, Compensation, and charge neutrality. Conductivity and mobility, Effect of temperature, Doping, and high electric field.

UNIT – II **(12 Hours)**

Interference: Interference of light, Fringe formation, interference in thin films, wedge-shaped film, Newton's rings, Michelson interferometer.

Diffraction - Single, Double & N- Slit, Diffraction grating, grating spectra, Rayleigh's criterion, and resolving power of grating.

UNIT – III **(12 Hours)**

Polarization: Phenomena of double refraction, Nicol prism, Production and analysis of plane, circular and elliptical polarized light, Fresnel's theory of optical activity, Polarimeters.

Laser: Basic principle, Spontaneous and stimulated emission of radiation, Einstein's Coefficients, Laser applications.

UNIT – IV **(3 Weeks)**

Photonics: Light Emitting Diodes, Construction, materials, and operation, Photodetectors: Photomultiplier tube. Phototransistors and Photodiodes (p-i-n, avalanche).

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Fiber optics: Principles and applications

Practical component-

1. To determine the type (n or p) and mobility of semiconductor material using Hall-effect
2. To determine the refractive index of a prism using a spectrometer

3. To determine the dispersive power of prism using spectrometer and mercury source.
4. To determine the wavelength of sodium light by Newton's Ring.
5. To determine the wavelength of sodium light using Michelson's Interferometer.
6. To determine the resolving power of diffraction grating
7. To determine the specific rotation of cane sugar using a polarimeter.
8. To find the wavelength of He-Ne Laser using a transmission diffraction grating.
9. To determine characteristics of LEDs and Photodetector.
10. To measure the numerical aperture of an optical fibre.

Essential/recommended readings

1. B. G. Streetman and S. Banerjee "Solid-state electronics devices", 5th Edition, PHI.
2. Donald A Neaman, "Semiconductor Physics and Devices Basic Principles" 3rd Ed TMH India.
3. Alok Dutta, "Semiconductor Devices and circuits", Oxford University Press.
4. Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education (2006)
5. AjoyGhatak –Optics, Fourth Edition, McGraw-Hill (2008).

Suggestive readings

1. Arthur Beiser -Concepts of Modern Physics, 6th Edition, Mc-Graw Hill.
2. S. O. Kasap, Optoelectronics, and Photonics: Principles and Practices, Pearson Education (2009)
3. Ghatak A.K. and Thyagarajan K., Introduction to fiber optics, Cambridge Univ. Press. (1998)

REGISTRAR

Category I

BSc. (Hons.) Instrumentation

DISCIPLINE SPECIFIC CORE COURSE -4 (DSC-4) – : Fundamentals of Digital Circuits

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		
Fundamentals of Digital Circuits	4	3	0	1	Class XII pass with Science	Nil

Learning Objectives

- To impart the knowledge of Number systems and codes.
- To familiarize with concepts of Boolean algebra, logic gates.
- To minimise and design various combinational logic circuits.
- To develop the basic understanding of flip flops and use them to design sequential circuits.
- To differentiate between various digital logic families.

Learning outcomes

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

Learn various number systems, binary codes and concepts of Boolean algebra.
Apply the knowledge of Boolean algebra to solve real time problems and determine how to interconnect logic gates to convert the circuit input signals to desired output signals.
Analyse the combinational and sequential circuits using flip flops and show how they can be used for designing various types of digital circuits used for processing and transmission of data.
Compare various digital logic families with respect to their speed, power consumption and cost

SYLLABUS OF DSC-4

Unit-1 **(09 Hours)**

Number System and Codes: Decimal, Binary, Hexadecimal and Octal number systems,

base conversions, Binary, octal and hexadecimal arithmetic (addition, subtraction by complement method, multiplication), representation of signed and unsigned numbers, Binary Coded Decimal code, gray code, excess-3 code.

Unit-2 **(12 Hours)**

Boolean algebra and Logic Gates: Introduction to Boolean Algebra and Boolean operators, Basic postulates and fundamental theorems of Boolean algebra, construction, and symbolic representation of OR, AND, NOT, XOR, XNOR Gate, Truth Tables, Universal (NOR and NAND) gates.

Digital Logic families: Fan-in, Fan out, Noise Margin, Power Dissipation, Figure of merit, Speed power product, TTL and CMOS families and their comparison.

Unit-3 **(12 Hours)**

Combinational Logic Analysis and Design: Standard representation of logic functions (SOP and POS), Karnaugh map minimization, Encoder and Decoder, Multiplexers and Demultiplexers, Implementing logic functions with multiplexer, binary Adder, binary subtractor, parallel adder/subtractor.

Unit-4 **(12 Hours)**

Sequential logic design: Latches and Flip-flops, S-R Flip flop, J-K Flip flop, T and D type Flip flop, Clocked and edge triggered Flip flops, master slave Flip flop, Registers, Counters (synchronous and asynchronous and modulo-N), State Table, State Diagrams, counter design using excitation table and equations, Ring counter and Johnson counter.

Programmable Logic Devices: Basic concepts- ROM, PLA, PAL, CPLD, FPGA

Practical component (if any) – Fundamentals of Digital Circuits Lab – 30 Hours

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.
2. To convert a Boolean expression into logic gate circuit and assemble it using logic gate ICs.
3. Design a Half and Full Adder.
4. Design a Half and Full Subtractor.
5. Design a Seven Segment display driver.
6. Design a 4 X 1 Multiplexer using gates.
7. Design a 2 X 4 Decoder using gates.
8. To build a Flip- Flop Circuits using elementary gates. (RS, Clocked RS, D-type).
9. Design a counter using D/T/JK Flip-Flop.
10. Design a shift register and study Serial and parallel shifting of data.

Essential/recommended readings

1. M. Morris Mano, Digital Logic & Computer Design, Pearson Education Asia (2016)

2. Thomas L. Flyod, Digital Fundamentals, Pearson Education Limited, 11th Edition, Global Edition (2015)
3. Kumar A. Anand, Fundamentals of Digital Circuits, 3rd Edition (2014), PHI Learning Private Ltd.
4. R. J. Tocci, Neal.SWindmer, Gregory L Moss, Digital Systems, Principles and Applications, 10th Edition, Pearson (2009)

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.

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

DISCIPLINE SPECIFIC CORE COURSE – 5 (DSC-5): Sensors and Actuators

Credit distribution, Eligibility and Prerequisites 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		
Sensors and Actuators	4	2	0	2	Class XII pass with Science	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To study different types of transducers – resistive, capacitive, inductive, light and temperature
- Be conversant in construction and working of various pressure and flow measuring instruments
- Get an exposure to actuators, micro actuators, and their different types

Learning outcomes

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

Identify and comprehend various sensors used in the real-life applications and paraphrase their importance

Classify and explain with examples of transducers, including those for measurement of temperature, strain, light, capacitance and inductance

Be conversant in construction and working of various pressure and flow measurement devices used for industrial purposes

Classify and explain the different types of actuators
To study various processing techniques of micro actuators

SYLLABUS

Unit 1 **(7 Hours)**

Classification of transducers: Active, Passive, Mechanical, Electrical and their comparison. Selection of Transducers, Principle and working of following types: Resistive (Strain Gauge), Capacitive, Inductive (LVDT), Piezoelectric, light (photo-conductive, photovoltaic, LDR), Temperature (RTD, Thermocouple, Thermistor)

Unit 2 **(7 Hours)**

Sensors in nature (Vision, Hearing, touch, and smell) and how we can learn from nature. Principles of Sensing, Classification and Terminology of Sensors, Measurands. Some basic discussion about electric field, potential, capacitance, resistance etc. Biomedical sensor, Mechanical Sensors, Acoustic sensors, Magnetic Sensors, Radiation detector (Gas-filled & Scintillation detectors), Chemical and Biosensors, Proximity sensor, Flow Sensor, Level Sensor.

Unit 3 **(8 Hours)**

Actuators: Definition, types and selection of Actuators; linear; rotary; Electrical actuators: Electric motors, DC servomotors, AC motors, Stepper motors, Solenoids, Hydraulic actuators - Control valves, Construction, Characteristics and Types - Directional Control valves, Pressure control valves, proportional control valves and Process control valves.

Unit 4 **(8 Hours)**

Micro Actuators: Actuation principle, Types of micro actuators- Electrostatic, Magnetic and Fluidic, Inverse piezo effect. Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials. Processing techniques: Vacuum deposition, sputtering, chemical vapor deposition and photolithography.

Practical component (if any) - Sensors and Actuators Lab – 60 Hours

1. Measurement of strain using strain gauge/load cells.
2. Measuring change in resistance using LDR
3. Measurement of displacement using LVDT.
4. Measurement using capacitive transducer.
5. Measurement of Temperature using Temperature Sensors.
6. Measurement of flow rate using electromagnetic flow meter.
7. Measurement of flow rate measurement using orifice plate flow meter.
8. System identification of any one of the actuators

(a) Electrical Actuator
(b) Electromechanical Actuator
(c) Electromagnetic Actuator
(d) Hydraulic and Pneumatic Actuator

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. Nakra& Choudhary, Instrumentation Measurements and Analysis, Tata McGraw-Hill, 2nd edition.
2. A.K. Sawhney, Electrical & Electronic Measurements & Instrumentation, 19th revised edition.
3. H.S Kalsi, Electronic Instrumentation, McGraw Hill, 4th edition.
4. DVS Murthy, Measurement & Instrumentation, PHI, 2nd edition.
5. D. Patranabis, Sensors and Transducers, PHI, 2nd edition.
6. A Course in Electrical and Electronic Measurements and Instrumentation, (2005), A.K. Sawhney, Dhanpat Rai& Co.
7. Mechanical and Industrial Measurements, 3rd Edition, Tenth Edition (1996), R.K. Jain, Khanna Publishers.
8. Andrzej M. Pawlak, "Sensors and Actuators in Mechatronics, Design and Applications", Taylor & Francis Group, 2006.
9. Andrew Parr, "Hydraulics and Pneumatics", Jaico Publishing House, Mumbai
10. Robert H. Bishop, "Mechatronic systems, Sensors and Actuators Fundamentals and Modeling, Taylor & Francis Group, 2007.

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

DISCIPLINE SPECIFIC CORE COURSE– 6 (DSC-6): Electronic Instrumentation

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		
Electronic Instrumentation INDSC2C	4	3	0	1	Class XII pass with Science	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To study different AC and DC measurement instruments used in laboratory like ohmmeter, voltmeter, ammeter and multimeter
- To learn about different measuring instruments–Universal counter, Cathode Ray Oscilloscope and Signal Generator
- To study about different spectrum analyzers and learn about basic concept of wave analyzers

Learning outcomes

The Learning Outcomes of this course are as follows:

Designing of different AC and DC bridges and their applications
Construction of different measuring devices-Ammeter, Voltmeter, Ohmmeter and Digital Frequency Meter
Develop an understanding of construction and working of different measuring instruments-Signal Generators and CRO for appropriate measurement
Understand the concepts of Spectrum Analyzer and Wave analyzers

SYLLABUS OF DSC-6

Unit-1 **(12 Hours)**

DC and AC Bridges based measurements: Wheatstone bridge, Kelvin bridge, General form of AC bridge balance, comparison bridges, Maxwell's bridge, Hay bridge, Schering bridge, Wien bridge, Wagner ground connection

DC and AC indicating instruments: DC voltmeter, ammeter, ohmmeters, multimeter,

AC voltmeter, Digital type voltmeters

Unit-2 **(12 Hours)**

Digital frequency meter: Elements of frequency meter, Universal counter and its different measurement modes, measurement errors and frequency range extension

Signal Generators: Types of generators and their operation: Audio oscillator, Function generators, Pulse generators, RF generators, Random noise generator, Sweep generator

Unit-3 **(12 Hours)**

Electronic Displays: Block diagram of a General-Purpose Cathode Ray Oscilloscope and its basic operation, electrostatic focusing and deflection, screens for CRT and graticules, CRT Connections

Types of CROs and measurement of frequency and phase: Dual trace oscilloscope, Digital storage oscilloscope (DSO), Sampling oscilloscope, Lissajous figures

Unit-4 **(09 Hours)**

Spectrum and Wave Analyzers: Spectrum analyzer, Harmonic distortion analyzer, Wave analyzer **Q- Measurement:** Q-meter connections for low and high impedance measurements and errors

Practical component (if any) - Electronic Instrumentation Lab – 30 Hours

1. Study and operation of Multimeters (Analog and Digital), Function Generator, Regulated Power Supplies, CRO
2. Study the generation of Lissajous figures to find unknown frequency and phase shift
3. Measurements of Resistance Using Wheatstone/Kelvin Bridge
4. Measurements of Inductance Using Maxwell's Bridge/Inductance Comparison Bridge
5. Measurements of capacitance Using Capacitance Comparison Bridge/De Sauty's Bridge
6. Frequency measurement using Wein's Bridge
7. Study of R, L, C and Q meter
8. Study of Universal Counter
9. To study Loop tests for ground faults
10. To generate different signal waveforms

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 seven.

Essential/recommended readings

1. H.S. Kalsi, Electronic Instrumentation and Measurements, Tata McGraw Hill (2019), 4th edition.

2. Joseph J Carr, Elements of electronic instrumentation and measurement, Pearson Education
3. (2005).
4. C.S. Rangan, G.R. Sarma and V.S. Mani, Instrumentation Devices and Systems, Tata McGraw Hill(1998).
5. H. Cooper, Modern electronic instrumentation and measurement techniques, Pearson Education (2015).
6. R.A. Witte, Electronic test instruments: Analog and digital measurements, Tata Mc Graw Hill (2004).
7. S. Wolf and R.F.M. Smith, Student Reference Manual for Electronic Instrumentation Laboratories, Pearson Education (2004).
8. David A. Bell, Electronic Instrumentation and Measurements, Prentice Hall of India, 2nd edition
9. U.A. Bakshi and A.V. Bakshi, Electronic Measurements and Instrumentation, Technical Publications

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

Pool of Generic Electives (GE) offered by Department of Electronic Sciences in Instrumentation

Category-IV

GENERIC ELECTIVES (GE-2A): **MATLAB and its Applications**

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	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MATLAB and its Applications	4	2	0	2	None	None	Electronic Science

Learning Objectives

- To learn to interact and perform the computations on MATLAB
- To plot the functions using various types of plot command
- To understand the difference between the functions & Scripts in MATLAB
- To familiarize with the fundamentals of digital image and signal processing

Learning outcomes

After completion of the course, students will be able to-

Interact with MATLAB for various computations
Generate plots and its use in reports
Familiar with inbuilt MATLAB functions and will be able to create user defined Functions and write scripts for various applications
Understands fundamental of digital image and signal processing

SYLLABUS

Unit-1 **(06 Hours)**

Introduction to MATLAB: MATLAB features, MATLAB Windows, defining variables, formatting output, types of operators, different operations on variables, checking existence, clear
Operations, data type, precedence.

Unit-2 **(08 Hours)**

Introduction to Arrays: Defining scalars, vectors, matrix, multi-dimensional arrays, different Operations (mathematical, logical, and relational) on array, reshaping matrices, importing & exporting of data.

Character and Strings: Defining character and string, accessing character or substring from string, string concatenation and comparing, conversion between strings and number. Defining and working with cell arrays.

Data Plotting: Graph, plot, types of plot, multiple plots, labeling graph, line colors, style and Marker.

Unit-3 **(08 Hours)**

Script and Function M File: M-file, writing script files, writing functions, error correction, saving files. Flow control statement: Conditional or selection, error handling, loop control, program termination.

Unit-4 **(08 Hours)**

Signal Processing: Generation of continuous time & discrete time signal, time shift, time scaling, amplitude scaling of signal. Generation of amplitude modulated signal, frequency modulated signal Image processing: Study of basic tools of Image Processing, Image segmentation, restoration, histogram processing, changing color of image.

Practical component (if any) - MATLAB and its Applications Lab- 60 Hours

1. Define variables, create a matrix of any size with all possible methods and perform various mathematical operations.
2. Create a multidimensional array and delete any Row/Column from it and create a new array.
3. Plot and label all the trigonometric functions using the subplot command.
4. Generate various kinds of continuous and discrete time signals. Plot them with different color, line style and markers and label the graph.
5. Generate various kinds of continuous and discrete time signals. Perform time scaling, time shifting and amplitude scaling on them.
6. Generate the (i) square wave and (ii) triangular wave of a specific amplitude and time period and plot it on a single graph.
7. Define a string and count the number of vowels, spaces and consonants in it. Also mention the size and length of the string.
8. Write a script to remove (i) all the alphabets from the alphanumeric string, (ii) all the spaces from a string.

9. Create a function which compares any two strings of equal length and return 'M' for matched character and 'U' for unmatched Character. Also display the number of characters matched.
10. Generate the (i) AP, (ii) GP and (iii) Fibonacci series.
11. Write a script to test whether a user defined no. is Prime or not.
12. Write a script which can evaluate the percentage (%) and grade of the student when subject marks are entered by the user.
13. Write a script to generate the amplitude and frequency modulated signal.
14. Create a function to change the colors of user defined images.

