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DEPARTMENT OF ELECTRONIC SCIENCE (INSTRUMENTATION)

DISCIPLINE SPECIFIC CORE COURSE- 19: Embedded Systems and Robotics (INDSC7A)

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		
Embedded Systems and Robotics (INDSC7A)	04	02	-	02	Course admission eligibility	Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand Embedded Systems: Learn the architecture, features, and applications of embedded systems, including RISC vs. CISC and Von-Neumann vs. Harvard architectures.
- Explore Microcontrollers: Get familiar with Arduino and AVR microcontroller (ATMega32) architecture and programming.
- Arduino Programming: Set up Arduino IDE and program digital inputs/outputs, analog inputs, and serial communication.
- Sensor and Actuator Integration: Interface sensors (e.g., temperature, light) and actuators (e.g., motors, servos) with Arduino.
- Robotics Basics: Understand robotics, motor control, and sensor integration to build basic robots and robotic arms using Arduino.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Embedded System Knowledge: Ability to describe the features, architecture, and applications of embedded systems, including key microcontroller architectures.
- Microcontroller Proficiency: Gain proficiency in programming and interfacing with Arduino and AVR microcontrollers (e.g., ATMega32).
- Arduino Programming Skills: Demonstrate the ability to program Arduino for handling digital/analog inputs, outputs, and serial communication.
- Sensor and Actuator Control: Successfully interface and control sensors and actuators (e.g., motors, temperature sensors) using Arduino.
- Robotics Application: Design and program basic robotic systems, including motor and sensor integration, using Arduino.

SYLLABUS OF DSC- 19

UNIT-I **(8 hours)**

Basic Concepts of Embedded Systems: Introduction to computer, microprocessor and microcontrollers. Characteristics, Requirements and Applications of Embedded Systems. Overview of Von- Neumann and Harvard architecture, RISC and CISC microcontrollers .

UNIT-II **(6 hours)**

Introduction to Arduino : Functional Block Diagram of Arduino, Functions of each Pin. Overview of the Integrated development environment (IDE), I/O Functions, Looping Techniques, Decision Making Techniques. ATMega32 microcontroller internal architecture, instruction set and addressing modes

UNIT-III **(8 hours)**

Programming with Arduino: Basic Programming with Sensors and Actuators. Serial Communication: Sending and receiving data with a peripheral (USART) . Interfacing : DC motors, servo motors, and stepper motors with Arduino and other Hardwares Seven Segment Display, LCD, Buzzer ,and Relays.

UNIT-IV **(8 hours)**

Introduction to Robotics: Origin of automation, types of Robot, robot joints, Forward and reverse kinematics , Basics of Electronics for Robotics , robotics skills with sensor integration, Basic interfacing programming concept

Practical component: **(60 hours)**

1. To analyze the block diagram of an embedded system and identify its components.
2. Setting up Arduino Environment, Install the Arduino IDE, understand its interface, and upload a "Blink LED" program.
3. Write a program and design a circuit to turn an LED on and off using a push button.
4. Write a program for reading analog Inputs and monitoring outputs.
5. Write a program to interface Temperature Sensors with Arduino.
6. Write a program to interface motors and control speed.
7. Write a program to interface Pressure Sensor Arduino
8. Write a program to interface Current Sensor with Arduino.
9. Write a program to Interface pH Sensor with Arduino for Water Quality Monitoring
10. Write a program to do serial communication to send and receive data between Arduino and a computer.
11. Write a program Controlling DC Motors with H-Bridge, speed using L293D motor driver IC.
12. Write a program to interface ultrasonic sensors to detect obstacles and control a motorized robot.
13. Any one of the following mini projects or on similar concepts incorporating data acquisition from sensors/ input device, data analysis & control and display of result on any output device: Digital Thermometer, Light-Activated Lamp, Distance Measurement System, Traffic Light Simulation, Line-Following Robot. Automatic Plant Watering System, Solar Power Monitoring System, Energy Consumption Tracker, Water Quality Monitoring System, Automatic Irrigation System, Smart Street Lighting System, Air Quality Monitoring, CO2 Emission Tracker, Temperature and Humidity Logger, Smart

Fish Tank Monitoring System, Biodiversity Protection System, Waste Segregation System, Smart Composting Bin, Smart Factory Prototype, Smart Health Monitoring System, Indoor Air Quality Monitor

Essential/recommended readings

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, The 8051 Microcontroller and Embedded Systems, Pearson education Asia, New Delhi (2007), 2nd Edition.
2. Michal Mc Roberts “Beginning Arduino” Second Edition, Technology in Action
3. Massimo Banzi, “Getting started with Arduino” 2nd Edition, Orelly 2011
4. Richard Blum, “ Arduino Programming in 24 Hours”, Pearson Education, 1st
5. edition, 2015.
6. James M. Fiore, Embedded Controllers using C and Arduino, 2019
7. https://docs.arduino.cc/learn/

Suggestive readings

1. Raj Kamal: Microcontrollers, Architecture, Programming, System Design, 2nd Edition, Pearson.

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

DISCIPLINE SPECIFIC CORE COURSE – 20: Industrial Automation using PLC and SCADA (INDSC8A)

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 Automation using PLC and SCADA (INDSC8A)	04	02	-	02	Course admission eligibility	Basic knowledge of programming

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the importance of automation techniques in manufacturing and process industries.
- To impart the role of PLC in industry automation.
- To understand the significance and usage of SCADA in process automation industry.
- To expose to various control techniques employed in process automation.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the need for automation in process industries and learn about PLC
- Learn the programming languages of PLC
- Design distributed Control Systems (DCS) and its applications
- Learn about SCADA, its usage in process automation industry and associated communication networks
- To apply PLC programming and implement it on PLC kits.

SYLLABUS OF DSC- 20

UNIT-I **(07 Hours)**

Single loop control, Centralized control, Distributed control systems, Open systems, SCADA systems, Types of data available, Data communication components and protocols.

UNIT-II **(08 Hours)**

Programmable Logic Controllers (PLC), Block diagram of PLC, input/output systems, CPU, memory Unit, Programmer Units, Peripheral devices, Controller programming tools, Programming of PLCs, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies.

UNIT-III **(07 Hours)**

Automation in Process Industries

Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS), PLC vs. DCS systems, Local control Units, dedicated card controllers, Unit Operations controllers, DCS multiplexers, DCS system integration

UNIT-IV **(08 Hours)**

Supervisory Control and Data Acquisition (SCADA) Systems, Types of supervisory systems, Components of SCADA Systems, field data interface devices, communication network and other details, System Architecture: monolithic, distributed, networked, application of SCADA in the industry; security and weakness of SCADA Systems

Practical component: (Software/ Hardware) (60 hours)

1. Identify various components, modules, and front panel status indicators of a given PLC
2. Design the PLC ladder diagram to test the START-STOP logic using two inputs and one output
3. Design the PLC ladder diagrams for all fundamental logic gates
4. Design the PLC ladder program to Verify DeMorgan‟s Theorems
5. Design the PLC ladder diagrams for various arithmetic operations
6. Design the PLC ladder diagrams for various logical operations
7. Design a PLC ladder program for the blinking of LEDs
8. Design the PLC ladder diagram for implementing a digital timer
9. Design the PLC ladder diagram for implementing a digital counter
10. Design the PLC ladder diagram for sequential control of the DC motor.
11. Design the PLC ladder diagram for a temperature control system
12. Design the PLC ladder diagram for a flow control system
13. Design the PLC ladder diagram for a level control system
14. Interface personal computers in a network using different topologies
15. Identify the various level of distributed control system
16. Develop a SCADA mimic diagram and tag database for On-Off control of lamp
17. Develop a SCADA mimic diagram and tag database for Traffic light control system
18. Develop a SCADA mimic diagram and tag database for level control system
19. Develop a SCADA mimic diagram and tag database for water distribution system
20. Develop a SCADA mimic diagram and tag database for an elevator system
21. At least one industrial visit to study applications related to the subject and submission of the relevant report.

Essential/recommended readings

1. Frank D. Petruzella, “Programmable Logic Controllers”, 5th Edition, McGraw-Hill, New York, 2016.
2. John W. Webb and Ronald A. Reis, “Programmable Logic Controllers: Principles and Applications”, 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Bhatkar, Marshal, “Distributed Computer Control & Industrial Automation”, 1st Ed., Dekker Publication, 1990.
4. Jai Prakash Gupta, Sanjay Gupta, “PC interface For Data Acquiring & Process Control”, 2nd Ed., Instrument Society of America, 1994.

Suggestive readings

1. Krishna Kant, “Computer - Based Industrial Control”, 2nd Edition, Prentice Hall, New Delhi, 2011.

2. Yoram Koren, “Robotics”, McGraw Hill, 1992.
3. Lukas M.P, “Distributed Control Systems”, Van Nostrand Reinhold Co., New York, 1986.

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

DISCIPLINE SPECIFIC ELECTIVE –: Modern Instrumental Methods of Analysis (INDSE7A)

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		
Modern Instrumental Methods of Analysis (INDSE7A)	04	03	-	01	Course admission eligibility	Analytical Instruments

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with advanced spectroscopic techniques such as Mass spectrometry, NMR spectroscopy and X-Ray spectroscopy
- To understand the perspective of different advanced analytical methods.
- To describe the principle, instrumentation and working of X-Ray spectroscopy and its applications
- To study principles and applications of modern and hyphenated chromatographic methods.
- To disseminate the principle and instrumentation of thermo-analytical instruments along with their applications for analyzing products of different origin.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Get the understanding of advanced spectroscopic techniques such as Mass spectrometry and NMR spectroscopy.
- Understand the principle, instrumentation, and application of electro analytical instruments.
- Describe the principle, instrumentation and working of X-Ray spectroscopy and its applications.

