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

After successful completion of the course, students will be able to:

- 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.


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

**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 analyse the image through various segmentation techniques.
- To develop a capacity to apply these processes in medical applications.

## Learning Outcomes

After successful completion of the course, students will be able to:

- Recognize and analyse image acquisition storage, processing, communication & display.
- Understand the formation of image models & basic enhancement techniques.
- Learn the image segmentation processing in detail.
- 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”, 4th ed., Addison - Pearson Publishing Company, 2017.
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”, 2nd ed. New York, NY: Taylor & Francis, 2012.

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 in-depth understanding of semiconductor device physics, operation, and behaviour.
- 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

After successful completion of the course, students will be able to:

- 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,3rd Edition, 2011
2. "Semiconductor Device Fundamentals" by Robert F. Pierret.1st Edition, published in 1996 by Pearson.
3. "Process Technology for VLSI and ULSI" by C. Y. Chang and S. M. Sze.2nd Edition, published in 1997 by Wiley.
4. "Process Simulation" by Robert E. King 1st Edition, published in 1997 by McGraw-Hill.
5. "Numerical Simulation of Submicron Semiconductor Devices" by Mark Lundstrom and Jing Wang.1st Edition, published in 2006 by Springer.
6. "Nanoscale Transistors: Device Physics, Modeling, and Simulation" by Hong Guo, Mark Lundstrom, and Jing Guo.1st Edition, published in 2006 by Springer.
7. "Numerical Methods for Engineers and Scientists" by Amos Gilat and Vish Subramaniam.3rd Edition, published in 2014 by Wiley.


**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 Devices and 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

After successful completion of the course, students will be able to:

- 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, **8th Edition**, published in **August 2024** by McGraw Hill Education
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 | 04 | 03 | - | 01 | Course | Basics of |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Process Control (INDSE8E)** | | | | | **admission eligibility** | **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

After successful completion of the course, students will be able to:

- 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. January 2015
2. Process Systems Analysis and Control: Donald Coughanowr, McGrawHill, Inc.3rd edition, 2017
3. Process Control and Instrumentation: Prof. R. P. Vyas, Central Techno Publications, 8th Edition, Jan 2015


**Suggestive readings**


1. Process Dynamics and Control: D. E. Seborg, T. F. Edgar, D. A. Mellichamp,4th Edition, published in 2016 by Wiley.

2. Control System Design: Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Prentice Hall,1st Edition, published in 2015 by Pearson Education India.

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

## DISCIPLINE SPECIFIC ELECTIVE COURSE: 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

After successful completion of the course, students will be able to:

- 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”, 7th Edition, published in February , 2024.
2. Majumdar S.R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGrawHill, July 2017.
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


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

## 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

The Learning Objectives of this course are as follows:

- 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

After successful completion of the course, students will be able to:

- 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/ Software)** **(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.
8.

**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: