ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

SCHOOL OF ELECTRONIC SCIENCES

Minor in Instrumentation Engineering (Smart and Intelligent Sensors)

Curriculum and Syllabus

(**2023-24 admitted students**)

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Admission Batch: 2023-24)

School/ Department: SCHOOL OF ELECTRONIC SCIENCES

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks) (ii) Quiz/ Assignment/Attendance (20 marks)					

Minor Degree in "Instrumentation Engineering (Smart and Intelligent Sensors)"

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PE	EI3265	Introduction to Embedded Systems	3	0	0	3	40	60	-	100
2		EI3566	Embedded Systems Lab	0	0	3	1.5	-	-	100	100
3		EI3266	Instrumentation Devices and Systems	3	0	0	3	40	60	-	100
4		EI4565	Instrumentation Devices and Systems Lab	0	0	3	1.5	-	-	100	100
5		EI4269	Process Control & Automation	3	0	0	3	40	60	-	100
6		EI4271	Industrial Internet of Things	3	0	0	3	40	60	-	100
7		EI4266	MEMS	3	0	0	3	40	60	-	100
Total				**15**	**0**	**3**	**18**	**200**	**300**	**200**	**700**

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Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.
Syllabus (Admission Batch: 2023-24)

Minor Degree in Instrumentation Engineering

(Smart and Intelligent Sensors)

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
INTRODUCTION TO EMBEDDED SYSTEMS	**EI3265**	**3-0-0**	**3**

Prerequisite: Basic Electronics, Digital Logic Design, C Programming

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Analyze embedded system architectures, comparing RISC and CISC for application suitability.

CO2: Apply microcontroller programming to interface sensors, ADCs, and actuators efficiently.

CO3: Design embedded solutions integrating microcontrollers, memory, and peripherals for targeted performance.

CO4: Create embedded system prototypes for applications like mobile devices, automotive, or robotics.

Module I: **7 Hours**

Computer organization basics, binary systems, and arithmetic, RISC vs. CISC architectures and computer languages, Memory units and organization, Introduction to embedded systems, features, domains, history, and trends

Module II: **8 Hours**

Microprocessor vs. microcontroller, classification (4–32 bit), performance metrics, Architecture of 8-bit MCUs (e.g., 8051), memory organization, Low-power design strategies in embedded systems

Module III: **8 Hours**

Pull-up/pull-down resistors and memory types (SRAM, DRAM, EEPROM), Sensor types and ADC interfacing, Actuators (motors, relays, opto-isolators) and their microcontroller interfacing

Module IV: **7 Hours**

Embedded applications in mobile, automotive, RFID, WISENET, robotics, and biomedical fields, Prototyping steps and case studies in consumer and industrial systems

Total lecture hours: **30 Hours**

Text Book:

1. Lyla B Das, Embedded systems: An Integrated Approach, 1st Ed., Pearson, 2013.

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Reference Book:

1. Shibu, K.V., Introduction to Embedded Systems, 1st Ed., TMH, 2009.
2. Kanta Rao B, Embedded Systems, 1st Ed., PHI.
3. Frank Vahid & Tony Givargis, Embedded System Design, 2nd Edition, John Wiley.

CO-PO-PSO MAPPING

INTRODUCTION TO EMBEDDED SYSTEMS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO1 2	PS Ol	PSO 2	PS O3
CO1	3	3	1	2	2	1	1	1	-	-	-	2	3	2	1
CO2	3	3	2	3	3	1	1	1	-	-	-	2	3	3	1
CO3	3	3	3	3	3	2	2	2	2	1	2	2	3	3	2
CO4	3	3	3	3	3	2	2	2	2	1	2	2	3	3	2
Average	3.0	3.0	2.25	2.75	2.75	1.5	1.5	1.5	1.0	0.5	1.0	2.0	3.0	2.75	1.5
Level of Correlation: 3 - High 2 - Medium 1 - Low															

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
EMBEDDED SYSTEM LABORATORY	EI3566	0-0-3	1.5

Prerequisite: Basic Digital Electronics, Programming in C, Fundamentals of Microprocessors

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Program assembly language and C programs for arithmetic operations

CO2: Interface I/O devices ADC, DAC, Keypad, SSD, with microcontroller-based systems

CO3: Develop the driver programs to on-chip and external Peripheral devices

CO4: Develop the communication software to on-chip and external communication interfaces UART, I2C, SPI, wi-fi and Bluetooth

List of Experiments: (Select any 8 experiments from the list of 12 experiments)

EXP 1: Write a program to perform arithmetic operations.