- Understand the principle and applications of modern and hyphenated chromatographic methods.
- Understand the principle and instrumentation of thermo-analytical instruments along with their applications for analyzing products of different origin.
- Appreciate the potential of different modern analytical methods for resolving various scientific challenges.

SYLLABUS OF DSE

UNIT-I **(13 hours)**

Nuclear Magnetic Resonance (NMR) Spectroscopy: Theory, chemical shift and spin-spin splitting, coupling constant, environmental effects- shielding and deshielding effects due to electronegativity on NMR spectra, instrumentation of NMR, FT-NMR and its advantages, applications.

UNIT-II **(10 hours)**

Mass Spectroscopy: Theory, gaseous ion source, sample inlet system, magnetic sector mass analyzer, electron multiplier detector, Isotopic abundances, metastable ions and applications.

UNIT-III **(10 hours)**

X-ray Spectroscopy: Principle, absorption, emission and diffraction of X-rays, Bragg‟s Law, Instrumentation: sources, X –ray tube, crystal monochromators, X-ray detectors (Ionization, proportional and GM counter, γ camera), applications.

UNIT-IV **(12 hours)**

Thermo-analytical Methods: Thermal detectors. Thermo-gravimetry, Differential Thermal analysis, Differential scanning calorimetry, Principle, Instrumentation, thermobalance, Applications of thermo-analytical techniques.

Hyphenated techniques: Introduction to GC-MS and LC-MS techniques and their applications.

Practical Component **(30 Hours)**

1. Quantitative Analysis of organic compounds using Gas chromatography/ GC/MS chromatography.
2. Quantitative Analysis of organic compounds using HPLC/ LC-MS chromatography.
3. Study of NMR (Simulation based/Demo).
4. Study of Mass spectrometer (Simulation based/Demo).
5. Study of X ray spectrometer (Simulation based/Demo).
6. Study of thermo-analytical instruments (Simulation based/Demo).
7. Industrial visits / Group Projects based on analytical techniques.

Essential/recommended readings

1. Skoog & Lerry, Instrumental Methods of Analysis, Saunders College Publications, New York, 4th Edition 1992.

2. H.H.Willard, Instrumental Methods of Analysis, CBS Publishers 7th Edition 1988.
3. D.C. Harris, Quantitative Chemical Analysis, W.H. Freeman, 7th Edition 2010.
4. Gary D. Christian, Analytical Chemistry, John & Sons, Singapore, 6th Edition 2004.
5. Skoog, West and Holler, Analytical Chemistry, Saunders College Publications, New York, 5th Edition 1990.
6. Vogel‟s Textbook of Qualitative Chemical Analysis, ELBS, 4th Edition 1978.
7. J.A. Dean, Analytical Chemistry Notebook, McGraw Hill, 14th Edition 1992.
8. John H. Kennedy, Analytical Chemistry: Principles, Saunders College Publication, 2nd Edition 1990.

Suggestive readings

1. Galen W. Ewing, Instrumental Methods of Chemical Analysis, McGraw-Hill Book Company, 1968.
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 ELECTIVE COURSE –: CMOS Digital Integrated Circuit Design (INDSE7B)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
CMOS Digital Integrated Circuit Design (INDSE7B)	04	03	-	01	Course admission eligibility	Digital electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To explain the operation of different MOS transistors and their characteristics.
- Design and Analyze CMOS Logic Gates.
- Develop Combinational and Sequential Logic Circuits.
- Learn Memory Design Principles.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Design and analyze CMOS logic gates and circuits.
- Create combinational and sequential logic circuits, demonstrating an understanding of their behaviour and functionality.
- Design and assess memory elements, such as SRAM and DRAM cells.
- Skilfully use simulation tools to model and analyze CMOS digital circuits.

SYLLABUS OF DSE

UNIT – I **(10 hours)**

CMOS Inverter: Basic CMOS inverter, Switch model of Inverter, Static behaviour, Voltage transfer characteristics, Switching threshold, Noise margin, and Gain calculation.

UNIT – II **(11 hours)**

Combinational CMOS Logic Circuits: CMOS logic gates – NOR & NAND gate, CMOS adder and subtractor, CMOS multiplexer, CMOS transmission gates, Designing with Transmission gates

UNIT – III **(12 hours)**

Sequential CMOS Logic Circuits: SR Latch, Clocked latch and flip-flop circuits, CMOS D latch and edge-triggered flip-flop

UNIT – IV **(12 hours)**

Memories: Introduction to Memory,Memory Classification,Memory architecture and building blocks,Memory Core,Read-Only Memory,Non-Volatile Read-Write Memory,Read Write memories.

Practical component (Hardware OR Simulation): **(30 hours)**

1. To design and plot the static (VTC) of a digital CMOS inverter.
2. To design and plot the dynamic characteristics of a digital CMOS inverter.
3. To design and plot the dynamic characteristics of 2-input NAND using CMOS technology.
4. To design and plot the dynamic characteristics of 2-input NOR, logic gates using CMOS technology.
5. To design and plot the characteristics of an Adder/subtractor.
6. Design and simulation of a D flip-flop or a latching circuit
7. Design and simulation of SRAM cell.

8. Design and simulation of DRAM cell.

Essential/recommended readings

1. CMOS Digital Integrated Circuits Analysis and Design – Sung-Mo Kang, Yusuf Leblebici, TMH, 4th Edition.

2. Digital Integrated Circuit: A Design Perspective-Rabaey, Chandrakasan and Nikolic, Pearson,2nd Edition.
3. Digital Integrated Circuit Design – Ken Martin, Oxford University Press, 2011
4. CMOS VLSI Design: A Circuits and Systems Perspective -Neil H. E. Weste and David Harris, Pearson,4th Edition
5. Essentials of VLSI Testing for digital, memory and mixed-signal VLSI Circuits - Bushnell and Agrawal, Kluwer Academic Publishers.

Suggestive readings

1. Analog Integrated Circuit Design" by David A. Johns and Ken Martin, Wiley,2nd Edition.
2. Fundamentals of Digital Logic with Verilog Design -Stephen Brown and Zvonko,TMH, 3rd Edition.

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

DISCIPLINE ELECTIVE COURSE: Advanced Electronic Instrumentation (INDSE7C)

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		
Advanced Electronic Instrumentation (INDSE7C)	04	03	-	01	Course admission eligibility	Analog Electronics-

Learning Objectives

- To provide sound knowledge about instrumentation amplifier.
- Discussion of different types of Optical Transducers and display devices. .
- To have sound knowledge about different measuring instruments

Learning outcomes

The Learning Outcomes of this course are as follows:

- Acquire the knowledge of purpose and scope of instrumentation in Industrial processes.
- Be competent to understand different display devices.
- Be conversant in construction and working of source measuring unit (SMU).
- Understand the calibration of various measuring instruments-wavemeter, power measurement instruments.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Instrumentation Amplifier & its applications: Instrumentation system, Instrumentation Amplifier using Transducer bridge, Applications of Instrumentation Amplifier-Temperature Indicators using Thermistor and Analog Weight Scale.
Convertors-D/A convertor with Binary-weighted resistors and with R & 2R resistors, Successive approximation A/D converter using Operational Amplifiers.

UNIT – II **(10 hours)**
Indicators: Electrodynamometer, Moving-Iron, Induction type, Electrostatic type.
Display devices: LED, LCD, Dot Matrix Display, Electro-Luminescent Displays

UNIT – III **(12 hours)**
AC measuring Instruments: Digital Capacitance Meter, Electrodynamic type Wattmeter, Reactive power meter, Power factor meter, Watthour meter, Digital Phase meter
Measuring Instruments: Source measuring unit (SMU): working, construction and Applications, Megger

UNIT – IV (11 hours)
Measurement of microwave frequencies: Wavemeters-Resonant Coaxial, Cavity Type and Lumped Type Wavemeter
Measurement of RF power: Bolometer: working principle, Construction and types

Practical Component (Hardware/ Software) **(30 hours)**

1. Designing of Basic Instrumentation Amplifiers using op-amp.
2. Designing of Instrumentation Amplifier using Transducer bridge
3. Designing of D/A convertor with Binary-weighted resistors
4. Designing of D/A convertor with R & 2R resistors
5. Measurement of power using wattmeter
6. Study of Watthour meter and measurement of electricity consumption in different conditions.
7. Study and analyse the operation of Source measuring unit (SMU).
8. To study diode characteristics using SMU.
9. Measurement of the Q-Factor of a Cavity (Virtual Lab)

Essential/recommended readings

1. BKG: Basic Electronics and Linear Circuits by N. N. Bhargava, D. C. Kulshreshtha and S. C. Gupta. Technical Teachers training Institute, Tata McGraw Hill Publishing Company Limited.
2. H & C: Modern Electronic Instrumentation & Measurement Techniques by Albert D. Helfrick & William D. Cooper (PHI) Edition.
3. K: Electronic Instrumentation by H. S. Kalsi, 2nd Edition, Tata McGraw Hill.

4. T: Digital electronics by G. L. Tokheim (6th Edition) (Tata Mc Graw Hill).
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.

Suggestive readings

1. H & H: The Art of Electronics, by Paul Horowitz & Winfield Hill (2nd Edition).
2. U.A. Bakshi and A.V. Bakshi, Electronic Measurements and Instrumentation, Technical Publications.
3. Joseph J Carr, Elements of electronic instrumentation and measurement, Pearson Education (2005).
4. C.S. Rangan, G.R. Sarma and V.S. Mani, Instrumentation Devices and Systems, Tata McGraw Hill (1998).