Essential/recommended readings

1. Khanna, M., Bhatt, G. and Kumar, P., MATLAB Essentials for Problem Solving, PHI Learning, New Delhi.
2. Mathews, J.H. and K.D. Fink, Numerical Methods Using MATLAB - Third Edition, Prentice Hall, Upper Saddle River, New Jersey.
3. Linfield, G. & Penny, J., Numerical methods using MATLAB, Ellis- Horwood.
4. Van Loan, C.F., Introduction to Scientific Computing - A Matrix-Vector Approach Using MATLAB, Prentice Hall, Upper Saddle River, New Jersey.
5. Nakamura, S., Numerical Analysis and Graphic Visualization with MATLAB - Second Edition, Prentice Hall PTR, Upper Saddle River, New Jersey

GENERIC ELECTIVES (GE-2B): **Sensors and its Applications**

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
		Lecture	Tutorial	Practical/ Practice		
Sensors and its Applications	**4**	**3**	**0**	**1**	**Class XII pass with Science**	**Nil**

Learning Objectives

- To understand the operation of commonly used sensors and actuators.
- To be able to analyze and select most appropriate sensors or actuators for an application.
- To analyze characteristics of sensors and actuators by knowing their basic laws and processes.

Learning outcomes

After completion of the course, students will be able to-

Identify and comprehend various sensors used in the real-life applications and paraphrase their importance.

Classify and explain with examples the utilization of sensors for measurement of temperature, strain, motion, position and light in the industry.

Understand the role of sensors and actuators to make sensitive measurements of physical parameters like pressure, flow, acceleration, velocity etc.

SYLLABUS

Unit 1 **(12 Hours)**

Mechanical and Electromechanical sensor: Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, Applications of electromechanical sensor: Human motion monitoring, Human health monitoring, Speech recognition, Human-machine interface

Unit 2 **(12 Hours)**

Transducers: Classification, Active and Passive. Principle, working and applications of following types: Resistive (Strain Gauge): Theory, type, materials, design consideration, sensitivity, gauge factor, Capacitive, Inductive (LVDT), Piezoelectric, Light (LDR), Temperature (RTD, Thermocouple, Thermistor). Magneto strictive type, brief discussion with respect to material, construction and input output variable, Ferromagnetic plunger type.

Unit 3 **(12 Hours)**

Flow meters, mechanical type: theory of variable head type flow meters-orifice plate, venturi tube, flow nozzle, Positive displacement flow meters. Rota meter: thermal mass flow meter, Principle and constructional details of electromagnetic flow meter, different types of ultrasonic flow meters.

Unit 4 **(9 Hours)**

Tachometers: Mechanical, Electric, Contact less, Frequency, Stroboscopic tachometers, Manometers: different types – elastic type pressure gauges, Bourdon type bellows, diaphragms.

Practical component (if any) - Sensors and its Applications Lab- 30 Hours

1. Measurement of pressure, strain and torque using strain gauge.
2. Measurement of displacement using LVDT.
3. Measurement using load cells.
4. Measurement using capacitive transducer.
5. Measurement using inductive transducer.
6. Measurement of temperature using Temperature Sensors.
7. Characteristics of Hall effect sensor.

8. Measuring change in resistance using LDR
9. Discharge coefficient of orifice plate.
10. Measurement of flow using E.M. flow meter.
11. Measurement of flow using Ultrasonic flow meter.

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 seven.

Essential/recommended readings

1. A.K Sawhney, A course in mechanical measurements and instrumentation, Dhanpat Rai& Co, 12th edition, 2001.
2. R.K. Jain, Mechanical and Industrial Measurements, Tata McGraw Hill, New Delhi, 1996, 11th edition.
3. A.K. Sawhney, Electrical & Electronic Measurements & Instrumentation, 19th revised edition, 2012
4. Nakra& Choudhary, Instrumentation measurements and analysis, Tata McGraw Hill, 2nd edition, Revised 2016-2017

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

DISCIPLINE SPECIFIC CORE COURSE – 7: Analytical Instrumentation I (INDSC3A)

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		
Analytical Instrumentation I (INDSC3A)	**04**	**02**	**0**	**02**	**Course admission eligibility**	**Basic knowledge of chemistry**

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with the classification of analytical methods
- To understand the fundamentals of qualitative and quantitative analysis concepts.
- To categorize and understand the principle behind various separation techniques (planar and columns) and their instrumentation.
- To understand the principle, instrumentation and applications of visible and ultraviolet molecular spectroscopy

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the classification of analytical methods
- Comprehend fundamentals of qualitative and quantitative analysis
- Differentiate between principle, instrumentation and operation of PaperChromatography and Thin layer chromatography
- Identify various Column Chromatographic techniques and their instrumentation
- Understand the concept of UV-Visible spectroscopy

SYLLABUS OF DSC-7

UNIT – I **(8 hours)**

Introduction to Analytical methods: Classification of Analytical Methods: Classical and Instrumental, Types of Instrumental Methods, Various sample extraction techniques. Instruments for analysis, Calibration of instrumental methods, Selecting an analytical method

UNIT – II **(7 hours)**

Chromatographic Separation methods: Planar Chromatographic methods: Principle and applications of Paper Chromatography, Thin layer chromatography (TLC) and High-Performance Thin Layer Chromatography (HPTLC).

UNIT – III **(8 hours)**

Column Chromatography: General Description of column chromatography, Classification of Chromatographic Methods, Elution in Column Chromatography, Migration rate of solutes, Band Broadening and column efficiency, Optimization of Column Performance.
Gel Permeation Chromatography (GPC): Principle, Instrumentation and Applications.

UNIT – IV **(7 hours)**

Molecular Spectro-analytical Methods of Analysis: Colorimetry and Spectrophotometry: Introduction, theory: molecular energy levels, types of molecular transitions, Lambert-Beer's Law and limitations, Instrumentation of single beam and double beam instrument.

Practical component: **(60 hours)**

1. Preparation of solutions and buffers.
2. Introduction to the use of Analytical Equipment (Analytical Balance, Volumetric Glassware, pH meter).
3. To extract the spinach pigments using liquid-liquid extraction.
4. Separation of plant pigments by paper chromatography.
5. Separation of food colours by paper chromatography.
6. Separation of pharmaceutical sample mixture using thin layer chromatography.
7. Separation of amino acids/sugar/carbohydrates by Thin Layer Chromatography.
8. Separation of cobalt chloride and Blue Dextran mixture by Gel Permeation Chromatography.
9. To study the effect of various solvents on membrane permeability of beetroot using visible spectroscopy
10. Determination of pKa value for a dye using visible spectroscopy.
11. Spectrometric determination of iron in water samples using double beam spectrophotometer.
12. To identify the given unknown colourless samples using UV spectrophotometer.

Essential/recommended readings

1. H.H. Willard, L.L Merrit, J.A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishers, 7th edition, 2004.
2. Skoog, Holler and Crouch, Principles of Instrumental Analysis, Cengage Learning, 7th edition, 2016.
3. James W. Robinson, Eileen Skelly Frame, George M. Frame II, Undergraduate Instrumental Analysis, CRC Press, 7th edition, 2014
4. Vogel's Textbook of Qualitative Chemical Analysis, ELBS, 6th edition 2009.

Suggestive readings

1. W. Kemp, Organic Spectroscopy, ELBS, 3rd Edition, 2019.
2. R.S Khandpur, Handbook of Analytical Instruments, Tata McGraw-Hill, 3rd Edition 2015.
3. B.K Sharma, Instrumental Methods of Chemical Analysis, Krishna Prakashan Media, 1st Edition, 2011

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

DISCIPLINE SPECIFIC CORE COURSE – 8: Operational Amplifiers and Applications (INDSC3B)

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		
Operational Amplifiers and Applications (INDSC3B)	04	03	0	01	Course admission eligibility	Basics of Analog Electronics- BJT circuits

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide understanding of DC and AC characteristics of operational amplifiers (op-amp)
- Design various filters and oscillators circuits using op-amps
- Study linear and non-linear applications of op-amp
- Design multivibrators and other circuits using op-amp.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the DC and AC characteristics of operational amplifiers (op-amp) and its effect on output, significance of op-amp parameters, and compensation techniques
- Elucidate and design circuits to study linear and non-linear applications of op-amps and special application ICs
- Explain the working of signal generators using op-amp
- Explain and compare the working of multivibrators using general purpose op-amp

SYLLABUS OF DSC- 8

UNIT – I **(11 hours)**

Basic Operational Amplifier: Concept of differential amplifiers (Dual input balanced and unbalanced output, Single input balanced and unbalanced output), constant current bias, current mirror, cascaded differential amplifier stages with concept of level translator, block diagram of an operational amplifier (IC 741).

UNIT – II **(12 hours)**

Op-Amp parameters: input offset voltage, input offset current, input bias current, differential input resistance, input capacitance, offset voltage adjustment range, input voltage range, common mode rejection ratio, slew rate, supply voltage rejection ratio.

Op-Amp Circuits: Open and closed loop configuration, Limitations of open loop, characteristics of ideal op-amp, frequency response of op-amp in open loop and closed loop. Non-Inverting & Inverting amplifiers, Summing & Difference amplifiers, Log & antilog amplifiers, Instrumentation Amplifier, Integrator & Differentiator circuit, Voltage to current converter, Current to voltage converter.

UNIT – III **(11 hours)**

Comparators: Basic comparator, Level detector, Schmitt Trigger. Voltage limiters, Signal **Generators:** Phase shift oscillator, Wein bridge oscillator, square wave generator, triangle wave generator, saw tooth wave generator, and Multivibrators using opamp.

UNIT – IV **(11 hours)**

Signal conditioning circuits: Sample and hold systems, Active filters: Low pass and high pass Butterworth filter (first and second order), Band pass filter, Band reject filter, and All pass filter.

Practical component: **(30 hours)**

1. Study of op-amp characteristics: CMRR and Slew rate.
2. Designing of an amplifier of given gain for an inverting and non-inverting configuration using an op-amp.
3. Designing of analog adder and subtractor circuit.
4. Designing of an integrator using op-amp for a given specification and study its frequency response.
5. Designing of a differentiator using op-amp for a given specification and study its frequency response.
6. Designing of a first order low-pass filter using op-amp and study its frequency response.
7. Designing of a first order high-pass filter using op-amp and study its frequency response.
8. Designing of a RC phase shift oscillator using op-amp.
9. Design an astable multivibrator using opamp.
10. Design a schmitt trigger circuit using op-amp and study its hysteresis loop.

Essential/recommended readings

1. R. A. Gayakwad, Op-Amps and Linear Integrated circuits, Pearson Education, 4th Edition, May 2015.
2. R. F. Coughlin and F. F. Driscoll, Operational amplifiers and Linear Integrated circuits, 6th Edition, Aug 2000, Pearson,
3. Pearson Education (2001).J. Millman and C.C. Halkias, Integrated Electronics, Tata McGraw-Hill, (2001).

Suggestive readings

1. A.P.Malvino, David J Bates, Electronic Principals, 7th Edition, Tata McGraw-Hil Education, (July 2017).

DISCIPLINE SPECIFIC CORE COURSE – 9: Mathematical Techniques for Instrumentation (INDSC3C)

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		
Mathematical Techniques for Instrumentation (INDSC3C)	**04**	**03**	**0**	**01**	**Course admission eligibility**	**Basic knowledge of mathematics**

Learning Objectives

The Learning Objectives of this course are as follows:

- To give an ability to apply knowledge of mathematics to engineering problems.
- To introduce the basic concepts required to understand, construct, solve and interpret
- differential equations.
- To teach methods to solve differential equations of various types.
- To teach students to understand the Laplace transform method to solve ordinary differential equations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Recognize ODEs of varying order and use these to solve engineering problems.
- Derive mathematical models of physical systems.
- Solve the most common PDEs, recurrent in engineering using standard techniques.
- Demonstrate the utility of Laplace transform in solving the ordinary differential equations

SYLLABUS OF DSC-8

UNIT – I **(12 hours)**

Ordinary Differential Equations: First Order Ordinary Differential Equations, Separable Ordinary Differential Equations, Exact and Non-Exact Differential Equations, Linear Ordinary Differential Equations. Linear Independence and Dependence, Linear Differential Equations of Second Order with Constant Coefficients and Variable Coefficients: Homogeneous and non-homogeneous.

Method of Variation of Parameters, Electric Circuits (RL, RC and RLC circuits).

UNIT – II **(11 hours)**

Partial Differential Equations: Formation of Partial Differential Equation, Partial Differential Equation of First Order: Linear and Non-linear. Method of Separation of Variables. Classification of Partial Differential Equations of Second Order, One-dimensional Heat equation, Modeling a Vibrating string and the Wave Equation.

UNIT – III **(11 hours)**

Laplace Transform: Laplace Transform and its properties, Convolution theorem, Laplace Transform of Periodic function, Inverse Laplace transforms and its properties. Application of Laplace Transform to Differential Equations with Constant Coefficients, Solution to System of Simultaneous Differential Equations.

UNIT – IV **(11 hours)**

Fourier series and Transforms: Fourier Series: Even and Odd functions, Half range expansions, Fourier Integral, Fourier Transforms: Fourier Sine and Cosine Transforms, Forced Oscillations.

Practical component: **(30 hours)**

1. Plot the trigonometric functions like sin (x), cos(x), tan(x).
2. Plot the following algebraic expressions log(x), exp(x), x^2, x^3, $x+x^2+\exp(x)$.
3. Plot the following unit step functions u(t), u(t-4) and u(t+2).
4. Solve the first-order ordinary differential equations.
5. Solve the linear differential equation of second order with constant coefficients.
6. Solve the linear differential equation of second order with variable coefficients.
7. Evaluate the Laplace Transform of a given function.
8. Evaluate the inverse Laplace transform of a given function.
9. Evaluate the Fourier series coefficients of a given function.
10. Computing the Fourier Transform of a given signals.

Essential/recommended readings

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition (2020).
2. B. V. Ramana, Higher Engineering Mathematics, Tata McGraw Hill Publishing ,7th Edition.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publisher, 43rd Edition (2017).
4. HK Dass, Higher Engineering Mathematics, S.Chand Publishing,22nd Edition.

Suggestive readings

1. Dennis G.Zill,Advanced Engineering Mathematics, Jones & Bartlett Publishers,6th Edition (2016).
2. John Bird**,** Higher Engineering Mathematics,2017

DISCIPLINE SPECIFIC ELECTIVE COURSE – 1: Signal and Systems (INDSE3A)

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		
Signal and Systems (INDSE3A)	04	03	0-	01	Course admission eligibility	Basic knowledge of mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To give information about signals and systems mathematically and perform mathematical operations on signals.
- To teach the properties and the response of the LTI system using convolution.
- To give knowledge about Laplace transform, Fourier Transform and Z-transform for analysing continuous-time and discrete-time signals and systems.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the basic concept and types of signals and systems and their properties which is useful to learn digital tele-communication
- Classify systems based on their properties and determine the response of LTI system using convolution
- Understand how to apply the Laplace transform, Fourier Transform and Z-transform for analyzing continuous-time and discrete-time signals and systems

SYLLABUS OF DSE-1

UNIT – I **(12 hours)**

Signals and Systems: Continuous and discrete time signals, Transformation of the independent variable, Exponential and sinusoidal signals, Impulse and Unit step functions, Continuous-Time and Discrete-Time Systems.

UNIT – II **(11 hours)**

Linear Time-Invariant Systems (LTI): Continuous & discrete time LTI systems, Convolution Sum, Convolution integral, Properties of LTI Systems: Commutative, Distributive and Associative. LTI systems with and without memory, Invariability, Causality, Stability.Unit Step response of System, Differential and Difference equation formulation, Block diagram representation of first order systems.

UNIT – III **(11 hours)**

Sampling: The Sampling Theorem and its implications. Spectra of sampled signals.
Laplace Transform: Laplace Transform Methods in Circuit Analysis, Impulse and Step response of RL, RC and RLC circuits.

UNIT – IV **(11 hours)**

Fourier Transform (FT): Complex exponential form of Fourier series, Fourier integral theorem, Fourier Sine & Cosine integrals, Fourier transform, Fourier Sine & Cosine transforms and their inverses.
Z-transform: properties, transfer function representation, inverse Z transform of rational functions- transform of input/output difference equation, stability of discrete time systems- frequency response of discrete time systems.

Practical component: **(30 hours)**

Learning Scilab/MATLAB (Experiments based on available systems).
Exploration of Signals and Systems using Scilab/MATLAB.

1. Generation of Signals: continuous time
2. Generation of Signals: discrete time
3. Addition, multiplication, folding and reversal of signals.
4. Convolution of Signals.
5. Solution of Difference equations.
6. Introduction to SIMULINK and calculation of output of systems represented by block diagrams.
7. Determination of Fourier Series coefficients of the given signals.
8. Determination of Fourier transform of the given signals.
9. Determination of Z transform of the given signals

Essential/recommended readings

1. H. P. Hsu, Signals and Systems, 4th Edition Tata McGraw Hill (2019).
2. S. T. Karris, Signal and Systems: with MATLAB Computing and Simulink Modelling, 4th EditionOrchard Publications (2008).
3. W. Y. Young, Signals and Systems with MATLAB, Springer (2014).
4. M. Roberts, Fundamentals of Signals and Systems, Tata McGraw Hill (2010).