EXP 2: Compare basic assembly code snippets on RISC (ARM) and CISC (e.g., x86) architectures.

EXP 3: Interface and blink an LED using GPIO to understand memory-mapped I/O.

EXP 4: Read a digital input from a switch and control an LED output.

EXP 5: Write a simple program for toggling I/O pins on an 8051 or equivalent MCU.

EXP 6: Generate precise time delays using hardware timers in an MCU.

EXP 7: Demonstrate and visualize ROM/RAM/Flash memory usage through a simple program.

EXP 8: Interface an analog temperature sensor (e.g., LM35) and display readings on serial or LCD.

EXP 9: Generate a PWM signal and vary duty cycle to control LED brightness.

EXP 10: Interface and control a DC motor using GPIO and external driver circuit.

EXP 11: Simulate a basic traffic light logic system using LEDs and timers.

EXP 12: Integrate sensor (temperature), ADC, PWM output (fan control), and display for a real-world prototype.

EXP 13: Project

Text Book:

1. Mazidi, M. A., Mazidi, J. G., & McKinlay, R. D. (2006). The 8051 Microcontroller and Embedded Systems Using Assembly and C (2nd ed.). Pearson Education.
2. Barrett, S. F., & Pack, D. J. (2019). Microcontroller Programming and Interfacing with Texas Instruments.
3. Ghoshal, S. (2010). 8051 Microcontroller: Internals, Instructions, Programming & Interfacing (2nd ed.). Pearson Education.
4. Dean, A. G. (2017). Embedded Systems: An Introduction Using the Arm Cortex-M0+. ARM Education Media.

Reference Book:

1. Ayala, K. J. (2004). The 8051 Microcontroller (3rd ed.). Cengage Learning.
2. Summerville, D. (2009). Embedded Systems Interfacing for Engineers Using the Freescale HCS08 Microcontroller I: Assembly Language Programming. Morgan & Claypool Publishers.
3. Yiu, J. (2013). The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors (3rd ed.). Newnes.
4. Kamal, R. (2014). Embedded Systems: Architecture, Programming and Design (3rd ed.). McGraw Hill Education.

CO-PO-PSO MAPPING

EMBEDDED SYSTEM LABORATORY															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	1	2	2	1	1	1	1	1	1	2	3	2	1
CO2	3	3	2	3	3	1	1	1	1	1	1	2	3	3	1
CO3	3	2	3	2	3	2	2	2	2	2	2	2	3	3	2
CO4	3	2	3	2	3	2	2	2	2	2	2	2	3	3	2
Average	3.0	2.5	2.25	2.25	2.75	1.5	1.5	1.5	1.5	1.5	1.5	2.0	3.0	2.75	1.5
Level of Correlation:			3 - High			2 - Medium				1 - Low					

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
INSTRUMENTATION DEVICES AND SYSTEMS	EI3266	3-0-0	3

Prerequisite: Understanding of basic principles of physics and chemistry

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Evaluation of sensor characteristics
CO2 : Identification of sensor for measurement of physical variables
CO3: Apply the concept of measurement techniques
CO4: Design of signal conditioning circuits for enhancement of sensor signal

Module I: **7 Hours**

Static Characteristics: systematic characteristics, statistical characteristics, calibration; Dynamic characteristics of measurement systems: transfer functions of typical sensing elements, step, and frequency response of first and second order elements, and dynamic error in measurement systems.

Module II: **8 Hours**

Transducers and sensors.

Displacement Measurement: Potentiometers, Capacitive sensing elements: variable separation, area and dielectric, LVDT and RVDT

Temperature Measurement: Resistance Temperature Detector (RTD), Thermistors, Thermoelectric sensing elements: thermocouple laws, characteristics, installation problems, cold junction compensation, IC temperature sensor.

PressureMeasurement: Bourdon tube, Bellows, Diaphragms, Manometer for use of pressure measurement, Low pressure (vacuum) measurements (Mechanical, Thermal, Ionization based).

Module III: **8 Hours**

Flow Measurement: Basics of Flow Measurement: Pitot-Static Tube, Flow-Obstruction Elements, Rotameter, Turbine-type flow meter, Electromagnetic flow meter, Ultrasonic flow meter.

