SEMESTER 8

APPLIED ELECTRONICS AND INSTRUMENTATION

SEMESTER S8

INSTRUMENTATION IN PETROCHEMICAL INDUSTRIES

Course Code	**PEAET861**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCAET602 Industrial Instrumentation	**Course Type**	Theory

Course Objectives:

1. To analyze the origin, characteristics and processing of petroleum.
2. To illustrate the sensors, instruments, control systems and safety aspects in the petroleum industry

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Petroleum Industry** Overview of the Petroleum Industry - Origin of Petroleum, source rock and matuarisation, Oil and gas traps, physical and chemical characteristics of crude oil, migration mechanism, basics of reservoir rock and cap rocks, Overview of refinery processing and refinery products. Processes in Petroleum Industry (Basics only) - Atmospheric Distillation of crude oil, Vacuum Distillation of crude oil, Thermal processes (cocking, visbreaking), and Catalytic processes (catalytic cracking).	**9**
2	**Instrumentation and Control in Petroleum Industry** P & I Symbols - Overview and symbols of process lines, process equipment, instrument bubbles, valve types, piping and heat exchanger. P & I diagram of Petroleum Refinery. Overview of Control Systems - Feedback, Feed-forward Control and cascade. Importance of instrumentation in the petroleum sector Pressure measurement - Types of pressure(Gauge, absolute, differential), Overview of pressure sensors (Bourdon tube, diaphragm, capsule, strain gauge), Pressure Transmitters and their Calibration, Control Valves and Pressure Controllers	**9**

3	**Measurements in Petroleum Industry** Temperature Measurement – Infrared Temperature Sensor, Temperature Transmitters, Thermowells and Temperature Controllers. Applications of temperature measurement in Petrochemical Processes. Flow Measurement - Types of Flow Meters (Electromagnetic, Ultrasonic, Coriolis), Basics of Flow Transmitters and Controllers, Flow Control Applications in Piping and Distribution Systems. Level Measurement (basics only) - Types of sensors (Capacitive, radar, and float-based sensors), Overview of Level Controllers and Switches, Applications of level sensors (storage tanks, reactors and separators).	**9**
4	**Analytical Instrumentation and Safety in Petroleum Industry** Introduction to Process Analyzers - Gas Chromatography, Spectroscopy, pH, and Conductivity Analyzers. Application of Analyzers in Petrochemical Industries, Integration of Analytical Instruments with Control Systems. Safety Instrumented Systems (SIS) and Standards – Basics of Safety Instrumented Systems and Safety Integrity Levels (SIL), Overview of IEC 61511 Standard for Functional Safety, Instrumentation for Safety: Emergency Shutdown Systems (ESD), Fire and Gas Detection Systems, Implementation and Maintenance of SIS in Petrochemical Plants.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze the origin, characteristics and processing of petroleum	**K2**
CO2	Illustrate and analyse process systems using P & I Diagram	**K3**
CO3	Familiarise pressure, level and temperature measurements and control systems in the petroleum industry	**K3**
CO4	Understand the safety aspects in the petroleum industry	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3		2		2							3
CO3	3		2		2							3
CO4	3		2		2							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Petroleum Refining	Mohamed A. Fahim, Taher A. Al-Sahhaf, and Amal El-Halwagi,	Elsevier	1st Edition, 2009
2	Process Control: Instrumentation Technology	Curtis D. Johnson	Pearson	8th Edition, 2005
3	Chemical Process Control: An Introduction to Theory and Practice	George Stephanopoulos	Pearson	1st Edition, 2015
4	Kenexis Safety Instrumented Systems Engineering Handbook	Kevin J. Mitchell, Todd M. Longendelpher, Matthew C. Kuhn	Kenexis	1st Edition, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction To Petroleum Exploration And Engineering	Andrew Clennel Palmer	World Scientific Publishing	1st Edition, 2016
2	Instrument Engineers' Handbook: Process Measurement and Analysis (Volume 1)	Bela G. Liptak	CRC Press	4th Edition, 2003
3	Measurement and Control Basics	Thomas A. Hughes	ISA Press	3rd Edition, 2002
4	Safety Instrumented Systems: Design, Analysis and Justification	Paul Gruhn and Harry L. Cheddie	ISA Press	2nd Edition, 2005