Suggestive readings

1. Alan V. Oppenheim, Alan S. Willsky with S. Hamid, Signals and Systems, 2nd edition, Pearson, Inc. (2022).

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – 2: VHDL Programming(INDSE3B)

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		
VHDL Programming (INDSE3B)	04	02	0	02	Course admission eligibility	Understanding of Digital Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop the basic understanding of VHDL Modules, entity and architectures.
- To familiarize with different VHDL elements, Keywords and Identifiers
- To describe hardware in VHDL using different Modeling styles.
- To understand concurrent and sequential assignments.
- To introduce built in primitive gates and understand Gate level Modelling

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn about HDL Modules and simulation tools.
- Apply the knowledge of entity, architectures, VHDL Modules to describe hardware.
- Write and analyze various VHDL codes for combinational and sequential logic circuits
- describe hardware using multiple modeling styles.

SYLLABUS OF DSE-2

UNIT – I **(8 hours)**

Introduction to VHDL: A Brief History of HDL, Structure of HDL Module, Comparison of VHDL and Verilog, Introduction to Simulation and Synthesis Tools, VHDL requirements, VHDL basic language elements, Keywords, Identifiers, White Space Characters, Comments, format, VHDL operators.

VHDL Modeling: Describing hardware in VHDL, entity, architectures, VHDL Modules, Delays, data flow style, behavioural style, structural style, mixed design style, simulating design.

UNIT – II **(8 hours)**

BehavioralModeling: Introduction to behavioural modelling, Signal assignment,

Concurrent and sequential assignments., Entity Declaration, Architecture Body, BehavioralModeling, Process statement, Loop control statements, Multiple Processes, Delay Models, inertial delay model, transport delay model, transport vs inertial delay, Signal Drivers.

UNIT – III **(7 hours)**

Dataflow and Structural Modeling: Data flow Modeling, Concurrent Assignment statements, Block statements, Structural Modeling, Component declaration and Instantiation, generate statements, Process, IF, CASE, LOOP, NEXT, EXIT and ASSERT statements.

UNIT – IV **(7 hours)**

Gate level modeling: Introduction, built in Primitive Gates, multiple input gates, Tri-state gates, pull gates, MOS switches, bidirectional switches, gate delay, array instances, implicit nets, Illustrative Examples (both combinational and sequential logic circuits).

Practical component: **(60 hours)**

Learning Scilab/MATLAB (Experiments based on available systems).
Exploration of Signals and Systems using Scilab/MATLAB.

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Clocked D FF, T FF and JK FF (with Reset inputs).
5. Multiplexer (4x1, 8x1) and Demultiplexer using logic gates.
6. Decoder (2x4, 3x8), Encoders and Priority Encoders.
7. Design and simulation of a 4-bit Adder.
8. Code converters (Binary to Gray and vice versa).
9. 3-bit Ripple counter.

Essential/recommended readings

1. J. Bhasker, VHDL Primer, Pearson, 3rd edition ,2015.
2. Volnei. A.Pedroni, Circuit Design with VHDL, MIT Press; Third edition, 2020
3. Sudhakar Yalamanchili, Introductory VHDL-From Simulation to Synthesis, Pearson Education India. First Edition, 2000

Suggestive readings

1. Douglas Perry, VHDL, McGraw-Hill Education; 4th edition, 2002
2. Charles.H.Roth, Digital system Design using VHDL, Cengage; 2nd edition, 2012

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – 3: Programming using MATLAB(INDSE3C)

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		
Programming Using MATLAB (INDSE3C)	04	02	0	02	Course admission eligibility	Basic knowledge of mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize the student with MATLAB software.
- The objective of this lab is to introduce students to the basic operations of MATLAB.
- To enable the student on how to approach solving Engineering problems using simulation tools.
- To prepare the students to use MATLAB in their project works.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Use MATLAB for interactive computations
- Generate plots and exports them for use in reports
- Familiar with inbuilt MATLAB functions and will be able to generate user defined functions for various applications
- Understands fundamental of digital image and signal processing

SYLLABUS OF DSE-3

UNIT – I **(8 hours)**

Introduction to MATLAB: MATLAB Features, MATLAB Windows, defining variables, variable naming, checking existence, different Operations on variables, clear Operations, data type, precedence, scalar, vectors and Arrays.

UNIT – II **(7 hours)**

Data and Data Flow in MATLAB: Operators in MATLAB, Matrix operations, Reshaping Matrices, Importing & Exporting of Data, Arrays, Data types, File Input-Output, Communication with External Devices.

Character and Strings: Defining character and string, accessing character or substring

from string, string concatenation and comparing, conversion between strings and number. Defining and working with Multidimensional Array and Cell arrays.

UNIT – III **(7 hours)**

Programming: Writing Script Files and Functions files, Error Correction, M-Lint Automatic Code Analyzer, Saving Files. Flow control statement: Conditional or selection, error handling, loop control, program termination. Solution of simultaneous linear equations.

UNIT – IV **(8 hours)**

MATLAB Graphics: Simple Graphics, Graphic Types, Plotting Functions, Creating Plot & Editing Plot, multiple plots, labeling graph, line colors, style and Marker. Introduction of Graphical User Interface (GUI), Generation and implementation of various functions on image.

Practical component: **(60 hours)**

1. Define variables, create a matrix of any size with all possible methods and perform various mathematical operations.
2. Create a multidimensional array and delete any Row/Column from it and create a new array.
3. Plot and label trigonometric functions using subplot command.
4. Generate various kinds of continuous and discrete time signals. Perform time scaling, time shifting and amplitude scaling on them.
5. Generate the (i) square wave and (ii) triangular wave of a specific amplitude and time period and plot it on a single graph.
6. Create a function which compares any two strings of equal length and return 'M' for matched character and 'U' for unmatched Character. Also display the number of characters matched.
7. Generate the (i) square wave and (ii) triangular wave of a specific amplitude and time period and plot it on a single graph.
8. Write a script to test whether a user defined no. is Prime or not.
9. Write a script which can evaluate the percentage (%) and grade of the student when subject marks are entered by the user.
10. Create a function which compares any two strings of equal length and return 'M' for matched character and 'U' for unmatched Character. Also display the number of characters matched.
11. Write a function to generate the AP series.
12. Write a function to generate the GP series.
13. Write a function to generate the Fibonacci series.
14. Write a function to generate the amplitude and frequency modulated signal.

Essential/recommended readings

1. Khanna, M., Bhatt, G. and Kumar, P., MATLAB Essentials for Problem Solving, (2019) PHI Learning, New Delhi.
2. Fausett, L. V., Applied Numerical Analysis Using MATLAB, (2005) Prentice Hall, Upper Saddle River, New Jersey.
3. Linfield, G. & Penny, J., Numerical methods using MATLAB, (2019) Ellis-Horwood.

Suggestive readings

1. Nakamura, S., Numerical Analysis and Graphic Visualization with MATLAB - Second Edition, Prentice Hall PTR, Upper Saddle River, New Jersey

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

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

GENERIC ELECTIVES (GE-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
		Lecture	Tutorial	Practical/ Practice		
Virtual Instrumentation (INGE3A)	04	02	0	02	Course admission eligibility	Basic knowledge Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To study the basic structure of virtual instrumentation
- To learn the basic programming concepts in LabVIEW
- To understand the basics of data acquisition for designing a Virtual Instrument

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the importance and applications of Virtual Instrumentation
- Learn the basic programming concepts in LabVIEW
- Recognize the components of Virtual instrumentation and use them for PC Based measurement

SYLLABUS OF GE-3

UNIT – I **(8 hours)**

Graphical System Design: Graphical system design model, Design flow with GSD,

Virtual Instrumentation, Virtual instrument, and traditional instrument, Hardware and software in virtual instrumentation, Virtual instrumentation for Test, control & design, Graphical system design using LABVIEW, Graphical programming & textual programming.

UNIT – II **(7 hours)**

LabVIEW Basics: Introduction, advantages of LABVIEW software environment, palettes, front panel controls & indicators, Block diagram, Data flow program. Repetition and Loops: For loops, while loops, structure tunnels, terminals inside or outside loops, shift registers, feed-back nodes, control timing, case structure.

UNIT – III **(8 hours)**

Arrays and Clusters: Arrays, Introduction, arrays in LABVIEW, creating one – dimensional array controls, indicators, and constants, creating two-dimensional arrays, creating multidimensional arrays, initializing array, deleting, inserting, and replacing elements, rows, columns, and pages within arrays, arrays functions. Clusters: Cluster controls and indicator, order of cluster elements, Cluster operations.

Plotting Data: Types of waveforms, waveform graphs, waveform charts, XY graphs, Intensity graphs & charts, Digital waveform graphs, 3D graphs, customizing graphs & charts, configuring a graph or chart, Displaying special planners on the XY graph.

UNIT – IV **(7 hours)**

File Input/ Output: File formats, file write &read, generating filenames automatically, String handling,string functions, LABVIEW string formats, parsing of strings. Instrument Control: Introduction, GPIB communication, Hardware specification, software architecture, Instrument I/O assistant, VISA, Instrument drivers, serial port communications, using other interfaces.

Practical component: **(60 hours)**

1. Build a VI to compute the expressions Y = (A*B*C) + (D*E) and Y = mx + c.
2. Split an input string into two outputs with reference to a separating character. Find the length of the input string and reverse the string.
3. Build a VI to perform various Boolean Operations (AND, OR, NAND, NOR, XOR).
4. Write a program in LabVIEW to find whether the given number is odd or even.
5. Create a VI to find the sum of first n natural numbers using a While Loop with a feedback node.
6. Create a VI to compute full adder logic using half adder logic as subVI.
7. Write a program in LabVIEW to find the square of the numbers from 1 to 100 using (a) a For Loop and (b) a While Loop.
8. Create a VI to compare the element of two clusters if the value of the corresponding elements are the same switch on LED in the output cluster.
9. Create a VI to compare clusters and Switch ON an LED in the output cluster if the nth element of cluster 1 is greater than the nth element of cluster 2.
10. Create a 2D numeric array (5 x 5) containing random numbers and find its transpose.
11. Create a VI to read a two-dimensional array and find the sum of the elements

in the row-wise and column-wise separately and display the sums of the rows and columns.

12. Create a 1D array and find its reverse.
13. Build a VI to plot a circle in the XY graph using a For Loop.
14. Build a VI that generates a 1D array of random numbers and sort the ascending descending array and also find the max. and min. value array element.
15. Build a cluster control that consists of a seven-segment LED display, a switch, a string control, and numeric control. Split the cluster elements using the Unbundle function and alter the values of some of the cluster controls. Bundle them again and display in a cluster indicator.
16. Using For loop determine the number of odd numbers between a range of numbers entered by the user.
17. Build a VI to plot different colors in an intensity graph using an array.
18. Create a VI to check whether the cluster elements are in range or not. Specify the upper and lower limits. Display the coerced output and a cluster of LEDs to indicate whether a particular cluster element is in the range or not.
19. Write a program to solve x2+bx+c=0.
20. Build a VI to generate two waveforms of different amplitude and frequencies add the signal to find the resultant and plot it on a separate waveform graph.
21. Create a VI to read a two-dimensional array and find the sum of the elements in the row-wise and column-wise separately and display the sums of the rows and columns.

Essential/recommended readings

1. Jovitha Jerome,Virtual Instrumentation Using Labview,PHI Learning Pvt. Ltd. (2010)
2. John Essick, Hands-on Introduction to LabVIEW for Scientists and Engineers, 3rd Edition, 2015.
3. Gupta, Virtual Instrumentation Using Labview 2E, McGraw Hill. (2010)

Suggestive readings

1. Jeffrey Travis, LabVIEW for everyone, Prentice-Hall PTR,2007.

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

GENERIC ELECTIVES (GE-3): Industrial and environmental techniques (INGE3B)

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
		Lecture	Tutorial	Practical/		

				Practice		
Industrial and environmental techniques (INGE3B)	**04**	**02**	**0**	**02**	**Course admission eligibility**	**Basic knowledge of chemistry or analytical chemistry**

Learning Objectives

The Learning Objectives of this course are as follows:

- Demonstration of a clear and exhaustive understanding of the basic concepts of Industrial analysis of different industrial products.
- Impart theoretical and practical knowledge of Analysis of food and food products
- Learn analysis of various pharmaceutical drugs as per the standard pharmacopeia
  To expose to different types of Environmental pollutants and their analysis:

Learning outcomes

The Learning Outcomes of this course are as follows:

- Identify the key environmental factors shaping an industry
- Demonstrate ability to use tools and methodologies for performing analysis for various types of industries
- Develop a detailed professional report of Industry Analysis conducted.

SYLLABUS OF GE-3

UNIT – I **(8 hours)**

Industrial analysis

Paints: Definition, constituents and their functions, flash point of paints, separation of pigments, binder and thinner. Analysis of vehicle and thinner.

Pigments: General outline of identification and analysis of pigments -organic and inorganic pigments, their qualitative chemical test, analysis of white and tinted pigments.

Pesticides: Definition and classification of pesticides, analysis of the following in outline – DDT, Malathion, Diagionon.

Alloys: Composition and estimation of main constituents in in the following – Stainless steel, Brass, Solder and Gun metal

Rubber and Polymers: Mechanical, Thermal, Electrical and Optical properties, Analysis and Characterization.

UNIT – II **(8 hours)**

Analysis of food and food products

Composition and analysis of the following: Milk- Specific gravity, total solid, fat, proteins, lactose, contaminants in milk (QAS, artificial color and antibiotic), Wheat flour- Moisture, ash, oil, fat, protein, fiber, acidity, starch and maltose. Beverages-

Alcohol contents. Tea- Moisture, ash, tannin and caffeine. cyclamate. Honey- Moisture, HMF, Free acid, pH and carbohydrate.

UNIT – III **(7 hours)**

Pharmaceutical analysis

Drug, classification of drugs, introduction to Indian pharmacopoeia. Analysis of following drugs as per IP and BP (monograms) - Amoxycillin, Analgin, Proponolol, Pilocarbine nitrate, Rifampicin, Paracetamol, Nimuselide, Ranitidine.

UNIT – IV **(7 hours)**

Environmental analysis

Analysis of water- color, Odor, pH, taste, conductivity, dissolved solid, hardness, DO, COD, BOD, chlorides, sulphates, nitrites and phosphates.

Analysis of air- Sampling, particulate matter, gaseous pollutants-SOX, NOX, COX and organic pollutant

Practical component: **(60 hours)**

1. Determination of physical parameters of wastewater: pH, color, conductivity and Oxidation reduction potential.
2. Determination of dissolved oxygen in given water sample.
3. Estimation of phosphorous in fertilizer
4. Determination of calcium in cement sample (Titrimetry)
5. Estimation of calcium and Magnesium in dolomite ore.
6. Analysis of water for COD.
7. Colorimetric estimation of trace of nitrogen in the given water sample using Nessler's reagent.
8. Analysis of tea and coffee.
9. Determination of refractive index of given edible oil/solvents and determine its percentage purity.
10. Determination of Ascorbic acid.
11. Colorimetric estimation of Rifampicin (IP 1996)
12. Assay of Aspirin.
13. Estimation of specific gravity and total solids present in milk samples.
14. Estimation of lactose content of milk.
15. Determination of glucose in honey.
16. Quality assessment of Rubber/polypropylene/polyethylene samples

Essential/recommended readings

1. Analytical chemistry: an introduction: D. A. Skoog, D. M. West and F. J. Holler, Saunders the College publishers, 6th edition.
2. Vogel's Textbook of Qualitative Chemical Analysis, ELBS, 6th edition 2009.
3. Indian Pharmacopeia (2018)
4. A.B. Mathur and I.S. Bhardwaj, Testing and Evaluation of Plastics, Allied Publishers Pvt Limited, 2003
5. Rao, E. S. (2013). Food Quality Evaluation (I ed.). New Delhi: Variety Book Publishers.
6. DeMan. (2007). Principles of Food Chemistry. Springer, 3rdedition.

Suggestive readings

1. Rao, E. S. (2013). Food Quality Evaluation (I ed.). New Delhi: Variety Book Publishers.
2. DeMan. (2007). Principles of Food Chemistry. Springer, 3rd edition.
1.

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SEMESTER-IV
DEPARTMENT OF INSTRUMENTATION
Category I

(B.Sc. Honours in Instrumentation)

DISCIPLINE SPECIFIC CORE COURSE – 10: Biomedical Instrumentation (INDSC4A)

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		
Biomedical Instrumentation (INDSC4A)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Sensors and Transducers

Learning Objectives

The Learning Objectives of this course are as follows:

- To identify and describe various biomedical signals.
- To describe the origin of biopotentials and explain the role of biopotential electrodes.
- To understand the synchronization between the physiological systems of the body.
- To understand the basic measurement principles behind biomedical instrumentation.
- To realize the working principle of numerous biomedical imaging techniques.
- To analyze the applications of biosensing in different domains of healthcare.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Analyze the origin of various bioelectric signals (ECG, EEG) and the method of recording using different types of electrodes.
- Develop basic knowledge about the Cardiovascular, respiratory and nervous systems.

- Develop an understanding of the measurement principles of medical instrumentation including measurement of respiratory function, cardiac variables, blood pressure as well as medical devices.
- Design various biomedical instruments with the help of respective transducers.