Level measurement: Using floats, Diaphragm type, Differential pressure gage, Air bubbler, Capacitive level indicator, Ultrasonic level indicator, Gamma-ray level indicator.

Module IV: **7 Hours**

Force and torque measurement.

Bridge circuits, Push-pull configuration for improvement of linearity, Instrumentation amplifier.

Total lecture hours: **30 Hours**

Text Book:

1. Principles of Measurement Systems-J.P. Bentley (3/e), Pearson Education, New Delhi.
2. Introduction to Measurement and Instrumentation-A.K. Ghosh (3/e), PHI Learning, New Delhi.
3. Measurement Systems Application and Design- E.O. Doeblin (4/e), McGraw-Hill, International, NY.

Reference Book:

1. Transducers and Instrumentation-D.V.S. Murthy (2/e), PHI Learning, New Delhi.
2. Instrumentation for Engineering Measurements- J.W. Dally, W.F. Riley and K.G. Mc Connel (2/e), John Wiley, NY.

CO-PO-PSO Mapping

INSTRUMENTATION DEVICES AND SYSTEMS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOl	PSO2	PSO3
CO1	3	3	3	3	2	2	1	2	2	1	2	3	2	3	2
CO2	3	2	3	3	2	2	1	2	2	1	2	3	2	3	2
CO3	3	3	3	3	2	3	1	2	2	1	3	3	2	3	2
CO4	3	2	3	3	2	2	1	2	2	1	3	3	2	3	2
CO5	3	3	3	3	2	3	1	2	2	1	3	3	2	3	2
Average	3	2.6	3	3	2	2.4	1	2	2	1	2.6	3	2	3	2
Level of Correlation: 3 - High 2 - Medium 1 - Low															

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
INSTRUMENTATION DEVICES AND SYSTEMS LAB	**EI4565**	**0-0-3**	**1.5**

Prerequisite: Understanding of basic principles of physics and chemistry

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Identification of sensor for measurement of physical variables.

CO2: Apply the concept of measurement techniques.

CO3: Design of signal conditioning circuits for enhancement of sensor signal.

CO4: Simulation of Instrumentation system elements

List of Experiments (Any Ten)

EXP 1: Temperature sensing using RTD, Thermistor, Semiconductor type temperature sensor and Thermocouple.

EXP 2: Study of Load cell for measurement of weight.

EXP 3: Measurement of linear displacement using LVDT.

EXP 4: Flow measuring transducers (Pitot tube, Rotameter, Orifice plate, Venturi meter etc.…)

EXP 5: Pressure measurement using Bourdon tube.

EXP 6: Measurement of level using differential pressure transmitter/bubbler method.

EXP 7: Measurement of level using capacitive sensor.

EXP 8: Design of Regulated power supply unit.

EXP 9: Design of active low pass, high pass & band pass filters.

EXP 10: Design of Instrumentation amplifier.

EXP 11: Any hardware innovative project

Text Book:

1. Principles of Measurement Systems-J.P. Bentley (3/e), Pearson Education, New Delhi.
2. Introduction to Measurement and Instrumentation-A.K. Ghosh (3/e), PHI Learning, New Delhi.
3. Measurement Systems Application and Design- E.O. Doeblin (4/e), McGraw-Hill, International, NY.

Reference Book:

1. Transducers and Instrumentation-D.V.S. Murthy (2/e), PHI Learning, New Delhi.
2. Instrumentation for Engineering Measurements- J.W. Dally, W.F. Riley and K.G. Mc Connel (2/e), John Wiley, NY.

CO-PO-PSO Mapping

INSTRUMENTATION DEVICES AND SYSTEMS LAB															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS Ol	PS O2	PS O3
CO1	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO4	3	3	2	3	3	2	2	2	3	3	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
Average	3	3	2.8	3	3	2	2	2	3	3	3	3	3	3	3
Level of Correlation: 3 - High 2 - Medium 1 - Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
PROCESS CONTROL & AUTOMATION	**EI4269**	**3-0-0**	**3**

Prerequisite: Knowledge of sensors/ transducers and control system.

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Apply the principles of controller, final control element, control strategy and automation technique used for control of a process.

CO2: Analyze the performance of controllers, final control elements, control strategies and automation techniques.

CO3: Select appropriate controller, final control element, control strategy and automation technique for control of a process.

CO4: Design of a process control loop.