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

DISCIPLINE SPECIFIC ELECTIVE COURSE : VLSI fabrication technology (INDSE7D)

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		
VLSI fabrication technology (INDSE7D)	04	03	-	01	Course admission eligibility	semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- Understanding of Semiconductor Materials and Properties.
- Understanding of Cleanroom Practices and Safety Protocols.
- Understanding the principles of photolithography, Etching and Thin-Film Deposition.

- Analyze Ion Implantation and Annealing.
- Describe Oxidation and Annealing and explore Chemical Mechanical Polishing (CMP).

Learning outcomes

The Learning Outcomes of this course are as follows:

- Follow cleanroom practices and safety protocols in a controlled laboratory or cleanroom environment.
- Explain the principles of photolithography and how it is used in semiconductor fabrication.
- Perform or simulate basic etching and thin-film deposition processes.
- Describe ion implantation, annealing, and oxidation processes in semiconductor manufacturing.
- Construct process flows for specific semiconductor manufacturing steps, including process integration.

SYLLABUS OF DSE

UNIT – I **(07 hours)**

Introduction to VLSI Technology: Evolution from early transistors to integrated circuits, Moore's Law in driving the miniaturization of devices. Overview of the semiconductor industry.

Cleanroom Practices and Safety: Cleanroom protocols and contamination control, Safety measures in a cleanroom environment.

UNIT – II **(15 hours)**

Lithography: Photolithography fundamentals, Step-by-step lithography process, Advanced lithography techniques (e.g., EUV). **Etching and Film Deposition:** Chemical and physical etching processes, Thin-film deposition techniques (CVD, PVD, ALD), Plasma processing.

UNIT-III **(15 hours)**

Ion Implantation: Introduction to ion implantation, Doping profiles, and implantation techniques. **Oxidation and Annealing:** Thermal oxidation of silicon, Annealing processes for activation and diffusion.

UNIT – IV **(08 hours)**

Wafer Fabrication Steps: Wafer cleaning and preparation, Photomask and reticle fabrication, Pattern transfer processes, Advanced Process Integration, Multiple patterning and self-alignment techniques. Process flow for CMOS technology.

Practical component (TCAD Software/Virtual Labs/ Hardware) **(30 hours)**

1. Demonstration of semiconductor fabrication facility or cleanroom to observe the cleanroom environment, equipment, and safety protocols.

2. Virtual Fabrication of a P-N Junction Diode.
3. Virtual Fabrication of a NPN Transistor.
4. Virtual Fabrication of PNP Transistor.
5. Virtual Fabrication of N-channel MOSFET.
6. Virtual Fabrication of P-channel MOSFET.
7. Virtual Fabrication of a Silicon Photovoltaic (Solar) Cell.
8. Industry visit

Essential/recommended readings

1. "Introduction to Microfabrication" by Sami Franssila
2. S.K.Gandhi, VLSI Fabrication principles, Wiley.
3. S.M. Sze, VLSI Technology, II edition, McGraw Hill.
4. W.R. Runyan, Silicon Semiconductor Technology, McGraw Hill.
5. J.Y.Chen CMOS Devices and Technology for VLSI, Prentice-Hall.
6. P.Van Zant, Microchip Fabrication, A Practical Guide to Semiconductor Processing, Third Edition, McGraw Hill.

Suggestive readings

1. BenG. Streetman, Solid State Electronic Devices, Prentice Hall.
2. "Microchip Fabrication: A Practical Guide to Semiconductor Processing" by Peter Van Zant
3. "Fundamentals of Semiconductor Manufacturing and Process Control" by Gary S. May and Costas J. Spanos
4. "Advanced Semiconductor Fundamentals" by Robert F. Pierret
5. "Semiconductor Manufacturing Technology" by Michael Quirk and Julian Serda
6. "Semiconductor Devices: Physics and Technology" by Simon M. Sze and Kwok K.Ng
7. "Process Technology for VLSI and ULSI" by C. Y. Chang and S. M. Sze

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

DISCIPLINE SPECIFIC ELECTIVE – : Measurement technology (INDSE7E)

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Measurement Technology (INDSE7E)	04	03	-	01	Course admission eligibility	Industrial instruments

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide sound knowledge about various techniques used for the measurement of industrial parameters and processes.
- Discussion of different types of speed and acceleration measuring instruments and their application in various Industrial processes.
- To have adequate knowledge of construction and working of various pressure measuring instruments
- Exposure to construction and working of various flow and level measurement devices used for industrial purposes.
- To have sound knowledge about the calibration of various industrial instruments

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Acquire the knowledge of purpose and scope of instrumentation in Industrial processes.
- Be competent to handle different types of speed and acceleration measuring instruments and their application in various Industrial processes.
- Be conversant in construction and working of various pressure measuring instruments.
- Be conversant in construction and working of various flow and level measurement devices used for industrial purposes.
- Understand the calibration of various industrial instruments.

Syllabus of DSE

UNIT-I **(12 hours)**

Pressure measurement: Units of pressure, Manometers-different types, elastic type pressure gauges, Bourdon type, bellows, diaphragms, measurement of vacuum, McLeod gauge, Pirani Gauge, thermal conductivity gauges, Hot cathode Ionization gauge, dead weight tester. Vacuum pumps- rotary and diffusion pumps.

UNIT-II **(12 hours)**

Flow Measurement: Introduction, definitions and units, classification of flow meters, Mechanical type flowmeters, orifice plate, venturi tube, Rotameter, thermal mass flow meter, Principle and constructional details of electromagnetic flow meter, ultrasonic flow meters, laser doppler anemometer systems, vortex shedding flow meter, guidelines for selection of flow meter.

UNIT-III **(11 hours)**

Measurement of Speed and Acceleration: Tachometers, Mechanical, Contact-less, Stroboscopic tachometers. Accelerometers, Elementary, Seismic and Practical accelerometers. Recorders: strip chart, circular and XY. Printers: Dot matrix, inkjet and laser.

UNIT-IV **(10 hours)**

Measurement of Humidity and Moisture: Basic principles, hygrometers, psychrometers, humidity charts, dew point, measurement systems for humidity, Infrared moisture measuring systems, radioactive moisture measuring systems.

Practical component: **(30 hours)**

1. Flow rate measurement using orifice plate flowmeter.
2. Calibration of pressure gauge using dead weight calibrator.
3. To find out the level of water using level transmitters.
4. Measurement of conductivity of test solutions using electrical conductivity meter.
5. To find the flow rate using electromagnetic flowmeter
6. To find the flow rate using an ultrasonic flowmeter.
7. To record the temperature variations using Circular chart recorder

Essential/recommended readings

1. Process Measurement and Analysis, 4th Edition (1995), Liptak B. G., Chilton Book Company, Pennsylvania.
2. Principles of Industrial Instrumentation, 3rd Edition (1997), D.Patranabis, Tata McGraw Hill Publishing Co., New Delhi.
3. A Course in Electrical and Electronic Measurements and Instrumentation, (2005), A.K. Sawhney, Dhanpat Rai & Co.
4. Mechanical and Industrial Measurements, 3rd Edition, Tenth Edition (1996), R.K. Jain, Khanna Publishers.
5. Measurement Systems: Application and Design, 5 th Edition (2003), Doeblin E. O, McGraw Hill, Singapore.
6. Instrumentation Measurement and Analysis, 4th Edition (2017), B.C. Nakra, K.K. Chaudhry, McGraw Hill Education Pvt. Ltd.
7. Instrumentation and Control Systems: 1st Edition (2016), K. Padma Raju, Y.J. Reddy, McGraw Hill Education Pvt. Ltd.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE-: Materials Science for Instrumentation and Sensor Development (INDSE7F)

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		

Materials Science for Sensor Development (INDSE7F)	**04**	**03**	**-**	**01**	**Course admission eligibility**	**Basic knowledge of semiconductor**

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the basics of materials science and its relevance to sensor development.
- Explore the properties of materials and their applications in instrumentation.
- Explore the role of functional materials in developing modern sensors.
- Understand the properties of advanced materials.
- To make students aware about the measuring instruments and the methods of measurement and the use of different sensors.
- Explore smart electronics materials for sensing applications.

Learning outcomes

The Learning Outcomes of this course are as follows:

- To understand different sensing materials properties
- To understand the working of different characterization instruments for sensing
- To understand different preparation method for sensing materials
- To understand about smart materials for sensors

SYLLABUS OF DSE

UNIT-I **(11 hours)**

Introduction to Materials Science: Role of materials in instrumentation and sensors, Brief Introduction of different types of materials used for sensing applications

Material Properties for Sensing Applications: Electrical properties, Mechanical properties, Thermal properties and Optical properties.

Material Characterization Techniques: Basics of X-ray diffraction (XRD), scanning electron microscopy (SEM) and spectroscopy techniques.

UNIT-II **(12 hours)**

Semiconducting Materials: Silicon based material**,** Compound, Ternary, Quaternary, Materials, Metal oxides (ZnO, TiO_2)

Polymers and Organic Materials: Conducting polymers (e.g., polyaniline, polypyrrole). Organic materials for flexible and wearable sensors.

UNIT-III **(12 hours)**

Piezoelectric Materials: Principles of piezoelectricity and applications in force and vibration sensing, Examples: Quartz, PZT, and polymer-based piezoelectrics.

2D Materials for Sensors: Introduction to graphene and Transition Metal Dichalcogenides (TMDs), Applications in gas, strain, and chemical sensing.