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/103105221
2	https://nptel.ac.in/courses/103105221 https://nptel.ac.in/courses/108105064 https://archive.nptel.ac.in/courses/103/105/103105130/
3	https://nptel.ac.in/courses/108105064 https://archive.nptel.ac.in/courses/103/105/103105130/
4	https://nptel.ac.in/courses/108105064 https://archive.nptel.ac.in/courses/103/105/103105130/

SEMESTER S8

INDUSTRY 4.0

Course Code	PEAET862	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To familiarize Industrial IoT and Industry 4.0
2. To understand various enabling technologies and trends in Industry 4.0

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Industry 4.0** Overview and evolution of Industry 4.0, Key aspects and components of Industry 4.0. Industrial IoT (IIoT) – Introduction, IIoT reference architecture, overview of three tier topology of IIoT (edge tier, platform tier and enterprise tier) Basics of cyber physical systems (CPS), CPS and IIoT, Applications of IIoT Industrial Internet Systems (IIS) – Fundamentals, elements of IIS (analytics, intelligent machines and connected people). Applications of Industry 4.0.	9
2	**Enabling Technologies in Industry 4.0.** Smart factories – Introduction, characteristics of smart factories, benefits, smart factories versus traditional factories. Industrial sensing – Smart sensors, enhanced sensors (virtual sensors, self-calibration, self-testing, self-learning), introduction to tool condition monitoring.	10

	Introduction to customized and modular robotic systems (basics only), Additive Manufacturing (AM) - Introduction, The general AM process chain, advantages and limitations of AM. Advantages of 3D printing technology for Industry 4.0	
3	**Big Data and AI in Industry 4.0** Big Data – Introduction, characteristics of big data, big data sources, big data acquisition and storage, necessity of big data analytics (basics only). Machine learning and artificial intelligence for industry 4.0 (overview only), applications of ML in industries. Blockchain for Industry 4.0 – Introduction, challenges for blockchain implementation.	**9**
4	**Recent Trends** Data Security (basics only) – types of cyber security threats, Need for security in IIoT (software security, network security, mobile device security) Introduction to Cloud Computing for Industry 4.0 (Overview and advantages only). Introduction to Smart supply chain management - Advantages of IIoT in inventory management. Introduction to Industry 5.0. Case study (application and benefits of IIoT only) – Manufacturing industry and Automotive industry.	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Illustrate the fundamentals of Industrial IoT and Industry 4.0	K2
CO2	Understand the enabling technologies for Industry 4.0	K2
CO3	Apply machine learning and big data for Industry 4.0	K3
CO4	Explain the cloud computing and security issues.	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**3**		**3**							**3**
CO2	**3**	**2**	**3**		**3**							**3**
CO3	**3**	**2**	**3**		**3**							**3**
CO4	**3**	**2**	**3**		**3**							**3**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industry 4.0: Concepts, Processes and Systems	Ravi Kant and Hema Gurung	CRC Press	1st Edition, 2024
2	Introduction to Industrial Internet of Things and Industry 4.0	Sudip Misra, Chandana Roy, Anadarup Mukherjee	CRC Press	1st Edition, 2021
3	Industry 4.0: The Industrial Internet of Things	Alasdair Gilchrist	APress	1st Edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industrial IoT Application Architecture and Use Cases	Suresh, Malarvizhi Nandagopal, Pethuru Raj, E. A. Neeba, Jenn Wei Lin	CRC Press	1st Edition, 2020
2	Hands On Industrial Internet of Things	Giacomo Veneri and Antonio Capasso	Packt	1st Edition, 2018
3	Industrial Internet of Things: Technologies and Research Directions	Anand Sharma, Sunil Kumar Jangir, Manish Kumar, Dilip Kumar Choubey, Tarun Shrivastava, S. Balamurugan	CRC Press	1st Edition, 2022
4	5G-Enabled Industrial IoT Networks	Amitava Ghosh, Rapeepat Ratasuk, Peter Rost, Simone Redana	Artech House	1st Edition, 2022
5	IoT Product Design and Development: Best Practices for Industrial, Consumer, and Business Applications	Ahmad Fattahi	Wiley	1st Edition, 2023
6	Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance	R. Anandan, S. Gopalakrishnan, Souvik Pal and Noor Zaman	Wiley	1st Edition, 2022
7	Technology for People: Industry 5.0 = Industry 4.0 + Society 5.0	Mune Moğol Sever	Literaturk Academia	1st Edition, 2024

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105195
2	https://nptel.ac.in/courses/106105195
3	https://nptel.ac.in/courses/106105195
4	https://nptel.ac.in/courses/106105195