Module I: **8 Hours**

Introduction to Process Control-Process definition, what is process-control, Block diagram with examples. Controller Principle-Introduction, Process characteristics, process load, process lag, self-regulation. Control system parameters-error, variable range, control parameter range, control lag, Dead Time, Cycling, Controller modes, Discontinuous controller modes-two position mode, Multi position mode, Floating control mode. Continuous control modes: P, I, D mode. Composite control modes: PI, PD, PID. Controller tuning –Process Reaction Curve (PRC), Ziegler Nichols tuning.

Module II: **7 Hours**

Final control element: Introduction, Final control operation, Signal Conversion, Actuator-pneumatic actuation, hydraulic actuation, Electric actuation. Control element-Control valve characteristics, control valve categories.

Module III: **8 Hours**

Special Control Structures: Cascade Control, Feedforward Control, Feedforward-Feedback Control Configuration, Ratio Control, Selective Control, Adaptive Control

Module IV: **8 Hours**

Digital Logic Controllers: Introduction to Programmable Automation Controller (PAC), Programmable Logic Controller (PLC), Principle of operation, Architecture, Programming.

Distributed Control: Distributed vs. Centralized, Advantages, Functional Requirements, System Architecture, Distributed Control Systems (DCS), Supervisory Control and Data Acquisition (SCADA), Communication options in DCS, Case Studies.

Total lecture hours: **31 Hours**

Text Book:

1. Process Control Instrumentation Technology by C.D. Johnson,8th edition, PHI Learning.
2. Computer-Based Industrial Control by Krishna Kant, PHI, 2009
3. Chemical process control by George Stephanopoulos, PHI Learning Private Limited, New Delhi, 2009

Reference Book:

1. Process control principles and applications by S. Bhanot, Oxford university Press,2010.
2. Digital Control and State Variable Methods by M. Gopal, Tata McGraw Hill, 2003

CO-PO-PSO MAPPING

PROCESS CONTROL														
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	3	2	2	-	-	-	-	-	-	2	3	3	2
CO2	3	2	3	2	2	-	-	-	-	-	-	2	3	3	2
CO3	3	3	3	2	2	-	-	-	-	-	-	2	3	3	2
CO4	3	3	3	2	2	-	-	-	-	-	-	2	3	3	2
Average	3	2.5	3	2	2	-	-	-	-	-	-	2	3	3	2
Level of Correlation: 3 - High 2 - Medium 1 - Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
INDUSTRIAL INTERNET OF THINGS	EI4271	3-0-0	3

Prerequisite: IoT Basics, Industrial Automation

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Apply IIoT smart sensors for real-time monitoring in manufacturing and healthcare with Industry 4.0/5.0 and AR/VR.

CO2: Analyse IIoT data using AI/ML for predictive maintenance and quality control.

CO3: Evaluate IIoT security and inventory methods like JIT and MRP for safety and efficiency.

CO4: Create IIoT architectures combining sensing, analytics, and security for sustainable Industry 5.0 applications.

Module I: Fundamentals of Industry 4.0 and 5.0 with IIoT **08 Hours**

Introduction to Industry 4.0 and Industry 5.0: Evolution, characteristics, and principles. Smart business concepts and global impacts. Definition and Role of IIoT in Industry 4.0 and 5.0, IIoT architecture and foundational concepts. Applications of IIoT in smart factories, cities, agriculture, and Industry 5.0 scenarios, Future-Ready IIoT Architectures.

Module II: IIoT Sensing and Applications **08 Hours**

Industrial sensors (Traditional vs. Modern Sensing in Industrial Environments) and smart sensors: Roles and applications. Industry use cases: Smart healthcare, smart manufacturing, supply chains (Industry 5.0-enabled Green Logistics), Integration of AR/VR and emerging tech in IIoT applications.

Module III: IIoT Analytics and Intelligence **07 Hours**

Introduction to IIoT data analytics: Role of Data Analytics in Industrial Operations, Types and frameworks, Industrial Internet Reference Architecture (IIRA) and Analytics. Artificial Intelligence and Machine Learning applications in IIoT, Challenges and Usefulness in Industry 5.0 Settings, Case studies in analytics for predictive maintenance, quality, and healthcare.

Module IV: Safety, Security, and Inventory Management in IIoT **07 Hours**

IIoT applications for industrial safety and plant security. Network and mobile device security techniques. Inventory control methods (Inventory Types: Finished Goods, Work-in-Progress, Raw Materials, MRO, Inventory Techniques: JIT, MRP, EOQ, DSI**)** and quality management using IIoT systems.