UNIT-IV **(10 hours)Smart Materials**

Introduction to Smart Material Systems; Overview of smart materials, Perovskite materials, Multiferroic materials, Shape memory alloys (SMA): Magnetostrictive materials, Magnetoresistive materials

Practical component: (Hardware/Software/Demo based/Virtual lab) **(30 hours)**

1. Measurement of electrical properties of sensing materials using a two-point probe method.
2. Measurement of electrical properties of sensing materials using a four-point probe method.
3. Measurement of different electrical properties of sensing materials using Hall sensor apparatus.
4. Measurement of piezoelectric response using vibration sensors.
5. Measurement of Dielectric constant of unknown material by using variable capacitor technique.
6. Learning Basics of Scanning Electron Microscopy: Secondary Electron and BSE imaging mode (Virtual Lab).
7. To understand electron diffraction for various materials (Virtual Lab).

Essential/recommended readings

1. D. J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons, Inc., 2007 (available online via MSU Library)
2. Agrawal, D.C., 2013. *Introduction to nanoscience and nanomaterials*. World Scientific Publishing Company.
3. Robertson, J. H. (1979). Elements of X-ray diffraction by BD Cullity.
4. Callister, William D., and David G. Rethwisch. *Materials science and engineering: an introduction*. Vol. 9. New York: Wiley, 2018.
5. Pavia, Donald L., Gary M. Lampman, George S. Kriz, and James A. Vyvyan. *Introduction to spectroscopy*. Cengage learning, 2014.
6. Egerton, Ray F. *Physical principles of electron microscopy*. Vol. 56. New York: Springer, 2005.

Suggestive readings

1. Raghavan, Viswanatha. *Materials Science and Engineering: A first course*. PHI Learning Pvt. Ltd., 2015.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE-: MEMS technology and applications (INDSE7G)

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		
MEMS technology and applications (INDSE7G)	04	03	-	01	Course admission eligibility	Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop fundamental concepts and techniques used in design and fabrication of nano/micro-systems are introduced from an engineering perspective.
- To introduce the basic concepts of micro systems and advantages of miniaturization.
- Micro-scale systems are compared with meso-scale systems and their mechanical, electrical, and optical properties are discussed.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Able to understand the operation of micro devices, micro systems and their applications.
- Able to design the micro devices, micro systems using the MEMS fabrication process.
- To study the various materials and their properties used for micromachining techniques.
- To teach the fundamentals of pressure sensors and accelerometer sensors through design and modeling.
- To give exposure to different MEMS devices.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Materials for MEMS, Thin film deposition, lithography and etching. Bulk micromachining, surface micromachining and LIGA process. Bulk micromachining, surface micromachining and LIGA process.

UNIT – II **(12 hours)**

MEMS devices, Engineering Mechanics for Micro System Design, Micro Pressure Sensor, Micro accelerometer. Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

UNIT – III **(12 hours)**

Introduction, An approach to MEMS design, Basic introduction to fabrication, Process Integration. Energy conserving transducer, Mechanics of membranes and beams.

Electrostatic Actuation and Sensing, Effects of electrical excitation. Design of Micro pressure sensor and Micro accelerometer

UNIT – IV **(12 hours)**

Applications of MEMS: Pressure Sensors**-** Piezoresistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance -Piezoresistive Coefficients of Silicon- Structural Examples-Signal Conditioning and Calibration.

Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance- Circuits for Capacitance Measurement Demodulation Methods- Case Study- Specifications- Sensor Design and Modeling Fabrication and Packaging.

RF MEMS

Practical component: (Software or Hardware) **(30 hours)**

1. Design and fabrication process of MEMS devices.
2. Determination of Capacitance change in Capacitive Pressure Sensor.
3. Design and Construction of different types of Accelerometer and determination of its natural frequency
4. Design and Analysis of Piezoresistive Accelerometer
5. Design and Analysis of Comb drive type Capacitive Accelerometer

Essential/recommended readings

1. Tai Ran Hsu, "MEMS & Microsystems Design and Manufacture", Tata McGraw Hill, New Delhi
2. Marc Madou, "Fundamentals of Microfabrication", CRC Press
3. Julian W. Gardner and Vijay K. Varadan, "Micro sensors, MEMS, and Smart Devices", John Wiley & Sons Ltd

Suggestive readings

1. Michael Wilson, KamaliKannangara, Geoff Smith, Michelk Simon, "Nanotechnology: Basic Science and Emerging Technologies".
2. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, New York, 2000.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE : Biosensors and Nanotechnology (INDSE8A)

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		
Biosensors and Nanotechnology (INDSE8A)	04	03	-	01	Course admission eligibility	Basics of semiconductor materials

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the working principles of biosensors and their components.
- Identify different types of biosensors based on sensing mechanisms and applications.
- Gain knowledge about the materials and techniques used in biosensor fabrication.
- Learn about the interfacing and signal processing involved in biosensors.
- Understand the principles of nanomaterials.
- Explore their integration into biosensing devices.
- Explore the role of nanotechnology in enhancing biosensor performance.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Develop a deep understanding of Biosensors and their Applications.
- Develop understanding of nanoscience and nanomaterials.
- Correlate properties of nanostructures with their size, shape and surface characteristics.
- Gain the improvements in drug delivery systems using nanotechnology.

SYLLABUS OF DSE

UNIT-I **(10 hours)**

Biosensors: Introduction to Biosensors, Definition, components and working principles
Classification of Biosensors: Based on transduction mechanism: Electrochemical, optical, piezoelectric and mass sensors.
Based on biorecognition elements: Enzyme-based, DNA-based and immunosensors.
Key Performance Parameters: Sensitivity, specificity, stability, response time and detection limit.

UNIT-II **(11 hours)**
Transducer Materials and Bioreceptors: Conducting polymers, nanomaterials, and biomaterials, Immobilization techniques: Adsorption, covalent bonding, entrapment, and cross-linking.
Signal Transduction and Amplification: Concepts of signal conversion and amplification, Noise reduction techniques in biosensors.

UNIT-III **(14 hours)**

Introduction to Nanotechnology: properties of nanomaterials: Optical, electrical, and mechanical. **Types of nanostructure:** Zero dimensional, One dimensional, Two dimensional and three-dimensional nanostructured materials, Quantum Dots shell
Synthesis of Nanomaterials: Top-down and bottom-up approaches, Techniques: Sol-gel method and nanolithography.

UNIT-IV **(10 hours)**
Nanostructured Materials in Biosensors: Use of nanoparticles, nanowires, nanotubes and quantum dots, Role of nanomaterials in signal enhancement and detection sensitivity. **Advanced Nano biosensors:** Plasmonic biosensors, Nano sensors for drug delivery and point-of-care diagnostics.

Practical component: **(Hardware/Software/Demo/Virtual Lab)** **(30 hours)**

1. Detection of Glucose Using a Commercial Glucose Sensor
2. To study the performance of Biosensor (Pulse measurement technique) (Virtual Lab)
3. To study the piezoelectric properties of ZnO thin films for biomolecule detection.
4. To study capacitive biosensor using a semiconductor material for detecting biomolecules.
5. Project on biosensors

Essential/recommended readings

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
2. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
3. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
4. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
5. Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeh and Benjamin Fry, Springer (2008).

Suggestive readings

1. Biosensor: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
2. Nanomaterials for Biosensors, Cs. Kumar, Wiley-VCH, 2007.
3. Smart Biosensor Technology,G.K. Knoff , A.S. Bassi, CRC Press, 2006.

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Discipline Specific Elective-: Medical Image Processing and Healthcare Management (INDSE8B)

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		
Medical Image Processing and Healthcare Management (INDSE8B)	04	03	-	01	Course admission eligibility	Basic Mathematics and MATLAB/ Scilab

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to provide a detailed introduction to image & its processing.
- To understand & to know how an image model is developed and processed.
- To develop a capacity to analyze the image through various segmentation techniques.
- To develop a capacity to apply these processes in medical applications.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Recognizing and analyzing image acquisition storage, processing, communication & display.

- Able to understand the formation of image models & basic enhancement techniques.
- Learn the image segmentation processing in detail.
- Able to understand the basic applications of image processing in medical systems.

SYLLABUS OF DSE

UNIT – I (12 hours)

Introduction to biomedical Image Processing: Image acquisition, storage, processing, communication and display.

Visual perception: Structure of the Human Eye, Image formation in a human eye, brightness and contrast, adaptation and discrimination, Block's Law and critical fusion frequency photographic film characteristics.

UNIT – II (11 hours)

Image Model: Uniform and non-uniform sampling, quantization, Image enhancement: Image smoothing, point operators, contrast manipulation, histogram modification, noise clipping image sharpening, spatial operators, frequency domain method, low pass and high pass filtering, homomorphic filtering, median filtering.

UNIT – III (11 hours)

Medical Image Segmentation: Histogram-based methods, Region growing and watersheds, Markov Random Field models, active contours, model-based segmentation. Multi-scale segmentation, semi-automated methods, clustering-based methods, classification-based methods, atlas-guided approaches, and multi-model segmentation.

UNIT – IV (11 hours)

Introduction to Healthcare Management: Health and Development: Social Determinants of Health, Environment and Health Sustainable Development, Health Policies, Healthcare Financing, Organizational Behaviour in Healthcare and Hospitals, Healthcare processes and Clinical pathways, Medical ethics and medical negligence.