SYLLABUS OF DSC-10

Unit-1 **(10 Hours)**

Biopotentials, Bio amplifiers, and Bioelectrodes: Introduction to bio-electric potential, bio- amplifier, components of man Instrument system, types of biomedical systems, design factors and limitations of biomedical instruments, terms, and transducers to measure various physiological events, types of bio-potential electrodes (Body surface electrodes, Internal electrodes, Microelectrodes), electrolyte interface, electrode circuit model, impedance and polarization, Properties of electrodes

Unit-2 **(13 Hours)**

Cardiac vascular system & measurements: ECG: origin, Instrumentation, the bipolar system lead system I, II, III, Einthoven's triangle, Augmented lead system, unipolar chest lead system, types of display. Blood pressure measurements: direct, indirect. Pacemakers- Internal, External

Unit-3 **(11 Hours)**

Respiratory Measurement Systems: Types of volume, types of measurements, Instrumentation of respiratory system, principle & types of pneumograph, Spirometer, pneumotachometers, nitrogen washout technique

Unit-4 **(11 Hours)**

Nervous system: Action potential of the brain, brain wave, Instrumentation of Electroencephalography (EEG), electrodes used for recording EEG analysis. Conventional X-ray, properties, generation of X-ray, Thermal imaging system, working, IR detectors, applications.

Practical component: **(30 hours)**

1. Characterization of biopotential amplifier for ECG signals.
2. Study on ECG simulator.
3. Recording of EEG.
4. Measurement of blood pressure and measurement of heart sound using a stethoscope.
5. Study of pulse rate monitor with alarm system.
6. Determination of pulmonary function using a spirometer.
7. Measurement of respiration rate using thermistor /other electrodes.
8. Study of Respiration Rate monitor/ apnea monitor.

Essential/recommended readings

1. Cromwell L., Wiebell F. J., Pfeiffer EA, Biomedical Instrumentation and Measurements, 2nd Edition, Prentice Hall (2010).
2. Carr J. J, Brown J. M. Introduction to Biomedical Equipment Technology, 4th Edition, Pearson Education Inc (2010).
3. Khandpur R.S., Handbook of Biomedical Instrumentation, 2nd Edition, Tata McGraw-Hill Publishing (2009).
4. Joseph D. Bronzino, The Biomedical Engineering Handbook, IEEE Press (2015), 4th edition, Volume 1.

Suggestive readings

1. Richard Aston, Principles of Biomedical Instrumentation & Measurement, 1st edition, Merrill Publishing Company (1990).
2. Mandeep Singh, Introduction to Biomedical Instrumentation, 2nd Edition, PHI learning private limited (2014).

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

DISCIPLINE SPECIFIC CORE COURSE – 11: Machine Learning (INDSC4B)

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		
Machine Learning (INDSC4B)	**04**	**02**	**-**	**02**	**Class XII passed with Physics + Mathematics /Applied Mathematics + Chemistry/ Computer Science/Informatics Practices**	**Understanding of Mathematics & programming language**

Learning Objectives

The Learning Objectives of this course are as follows:

- Students have an understanding of issues and challenges of Machine Learning.
- Students should be able to select data, model selection, model complexity etc.
- Understanding of the strengths and weaknesses of many popular machine learning approaches.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Identify the characteristics of datasets and compare the trivial data and big data for various applications.
- Understand machine learning techniques and computing environments that are suitable for the applications under consideration .
- Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.
- Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications.
- Implement various ways of selecting suitable model parameters for different machine learning techniques.
- Integrate machine learning libraries, and mathematical and statistical tools with modern

- technologies like hadoop distributed file system and mapreduce programming model
- Familiarize with Simple Linear Regression and Logistic Regression.
- Appreciate the various nuances of Multiple Regressions and Model Building.
- Identify and apply the Classification algorithms.
- Apply the Clustering algorithms for developing applications

SYLLABUS OF DSC-11

UNIT – 1 **(8 hours)**

Introduction to Machine Learning: varieties of machine learning, Supervised Learning, Unsupervised Learning, Reinforcement Learning. Dimensionality Reduction, Subset Selection, Shrinkage Methods, Principal Components Regression: Linear Classification, Logistic Regression, Linear Discriminant Analysis, Optimization, Classification-Separating Hyperplanes Classification.

UNIT – 2 **(8 hours)**

Learning input/output functions, sample application. Boolean functions and their classes, CNF, DNF, decision lists and Bias – Variance, Version spaces for learning, version graphs, learning search of a version space, candidate elimination methods.

UNIT – 3 **(8 hours)**

Artificial Neural Networks (Early models, Back Propagation, Initialization, Training & Validation) Parameter Estimation (Maximum Likelihood Estimation, Bayesian Parameter Estimation) Decision Trees: ID4, C4.5, CART, Evaluation Measures, Hypothesis Testing.

UNIT – 4 **(6 hours)**

Clustering, Gaussian Mixture Models, Spectral Clustering, Ensemble Methods Learning Theory, Graphical Models.

K-Nearest Neighbors: Computational geometry; Voronoi Diagrams; Delaunay Triangulations K-Nearest Neighbor algorithm; Wilson editing and triangulations. Aspects to consider while designing K-Nearest Neighbor, Support Vector Machines and its classifications. Linear learning machines and Kernel space, Making Kernels and working in feature space.

Practical component: **(60 hour)**

Hardware requirement: i5 Processor, 8GB RAM, Internet Connection

Software Environment: IDE recommended PYCHARM (Recommended), JUPYTER, VISUAL STUDIO

1. Introduction to pandas and NumPy
2. Prediction based on different dataset: Vegetable Quality Prediction, Housing Price Prediction, Air Quality Prediction, Car Price Prediction

3. Prediction of diseases e.g. Liver Disease Prediction, Heart Disease Prediction, Crop disease.
4. Credit Default Prediction, Airline Passengers Prediction, Stock Price Prediction.
5. Bank Marketing, Media Content Problem, Online Retail Case Study
6. Energy Efficiency Analysis, Movie Sentiment Analysis, Car Evaluation
7. Program to demonstrate Simple Linear Regression
8. Program to demonstrate Logistic Regression using SCIKIT learn
9. Program to demonstrate Logistic Regression
10. Program to demonstrate k-Nearest Neighbor flowers classification
11. Program to demonstrate Decision Tree – ID3 Algorithm
12. Program to demonstrate Naïve- Bayes Classifier
13. Program to demonstrate Back-Propagation Algorithm
14. Program to demonstrate k-means clustering algorithm
15. Program to demonstrate K-Means Clustering Algorithm on Handwritten Dataset
16. Program to demonstrate K-Medoid clustering algorithm
17. Program to demonstrate DBSCAN clustering algorithm
18. Program to demonstrate SVM based classification
19. Program to demonstrate PCA on face recognition
20. Program to demonstrate PCA and LDA on Iris dataset
21. Mini Project works shall be given with a batch of four students considering different datasets such as digit dataset, face dataset, flower dataset and micro-array dataset.

Essential/recommended readings

1. Introduction to Machine learning, Nils J.Nilsson
2. Pattern Recognition and Machine Learning. Christopher Bishop. First Edition, Springer, 2006.
3. Pattern Classification. Richard Duda, Peter Hart and David Stock. Second Edition, Wiley-Interscience, 2000.
4. Machine Learning. Tom Mitchell. First Edition, McGraw-Hill, 1997.
5. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.

Suggestive readings

1. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.
2. Tom M. Mitchell, “Machine Learning”, McGraw-Hill, 2010
3. Bishop, Christopher. Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995.

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

DISCIPLINE SPECIFIC CORE COURSE – 12: Optical Instrumentation (INDSC4C)

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		
Optical Instrumentation (INDSC4C)	**04**	**03**	**-**	**01**	**Class XII passed with Physics + Mathematics/ Applied Mathematics + Chemistry/ Computer Science/Informatics Practices**	**Optics and Electronics**

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To understand concepts of light and optical effects
- To impart in-depth knowledge of opto-electronic devices and optical measurements
- To provide basic knowledge of interferometry and refractometers
- To introduce the concept of optical fiber-based sensing and measurements

Course Learning Outcomes

The Learning Outcomes of this course are as follows:

- Explain different light phenomenon, optical effects and their applications
- Design photo detector circuits using LED and Lasers as sources
- Understand the optical measurements using interferometers
- Analyze Fiber optic fundamentals and Measurements

SYLLABUS OF DSC-12

Unit-1 **(12 hours)**

Light as Source and optical effects: Concept of light, coherent and incoherent light sources, classification of different light phenomenon (interference, diffraction and polarization), Diffraction grating, Electro-optic effect, Acousto-optic effect and Magneto-optic effect.

Unit-2 **(12 hours)**

Opto–Electronic Devices: Light emitting diode (LED), Materials used to fabricate LEDs, Characteristics of LEDs, LED based optical communication, Lasers: Concept of laser (Spontaneous emission, stimulated emission and stimulated absorption), Ruby laser, He-Ne laser, semiconductors laser. Detectors: Photo diode, PIN diode, Photo-conductors, Solar cells.

Unit-3 **(10 hours)**

Interferometry for optical measurements: Michelson's Interferometer and its application, Rayleigh's interferometers, Abbe Refractometer, Fabry-Perot Interferometer, Holography: Concept of holography in brief (Recording and reconstruction).

Unit-4 **(11 hours)**

Optical Fiber for sensing and measurements: Step index and graded index fibers, Single and multi-mode fibers, Characteristics of optical fiber, Fiber losses, Fiber optic communication system, Dispersion measurement, Active and passive optical fiber sensors, Single mode fiber sensor, Fiber-optic refractive index sensor

Practical component: **(30 hours)**

1. To study characteristics of LED
2. To determine the slit width using He-Ne laser
3. To determine the wavelength of monochromatic source using Michelson interferometer.
4. Determine the numerical aperture and bending loss of optical fiber
5. To find the wavelength of a laser using transmission diffraction grating
6. To measure the intensity pattern of a single slit using He-Ne laser
7. To find the I-V characteristics of a solar cell
8. To measure the refractive index of the prism using a spectrometer.

Essential/recommended readings

1. Ajoy Ghatak, Optics, Tata McGraw Hill, New Delhi (2008)
2. S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, Pearson Education (2009)
3. E. Hecht, Optics, Pearson Education Ltd. (2002)
4. Rajpal S. Sirohi, Wave Optics and its Application, 1st ed. (2001)
5. Pollock, Fundamentals of OPTOELECTRONICS, (1994)
6. Photonic Devices and Systems –by Robert G. Hunsperger, Taylor & Francis, 1994,
7. G. Hebbar, "Optical Fiber Communication", Cengage

Suggestive reading

1. J. Wilson and J. F. B. Hawkes, Optoelectronics: An Introduction, Prentice H. India (1996)

2. Ghatak A.K. and Thyagarajan K., “Introduction to fiber optics,” Cambridge Univ.Press. (1998)
3. 10. A. Yariv, Optical Electronics/C.B.S. College Publishing, New York, (1985)

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 ELECTIVE: Linear Integrated Circuits (INDSE4A)

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		
Linear Integrated Circuits(INDSE4A)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics+ Chemistry / Computer Science/Informatics	Understanding of Analog electronics & Operational Amplifiers

Learning Objectives

The Learning Objectives of this course are as follows:

- Familiarity and designing of various non-linear circuits using op-amp
- Familiarity and designing of multivibrators using 555 timer.
- Use of op-amp in designing of D/A and A/D convertors.
- Familiarity with different Linear ICs like 380, 555, 565, 566, 78xx and 79xx.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Design and explain the working of log & anti-log amplifier, analog multiplier and precision rectifier using op-amp.
- Design and explain the working of D/A and A/D convertors using op-amp.
- Design and explain the working of different types of multivibrators using IC 555.
- Use the regulator ICs for regulation purposes.

SYLLABUS OF DSE-2

UNIT – 1 **(12 hours)**

Sample and hold circuits, logarithmic amplifiers, antilogarithmic amplifiers, analog multipliers, Precision rectifier circuit: Half wave rectifier, full wave rectifier, bridge rectifier, peak rectifier, clipper, clamping, and applications of precision rectifier circuits.

UNIT – 2 **(12 hours)**

D/A convertor: Binary weighted resistors, R/2R resistor. A/D convertor: Successive approximation.

Power Amplifiers: Monolithic power amplifier (IC 380), use of power boosters (IC 3329/03), application of power amplifiers

UNIT – 3 **(12 hours)**

Multivibrators (IC 555): Pin and block diagram, Astable and monostable multivibrator circuit, applications of astable and monostable multivibrators.

Phase locked loops (PLL): Block diagram, operating principle, phase detector types, monolithic phase locked loops (IC565). Application of PLL IC 565: Frequency multiplier and frequency shift keying. Voltage controlled oscillator (IC 566).

UNIT – 4 **(9 hours)**

Voltage Regulators IC: Fixed voltage regulator (IC 78xx and IC 79xx), adjustable voltage regulator (IC 317 and IC 337), switching regulator (IC 1723) and special regulator.

Practical component: **(30 hours)**

1. Designing of precision half wave rectifier circuit.
2. Designing of precision full wave rectifier circuit.
3. Designing of precision positive and negative clipper circuit.
4. Designing of precision positive and negative clamper circuit.
5. Designing of binary weighted D/A convertor OR R/2R resistor D/A convertor
6. Design an astable multivibrator using IC 555.
7. Design a monostable multivibrator using IC 555.
8. Design a voltage regulator circuit using voltage regulator IC.

Essential/recommended readings

1. Skoog &Lerry, Instrumental Methods of Analysis, Saunders College R. A. Gayakwad, Op-Amps and Linear IC's, Pearson Education 4th Edition, May 2015.

2. R. F. Coughlin and F. F. Driscoll, Operational amplifiers and Linear Integrated circuits, Pearson Education (2001).
3. J. Millman and C.C. Halkias, Integrated Electronics, Tata McGraw-Hill, (2001).
4. A.S. Sedra and K.C. Smith, Microelectronics Circuit, Oxford (2011).

Suggestive readings

1. A.P.Malvino, David J Bates, Electronic Principals, 7th Edition, Tata McGraw-Hil Education, (July 2017).

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

DISCIPLINE SPECIFIC ELECTIVE: Statistical Tools and Techniques (INDSE4B)

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		
Statistical Tools and Techniques (INDSE4B)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics/Biology+ Chemistry / Computer Science/Informatics	Class X Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop the students' ability to deal with numerical and quantitative issues in industries.
- To enable the use of statistical, graphical, and algebraic techniques wherever relevant.
- To have a proper understanding of Statistical applications in different fields.
- To identify and discuss critically, the uses and limitations of statistical analysis.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Describe and discuss the key terminology, concepts tools, and techniques used in statistical analysis
- Understand the concept of probability and sampling distributions

- Perform different parametric and non-parametric tests for various statistical analysis.

SYLLABUS OF DSE-02

Descriptive statistics: Graphical and Tabular representation of data. Measures of Central Tendency, Measures of Dispersion, Measures of Skewness and Kurtosis.

Unit-1 **(13 hours)**

Correlation and Regression: Linear Regression and Correlation.

Unit-2 **(12 hours)**

Probability and Distributions: Introduction to probability, Experiment, sample space, event, probability, conditional probability, Baye's Theorem, Random Variables, Probability Distributions- Normal, Binomial, Poisson, Mathematical Expectation.

Unit-3 **(10 hours)**

Sampling and Sampling Distributions: Sampling distributions and Standard errors. One and two-sample estimation of means and proportions. One and two-sample tests of hypothesis- means, proportions and variances, t-test, Chi-square test.

Unit-4 **(10 hours)**

Nonparametric Statistics: Nonparametric tests, Sign test, Signed-Rank test, Rank-Sum test, Kruskal-Wallis test, Runs test.

Practical component: **(30 hours)**

1. Collection, tabulation, and statistical interpretation of data.
2. To study measures of central tendency- mean, median, mode.
3. To study measures of dispersion- range, standard deviation, variance.
4. To study the coefficient of variation.
5. To study measures of skewness.
6. To study the continuous and discrete distribution.
7. To study nonparametric tests.

Essential/recommended readings

1. Probability and Statistics for Engineers and Scientists by Walpole, Myers, Myers and Ye, 9th Edition, Pearson Education, 2012.
2. Mathematical Statistics and Applications by John E. Freund, 8th Edition, Prentice Hall, India, 2014.
3. Introduction to Statistical Quality Control by Montgomerry, 8th Edition, John Wiley and Sons, 2019.

Suggested Books:

4. Principles of Biostatistics by M. Pagano and K. Gauvrean: Thompson learning (2nd edition); 2018.
5. Biostatistics: A Foundation for Analysis in the Health Sciences by W. W. Daniel and Chad L. Cross; John Wiley and Sons Inc (11th edition); 2018 .

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

DISCIPLINE SPECIFIC ELECTIVE: Virtual Instrumentation (INDSE4C)

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		
Virtual Instrumentation Techniques and Applications (INDSE4C)	04	02	-	02	Class XII passed with Physics + Mathematics/Applied Mathematics+ Chemistry / Computer Science/Informatics	Electronic Instruments & programming language

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the importance of Virtual Instrumentation and study its applications.
- To learn the basic programming concepts in LabVIEW.
- To understand the basics of data acquisition for designing a Virtual Instrument.
- To recognize the various building blocks of Virtual instrumentation and use them for PC-based Measurement.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the importance and applications of Virtual Instrumentation.
- Learn the basic programming concepts in LabVIEW.
- Recognize the components of Virtual instrumentation and use them for PC Based Measurement.