Total lecture hours: **30 Hours**

Text Book:

1. Sudip Mishra, Chandana Roy, and Anandarup Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0, CRC Press., 2020.
2. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, 2017.
3. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press.
4. Jay Lee, Behrad Bagheri, Hung-An Kao, "A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems", Springer.

Reference Book:

1. R. Anandan, Suseendran Gopalakrishnan, S. Pal, N. Zaman, Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance, Wiley-Scrivener, 2022.
2. Ovidiu Vermesan & Peter Friess, "Internet of Things – From Research to Market Deployment", River Publishers.
3. Kevin Ashton, "How Protocol Conversion Addresses IIoT Challenges", RedLion White Paper.
4. Deloitte Insights, "Inside the Internet of Things (IoT)", Deloitte University Press.

CO-PO-PSO MAPPING

INDUSTRIAL INTERNET OF THINGS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	2	1	3	1	1	1	2	1	1	2	3	2	1
CO2	2	3	2	3	3	1	1	1	2	2	1	2	2	3	2
CO3	2	2	3	2	2	2	2	3	2	2	1	2	1	2	3
CO4	3	3	3	3	3	2	2	2	3	3	2	3	3	3	3
Average	2.5	2.5	2.5	2.25	2.75	1.5	1.5	1.75	2.25	2	1.25	2.25	2.25	2.5	2.25
Level of Correlation:				3 - High			2 - Medium				1 - Low				

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
MEMS	**EI4266**	**3-0-0**	**3**

Prerequisite: Nil

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Evaluate the knowledge of mechanisms in MEMS.

CO2: Apply the knowledge of MEMS fabrication to calculate the design parameters.

CO3: Apply the knowledge of Micro-sensors and actuators to design sensors.

CO4: Evaluate the performance of Optical MEMS devices.

Module I: **6 Hours**

Overview of MEMS and various devices, Scaling geometry, Rigid Body Dynamics, Fluid mechanics and Heat transfer. Engineering mechanics for Microsystems design: Static Bending of Thin plates, Mechanical vibration, Resonant vibration, Design theory of Accelerometers

Module II: **8 Hours**

Introduction to Electrostatic Sensors and Actuators, Parallel-Plate Capacitors, Applications of Parallel Plate Capacitors. Thermal Sensing and Actuation: Introduction, Sensors and Actuators Based on Thermal Expansion, Thermal Couples, Thermal Resistors, Applications. Magnetic Actuation.

Module III: **8 Hours**

Finite Element Analysis: Concept of FEA, Comparison with other methods, Formulation from the governing Differential equations. Overview of Micro – Scale fabrication: Lithography, Dry and wet etching, thin film deposition- PVD, CVD, LIGA, Micro molding, Electro-deposition.

Module IV: **8 Hours**

Polymer MEMS: Introduction, Polymers in MEMS, Liquid Crystal Polymer (LCP), PMMA. Applications-Acceleration Sensors, Pressure Sensors, Flow Sensors, Tactile Sensors. Optical MEMS: Passive MEMS Optical Components-Lenses, Mirrors, Actuators for Active Optical MEMS.

Total lecture hours: **30 Hours**

Textbook:

1. Tai-ran Hsu, MEMS and microsystems design and manufacture, Nanoscale Engineering, TMGH, 2008.
2. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.
3. Microelectromechanical Systems by Nitaigour Mahalik.
4. Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures, CRC, 2002.

Reference book

1. Stephen D Senturia, Microsystem Design, Springer Publication, 2000.
2. P.Seshu, Text Book of Finite Element Analysis, PHI,2006.
3. Designing CMOS MEMS by Lisa Su and MarijaVasilevska.
4. Introduction to Microelectromechanical Systems Engineering by Nadim Maluf and Kirt Williams.

CO-PO-PSO MAPPING

MEMS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	2	1	2	-	-	-	3	2	1	-	3	2	1
CO2	3	-	2	1	2	-	-	-	2	2	1	-	3	2	-
CO3	3	3	-	2	-	-	-	-	1	-	-	1	3	2	2
CO4	3	3	-	2	-	-	-	-	1	-	-	1	3	1	1
Average	3	2	1	1.5	1	-	-	-	1.75	1	0.5	0.5	3	1.75	1
Level of Correlation: 3 - High 2 - Medium 1 - Low															