Practical component: (30 hours)

1. To represent basic signals (Unit step, unit impulse, ramp, exponential, sine, and cosine).
2. To develop a program for obtaining Fourier transform & inverse Fourier transform.
3. To develop a program for obtaining Laplace transform & inverse Laplace transform.
4. To develop a program for obtaining z- transform & inverse z-transform.
5. To develop a program for discrete convolution.
6. To develop a program for discrete correlation.
7. To develop a program for converting an RGB image to a GRAY scale.
8. To develop a program for obtaining a histogram of an image.
9. To develop a program for adding & removing salt and pepper noise.
10. To develop a program for performing filtering operations on images.

11. To develop a program for blurring & sharpening of an image.

Essential/recommended readings

1. Rafel C Gonzalez, Richard E Woods, "Digital Image Processing", 2nd ed., Addison - Wesley Publishing Company, New Delhi, 2002.
2. William R Hendee, E. Russell Ritenour, "Medical Imaging Physics", 4th ed., John Wiley & Sons, Inc., New York, 2002.
3. Gonzalez, R., and R. E. Woods. "Digital Image Processing", 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2002. ISBN: 9780201180756.
4. Epstein, C. L. "Mathematics of Medical Imaging", Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 9780130675484.
5. Webb, S. "The Physics of Medical Imaging", New York, NY: Taylor & Francis, 1988. ISBN: 9780852743492.
6. Hospital Administration and Human Resource Management: DK Sharma and RC Goyal, PHI Learning Pvt. Ltd., 01-Aug-2017.
7. Hospital Information Systems: A Concise Study: AS Kelkar, PHI Learning Pvt. Ltd., 2010.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE: Semiconductor device modeling and simulation (INDSE8C)

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		
Semiconductor device modeling and simulation (INDSE8C)	04	02	-	02	Course admission eligibility	semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will develop a solid understanding of semiconductor device physics, operation, and behavior.
- Students will grasp the fundamentals of semiconductor fabrication processes and how to model them effectively.

- Students will learn to use modeling tools and techniques for simulating semiconductor devices and processes.
- Students will be able to analyze simulation results, extract relevant data, and interpret the implications for device and process performance.

Learning outcomes

- Describe the fundamental principles of semiconductor devices.
- Model and simulate semiconductor fabrication processes, such as oxidation, diffusion, deposition, and etching, using appropriate software tools.
- Use numerical methods to solve semiconductor device and process equations, and understand the mathematical foundations of modeling.
- Analyze and interpret simulation results to draw meaningful conclusions about device and process performance.
- Explain the importance of TCAD in semiconductor manufacturing and design.

SYLLABUS OF DSE

UNIT – I **(8 hours)**

Introduction to Semiconductor Device Modeling: Importance of device modeling in semiconductor industry

Fundamental Equations: Poisson’s equation, continuity equation, drift-diffusion equation

UNIT – II **(8 hours)**

Device Modeling Techniques: Physical Models: Solving Poisson’s and continuity equations.Compact Models**:**Shockley model for Diodes and Gummel-Poon model for BJTs.

UNIT – III **(6 hours)**

Simulation Tools and Techniques: Introduction to state-of-the-art simulation tools used for nanoscale device analysis, including TCAD (Technology Computer-Aided Design) software, Standard industry TCAD tools

UNIT – IV **(8 hours)**

Device Simulation: Techniques for optimizing device structures and scaling advanced devices for high performance. Simulation of emerging devices (e.g. FinFETs, nanoscale devices)

Practical component: (TCAD software) **(60 hours)**

1. Simulate and model diode using software.
2. Simulate and model NPN transistor using software.
3. Simulate and model PNP transistor using software.
4. Simulate and model N-channel MOSFET using software.
5. Simulate and model P-channel MOSFET using software.
6. Explore the effect of temperature on N-channel MOSFET characteristics.

7. Explore the effect of gate oxide thickness on N-channel MOSFET characteristics
8. Explore the effect of temperature on P-channel MOSFET characteristics.
9. Explore the effect of gate oxide thickness on P-channel MOSFET characteristics
10. Utilize TCAD tools to simulate semiconductor fabrication processes, such as oxidation, diffusion, and etching.
11. Explore the modeling of advanced semiconductor devices, such as FinFETs

Essential/recommended readings

1. "Introduction to Semiconductor Device Modelling" by B. Van Zeghbroeck
2. "Semiconductor Device Fundamentals" by Robert F. Pierret
3. "Process Technology for VLSI and ULSI" by C. Y. Chang and S. M. Sze
4. "Process Simulation" by Robert E. King
5. "Numerical Simulation of Submicron Semiconductor Devices" by Mark Lundstrom and Jing Wang
6. "Nanoscale Transistors: Device Physics, Modeling, and Simulation" by Hong Guo, Mark Lundstrom, and Jing Guo
7. "Numerical Methods for Engineers and Scientists" by Amos Gilat and Vish Subramaniam

Suggestive readings

1. "Semiconductor Device Modeling with Spice" by Giuseppe Massobrio and Paolo Antognetti
2. "Technology CAD — Computer Simulation of IC Processes and Devices" by Wolfgang M. Olthoff

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

DISCIPLINE SPECIFIC Elective COURSE: Optoelectronic Applications (INDSE8D)

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		
Optoelectronic devices and Applications (INDSE8D)	04	03	-	01	Course admission eligibility	Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a detailed exposure to the physics, principle of operation, design, and characteristics of widely used optoelectronic devices for applications in Optoelectronics, Optical Communication and Optical Signal Processing.
- Specific emphasis will be on optical amplifiers, sources, detectors, and modulators, which also lead to the realization of Photonic Integrated Circuits.
- Understand how the fundamental concepts affect the performance of practical optoelectronic devices

Learning outcomes

The Learning Outcomes of this course are as follows:

- Describe the optical absorption and emission characteristics of a given semiconductor material under certain excitation conditions
- Predict the most fundamental performance characteristics of a given optoelectronic device design.
- Choose the most appropriate optoelectronic device for a specific application and understand possibilities and limitations offered by that particular device.
- Perform measurements to investigate the basic properties of optical fibre and detecting devices.

SYLLABUS OF DSE

UNIT – I **(10 hours)**

Wave Nature of Light – Conceptual Overview

Wave Equation, Refractive index, group and phase velocity, Pointing vector, Snell's law, Fresnel's equations, Optical Resonators, Optical Tunneling, Coherence

UNIT – II **(12 hours)**

Optical Waveguides and Fibers

Optical waveguides and their classifications, Fiber optic components: fiber Bragg gratings, directional couplers, Fiber optic wave-plates, Optical Amplifier.

UNIT – III **(12 hours)**

Polarization and Modulation

Polarization, propagation in anisotropic media, birefringent devices, integrated optical modulators, acousto-optic modulators, magneto-optic modulators, nonlinear effects.

UNIT – IV

Optical Devices and Detector **(11 hours)**

Laser Diodes, Semiconducting Laser Amplifiers, LDR science and operation, Photodiode science and operation, avalanche and heterojunction photodiodes, phototransistors, photoconductive gain.

Practical component: **(30 hours)**

1. Study of Characteristics of phototransistors.

2. Study of Characteristics of laser diode.
3. Study of Characteristics of photodiodes.
4. Study of Characteristics of LDR.
5. Study of Characteristics of opto-couplers.
6. Study of Measurement of beam characteristics of lasers.
7. Measurement of losses- attenuation, bending in optical fibers.
8. Measurement of power gain in an optical amplifier.

Essential/recommended readings

1. Ajoy Ghatak, Optics, McGraw-Hill, 7th edition, 2020
2. S. O. Kasap, *Optoelectronics and Photonics: Principles and Practices*, Prentice Hall, 2012.
3. P. N. Prasad, *Nanophotonics*, John Wiley & Sons, 2004.
4. J. Singh, *Optoelectronics: An introduction to materials and devices*, McGraw-Hill, 1996.
5. Fiber Optic Sensors, An introduction for Engineers and Scientists, Eric Udd and W. B. Spillman, 2nd Ed, Wiley,2012, New Jersy, USA.
6. Kathryn M. Booth, The Essence of Optoelectronics, Prentice Hall, 2007

Suggestive readings

1. Optical Fiber Sensors: Systems and Applications, Ed. B. Culshaw and John Dakin, Artech House, Inc., 1989, Noewood, USA.
2. Fundamentals of Optical Fiber Sensors, Z. Fang, K.K.Chin, R. Qu, H. Cai, Wiley,2012, New ersy, USA.
3. G. P. Agrawal, *Fiber optics communication system*, John Wiley & Sons, 2011.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE –: Advanced Process Control (INDSE8E)

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		
Advanced Process Control (INDSE8E)	04	03	-	01	Course admission eligibility	Basics of Process Control

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the fundamentals of process control and its role in industrial systems.
- To comprehend the dynamic behavior of various processes like flow, temperature, pressure, and level control systems.
- To explore different control strategies, such as feedback, feedforward, and cascade control.
- To familiarize students with essential control hardware (sensors, transmitters, controllers, and actuators).

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand and analyze the dynamic behavior of first-order, second-order, and higher-order processes, focusing on key parameters like time constant, transient response, and steady-state error.
- Develop mathematical models for open-loop and closed-loop control systems and classify their structure and functionality.
- Implement and evaluate control strategies, including feedback, feedforward, and cascade control, to mitigate process disturbances.
- Identify and understand the roles of sensors, actuators, controllers in industrial automation.
- Use tools like MATLAB/Simulink to model, simulate, and analyze process control systems, and apply these concepts to real-world industrial processes.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Basics of Process Control, Process Dynamics, Types of processes, Control Strategies: Feedback control, Feedforward control, Cascade control. Introduction to Control Hardware and Software: Overview of sensors, transmitters, controllers, and actuators

UNIT – II **(11 hours)**

PID Control forms and closed loop tuning and direct synthesis method, Internal Model Control, IMC based PID procedure, control actions, Tuning methods, Controller Design, Controller Implementation

UNIT – III **(11 hours)**

Advanced Control Strategies: Ratio control, Adaptive control, and Inferential control, Concept of Model Predictive Control (MPC) and its applications, Multivariable Process Control, Nonlinear and Optimal Control: Concept of nonlinear systems and need for nonlinear control.