SYLLABUS OF DSE-02

Unit 1 **(6 hours)**

Introduction to Virtual Instrumentation: Historical perspective, advantages, Block diagram and Architecture of a Virtual Instrument, Data Flow Techniques, Graphical programming in the data flow, comparison with Conventional programming.

Unit 2 **(10 hours)**

LabVIEW Programming Environment: Basic operations, Controls/ Indicators, Auto indexing, Debugging, Timing issues (counters).

VI Programming Techniques: Modular programming: VIS and sub-VIS, loops, Arrays, Clusters, Graphs, Charts, Case & Sequence structures. Formula nodes, Local and Global variables, String & file input.

Unit 3 **(10 hours)**

Instrument Control: GPIB Communication, Instrument I/O Assistant, Virtual Instrument Software Architecture (VISA), Instrument Drivers, Serial Port Communication

Data Acquisition Basics: Signals Handling and Classification, Signal Conditioning, Analog Interfacing (I/O), Counters & Timers, Digital (I/O) - DAQ Hardware, DAQ Software Architecture, DAQ Assistant

Unit 4 **(4 hours)**

Developing applications on LabVIEW: Process control, Waveform generator, Motion control using a stepper motor.

Practical Components **(60 hours)**

1. The length and breadth of a rectangle and the radius of a circle are inputs. Build a VI to calculate the area and perimeter of the rectangle and the area and circumference of the circle.
2. Convert a binary number to a decimal number.
3. Compute the equations (X1 + 2)*3 and 5 + X2*log(X2) using functions, Expression node, and Express Formula for the given inputs X1 and X2.
4. Build a VI to find the factorial of a number.
5. Create a VI to find the sum of first n natural numbers using a While Loop with a feedback node.
6. Write a program in LabVIEW to read a positive number n and to generate the following number series using (a) a For Loop and (b) a While Loop
   1, 22, 32, 42, …, n2
   0, 2, 4, 6, …, n
7. Create a VI to compare the element of two clusters if the value of the corresponding element is the same switch on LED in the output cluster.
8. Build an array of cluster controls in which each cluster consists of a numeric control and a 1D numeric array (with 5 elements). This forms a database of marks of students. The numeric control indicates the roll number and the array indicates the test marks of five subjects. Build logic to modify the mark in a particular subject of a particular student. Input the roll number, the subject in which the mark is to be changed, and the new marks. Display the changed database on a separate array indicator.
9. Create a 1D numeric array that consists of ten elements and rotate it ten times. For each rotation display the equivalent binary number of the first array element in the

form of a Boolean array. Also, display the reversed Boolean array. Provide delay to view the rotation.

10. Create two 2D numeric arrays and add them. Change the number of rows and number of columns of each array and see the result.
11. Create a 1D array and find its reverse.
12. Build a VI to plot a circle in the XY graph using a For Loop.
13. Build a VI that generates a 1D array of random numbers and sort the ascending descending array and also find the max. and min. value array element.
14. Build a cluster control that consists of a seven-segment LED display, a switch, a string control, and numeric control. Split the cluster elements using the Unbundle function and alter the values of some of the cluster controls. Bundle them again and display them in a cluster indicator.
15. Using a for loop determines the number of odd numbers between a range of numbers entered by the user.
16. Write a for loop which takes the given values of u from a numeric control labeled coefficient of kinetic friction. Calculate f‟ from theta=0 to 90 degree in 1-degree increment then display the resulting array f‟ values on a waveform graph.
17. Create a VI to check whether the cluster elements are in range or not. Specify the upper and lower limits. Display the coerced output and a cluster of LEDs to indicate whether a particular cluster element is in the range or not.
18. Split an input string into two outputs with reference to a separating character. Find the length of the input string and reverse the string.
19. Write a program to solve x2+bx+c=0.
20. Build a VI to generate two waveforms of different amplitude and frequency add the signal to find the resultant and plot it on the separate waveform graph.

Essential/recommended readings

1. John Essick , Hands-on Introduction to LabVIEW for Scientists and Engineers, 3rd Edition, 2015.
2. Gary Johnson, LABVIEW Graphical Programming, McGraw Hill, 4th Edition, 2006.
3. Lisa K. Wells and Jeffrey Travis, LABVIEW for Everyone, PHI, 3rd Edition, 2006.
4. James K, PC interfacing and data acquisition, 2002.
5. Skolkoff, Basic concepts of LABVIEW 4, PHI, 1998.

Suggested Books

1. Technical Manuals for DAS Modules of Advantech and National Instruments. L.T. Amy, Automation System for Control and Data Acquisition, ISA, 4thEdition, 1992.
2. S. Gupta, J.P. Gupta, PC Interfacing for Data Acquisition and Process Control, ISA, 2nd Edition, 2nd Edition, 1994.

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

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENT

GENERIC ELECTIVE: Signal and image processing (INGE4A)

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		
Signal and image processing (INGE4A)	04	03	-	01	Class XII passed with Mathematics/ Applied Mathematics/ Computer Science/Informatics Practices	Engineering Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the fundamental concepts of signal and Image processing.
- To explore DFT for 1-D and 2-D signal and FFT for 1-D signal
- To apply processing techniques on 1-D and Image signals.
- To apply signal and image processing techniques for edge detection.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply the concept of DT Signal and DT Systems.
- Classify and analyze discrete time signals and systems
- Implements Digital Signal Transform techniques DFT and FFT.
- Use the enhancement techniques for digital Image Processing
- Differentiate between the advantages and disadvantages of different edge detection techniques
- Develop small projects of 1-D and 2-D Digital Signal Processing.

SYLLABUS OF GE-4

UNIT – 1 **(12 hours)**

Discrete Time Signals and Systems: Introduction, discrete time sequences, Examples of sequences – step, impulse, ramp, sine and exponential, properties of signals and sequences, interpolation and decimation, linear time invariant systems and their properties, stability, causality, system responses, convolution and correlation, sum, solutions of system using difference equations, ZIR, ZSR, natural and forced responses. Z-Transform.

UNIT – 2 **(11 hours)**

Discrete Fourier Transform: Introduction to DTFT and DFT, Relation between DFT and DTFT, IDFT, Properties of DFT without mathematical proof (Scaling and Linearity, Periodicity, Time Shift and Frequency Shift, Time Reversal, Convolution Property and Parsevals' Energy Theorem). DFT computation using DFT properties. Transfer function of DT System in frequency domain using DFT. Linear and Circular Convolution using DFT, Convolution of long sequences, Introduction to 2-D DFT.

UNIT – 3 **(11 hours)**

Fast Fourier Transform: Need of FFT, Radix-2 DIT-FFT algorithm, DIT-FFT Flow graph for N=4 and 8, Inverse FFT algorithm. Spectral Analysis using FFT. FIR and IIR filter.

Representation of Digital Image, Image File Formats, Fundamental steps in Digital Image Processing, Elements of visual perception, Image sensing and Acquisition, Image Sampling and Quantization, Imaging geometry.

UNIT – 4 **(11 hours)**

Image Enhancement:

Spatial Domain: Basic relationship between pixels- Basic Gray level Transformations Histogram Processing – Smoothing spatial filters- Sharpening spatial filters.

Frequency Domain: Smoothing frequency domain filters- sharpening frequency domain filters Homomorphic filtering, Image Compression and Image Segmentation

Practical component: **(30 hours)**

1. (a) Represent basic signals like:Unit Impulse, Ramp, Unit Step, Exponential.
   (b) To generate discrete sine and cosine signals with a given sampling frequency.
2. (a) To represent complex exponentials as a function of real and imaginary parts.
   (b) To determine impulse and step response of two vectors using MATLAB.
3. (a) To perform convolution between two vectors using MATLAB.
   (b) To perform cross correlation between two vectors using MATLAB.

4. To compute DFT and IDFT of a given sequence using MATLAB.
5. To perform linear convolution of two sequences using DFT using MATLAB.
6. (a) To determine z-transform from the given transfer function and its ROC using MATLAB.
   (b)To determine rational z-transform from the given poles and zeros using MATLAB.
7. To determine partial fraction expansion of rational z-transform using MATLAB
8. Implementation of Image negative, Gray level Slicing and Thresholding
9. Implementation of Contrast Stretching, Dynamic range compression & Bit plane Slicing
10. Implementation of Histogram Processing, Image smoothing/ Image sharpening

Essential/recommended readings

1. John G. Proakis, Dimitris and G.Manolakis, 'Digital Signal Processing: Principles, Algorithms, and Applications' 4th Edition 2007, Pearson Education.
2. A. Anand Kumar, 'Digital Signal Processing', PHI Learning Pvt. Ltd. 2013.
3. Rafel C. Gonzalez and Richard E. Woods, 'Digital Image Processing', Pearson Education Asia, 3rd Edition, 2009.
4. S. Sridhar, 'Digital Image Processing', Oxford University Press, Second Edition, 2012.

Suggestive readings

1. Sanjit K Mitra, 'Digital Signal Processing: A Computer Based Approach', TataMcGraw Hill, 3rd Edition.
2. S. Salivahanan, A. Vallavaraj, and C. Gnanapriya, 'Digital Signal Processing', Tata McGraw Hill Publication 1st Edition (2010).
3. S. Jayaraman, E. Esakkirajan and T. Veer Kumar, 'Digital Image Processing' TataMcGraw Hill Education Private Ltd, 2009.
4. Anil K. Jain, 'Fundamentals and Digital Image Processing', Prentice Hall of India Private Ltd, 3rd Edition.

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

GENERIC ELECTIVE : Nuclear and Biomedical Instrumentation (INGE4B)

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		
Nuclear and Biomedical Instrumentation (INGE4B)	04	03	-	01	Class XII passed with Physics+ Mathematics/Applied Mathematics/ Biology + Chemistry	Chemistry & Analog Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To gain the basic technical knowledge of biomedical instrumentation.
- To familiarize with various bioelectric signals and understand their source of generation.
- To understand the working principle and applications of medical imaging instruments and the modalities involved in each technique.
- To apprehend the essential operation of the nuclear medicine system.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn the technical vocabulary associated with basic instrumentation and design and fundamental signal analysis
- Develop a clear understanding of the various bioelectric signals produced by the body which could be obtained and analyzed using the basic implementation of Instrumentation
- Explain and compare the origin, instrumentation, and analysis of biological signals produced by the cardiovascular, respiratory, and nervous system

- Understand the basic difference between the working principle, instrumentation, and application of different medical imaging systems such as ultrasound, X-ray, and Computed tomography
- Infer the measurement principle and operating conditions of various detectors used in a nuclear medicine system

SYLLABUS OF GE-4

UNIT – 1 **(7 hours)**

Introduction to bioelectric potential, bio-amplifier, components of man Instrument system, design factors of biomedical instruments, types of biopotential electrodes.

UNIT – 2 **(14 hours)**

Measurement of Biopotentials: Cardiac vascular system, Origin of (Electrocardiography) ECG signals, Instruments of ECG, bipolar system lead system I, II, III, Einthoven's triangle, Augmented lead system, unipolar chest lead system, types of display.

The nervous system, Action potential of the brain, brain wave, Instrumentation Electroencephalography (EEG).

Measurement of Physiological Parameter: Respiratory system, Types of volume, types of measurements, Instrumentations of the respiratory system, pneumograph, principle & types of pneumograph, Spirometer.

UNIT – 3 **(14 hours)**

Medical Imaging System: Ultrasound, properties, beam width, its generation & detection, types of transducers, diagnostic application – A Scan, B Scan, and M Scan

Radiography: Conventional X-ray, properties, generation of X-ray, X-ray Computed Tomography (CT scanner), and Computer-aided tomography (CAT).

UNIT – 4 **(10 hours)**

Medicine System: Introduction to nuclear medicine system, safety aspects, Nuclear detectors, Gas filled detectors: Ionization, Proportional, and Geiger Muller (GM) Counter, Scintillation counter – principle, operating condition.

Practical component: **(30 hours)**

1. Characterization of biopotential amplifier for ECG signals.
2. Study on ECG simulator.
3. Recording of EEG.
4. Heart sound measurement using an electronic stethoscope.
5. Study of pulse rate monitor with alarm system.
6. Determination of pulmonary function.
7. Study on ultrasound transducers based on the medical systems.
8. Study of Respiration Rate monitor/ apnea monitor.
9. Study of conventional X-ray and CT film.

Essential/recommended readings

1. Cromwell L., Wiebell F. J., Pfeiffer EA, Biomedical Instrumentation and Measurements, Prentice Hall, 2nd edition, 2010.
2. Carr J. J, Brown J. M. Introduction to Biomedical Equipment Technology, Fourth edition, Pearson Education, Inc, 4th edition, 2010.
3. Khandpur R.S., Handbook of Biomedical Instrumentation, Tata McGraw-Hill Publishing, India, 2nd edition, 2009.
4. Joseph D. Bronzino, The Biomedical Engineering Handbook, 4th Edition (2015), Volume 1, IEEE Press.

Suggestive readings

1. Richard Aston, Principles of Biomedical Instrumentation & Measurement, 1st edition, Merrill Publishing Company (1990).
2. Mandeep Singh, Introduction to Biomedical Instrumentation, 2nd Edition, PHI learning private limited (2014).

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

SEMESTER-V
DEPARTMENT OF INSTRUMENTATION
Category I

(B.Sc. Honours in Instrumentation)

DISCIPLINE SPECIFIC CORE COURSE – 13: Advance Biomedical Instrumentation (INDSC5A)

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		
Advance Biomedical Instrumentation (INDSC5A)	04	02	-	02	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Biomedical & Electronic Instrumentation

Learning Objectives

The Learning Objectives of this course are as follows:

- To realize the importance of the instruments used in critical care units of the hospital.
- To understand the principle behind the measurement of biochemical signals.
- To understand the concept of instruments used in medical imaging diagnostics and therapeutics.
- To appreciate the efficiency of the surgical and diathermy apparatus in the medical incision.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand instruments used in critical care and operating units of hospitals
- Gain knowledge of the instruments used for biochemical analysis in healthcare
- Understand the concepts of various medical imaging techniques and their applications

- Understand instruments used for medical assistance and therapy

SYLLABUS OF DSC-13

Unit-1 **(8 Hours)**

Ventilators: Basic principles and types of ventilators.

Anaesthesia Machine: Need of anaesthesia, anaesthesia delivery system, breathing circuits. **Clinical Laboratory Instruments**: General principle and working of Blood Gases Analyzer, Auto-analyser, Blood Cell Counters, ELISA reader.

Unit-2 **(8 Hours)**

Medical Imaging System: Ultrasound, properties, its generation & detection, types of transducers, real-time ultrasonic imaging, linear array scanners, X-ray computed tomography (CT Scanner) principle, contrast scale, scanning system, processing Unit, viewing, storage. Magnetic Resonance Imaging: Basic principle, working and construction.

Unit-3 **(6 Hours)**

Nuclear Medicine System: radioactive emissions, gamma camera, imaging system, ECT (emission coupled tomography) and its different approaches: positron emission tomography (PET), Single-photon emission computed tomography (SPECT).

Unit-4 **(8 Hours)**

Surgical Scopy and Diathermy Equipments: Fibre Optics- Endoscopes -light sources, video processors, camera, and fibre optic cable, Principles and applications. Diathermy: Working Principle, Construction, and different types (Infrared radiation (IR), ultraviolet (UV), short wave, microwave, ultrasonic, and Surgical Diathermy).

Practical component: **(60 Hours)**

1. Study of ultrasound transducers based on the medical system.
2. Study of vital organs (such as Heart, Kidney, liver, etc) using Ultrasonography.
3. Demonstration of X-ray/Computed Tomography/nuclear imaging.
4. Experiment based on clinical instruments such as Blood cell counter/ ELISA reader.
5. Estimation of serum total protein using a spectrometer.
6. Estimation of sodium and potassium in blood serum or urine sample.
7. Project based on designing and applications of Biomedical Instrumentation.

Essential/recommended readings

1. Carr J. J, Brown J. M. Introduction to Biomedical Equipment Technology, Fourth edition, Pearson Education Inc (2010), 2nd edition
2. Khandpur R.S., Handbook of Biomedical Instrumentation, Second edition, Tata McGraw- Hill Publishing (2009), 2nd edition

3. Joseph D. Bronzino, The Biomedical Engineering Handbook, IEEE Press (2015), 4th edition, Volume 1.
4. Richard Aston, Principles of Biomedical Instrumentation & Measurement, Merrill Publishing Company, (1990), 1st edition
5. Mandeep Singh, Introduction to Biomedical Instrumentation, PHI learning private limited (2014), 2nd Edition.
6. Cromwell L., Wiebell F. J., Pfeiffer EA, Biomedical Instrumentation and Measurements, Second edition, Prentice Hall (2010), 2nd Edition.

Suggestive readings

1. John G Webster, Medical Instrumentation Applications and Design, John Willey, 5th Edition, 2020.
2. L A Geddes, L E Baker, Principles of Applied Medical Instrumentation, John Wiley, Edition 3, 1989.