UNIT – IV **(11 hours)**

Industrial Process Control Applications, Case Studies and Simulation Projects, Current Trends in Process Control: Introduction to Industry 4.0 and Smart Process Control, Role of IoT, AI, and ML in predictive and self-tuning controllers, Emerging trends in sustainable and green process control systems.

Practical component: **(30 hours)**

1. Analysis of First-Order Dynamic Systems: Response to Step, Impulse, and Ramp Inputs.
2. Analysis of Second-Order Dynamic Systems: Response to Step, Impulse, and Ramp Inputs.
3. Design, Implementation, and Performance Analysis of P Controller for Process Control Systems.
4. Design, Implementation, and Performance Analysis of PI Controller for Process Control Systems.
5. Design, Implementation, and Performance Analysis of PD Controller for Process Control Systems.
6. Design, Implementation, and Performance Analysis of PID Controller for Process Control Systems.
7. Design and Implementation of a Cascade Control System.
8. Analysis of Multivariable Control Systems Using Relative Gain Array Method.
9. Design, Simulation, and Performance Evaluation of a Model Predictive Controller.

Essential/recommended readings

1. Chemical Process Control: George Stephanopoulos, Prentice Hall India Pvt. Ltd.
2. Process Systems Analysis and Control: Donald Coughanowr, McGrawHill, Inc.
3. Process Control and Instrumentation: Prof. R. P. Vyas, Central Techno Publications, Nagpur

Suggestive readings

1. Process Dynamics and Control: D. E. Seborg, T. F. Edgar, D. A. Mellichamp, Wiley.
2. Control System Design: Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Prentice Hall.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE: Pneumatic and Hydraulic Systems (INDSE8F)

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		

Pneumatic and Hydraulic Systems (INDSE8F)	**04**	**03**	**-**	**01**	**Course admission eligibility**	**Basics of Electric Circuits**

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the concept, importance, and real-world applications of pneumatic and hydraulic systems.
- Identify and describe the components of a fluid power system, including actuators, valves, pumps, compressors, and reservoirs.
- Develop foundational knowledge of the working principles of hydraulic and pneumatic systems.
- Differentiate between hydraulic and pneumatic systems based on their operational principles, advantages, and limitations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Define the concept of fluid power and explain its role in industrial applications.
- List and describe the key components of a fluid power system and their respective functions.
- Differentiate between hydraulic and pneumatic systems, citing examples of where each is used.
- Apply the basic principles of fluid mechanics, such as Pascal's Law, to understand system pressure and force transmission.
- Illustrate the layout and components of a basic fluid power system.

SYLLABUS OF DSE

UNIT – I : Introduction to Pneumatic and Hydraulic Systems (10 Hours)
Basics of Fluid Power Systems: Definition, importance, and applications in industry. Components of fluid power systems: Actuators, Valves, Pumps, Compressors, and Reservoirs. Fundamentals of Hydraulics, Fundamentals of Pneumatics.

UNIT – II: Components and Design of Hydraulic Systems (12 Hours)
Hydraulic Actuators: Types of hydraulic actuators, Hydraulic cylinders, Hydraulic motors, Hydraulic Valves, Pressure control valves, Flow control valves and Directional control valves. **Hydraulic Circuits:** Regenerative circuits and their applications. **Accumulators:** Types, working, and applications

UNIT – III: Components and Design of Pneumatic Systems (12 hours)

Pneumatic Actuators: Types of pneumatic actuators, Pneumatic cylinders, Pneumatic motors.

Pneumatic Valves and Accessories: Types of control valves, Valve actuation, Pneumatic Circuits, Compressor Systems: Types of compressors, Air storage and distribution, Maintenance and troubleshooting of pneumatic systems.

UNIT – IV: Control, Troubleshooting, and Applications (12 hours)

Control Systems in Pneumatic and Hydraulic Systems: Control logic for automated systems. Role of proportional, servo, and electrohydraulic systems in automation. Troubleshooting and Maintenance. Applications of Pneumatic and Hydraulic Systems

Practical component: (Hardware/ Software) (30 hours)

1. Modeling and Simulation of a Hydraulic/Pneumatic System Using MATLAB Simulink
2. Write a MATLAB script to calculate flow rate and pressure drop using the Hagen-Poiseuille equation.
3. Design and simulate the operation of hydraulic actuators.
4. Design and analyze the working of pressure control valves.
5. Design a regenerative hydraulic circuit and analyze its performance.
6. Design and simulate pneumatic actuators and cylinders.
7. Design a pneumatic control system for sequential operations.
8. Design a hydraulic system for controlling the position of an actuator.
9. Industrial visits for applications of hydraulic and pneumatic systems and their reports.

Essential/recommended readings

1. Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2005.
2. Majumdar S.R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGrawHill, 2001.
3. Anthony Lal, “Oil hydraulics in the service of industry”, Allied publishers, 1982.
4. Dudelyt, A. Pease and John T. Pippenger, “Basic Fluid Power”, Prentice Hall, 1987.

Suggestive readings

1. Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 1995
2. Michael J, Prinches and Ashby J. G, “Power Hydraulics”, Prentice Hall, 1989.
3. Shanmugasundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books

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DISCIPLINE ELECTIVE COURSE –: Sustainable Energy Technologies (INDSE8G)

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		
Sustainable Energy Technologies (INDSE8G)	04	02	-	02	Course admission eligibility	Basics Knowledge of Physics

Learning Objectives

- To provide sound knowledge about different sustainable resources.
- Discussion of different types of solar thermal systems and solar photovoltaic systems.
- To have adequate knowledge of construction and working of various types of wind energy systems and micro-hydro power systems
- To have sound knowledge about bioenergy systems

Learning outcomes

The Learning Outcomes of this course are as follows:

- Acquire the knowledge about sustainable energy and its different types
- Be conversant in construction and working of concentrated solar power systems and Solar Photovoltaic systems
- Be conversant in construction and working of different wind energy systems and different micro-hydro systems.
- Understand different bio-energy systems

SYLLABUS OF DSE

UNIT – I (8 hours)

Introduction to sustainable energy and Energy Fundamentals: Sustainable energy, Alternative energy sources: Primary, secondary and tertiary sources, Introduction to different types of sustainable energy resources-solar energy, wind energy, water energy and biomass energy.

UNIT – II (8 hours)

Classification of Solar Photovoltaic systems: Grid connected, off-grid, stand-alone systems. Photovoltaic cells: Types, merits and demerits, Different types of panels, Battery and other accessories, Recent trends and promotional schemes

UNIT – III (8 hours)

Wind energy systems and Micro-hydro Power systems

Types of wind energy systems: Large and small, commercial and domestic, grid connected and stand-alone, Small Horizontal axis and vertical axis wind turbines: construction, working, specifications and maintenance procedure.

Micro hydro power systems**:** Classification, Layout, construction and working, Installation: procedures and precautions, operating procedures and maintenance.

UNIT – IV (6hours)

Bio-energy Systems

Classification of biofuels: biogas and biodiesel, Biomass power plants: Layout, construction and principle of working and specification, Applications of various bio-fuels: Domestic and commercial

Practical Component (Hardware/ Softaware) (60 hours)

1. Identify the components of solar flat plate collector.
2. Use pyranometer for measurement of solar radiation flux density.
3. Assemble a solar PV system with and without battery connection.
4. Measure heat output, Maximum power, power output efficiency of solar PV panel.
5. Use vane anemometer for measurement of different locations for site selection for wind mill.
6. Industrial visit
7. Project based on sustainable technologies.

Project based on sustainable technologies

Essential/recommended readings

1. C. S. Solanki, *Solar Photovoltaics*. PHI Learning Pvt. Ltd., 2015.
2. Solar energy, 4th edn , January 2017 by S P Sukhatme and J K Nayak
3. T. Ackermann, *Wind Power in Power Systems*. John Wiley & Sons, 2012.
4. D. P. Kothari, *Renewable Energy Sources and Emerging Technologies*. 2022.
5. V. C. Nelson, *Introduction to Bioenergy*. CRC Press, 2017.

Suggestive readings

1. K. Lovegrove, *Concentrating Solar Power Technology*. Elsevier, 2012.

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

GENERIC ELECTIVE COURSE: Instrumentation and Control (INGE7A)

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		
Instrumentation and Control (INGE7A)	**04**	**03**	**-**	**01**	**Course admission eligibility**	**Basic instrumentation**

Learning Objectives

The Learning Objectives of this course are as follows:

- To study about how to analyse the stability and response of the closed and open loop systems
- To teach students about how to develop the mathematical model of the physical systems
- To study about how to analyse performance characteristics of system using Frequency response methods
- To study how to compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability

Learning outcomes

- Analyze the stability and response of the closed and open loop systems
- Develop the mathematical model of the physical systems
- Analyze performance characteristics of system using Frequency response methods
- Compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability
- Handle different types of controller like electronic, pneumatic and hydraulic

SYLLABUS

Unit-I **(13 hours)**

Basic concepts of Instrumentation: Generalized Instrumentation systems, block diagram representation, scope of instrumentation in Industrial organization.

Transducers: Active and Passive transducers, Mechanical transducers and Electrical transducers, Introduction to Resistive, Capacitive, Inductive, light (Photo-conductive, Photo-emissive, Photo-voltaic), Temperature transducers (RTD, thermocouple).

Unit-II **(12 hours)**

Signal Generators-Audio oscillator, Function generators, Pulse generators, RF generator, and Random noise generator.
Controller Hardware: Electronic pneumatic and hydraulic controller's implementation, single and composite modes of controller

Unit-III **(10 hours)**
Basics of control system: Open loop and closed loop control systems, mathematical modeling of physical systems, transfer function. Effect of feedback on control systems.
Time – Domain Analysis and Stability: Time domain performance criteria, transient response of first and second order systems. Asymptotic stability and conditional stability, relative stability analysis.

Unit-IV **(10 hours**)

Frequency Domain Analysis: Correlation between time and frequency response, frequency domain specifications.
Final Control Elements: Control valves types, actuators, Solenoid, I/P P/I converters, stepper motors.

Practical Components **(30 Hours)**
Some of the experiments mentioned can be simulated on software (MATLAB/MathCAD/LabVIEW/SciLab)

1. Study and operation of Multimeters (Analog and Digital), Function Generator, Regulated Power Supplies, CRO, DSO.
2. To measure displacement using capacitive transducer
3. To measure displacement using LVDT
4. Measuring change in resistance using LDR
5. Measurement of Temperature using Temperature Sensors.
6. To study position control of DC motor
7. To study speed control of DC motor
8. To study time response of first and second order systems.
9. To study the effect of the damping factor on performance of second order systems.

Essential/Recommended readings

1. K. Ogata, Modern Control Engineering, PHI 2002, 4th Edition.
2. B. C. Kuo , "Automatic control system", Prentice Hall of India, 2000, 7th Edition.
3. I. J. Nagrath& M. Gopal, Control System Engineering, New Age International, 2000,

2nd Edition.
4. Nakra&Choudhary, Instrumentation Measurements and Analysis, Tata McGraw-Hill, 3rd Edition (2010).

Suggestive readings

1. Johnson .C.D., Process Control Instrument Technology, Prentice Hall Inc, 8th Edition (2006).

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GENERIC ELECTIVE COURSE: Photovoltaic Technology and Applications (INGE7B)

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		
Photovoltaic technology and applications (INGE7B)	04	03	-	01	Course admission eligibility	Familiarity with electronic components and circuit designing

Learning Objectives

The Learning Objectives of this course are as follows:
- Students will develop a fundamental understanding of solar cells, its working, and characteristics.
- Students will be able to develop basic solar cells and calculate its efficiency.
- Students will learn about various generations of solar cells.
- Students will be able to recognize the various applications of solar cells.

Learning outcomes

- Describe the fundamental principle and working principle of solar cells.
- Evolution of solar cells and different generations of solar cells.
- Learn various techniques to develop solar cells.
- Analyze and interpret efficiency of solar cells and draw meaningful conclusions about device and process performance.
- Explain the applications of photovoltaics in industries.

SYLLABUS OF GE

UNIT – I **(12 hours)**

Energy and its Sources, Introduction to Solar Energy, Absorption spectra, Band Theory, Energy Band Diagram, Charge Carrier Dynamics in Semiconductor, Solar cell working principle, Current-Voltage Characteristics of Solar Cell, Equivalent Circuits of Solar Cells

UNIT – II **(12 hours)**

1st and 2nd Generation solar cells: monocrystalline Silicon solar cell, polycrystalline Silicon solar cell,amorphous Si solar cells, Cadmuim telluride Solar Cells,Copper indium gallium selenide (CIGS) solar cells

UNIT – III **(11 hours)**

3rd and 4th Generation solar cells:CZTS solar cells,Organic materials (OSC) solar cells, Perovskites (PSC) solar cells,polymer solar cells,hybrid solar cells,Multi-junction photovoltaic cells,nanocrystalline solar cells,Quantum dots (QD) photovoltaic cells,Dye-sensitized (DSSC) photovoltaic cells.

UNIT – IV **(10 hours)**

Installations techniques, cost effectiveness, Applications of solar cells of Industry, household, military, solar farms, remote locations, space, transportation, building integrated systems, power generation rural areas.

Practical component: **(30 hours)**

1. To calculate various parameters of solar cells.
2. To synthesize, dye synthesis solar cells and calculate its efficiency.
3. To develop and characterize thin film.
4. To study absorption spectra of different materials for solar cells.
5. To develop a project using solar panels.
6. Simulate and model basic solar cells using software.
7. An industrial visit for exposure to the photovoltaic industry.

Essential/recommended readings

1. Semiconductors for Solar Cells" by H J Moller
2. The Physics of Solar Cells" by J Nelson
3. Photovoltaic Solar Energy: From Fundamentals to Applications" by Angèle Reinders and Pierre Verlinden

Suggestive readings

1. "Semiconductor Device Modeling with Spice" by Giuseppe Massobrio and Paolo Antognetti
2. "Technology CAD — Computer Simulation of IC Processes and Devices" by Wolfgang M. Olthoff.

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GENERIC ELECTIVE COURSE-: Machine Intelligence (INGE7C)

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 Intelligence (INGE7C)	04	02	-	02	Course admission eligibility	Basics of statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- To apply machine intelligence techniques in applications which involve perception,
- reasoning and learning.
- To acquire knowledge of real-world knowledge representation
- To use different machine learning techniques to design AI machine and enveloping
- applications for real world problems.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply machine intelligence techniques in applications which involve perception,
- reasoning and learning
- Acquire knowledge of real-world knowledge representation
- Use different machine learning techniques to design AI machines and enveloping applications for real world problems.

SYLLABUS OF GE

UNIT – I **(8 hours)**

Components of AI, Human Intelligence vs. Machine Intelligence, Knowledge Acquisition, Representation and Organization, Structured Knowledge Representation using Semantic Networks and Frames, Expert System Architecture, and Functions of Expert Systems.

UNIT – II **(8 hours)**

Structure and Function of a Single Neuron, Artificial Neuron Models, Types of Activation Functions, Neural Network Architectures, Neural Learning, Supervised Learning, Unsupervised Learning and Application Areas of Neural Networks.

UNIT – III **(8 hours)**

Introduction to Fuzzy Logic, Fuzzy Sets and Systems, Membership Functions and Fuzzification, Knowledge and Rule-Based Systems, Decision-Making Logic and Inference Systems, Defuzzification and Applications of Fuzzy Logic.

UNIT – IV **(8 hours)**

Genetic Algorithm (GA) Concepts, GA Operators and Techniques, Applications of Genetic Algorithms and Hybrid Systems.

Practical component: **(60 hours)**

1. Simulate simple AI components like perception (input gathering), learning (pattern recognition), and reasoning (decision making).
2. Build a decision tree for a simple classification task. Implement depth-first search (DFS) to explore the tree.
3. Use a dataset to implement a basic machine learning model (e.g., k-NN or Decision Tree) that simulates human-like decision-making.
4. Compare the results of a machine learning model (e.g., classification) with human decisions on the same dataset, and analyze the differences.
5. Implement an expert system with a knowledge base for medical diagnosis. Simulate decision-making based on user inputs.
6. Create a semantic network and frames to represent and query knowledge. Visualize relationships between concepts.
7. Develop a basic expert system, focusing on constructing the knowledge base and implementing a simple inference engine.
8. Implement forward and backward chaining inference methods to derive conclusions from a knowledge base.
9. Implement a rule-based fuzzy logic expert system for decision-making, such as diagnosing conditions based on input parameters.
10. Create a model of a single artificial neuron, focusing on inputs, weights, and activation functions (e.g., Sigmoid).
11. Implement and visualize common activation functions (Sigmoid, ReLU, Tanh). Compare their output behaviors.
12. Build and simulate a basic feedforward neural network. Implement simple tasks like classification.
13. Train a neural network using the backpropagation algorithm. Use it to classify a simple dataset.
14. Implement basic fuzzy logic operators (AND, OR, NOT), applying them to sample fuzzy sets and visualizing the results.
15. Implement a genetic algorithm (GA) to solve an optimization problem, such as function maximization or finding optimal parameters for a model.

Essential/recommended readings

1. Timothy J. Ross, Fuzzy logic with Engineering Applications , McGraw Hill, New York, 3rd Edition.
2. S. Rajasekaran, G. A. VijayalakshmiPai Neural Networks, Fuzzy Logic And Genetic

Suggestive readings

1. Algorithm: Synthesis and Applications, PHI Learning Pvt. Ltd., 2003, 1st Edition.
2. Martin T. Hagan, Howard B. Demuth, Mark H. Beale, Neural Network Design,PWS Publishing Company, Thomson Learning, 1st Edition 4. N.P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 1st Edition

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GENERIC ELECTIVE COURSE-: Robotics (INGE8A)

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		
Robotics (INGE8A)	04	02	-	02	Course admission eligibility	Basic programming.

Learning Objectives

The Learning Objectives of this course are as follows:

- After completion of this course students should be well versed in programming a microcontroller.
- They should be able to use various sensors and make the microcontroller respond to the external environment.
- Students would be in a position to make a rudimentary robot which is capable of moving along a predetermined path, follow a drawn line and equivalent applications.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understanding the history, concepts and key components of robotics technologies.
- Understanding the control systems related to robotics.

- Analysis of various robot sensors, Actuators and their perception principles that enable a robot to analyses their environment
- Analyze the robot motion, kinematics, navigation and path planning.
- Designing the programming principles for robot control systems.