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

DISCIPLINE SPECIFIC CORE COURSE – 14: Essentials of microprocessor 8085 & 8086 (INDSC5B)

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		
Essentials of microprocessor 8085 & 8086 (INDSC5B)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Digital Electronics

Learning Objectives

- To understand the general architecture of a microcomputer system
- To comprehend the architecture and organization of 8085 and 8086 microprocessor
- To learn the Interfacing of 8-bit microprocessor with memory and peripheral chips involving system design
- To interpret and classify the instruction set of 8085 microprocessor and distinguish the use of different instructions and apply it in assembly language programming
- To understand difference between RISC and CISC based microprocessors

Learning outcomes

- Describe the general architecture of a microcomputer system
- Understand the architecture and organization of 8085 and 8086 microprocessor
- Learn the Interfacing of 8-bit microprocessor with memory and peripheral chips involving system design
- Interpret and classify the instruction set of 8085 microprocessor and distinguish the use of different instructions and apply it in assembly language programming
- Differentiate between RISC and CISC based microprocessors

- Understand the architecture and operation of Programmable Interface Devices and realize the programming & interfacing of it with 8085 microprocessor

SYLLABUS OF DSC-14

Unit-1 **(15 hours)**

8085 Microprocessor: Introduction to Microprocessor 8085, Pin description of 8085, Architecture, registers of 8085, addressing modes. Instruction Type and Instruction Set, Machine Cycle, Instruction Cycle, Timing Diagram, Memory System, Hardware Interfacing or Types of I/O Addressing-Interfacing Memory and Peripheral (I/o Mapped I/O and memory mapped I/O)

Unit-2 **(10 hours)**

Programming: Assembly Language Programming, Stacks and Subroutine

Interrupts of 8085: Hardware and Software interrupts, Difference between RISC and CISC Processor

Unit-3 **(10 hours)**

Interfacing ICs: Programmable Peripheral Interface: 8255, 8253

Unit-4 **(10 hours)**

Introduction to 8086 Microprocessor: Introduction to microprocessor 8086: Architecture of 8086, Pin Diagram, Physical memory organization, Memory Segmentation (8086), General bus operation, Minimum and Maximum Mode, Addressing modes (8086), Difference between microprocessor and microcontroller.

Practical component: **(30 hours)**

1. To write an assembly language program to perform-addition, subtraction.
2. To write an assembly language program to find count of even numbers/odd numbers from given block of data.
3. To write an assembly language program to find largest/smallest number in given block of data.
4. To write an assembly language program to perform-multiplication, division.
5. To write an assembly language program to convert a number from one number system to another.
6. To perform addition/subtraction by interfacing 8085 with 8255 in simple I/O and polling mode.
7. To generate a square/rectangular wave by interfacing 8253 with 8085.
8. To write an assembly language program to generate first N terms of an A.P. series.
9. To write an assembly language program to generate first N terms of Fibonacci series.
10. To write an assembly language program to arrange the given list of number in ascending / descending order.

Essential/recommended readings

1. Ramesh Gaonkar, Microprocessors architecture, programming and Applications, WileyEastern Ltd. (2013), 6th Edition.
2. P.K Ghosh & P.R Sridhar, 0000 to 8085 microprocessor, John Wiley & Sons, 2nd Edition.
3. Liu Gibson, Microprocessor Systems: The 8086/8088 family Architecture, Programming&Design, PHI, 2015, 2nd Edition.
4. K. Udaya Kumar & B.S. Uma Shankar, The 8085 Microprocessor: Architecture, Programming, and Interfacing", Pearson Education, 1st Edition, 2008.
5. Barry B. Brey and C R Sarma, The Intel Microprocessors 8086/8088, 80186/80188, 80286,80386, 80606, Pearson Education Limited, 8th Edition, 2005.
6. K. M. Bhurchandi, *Advanced Microprocessors & Peripherals*. Tata McGraw-Hill Education, 2013.

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

DISCIPLINE SPECIFIC CORE COURSE – 15: Power devices and Electrical Machines (INDSC5C)

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 devices and Electrical Machines (INDSC5C)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- Use of electronics for control and conversion of electrical power.
- To learn various high-power devices, their construction, and their applications.
- To understand the working, construction, and principle of DC and AC machines.
- To provide the clear understanding of working and construction of Transformer
- To give knowledge about different types of Power Supply.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand different power devices and study their construction, characteristics and turning on circuits.
- Understand the analysis of controlled rectifiers for different loads, inverters, DC choppers and AC voltage controllers.
- Familiarize with the basics of DC Machines, Generators and Motors.
- Acquire knowledge about fundamental of Transformer.

SYLLABUS OF DSC-15

Unit-1 **(13 Hours)**

Power Devices and their applications: SCR, structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Factors affecting the characteristics/ratings of SCR, and Gate-triggering circuits. Applications of SCR: Basic series inverter circuit, Chopper

circuit – Basic concept, step up and step-down choppers. Diac and Triac: Basic structure, working and I-V characteristic of, application of a Diac as a triggering device for a Triac.

Unit-2 **(13 Hours)**

Types of Motor: Comparison of the generator and motor action & interchangeability, the principle of operation, the significance of back EMF, maximum power, Torque and speed relation, Characteristics of series, shunt and Compound excited motors & applications, losses & efficiency, the necessity of motor starters, Three-point starter, Speed control of DC motors. Induction Motors, Single and three phase Motors, Stepper Motors, and Servo Motors.

Unit-3 **(10 Hours)**

Transformer: Types of transformers, Transformer Construction, E.M.F. equation, Transformer Losses, Condition for maximum efficiency, all day efficiency, Auto transformers.

Unit-4 **(9 Hours)**

Supplies: Regulated power supply, Uninterrupted power supply (UPS) and Switched mode power supply (SMPS).

Practical Components **(30 Hours)**

1. Study of I-V characteristics of DIAC
2. Study of I-V characteristics of a TRIAC
3. Study of I-V characteristics of an SCR.
4. Study of Load characteristics of D.C. motor.
5. Study of Speed control of D.C. motor.
6. Study of Load characteristics of Servomotor.
7. Study of speed control and blocked rotor test on single phase Inductor motor.

Essential/recommended readings

1. Electrical Technology, 25th Edition (2017), B. L. Thareja and A. K. Thareja, S. Chand & Sons.
2. Power Electronics: Circuits, Devices and Applications, 3rd Edition (2014), M.H. Rashid, Pearson Education
3. Power Electronics, 2nd Edition (2007), M. D. Singh, K. B. Khanchandani, Tata McGraw Hill.
4. Electronic Principles, 7th Edition (2007), A. Malvino, D. J. Bates, Tata McGraw Hill.
6. Power Electronics, 4th Edition (2002), P. S. Bimbhra, Khanna Publishers.

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 ELECTIVE COURSE: Reliability and Quality Control (INDSE5A)

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		
Reliability and Quality Control (INDSE5A)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics/ + Chemistry/Computer Science/Informatics Practices	Statistics & probability

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide the thorough understanding of concepts of reliability
- To clarify the basic knowledge of quality concepts and techniques for quality improvement
- To teach, how to use various control charts for improving the product quality
- To provide the clear understanding of different sampling plans and methods

Learning outcomes

The Learning Outcomes of this course are as follows:

- Acquire the basic knowledge of quality concepts and techniques for quality improvement
- Learn to use various control charts for improving the quality of products
- Describe and compare the different sampling plans and methods
- Understand the concepts of reliability

SYLLABUS OF DSE-3

UNIT – 1 **(12 hours)**

Quality Concepts: Meaning of Quality, Approaches- Deming's Approach, Juran's Approach, Quality of Product, Quality of Service, Cost of Quality, Value of Quality, Difference between Inspection, Quality Control and Quality Assurance, Evaluation of Quality control, Quality Improvement Techniques Pareto Diagrams, Cause-Effect Diagrams Quality Circles, Kaizen, six sigma.

UNIT – 2 **(11 hours)**

Control Charts: Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, ARL, sensitizing rules for control charts, Control Charts for X-bar & R and control chart for attribute (p, np, c).

UNIT – 3 **(11 hours)**

Acceptance Sampling: Meaning, objective, and types of research, approaches, Principle of acceptance sampling, Producer's and consumer's risk. AOQL and LTPD, Sampling plans: single, double, OC curve.

UNIT – 4 **(11 hours)**

Reliability: Different types and modes of failure, causes of failure in electronic components, reliability theory, hazard rate, failure density function, availability, maintainability, mean time to failure and repair system structures: series, parallel, K-type, Fault tree analysis.

Practical component: **(30 hours)**

1. Descriptive statistics
2. Control charts for variable
3. Control charts for attribute
4. OC curve
5. Single sampling and double sampling
6. AOQ curve

Essential/recommended readings

1. D. C. Montgomery , Introduction to Statistical Quality Control, 8th edition, John Wiley and sons (2019).
2. Reliability Engineering by S.Shreenath, 4th Edition, East West Press (2008).
3. Statistical Quality Control by M. S. Mahajan, 1st Edition, Dhanpat Rai Publishing Co Pvt Ltd (2016).

Suggestive readings

1. Reliability Engineering and Quality Management by O.N. Pandey & Bhupesh Aneja, 1st Edition, 2011.
2. Modern Methods for Quality Control and Improvement, by Harrison M. Wadsworth, Kenneth S. Stephens, A. Blanton Godfrey, Second edition (17 May 2008)

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

DISCIPLINE SPECIFIC ELECTIVE COURSE : Communication Systems (INDSE5B)

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		
Communication Systems (INDSE5B)	04	03	-	01	Class XII passed with Physics + Mathematics/ Applied Mathematics+ Chemistry /Computer Science/Informatics	Analog and Digital Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand basic elements of a communication system.
- Analyze baseband signals in time and frequency domain.
- Understand various analog and digital modulation/demodulation techniques along with their performances in various transmission environments.
- To understand working of radio receivers and transmitters

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn in detail about the various components of communication systems like transmitter, modulator, channel, and receiver
- Gain in-depth knowledge of analog (amplitude, frequency, and phase) and digital modulation and demodulation techniques
- Understand different multiplexing techniques for efficient utilization of available bandwidth

SYLLABUS

Unit-1 **(10 hours)**

Basic communication system: Block diagram, Noise, Analog and digital communication, Types of communication systems: optical communication, cellular communication and satellite communication, LAN

Unit-2 **(11 hours)**

Amplitude Modulation, Frequency and phase modulation: Definition - AM waveforms - Frequency spectrum and bandwidth - Modulation index - DSB-SC, SSB-SC, Vestigial SB - Comparison and application of various AM schemes, Definition-Relationship between FM & PM - Frequency deviation - Spectrum and transmission BW of FM, comparison of AM and FM systems.

Unit-3 **(12 hours)**

Radio Transmitter and Receiver: AM transmitters-High level and low level transmitters - SSB transmitters - FM transmitters - Block diagram. AM receivers-operation - performance parameters - Communication Transceivers - Block diagram - SSB receiver - FM receivers - Block diagram.

Unit-4 **(12 hours)**

Digital Communication: Pulse Analog Modulation: Sampling theorem, Errors in Sampling. Pulse Amplitude Modulation (PAM), Time Division Multiplexing (TDM). Pulse Width Modulation (PWM) and Pulse Position Modulation(PPM). Generation and detection of PAM, PWM, PPM, PCM- Need for digital transmission, Quantizing, Uniform and Non-uniform Quantization, Quantization Noise, Companding, Coding, Digital Formats. Decoding, Regeneration, Transmission noise and Bit Error Rate. Differential Pulse Code Modulation, Delta Modulation, Quantization noise, Adaptive Delta Modulation.

Practical component: **(30 hours)**

1. Study of Amplitude Modulation and Demodulation
2. Study of Frequency Modulation and Demodulation
3. Study of Single Side Band Modulation and Demodulation
4. Study of AM Transmitter and Receiver
5. Study FM Transmitter and Receiver
6. Study of Pulse Amplitude Modulation
7. Study of Pulse Width Modulation
8. Study of Pulse Position Modulation
9. Study of Pulse Code Modulation

Essential/recommended readings

1. Electronic communication systems- Kennedy, 3rd edition, McGraw international publications
2. Principles of Electronic communication systems – L. E. Frenzel, 3rd edition, McGraw Hill
3. Modern Digital and Analog Communication Systems, B. P. Lathi (2nd Edition).
4. Communication systems, R.P.Singh and S.D.Sapre 2nd edition TMH 2008
5. Advanced electronic communications systems – Tomasi, 6th edition, PHI
6. L. W. Couch II, Digital and Analog Communication Systems, Pearson Education.
7. T. G. Thomas and S. Chandra Sekhar, Communication Theory, Tata McGraw Hill.

Suggestive readings

1. H. Taub and D. Schilling, Principles of Communication Systems, Tata McGraw Hill
2. W. Tomasi, Electronic Communication Systems: Fundamentals through Advanced, Pearson Education
3. S. Haykin, Communication Systems, Wiley India.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE : Computer Aided Design (INDSE5C)

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		
Computer Aided Design (INDSE5C)	04	02	-	02	Class XII passed with Physics + Mathematics/Applied Mathematics+ Chemistry / Computer Science/Informatics	Analog and Digital Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with MultiSim and PSPICE circuit simulation tools
- To verify response of various analog and digital circuits
- To provide knowledge of Industry standard TCAD simulation tools like Silvaco-ATLAS and and Synopsis-SENTAURUS

Learning outcomes

The Learning Outcomes of this course are as follows:

- Simulate and verify the functionality of diodes and transistor circuits using MultiSim and PSpice software
- Design and verify devices/ circuits using TCAD tools

SYLLABUS OF DSE-3

UNIT – 1 **(6 hours)**

Introduction to Multisim software: MultiSim Environment: Design Process, setting environment preferences, Multisim GUI, Schematic capture of circuits: Placing components, wiring components, Measuring instruments in MultiSim, simulation and result display in MultiSim

UNIT – 2 **(6 hours)**

Electronics circuit design using Multisim: Resistive circuits, Design of Bridge rectifier, Half-Wave rectifier, clippers and clampers using a diode, DC transfer curve analysis, Transient analysis, simulation of digital circuits.

UNIT – 3 **(8 hours)**

Introduction to PSpice software Understanding the SPICE Environment, Schematic Designing Brief Introduction of p spice simulator, Using Model Editor, Understanding the PSPICE Environment, Using Magnetic Parts Editor, Using Stimulus Editor, Drawing a Circuit Preparation for Simulation: Preparing schematic for simulation, Understand the sources for simulation, Understand different markers and errors

UNIT – 4 **(10 hours)**

Introduction to Industry standard TCAD tools, Silvaco- ATLAS device simulation software, Synosis-SENTAURUS. Online Simulation resources-NANOHUB. Simulation of n-channel MOSFET; Silicon on Insulator.

Practical component: **(60 hours)**

1. Designing RC Low pass filter using MULTISIM
2. Designing active RC Low pass filter (OpAmp based) using MULTISIM
3. Half wave rectifier using MULTISIM
4. Wein bridge Oscillator using MULTISIM
5. Simulating high pass filter Circuit using PSPICE
6. Designing active RC High pass filter (OpAmp based) using PSPICE
7. Half wave rectifier using PSPICE
8. Designing and Simulating Full wave rectifier using PSPICE
9. Output characteristics of MOSFET using SILVACO-ATLAS/ Synopsis TCAD
10. Transfer characteristics of MOSFET using SILVACO-ATLAS/ Synopsis TCAD

Essential/recommended readings

1. Introduction To PSpice Using OrCADfor Circuits and Electronics, Muhammad H. Rashid,Paperback – Import,3rd Edition, 2003.
2. Electronic Devices and circuit theory, Robert Boylstead and Louis Nashelsky, PHI, 10th Edition, 2009.
3. https:i/nanohub.org/resources/tools
4. https ://www.silvaco. com/contenVkbase/device.pdf

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

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENT

GENERAL ELECTIVE COURSE : Industrial Safety Instruments (INGE5A)

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		
Industrial Safety Instruments (INGE5A)	04	03	-	01	Class XII passed with Mathematics/Applied Mathematics/ Biology/+ Chemistry + Physics	Class XII Science

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge on design features for a process industry and safety in the operation of various equipment in industry.
- To understand the various hazards and prevention in the commissioning stage of industry.
- To recognise and identify the safe operation of equipment in the process industry.
- To plan and train for emergency planning in a process industry.
- To get fundamental knowledge on safe storage of chemicals.

Learning outcomes

The Learning Outcomes of this course are as follows:

- This course would make them familiar with safe design of equipment which are essential to the chemical industry and leads to the design of entire process industries.
- Students would understand the problems and find innovative solutions while industries facing problems in commissioning and maintenance stages.

- Students would understand the chemical plant operations.
- Students can prepare emergency planning for chemical industry problems.
- Students would be able to create safe storage systems

SYLLABUS OF GE-5

UNIT – 1 **(11 hours)**

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages. Design process, conceptual design and detail design.

UNIT – 2 **(11 hours)**

Personal protection in work environment

Personal protection in the work environment, Types of PPEs, Personal protective equipment respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

UNIT – 3 **(12 hours)**

Electrical safety and hazards

Introduction – electrostatics, electromagnetism, stored energy, energy radiation and electromagnetic interference –Indian electricity act and rules-statutory requirements from electrical inspectorate- international standards on electrical safety – first aid-cardiopulmonary resuscitation (CPR). Primary and secondary hazards - shocks, burns, scalds, falls - Human safety in the use of electricity - Classes of insulation-voltage classifications -current surges- over current and short circuit current-heating effects of current electrical causes of fire and explosion. Lightning hazards, lightning arrestor, installation – earthing, specifications, earth resistance, earth pit maintenance.