SYLLABUS OF GE

UNIT-1 **(8 Hours)**

Introduction to Robotics: Brief history of robotics, future perspectives of robotics, classification of robots,basic components of robot, Degrees of freedom of robots, Robot configurations and concept of workspace, human system and robotics, safety measures in robotics, social impact, advantages and disadvantages of robots, Robotics applications **.**

UNIT-2 **(8 Hours)**

Basic components for Robotic Applications

Actuators: DC Motors, Gearing and Efficiency, Servo Motors, Stepper motors, Motor Control and its implementations

Sensors: Sound Sensor, Gas Sensor, Ultrasonic Sensor, IR Sensor, LDR, Temperature Sensor, PIR Sensor, contact Sensor, Proximity sensor , pressure sensor .

Indicators: LCD, LEDs, Buzzer, Relays

UNIT-3 **(8 Hours)**

Programming Environments: Integrated Development Environment (IDE) for microcontrollers, free IDEs like AVR Studio, WIN AVR. Installing and configuring for Robot programming, In System Programmer (ISP), loading programs on Robot. Languages used in Robotics (Basic concept)

UNIT-4 **(6 Hours)**

Programming and interfacing . Programming Robot to follow a given path; Direction controlled movements of Robot using sensors like LDR/IR sensors and sound Sensor, Line Follower Robot. Wired RS232 (serial) Communication, Application of USART in commanding Robot using Bluetooth, WiFi modules etc.

Practical Component **(60 hours)**

Software /hardware based practicals (Microcontroller/Arduino/RobotStudio/ or any available software)

1. Program to blink LED
2. Program to display decimal numbers on Seven segment display
3. Program to interface LCD and display messages .
4. Program to interface sound sensor /IR sensors/Ultrasound sensor

5. Program to interface motors (DC/stepper/Servo).
6. Program to interface Camera/Relay
7. Buzzer interfacing
8. interfacing with Zigbee
9. Write a program to do object detection with Robots.
10. To design White line follower Robot.
11. Programming using USART.
12. Project

Essential/recommended readings

1. Saha, S.K., Introduction to Robotics, 2nd Edition, McGraw-Hill Education, New Delhi,
2. 2014
3. R.K. Mittal, I.J. Nagrath, Robotics & Control‖, Tata McGraw & Hills, 2005. M P Groover, Industrial Robotics, Tata McGraw & Hills, 2nd Edition 2012
4. S R Deb and Sankha Deb, Robotics Technology and Flexible Automation, Tata McGraw & Hills. 2010

Suggestive readings

1. Craig. J. J, Introduction to Robotics- Mechanics and Control, Pearson Education India, 3 nd Edition. 1999

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GENERIC ELECTIVE COURSE-: Augmented and virtual reality (INGE8B)

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		
Augmented and virtual reality (INGE8B)	04	02	-	02	Course admission eligibility	Basics of programming language

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the relevance of this course to the existing technology through demonstrations, case studies and applications with a futuristic vision along with socio-economic impact and issues.

- To understand virtual reality, augmented reality and using them to build Biomedical engineering applications.
- To know the intricacies of these platforms to develop PDA applications with better optimality.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Analyse & design a system or process to meet given specifications with realistic engineering constraints.
- Identify problem statements and function as a member of an engineering design team.
- Utilise technical resources
- Propose technical documents and give technical oral presentations related to design mini project results.

SYLLABUS OF GE

UNIT – I **(8 hours)**

Introduction to Virtual Reality (VR), The Three I's of Virtual Reality, Commercial VR Technology, Five Classic Components of a VR System, Input Devices – Trackers, Navigation and Manipulation Interfaces, Gesture Interfaces, Output Devices – Graphics, Sound, and Haptic Feedback

UNIT – II **(8 hours)**

Introduction to VR Development Process, Geometric and Kinematics Modelling, Physical Modelling in VR, Behaviour Modelling, Model Management in VR, Content Creation Considerations for VR, User Performance Studies in VR, Health, Safety, and Usability Issues in VR

UNIT – III **(8 hours)**

VR on the Web, VR on Mobile Devices, JavaScript for VR, Frameworks for VR Development, Google VR for Android, Mobile VR Development, Teleporting, Spatial Audio, and Interaction, Assessing Human Parameters and Designing Haptics.

UNIT – IV **(6 hours)**

Medical applications-military applications-robotics applications- Advanced Real time Tracking- other applications- games, movies, simulations, therapy.

Practical component: **(60 hours)**

1. Design and implement basic interaction scenarios focusing on immersion, interaction, and imagination.
2. Develop a program to demonstrate simple navigation in VR, utilizing a basic 3D environment.

3. Implement gesture recognition using Python and OpenCV for simple VR interactions.
4. Build a basic VR environment with graphics output using Python and OpenGL.
5. Simulate sound and haptic feedback using Python libraries.
6. Implement simple 3D models using Python libraries.
7. Design basic behaviors and interactions of objects in a VR environment.
8. Implement user tracking in a VR simulation to assess interaction and performance.
9. Build a basic WebVR environment using JavaScript with Python-based backend integration.
10. Set up Python environments for mobile development.
11. Integrate Python and JavaScript for interactive VR experiences on the web.
12. Simulate simple mobile VR interactions and assess user experience using Python.
13. Develop a simulation of a medical procedure or virtual therapy using VR.
14. Create a VR environment for military training or robotics simulation.
15. Develop a simple VR game or simulation that integrates multiple VR components (navigation, interaction, feedback).
16. Any one of the following mini projects or on similar concepts: VR Environment Simulation, Interactive Gesture-Based VR Interface, VR Interaction Simulation, User Interaction Evaluation, Mobile VR Experience, WebVR Application, Medical VR Simulation, Robotics in VR.

Essential/Recommended readings

1. C. Burdea & Philippe Coiffet, “Virtual Reality Technology”, Second Edition, Gregory, John Wiley & Sons, Inc.,2008
2. Jason Jerald. 2015. The VR Book: Human-Centred Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA.
3. Augmented Reality: Principles and Practice (Usability) by Dieter Schmalstieg & Tobias Hollerer, Pearson Education (US), Addison-Wesley Educational Publishers Inc, New Jersey, United States, 2016. ISBN: 9780321883575

Suggestive readings

1. Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability), Steve Aukstakalnis, Addison-Wesley Professional; 1 edition, 2016.
2. The Fourth Transformation: How Augmented Reality & Artificial Intelligence Will Change Everything, Robert Scoble & Shel Israel, Patrick Brewster Press; 1 edition, 2016.

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Generic Elective COURSE: 3D printing and design (INGE8C)

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		
3D printing and design (INGE8C)	04	02	-	02	Course admission eligibility	Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To know the importance of 3D printing in manufacturing
- To know the different 3D printing technologies
- To select suitable material for 3D printing
- To understand the applications of 3D printing

Learning outcomes

The Learning Outcomes of this course are as follows:

- Knowledge of the 3D Printing approach and basic terminology
- Knowledge of the main 3D Printing processes, their advantages, and limitations
- Knowledge of materials in 3D Printing
- Knowledge of STL file format and advantages and limitations of 3D Printing for different applications

SYLLABUS OF GE

UNIT – I **(8 hours)**

Introduction: Introduction to 3D printing technologies, Process, Classifications, Advantages, Additive v/s Conventional Manufacturing processes, Applications.
3D Printing Process chain: Steps in Additive Manufacture, Variations from one 3D printing machine to another, maintenance of equipment, Design for 3D .

UNIT – II **(8 hours)**

Powder Bed Fusion Processes: Introduction, SLS process description, material, advantages, and disadvantages.

Extrusion-Based Systems: Introduction, Basic principles, plotting and path control, materials, limitations of FDM.

UNIT – III **(8 hours)**

Design for 3D Printing - Design for Manufacturing and Assembly, Core DFM for 3D Printing Concepts and Objectives, Design Tools for 3D Printing. Guidelines for Process Selection - Selection Methods for a Part, Challenges of Selection, Preliminary Selection, Production Planning, and Control.

UNIT – IV **(6 hours)**

Software for 3D Printing - Preparation of CAD Models – the STL File, STL File Manipulation. Product Quality: Inspection and testing, Defects and their causes

Practical component: **(60 hours)**

(For simulation: OpenSCAD/Free CAD/Meshmixer and or any available software)

1. To simulate the anatomy of a 3D Printer, to get in-depth knowledge of the mechatronics of a 3D printer.
2. To simulate the construction of a cartesian 3D printer and to get in-depth knowledge of the mechatronics of polar 3D printers.
3. To simulate the construction of a polar 3D printer and to get in-depth knowledge of the mechatronics of a polar 3D printer
4. 3D Modelling of a single component.
5. Assembly of CAD modelled Components.
6. Exercise on CAD Data Exchange.
7. Generation of .stl files.
8. Inspection and defect analysis of the additively manufactured product.
9. To simulate the stereolithography (SLA) process.
10. To simulate the Fused diffusion modelling (FDM) process.
11. Simulation of powder binding and jetting process.
12. Simulation of pre-processing in additive manufacturing
13. Simulation of post-processing in additive manufacturing

Essential/recommended readings

1. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010
2. B. Redwood, The 3D Printing Handbook. 2017.
3. L. W. Kloski, Getting Started with 3D Printing. Maker Media, Inc., 2016.
4. H. (Electrical Richard, 3D printing for dummies. Hoboken, NJ: John Wiley & Sons, 2017.

Suggestive readings

1. B. van den, 3D Printing. Springer, 2015.

2. J. Micallef, Beginning Design for 3D Printing. Apress, 2015.

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