UNIT – 4 **(11 hours)**

Hazard and risk, Types of hazards Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS)

Practical component: **(30 hours)**

1. Conduct the inspection and evaluate the hazards using analytical instruments and methods.
2. Conduct unaided safety inspection of a workplace, identifying the more common hazards, deciding whether they are adequately controlled and, where necessary, suggesting appropriate and cost effective remedial action.
3. At the end of the course a safety assessment report can be added in the Mini project report along with Industry inspection report.

Essential/recommended readings

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
3. Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi.
4. John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All IndiaTraveller Book Seller, Delhi.
5. Ronald P. Blake. (1973). Industrial safety. Prentice Hall, NewDelhi.

Suggested books

1. Alan Waring. (1996). Safety management system. Chapman & Hall, England.
2. Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai
3. Montgomery, D.C., “Design and Analysis of experiments”, John Wiley and Sons, 8th edition, 2012.

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

GENERAL ELECTIVE COURSE : Instruments for chemical analysis (INGE5B)

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		
Instruments for chemical analysis (INGE5B)	04	03	-	01	Class XII passed with Mathematics/Applied Mathematics/ Biology/ + Chemistry + Physics	Analog electronics and Chemistry till class XII

Learning Objectives

- To understand the principle, instrumentation, characteristics and working mechanisms of common spectroscopic, chromatographic, and potentiometric instruments
- To learn about the applications of potentiometry, GC and HPLC in different industries (food, chemical, pharmaceutical, petroleum, etc.)
- To understand the concept of qualitative and quantitative analysis
- To understand the planar and column chromatography for different applications

Learning outcomes

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

- Understand the principle, instrumentation, characteristics and working mechanisms of common spectroscopic, chromatographic, and potentiometric analytical instruments.
- Explore the potential of analytical techniques of potentiometry, GC and HPLC in different industries (food, chemical, pharmaceutical, petroleum, etc.
- Carry out the qualitative and quantitative analysis of a given sample.
- Utilize planar and column chromatography for different applications.

SYLLABUS OF GE-5

Unit-1 **(11 hours)**

Molecular Spectroscopy: Ultraviolet-Visible (UV-Vis) spectroscopy: principle, instrumentation, and applications. Infra-Red spectroscopy: principle, instrumentation, and applications

Unit-2 **(10 hours)**

Atomic spectroscopy: Theory, instrumentation and application of flame photometry and atomic-absorption spectroscopy.

Unit-3 **(14 hours)**

Planar chromatography: Theory and application of paper and thin layer chromatography. Column chromatography: Principle, instrumentation and application of Gas Liquid Chromatography and High-Performance Liquid Chromatography.

Unit-4 **(10 hours)**

Potentiometry: Introduction, reference and indicator electrodes, ion selective electrodes: glass electrode and its applications.

Practical component: **(30 hours)**

1. Verification of Beer's Law and determination of concentration of the unknown solution using colorimeter.
2. Spectrometric determination of iron using a double beam spectrophotometer.
3. To learn the operation of a pH meter and determine pKa value for bromophenol blue using a double beam spectrophotometer.
4. To study the effect of organic solvents on membrane permeability of beetroot using colorimeter/ spectrophotometer.
5. Determination of concentration of solutes in a mixture using colorimeter.
6. Spectrum analysis using FT-IR (Qualitative analysis).
7. Determination of concentration of sodium, calcium, lithium and potassium in sample using flame photometer.
8. Paper chromatographic separation of samples from different origins (Biological/pharmaceutical/food).
9. Thin layer chromatographic (TLC) separation of samples from different origin (Biological/pharmaceutical/food).
10. Qualitative and quantitative analysis of organic compounds using Gas chromatography.

Essential/recommended readings

1. Skoog & Lerry, Instrumental Methods of Analysis, Saunders College Publications, New York, 4th edition, 1970.

2. H.H. Willard, L.L Merrit, J.A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishers, 7th edition, 1988.
3. Skoog, Holler and Crouch, Principles of Instrumental Analysis, Cengage Learning, 6th edition, 2007
4. James W. Robinson, Eileen Skelly Frame, George M. Frame II, Undergraduate Instrumental Analysis, CRC Press, 7th edition, 2014
5. Vogel's Textbook of Qualitative Chemical Analysis, ELBS, 4th edition 1978.

Suggestive readings

1. W. Kemp, Organic Spectroscopy, ELBS, 3rd Edition, 1996.
2. R.S Khandpur, Handbook of Analytical Instruments, Tata McGraw-Hill, 3rd Edition 2006.
3. B.K Sharma, Instrumental Methods of Chemical Analysis, Krishna Prakashan Media, 1st Edition, 2011

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

Semester-VI
ELECTRONIC SCIENCE

DEPARTMENT OF INSTRUMENTATION
Category I

(B.Sc. Honours in Instrumentation)

DISCIPLINE SPECIFIC CORE COURSE – 16: Analytical Instrumentation II (INDSC6A)

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		
Analytical Instrumentation II (INDSC6A)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Understanding of electronics and Chemistry till class XII

Learning Objectives

- To understand the perspective of different advanced analytical methods
- To understand the principle, instrumentation, and application of various electro analytical instruments
- To disseminate with principle and instrumentation of thermo analytical instruments along with their applications for analysing products of different origin
- To familiarize with detail principle, instrumentation, operation and applications of IR spectroscopy
- To differentiate between principle, instrumentation and operation of Atomic absorption and atomic emission spectroscopy.
- To understand the principle, instrumentation, and applications of Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC)

Learning outcomes

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

- Appreciate the potential of different analytical methods for resolving various scientific challenges.
- Describe the principle, instrumentation and application of electro analytical instruments.
- Understand the principle and instrumentation of thermo analytical instruments along with their applications for analyzing products of different origin.
- Understand the different terms, principle, instrumentation, operation, and applications of IR spectroscopy.
- Differentiate between principle, instrumentation and operation of atomic absorption spectroscopy and atomic emission spectroscopy.

SYLLABUS OF DSC-16

Unit-1 **(14 hours)**

Infrared Spectroscopy: Theory, diatomic molecule as a simple harmonic oscillator, instrumentation, sample handling techniques. Fourier Transform Infrared Spectroscopy (FTIR): instrumentation and advantages.

Atomic Spectroscopy: Principle, comparison of atomic and molecular spectroscopy, Atomic emission spectroscopy (AES): Flame photometer and its instrumentation, atomization process, types of flames- fuel/ oxidant combinations, instrumentation, Interferences and applications. Introduction to Atomic absorption spectroscopy (AAS).

Unit-2 **(10 hours)**

Electro analytical Methods of Analysis: Potentiometry: Introduction, reference electrode, indicator electrodes, ion-selective electrodes: glass electrode and liquid membrane electrode and their applications, potentiometric titrations.

Unit-3 **(12 hours)**

Gas Chromatography (GC): Principle, Carrier gasses, different types of injection systems, columns, stationary phases, and detectors. Isothermal mode, temperature-programming mode, applications.

Unit-4 **(9 hours)**

High Performance Liquid Chromatography (HPLC): mobile phase, isocratic and gradient elution, pumps, injection systems, columns, stationary phases, normal phase and reverse phase chromatography, detectors, and applications.

Practical component: **(30 hours)**

1. Determination of concentrations of sodium/calcium/lithium/potassium in sample using Flame Photometer.

2. Determination of concentration of sodium/calcium/lithium/potassium ions in sample by standard addition method using flame photometer
3. Spectrum interpretation using FTIR.
4. Qualitative/Quantitative analysis of samples using Gas chromatography.
5. Qualitative/Quantitative analysis of samples using High Performance Liquid Chromatography
6. Potentiometric titrations: (i) Strong acid with strong base (ii) weak acid with strong base and (iii) dibasic acid with strong base
7. Potentiometric titration of Mohr's salt with potassium dichromate
8. pH metric titrations of (i) strong acid and strong base (ii) weak acid and strong base

Essential/recommended readings

1. Skoog & Lerry, Instrumental Methods of Analysis, Saunders College Publications, New York, 4th edition, 1970.
2. H.H. Willard, L.L Merrit, J.A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishers, 7th edition, 1988.
3. Skoog, Holler and Crouch, Principles of Instrumental Analysis, Cengage Learning, 6th edition, 2007
4. James W. Robinson, Eileen Skelly Frame, George M. Frame II, Undergraduate Instrumental Analysis, CRC Press, 7th edition, 2014
5. Vogel's Textbook of Qualitative Chemical Analysis, ELBS, 4th edition 1978.

Suggestive readings

1. W. Kemp, Organic Spectroscopy, ELBS, 3rd Edition, 1996.
2. R.S Khandpur, Handbook of Analytical Instruments, Tata McGraw-Hill, 3rd Edition 2006.
3. B.K Sharma, Instrumental Methods of Chemical Analysis, Krishna Prakashan Media, 1st Edition, 2011

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

DISCIPLINE SPECIFIC CORE COURSE – 17: Analog Devices and Circuits (INDSC6B)

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		
Analog Devices and Circuits (INDSC6B)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce different types of diodes like Tunnel diode, Varactor diode, Schottky diode, Photodiode etc.
- To explain construction and characteristics of JFETs, MOSFETs and UJT
- The student should be able to explain and calculate small signal parameters of MOSFET.
- To learn the basics of MOSFET Circuits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Explain the operation of Tunnel diode, Varactor diode, Schottky diode, Photodiode etc.
- Reproduce the I-V characteristics of JFET, MOSFET and UJT.
- Analysis of the operation of MOS transistor
- Ability to understand the fundamentals of MOSFET circuits.

SYLLABUS OF DSC-17

UNIT – 1 **(8 hours)**

Special purpose electronic devices: Principal of operation and Characteristics of Tunnel Diode, Varactor Diode, Schottky Diode, Photo diode, Photoconductive cells, IR emitter, Liquid crystal displays, Solar cells, and Thermistor.

UNIT – 2 **(12 hour)**

Junction Field Effect Transistors (JFET): JFET, Construction, Idea of Channel Formation, Pinch-Off and Saturation Voltage, Current-Voltage Output Characteristics. FET Amplifiers: FET Common source Amplifier, Common Drain Amplifier, Generalized FET Amplifier, FET biasing.

UNIT – 3 **(13 hours)**

Metal Oxide Semiconductor Field Effect Transistor (MOSFET): Types of MOSFETs, Circuit symbols, Working and Characteristic curves of Depletion type MOSFET (both N channel and P Channel) and Enhancement type MOSFET (both N channel and P channel). Biasing of MOSFETs, Small Signal Parameters, Common Source amplifier circuit analysis.

UJT, Basic construction and working, Equivalent circuit, intrinsic Standoff Ratio, Characteristics, and Relaxation oscillator

UNIT – 4 **(12 hours)**

MOS Inverter: Introduction, Voltage Transfer Characteristic (VTC), Noise Immunity and Noise margins, Resistive-Load Inverter, CMOS Inverter, DC Characteristics of CMOS Inverter, Calculation of VIL, VIH, VOL, VOH and Vth, Design of CMOS Inverters, Supply Voltage Scaling in CMOS Inverters, Power, and Area considerations

Practical component: **(30 hours)**

1. To verify practically the response of various special purpose electronic devices.
2. To Study the I-V Characteristics of JFET.
3. To Study the I-V Characteristics of MOSFET
4. To obtain the frequency response of a MOSFET amplifier in common source configuration with given specifications.
5. To Study I-V Characteristics of the UJT.
6. NMOS inverter: (a)Transient analysis using Step input and Pulse input. (b) DC analysis (VTC).
7. CMOS inverter: (a)Transient analysis using Step input and Pulse input. (b) DC analysis (VTC).

Essential/recommended readings

1. R. L. Boylestad, L. Nashelsky, K. L. Kishore, Electronic Devices and Circuit Theory, Pearson Education (2006)
2. J. R. C. Jaegar and T. N. Blalock, Microelectronic Circuit Design, Tata McGraw Hill (2010)
3. Donald E. Neaman, “Electronic Circuit, Analysis and Design”, Tata McGraw Hill Publishing Company Limited, Second Edition, 2006.
4. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (2001)
5. CMOS Digital Integrated circuits – Analysis and Design by Sung – Mo Kang, Yusuf Leblebici, TATA McGraw-Hill Pub. Company Ltd.

Suggestive readings

1. D. L. Schilling and C. Belove, Electronic Circuits: Discrete and Integrated, Tata McGraw Hill (2002)
2. Michael Shur, “Physics of Semiconductor Devices,” Prentice Hall
3. Thomas L. Floyd, David M. Buchla, Electronics Fundamentals: Circuits, Devices & Applications, 8th Edition, Pearson education, 2014.

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

DISCIPLINE SPECIFIC CORE COURSE – 18: Control Systems (INDSC6C)

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		
Control Systems (INDSC6C)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Engineering Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To study how to interpret and apply block diagram representations of control systems and design PID controllers based on empirical tuning rules
- To help the students understand and practice feedback and feed-forward control architecture and discuss the importance of performance, robustness and stability in control system design
- To teach about how to solve the steady state and transient analysis of a system for standard inputs
- Introduce students how to compute stability of linear systems using the Routh array test and use this to generate control design constraints
- To teach students the use Evans root locus techniques in control design for real world systems

Learning outcomes

The Learning Outcomes of this course are as follows:

- Interpret and apply block diagram representations of control systems and design PID controllers based on empirical tuning rules
- Define and explain feedback and feed-forward control architecture and discuss the importance of performance, robustness and stability in control system design
- Solve the steady state and transient analysis of a system for standard inputs

- Compute stability of linear systems using the Routh array test and use this to generate control design constraints
- Use Evans root locus techniques in control design for real world systems
- Compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability

SYLLABUS OF DSC-18

UNIT – 1 **(11 hours)**

Introduction to Control System: Introduction of open loop and closed loop control systems, mathematical modelling of physical systems (Electrical, Mechanical), derivation of transfer function, Armature controlled and field controlled DC servomotors, block diagram representation & signal flow graph, reduction technique, Mason's Gain Formula, effect of feedback on control systems.

UNIT – 2 **(11 hours)**

Time Domain Analysis: Time domain performance criteria, transient response of first, second, steady state errors and static error constants, performance indices.

Concept of Stability: Asymptotic stability and conditional stability, Routh – Hurwitz criterion, relative stability analysis, Root Locus plots and their applications.

UNIT – 3 **(12 hours)**

Frequency Domain Analysis: Frequency Domain Analysis: Correlation between time and frequency response, Polar plots, frequency domain specifications, Logarithmic plots (Bode Plots), gain and phase margins, Nyquist stability criterion, relative stability using Nyquist criterion.

UNIT – 4 **(11 hours)**

State Space Analysis: Definitions of state, state variables, state space, representation of systems, Solution of time invariant, homogeneous state equation, state transition matrix and its properties.

Controllers and Compensation Techniques: Basic Control Actions: Proportional, Integral and Derivative controls, response with P, PI and PID Controllers, Basic concept of compensation, Lag, Lead and Lag-Lead networks.

Practical component: **(30 hours)**

1. To study characteristics of :
   a. Synchro transmitter receiver
   b) Synchro as an error detector
1. To study position control of DC motor
2. To study speed control of DC motor
3. To find characteristics of AC servo motor
4. To study time response of type 0,1 and 2 systems
5. To study frequency response of first and second order systems

6. To study time response characteristics of a second order system.
7. To study effect of damping factor on performance of second order system
8. To study frequency response of Lead and Lag networks.
9. Study of P, PI and PID controller.

Essential/recommended readings

1. J. Nagrath& M. Gopal, Control System Engineering, New Age International, 2021, 7th Edition.
2. K. Ogata, Modern Control Engineering, Prentice Hall of India, 2015, 5th Edition.
3. B. C. Kuo , "Automatic control system", Prentice Hall of India, 2010, 9th Edition.
4. B. S. Manke, Linear Control Systems, Khanna Publishers, Delhi, 7th Edition.

Suggestive readings

1. N.K Jain, Automatic Control System Engineering, DhanpatRai Publication, 2019, Standard Edition.
2. Veenadevi S V and Sujatha Hiremath, Control System, I K International Publishing House Pvt Ltd, 2022.

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 ELECTIVE COURSE : Artificial Intelligence (INDSE6A)

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		
Artificial Intelligence (INDSE6A)	04	03	-	01	Class XII passed with Physics + Mathematics /Applied Mathematics + Chemistry / Computer Science/Informatics Practices	Class XII Mathematics, Any programming language

Learning Objectives

The Learning Objectives of this course are as follows:

- To realize the significance of Artificial Intelligence and expert systems in today‟s era
- To study neural networks and become able to design neural network based algorithms
- To study fuzzy logic and use it as an alternative tool for modeling.
- To study genetic algorithms and learn about optimizing solutions using genetic algorithms
- Become able to apply the knowledge of artificial control tools to any control application
- To be able to work with imprecise and uncertain solution data for solving problems.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Realize the significance of Artificial Intelligence and expert systems

- Learn the neural network algorithms, modeling using fuzzy logic and optimizing
- solutions using genetic algorithms
- Apply the knowledge of artificial control tools to any control application
- Work with imprecise and uncertain solution data for solving problems

SYLLABUS OF DSE

UNIT – 1 **(12 hours)**

The concept and importance of Artificial Intelligence, human intelligence vs machine intelligence, General concept of knowledge, Acquisition, Knowledge representation and organization, Expert systems: advantages, disadvantages, Expert system architecture, functions of various parts, mechanism and role of inference engine, Role of expert systems in instrumentation and control.

UNIT – 2 **(11 hours)**

Neural Networks: Biological Neural-system, Mathematical Models of Neurons, ANN architecture, Artificial neuron models, Types of activation functions, Learning rules, Learning Paradigms-Supervised, Unsupervised and Reinforcement Learning, ANN training algorithms perceptron, training rules, Delta, Back Propagation Algorithm, parameters in BPN, Hopfield Networks, Recurrent networks, Associative Memories, Applications in identification, optimization, pattern recognition etc.

UNIT – 3 **(11 hours)**

Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Approximate reasoning, Aggregation, Fuzzy logic modeling and control, fuzzification, inferencing and defuzzification, Linguistic Variables, Arithmetic Operations on Intervals & Numbers. Applications of Fuzzy Logic in process Control and motion control.

UNIT – 4 **(11 hours)**

Genetic Algorithm: An Overview: Introduction and concept as a process modeling tool, creation of off-springs, encoding, fitness function, reproduction, cross over, insertion, deletion and mutation scaling, Fitness, Implementation of Genetic algorithm, applications.

Hybrid Systems: Introduction to Neuro-fuzzy systems, Fuzzy-Expert system, Fuzzy-GA systems.

Practical component: **(30 hours)**

1. Implementation of perceptron learning model
2. Pattern recognition using Hopfield network
3. Identification using associative memories
4. Implement fuzzy logic operations on fuzzy sets

5. Implement conversion of given crisp temperature into its equivalent fuzzy variable
6. Implement conversion of error into its equivalent fuzzy variable
7. Design model of fuzzy logic PID controller
8. Design fuzzy logic based temperature control system
9. Design fuzzy logic based washing machine/aircraft landing system

Essential/recommended readings

1. Ross Timothy. J, Fuzzy logic with Engineering Applications, McGraw Hill, New York, 3rd Edition.
2. Hagan M.T , Demuth H.B, Beale M.H, Neural Network Design, PWS Publishing Company, Thomson Learning, 1st Edition.
3. N.P.Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 1st Edition.
4. Rajasekaran S., VijayalakshmiPai G. A., Neural Networks, PHI Learning Pvt. Ltd., 2003, 1st Edition.

Suggestive readings

1. Klir George J , Yuan B, Fuzzy Sets and Fuzzy Logic Theory and Applications, Prentice Hall PTR, 1st Edition.
2. J. Nilsson, “Artificial Intelligence: A new Synthesis”, Elsevier Publishers.

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

DISCIPLINE SPECIFIC CORE COURSE: Process Control Dynamics (INDSE6B)

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		
Process Control Dynamics (INDSE6B)	04	03	-	01	Class XII passed with Physics + Mathematics/ Applied Mathematics+ Chemistry / Computer Science/Informatics Practices	Control Systems and Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To study about the importance and application of good instrumentation system for the efficient design of process control loops for process engineering plants
- To teach students about the basic elements of process control including analysis, tuning and design of the control system using tools of differential equations and transfer functions, with the specific focus on PID control strategy
- To help students understand and discuss about the major issues in the control applications in chemical engineering processes with specific attention to reactor and distillation units
- To study additional techniques of frequency response for robust design based on stability margins. Also, to explore other advanced control strategies currently used in the process industries

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the importance and application of good instrumentation system for the efficient design of process control loops for process engineering plants
- Know about the basic elements of process control including analysis, tuning and design of the control system using tools of differential equations and transfer functions, with the specific focus on PID control strategy

- Interpret the major issues in the control applications in chemical engineering processes with specific attention to reactor and distillation units
- Understand additional techniques of frequency response for robust design based on stability margins. Also, to explore other advanced control strategies currently used in the process industries

SYLLABUS OF DSE

UNIT – 1 **(12 hours)**

Introduction: Dynamics of Processes, Dead time processes, Inverse response behaviour of processes, Dynamic Behaviour of first and second order systems. Interacting and non-interacting Systems. Batch & Continuous Process, concept of self-regulation, Controller Principle, discontinuous, continuous and composite controller modes/actions (P, I, D, PI, PD and PID), Pneumatic, Hydraulic, Electronic controllers. Need for controller tuning.

UNIT – 2 **(11 hours)**

Controls: Cascade control, Selective control, Ratio Control, Split range control, feed forward control, Feed forward combined with feedback control, Inferential Control, dead time and inverse response compensators, selective control, Adaptive control, Examples from Distillation columns, Chemical Reactors, Heat Exchangers and Boiler.

UNIT – 3 **(11 hours)**

Discrete-State process control: Variables, process specification and event sequence description, Sampling and reconstruction, Transform analysis of sampled-data systems: z transform and its evaluation, inverse z transform, pulse transfer function, stability analysis in z-plane, implementation of digital controller. PLC Block Diagram, Scan cycle, memory organization, addressing, programming.

UNIT – 4 **(11 hours)**

Converters and Actuators: I/P, P/I converters, Final control elements, Pneumatic and electric actuators. Types of control valves, Valve positioner and its importance, Inherent and Installed characteristics of control valves.

Practical component: **(30 hours)**

1. Study of PID controller response and it‟s tuning
2. Study of ON-OFF and Proportional controller responses on temperature loop.
3. Analysis of Flow loop/Level loop/Temperature loop/Pressure loop.
4. Tuning of controllers on a pressure loop.
5. Control valve characteristics with and without positioner.
6. Study of cascade control
7. Study of ratio control/selective control
8. Study of feed forward control

9. Study of pneumatic/ hydraulic controllers
10. Problem solving/Ladder Programming in PLC.

Essential/recommended readings

1. Eckman. D.P, Automatic Process Control, Wiley Eastern Ltd., New Delhi, 1993, Original Edition.
2. Johnson C.D., Process Control Instrument Technology, Prentice Hall Inc. 1988, 7th Edition.
3. Bequette B. W., Process Control Modelling, Design and Simulation, PHI Learning, Original Edition.
4. Ogata K., Discrete Time Control Systems, Pearson Education, 2nd Edition.
5. Kuo B. C. , "Automatic control system", Prentice Hall of India, 2010, 9th Edition.
6. Nagrath I. J. and Gopal M., Control System Engineering, New Age International,2021, 7th Edition.
7. Stephanopoulis G., Chemical Process Control, Prentice Hall of India, New Delhi, 1990, Original Edition.
8. Liptak B.G., Instrument Engineers Handbook, Process Control, Chilton Book Company, 3rd Edition.

Suggestive readings

1. Harriott P., Process Control, Tata McGraw Hill, Edition 1972.
2. Anderson N.A., Instrumentation for Process Measurement and Control, Chilton company 1980, 3rd Edition.
3. Pollard A., Process Control, Heinemann educational books, London, 1971, Original Edition.
4. Smith C.L. and Corripio A. B., Principles and Practice of Automatic Process Control, John Wiley and Sons, New York, 2nd Edition.
5. Shinskey, Process Control Systems, McGraw Hill, Singapore, 1996, 4th Edition.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE: Research Methodology (INDSE6C)

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		
Research Methodology (INDSE6C)	04	03	-	01	Physics + Mathematics /Applied Mathematics / Biology + Chemistry / Computer Science/Informatics Practices	Elementary Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand some basic concepts of research and its methodologies
- To select and define appropriate research problem and parameters
- To write a research report and thesis

Learning outcomes

The Learning Outcomes of this course are as follows:

- Acquire the basic knowledge of quality concepts and techniques for quality improvement
- Learn to use various control charts for improving the quality of products
- Describe and compare the different sampling plans and methods
- Understand the concepts of reliability

SYLLABUS OF DSE

Unit -1 **(12 hours)**

Introduction and Design of research : Meaning, Objectives and Importance of Research, Types of research, need and purpose of research, approaches to research, components of the research problem, criteria for selecting the problem, necessity of defining the problem.

Unit – 2 **(10 hours)**

Importance of literature review in defining a problem, Critical literature review – Identifying gap areas from literature review - Development of working hypothesis, various tools for literature survey-Searching journals, metrics of Journals, e book, monograph, patents, Citations, Intellectual Property Rights.

Unit -3 **(12 hours)**

Data Collection and Analysis: Observation and Collection of data - Methods of data collection – Modeling, Mathematical Models for research, Sampling Methods- Data processing and Analysis strategies. Data Analysis with Statistical Packages – Hypothesis-testing, Sampling, Sampling Error, Statistical Methods/Tools - Measures of Central Tendency and Variation, Test of Hypothesis- z test, t test, F test, ANOVA, Chi square, correlation and regression analysis, Error Estimation.

Unit - 4 **(11 hours)**

Writing Research Articles and Thesis: Data Presentation- Types of tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References – Styles and methods, Citation and listing system of documents. Ethical considerations in Research, precautions in preparing report, plagiarism

Practical component: **(30 hours)**

Use latest software package like SPSS/any similar, to conduct experiments based on:

1. Measures of central tendency
2. Normal distribution
3. Chi square test
4. T test
5. Z-test

Essential/recommended readings

1. Ranjit Kumar, Research Methodology, A step by step guide for beginners, SAGE Publications (2015)
2. D. C. Montgomery, Introduction to Statistical Quality Control, 8th edition, John Wiley and sons (2019).
3. Leedy, P. D. and Ormrod, J. E., 2004 Practical Research: Planning and Design, Prentice Hall.
4. C.R Kothari, Research Methodology: Methods and Techniques, New Age International Publishers (2015)

Suggestive readings

1. Prabhat Pandey, Meenu Mishra Pandey, Research Methodology: Tools and Techniques, Bridge Center (2015)
2. S.P Gupta, Statistical Methods, 46th edition, Sultan Chand & Sons (2021)

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COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENT

GENERIC ELECTIVE : Standardization and Quality Control (INGE6A)

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		
Standardization and Quality Control (INGE6A)	4	3	-	1	Class XII passed with Mathematics/ Applied Mathematics + Biology/ Computer Science/Informatics Practices	Probability and Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basic concepts of Total Quality Management.
- To enable the student on how to apply various Statistical Process Control (SPC) techniques to ensure the quality level of products.
- To understand the significance of Control Charts and Acceptance sampling in modern quality control systems.
- To make students learn the national and international quality assurance standards.

Course Learning Outcome

The Learning Outcomes of this course are as follows:

- Apply the principles and techniques of Total Quality Management in improving quality practices within an industrial or service organization

- Use statistical process control (SPC) techniques such as pareto charts, control charts and cause-effect diagrams recognized throughout industries to ensure the quality level of products
- Understand the role of Acceptance Sampling (AS) in modern quality control systems
- Develop an understanding of national and international quality assurance standards such as ISO 9000 and 14001

SYLLABUS OF GE

Unit-1 **(11 hours)**

Quality Concepts: Meaning of Quality, Dimensions of Quality, Quality Approaches-Deming's Approach, Juran's Approach, Difference between Inspection, Quality Control and Quality Assurance, Evaluation of Quality control, Quality Improvement Techniques-Quality Circles, Kaizen, Six Sigma.

Unit-2 **(12 hours)**

Quality Control: Graphical and Tabular representation of data, Measures of Central Tendency, Measures of Dispersion, Random Variables, Chance and assignable causes of variation, Quality Control Tools-Histogram, Pareto Chart, Cause-Effect Diagram, Control Charts. Control Chart for variables (X-bar & R), Control limits, Warning Limits, Process Capability, Sample Size and Sampling Frequency, Sensitizing rules for Control Charts, Control Chart for Attributes (p, np, c).

Unit-3 **(11 hours)**

Acceptance Sampling: Advantages and Disadvantages of Sampling, Types of Sampling, Lot formation, Principle of acceptance sampling, OC curve, Producer’s and consumer’s risk, Acceptable Quality Level, Lot Tolerance Percentage Defective, Sampling plans: single, double, Average outgoing Quality, AOQL.

Unit-4 **(11 hours)**

ISO 9001-2000 & 14000 Series of Standards: History and Evolution of ISO 9000 Series, Importance and overview of ISO 9000- 1998 Series standards, structure of ISO 9000-2000 Series standards, clauses of ISO 9000 series standards and their interpretation and implementation, quality system documentation and audit. Environmental management concepts, and requirement of ISO 14001, benefits of environmental management Systems.

Practical component: **(30 hours)**

Use latest statistical software package like SPSS to conduct experiments based on:

1. Descriptive statistics
2. Histogram
3. Pareto Chart
4. Control charts for variables
5. Control charts for attributes
5. OC curve
6. AOQ curve

Essential/recommended readings

1. D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley and sons, 6th edition, 2008.
2. Subburaj Ramasamy, Total Quality management, Tata McGraw Hill, 2 nd Edition, 2012
3. E. L. Grant & R.S. Leavenworth-Statistical Quality Control, 7th Edition, 2000.
4. Kaoru Ishikawa-Guide to Quality Control, Asian Productivity Organization, Series, 1986

Suggestive readings

1. M. S. Mahajan, Statistical Quality Control, 1st Edition, Dhanpat Rai Publishing Co Pvt Ltd (2016).
2. Ranjit Kumar, Research Methodology, A step by step guide for beginners, SAGE Publications (2015)
3. Prabhat Pandey, Meenu Mishra Pandey, Research Methodology: Tools and Techniques, Bridge Center (2015)
4. S.P Gupta, Statistical Methods, 46th edition, Sultan Chand & Sons (2021)

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GENERAL ELECTIVE COURSE : Wireless Networks (INGE6B)

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		
Wireless Networks (INGE6B)	**04**	**03**	**-**	**01**	**Class XII passed with Mathematics/Applied Mathematics/ + Computer Science/Informatics**	Mathematics in class XII and digital communication

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the concept about Wireless networks, protocol stack and standards
- To understand and analyze the network layer solutions for Wireless networks
- To study about fundamentals of 3G Services, its protocols and applications
- To have in depth knowledge on internetworking of WLAN
- To learn about evolution of 4G and 5G Networks, its architecture and applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Conversant with the latest 3G/4G networks and its architecture
- Design and implement wireless network environment for any application using latest wireless protocols and standards
- Ability to select the suitable network depending on the availability and requirement
- Implement different type of applications for smartphones and mobile devices with latest network strategies

SYLLABUS OF GE

UNIT – 1 **(12 hours)**

WIRELESS LAN

Introduction-WLAN technologies: Infrared, UHF narrowband, spread spectrum -IEEE 802.11: System architecture, protocol architecture, physical layer, MAC layer, 802.11b, 802.11a – Hiper LAN, BRAN (Broadband Radio Access Networks), HiperLAN2 Bluetooth: Architecture, Radio Layer, Baseband layer, Link manager Protocol, security IEEE 802.16-WIMAX: Physical layer, MAC, Spectrum allocation for WIMAX.

UNIT – 2 **(11 hours)**

MOBILE NETWORK LAYER

Introduction - Mobile IP: IP packet delivery, Agent discovery, tunneling and encapsulation, IPV6- Network layer in the internet- Mobile IP session initiation protocol - mobile ad-hoc network: Routing, Destination Sequenced distance vector, Dynamic source routing

UNIT – 3 **(11 hours)**

MOBILE TRANSPORT LAYER

TCP enhancements for wireless protocols - Traditional TCP: Congestion control, fast retransmit/fast recovery, Implications of mobility - Classical TCP improvements: Indirect TCP, Snooping TCP, Mobile TCP, Time out freezing, Selective retransmission, Transaction oriented TCP - TCP over 3G wireless networks.

UNIT – 4 **(11 hours)**

4G NETWORKS

Introduction – 4G vision – 4G features and challenges - Applications of 4G – 4G Technologies: Multicarrier Modulation, Smart antenna techniques, OFDM-MIMO systems, Adaptive Modulation and coding with time slot scheduler, Cognitive Radio.

5G NETWORKS

Introduction – 5G vision – 5G features and challenges - Applications of 5G – 5G Technologies

Practical component: **(30 hours)**

1. Program in NS 3 to connect WIFI TO BUS(CSMA)
2. Program in NS 3 to create WIFI SIMPLE INFRASTRUCTURE MODE
3. Program in NS 3 to create WIFI SIMPLE ADHOC MODE
4. Program in NS 3 to connect WIFI TO WIRED BRIDGING
5. Program in NS 3 to create WIFI TO LTE(4G) CONNECTION
6. Program in NS3 for CREATING A SIMPLE WIFI ADHOC GRID
7. Introduction to GSM Architecture

Essential/recommended readings

1. Wireless Communication and Networks, Second Edition, Williant Stallings.

2. Erik Dahlman, Stefan Parkvall, Johan Skold and Per Beming, "3G Evolution HSPA and LTE for Mobile Broadband", Second Edition, Academic Press, 2008.
3. Anurag Kumar, D.Manjunath, Joy kuri, "Wireless Networking", First Edition, Elsevier 2011.
4. Simon Haykin, Michael Moher, David Koilpillai, "Modern Wireless Communications", First Edition, Pearson Education 2013

Suggestive readings

1. Jochen Schiller, "Mobile Communications", Second Edition, Pearson Education 2012.
2. Vijay Garg, "Wireless Communications and networking", First Edition, Elsevier 2007.

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