SEMESTER S8

AEROSPACE INSTRUMENTATION

Course Code	PEAET863	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To develop a comprehensive understanding of the fundamental principles and instruments in aerospace engineering and aerodynamics
2. To attain knowledge in aircraft and space vehicle instrumentation, navigation systems and advanced technologies used in modern aerospace operations

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Aerospace Engineering and Aerodynamics** History of aviation and space flight, Anatomy of airplanes and space vehicles, Fundamentals of aerodynamics, Airfoil nomenclature, Lift and drag concepts, Types of drag. Finite wings and swept wings, Flaps and control surfaces. Basic aircraft performance parameters - Thrust and power, Rate of climb, Ceiling (absolute and service), Range and endurance	9
2	**Propulsion Systems and Space Vehicle Dynamics** Aircraft propulsion - Introduction to turbojet, turbofan and ramjet engines. Basic engine instrument - Fuel content gauges. Space vehicle propulsion - Rocket engines and propellants, Staging concepts. Space vehicle trajectories - Kepler's laws, Basics of Orbital mechanics. Introduction to guidance, navigation and avionics.	9
3	**Aircraft Instruments and Navigation Systems** Atmospheric measurements - Standard atmosphere, Altimeters (aneroid and	9

	radio), Air speed indicators and Mach meters, Heading indicator. Aircraft compass systems - Magnetic compass, Remote indicating magnetic compass. Pitot - static system, Rate of climb indicator, Attitude indicator, Integrated flight instruments. Radio navigational aids (Basic concepts only) - Automatic direction finder, VHF direction finder.	
4	**Advanced Navigation and Inertial Sensors** Global Navigation Satellite Systems (GNSS) and GPS Inertial navigation systems – Principles and components. Gyroscopes - Principles and types (Ring laser gyroscope, Fiber optic gyroscope, MEMS gyroscopes). Accelerometers – Basic Principles, MEMS accelerometers. IFR and VFR, Introduction to Automatic pilots and flight control systems.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the fundamental principles of aerodynamics, aircraft performance, and propulsion systems in aerospace engineering	K2
CO2	Analyze the working principles and applications of various aircraft instruments and navigation systems used in aerospace	K3
CO3	Evaluate advanced navigation technologies and inertial sensors employed in modern aerospace systems	K3
CO4	Demonstrate basic instrumentation systems for aerospace applications	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3		3	2	3							3
CO2	3		3	2	3							3
CO3	3		3	2	3							3
CO4	3		3	2	3							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aircraft Instruments and Integrated Systems	E.H.J. Pallett	Pearson Education India	1st Edition, 1992
2	Elements of Electronic Navigation	N.S. Nagaraja	Tata McGraw Hill	2nd Edition, 2017
3	Avionics: Fundamentals of Aircraft Electronics	Scott Kenney	Avotek Information Resources	1st Edition, 2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Aerospace Engineering with a Flight Test Perspective	Stephen Corda	Wiley India	1st Edition, 2017
2	Flight Mechanics: Theory of Flight Paths	Angelo Miele	Dover Publications	1st Edition, 2016
3	Measurement Systems: Application and Design	Ernest O. Doebelin and Dhanesh N. Manik	Tata McGraw Hill	4th Edition, 1989

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/101/101/101101079/ https://archive.nptel.ac.in/courses/101/105/101105059/
2	https://archive.nptel.ac.in/courses/101/101/101101001/
3	https://archive.nptel.ac.in/courses/101/104/101104062/
4	https://archive.nptel.ac.in/courses/101/108/101108056/

SEMESTER S8

MEMS AND NANOELECTRONICS

Course Code	PEAET864	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To understand the materials and technology of MEMS
2. To understand the basic principles of nanoelectronics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction - Overview of Nano and Microelectromechanical Systems, Applications of Micro and Nanoelectromechanical systems. MEMS - Definition, devices and structures. Materials for MEMS - Silicon, Silicon compounds – Silicon Nitride, Silicon Dioxide, Poly Silicon, Silicon Piezo resistors. Polymers in MEMS – SU-8, PMMA, PDMS, Langmuir – Blodgett Films. Stress-strain relationship and mechanical properties of Silicon	8
2	Microsystem fabrication processes - Photolithography, Ion Implantation, Diffusion and Oxidation. Thin film depositions - LPCVD, Sputtering, Evaporation, Electroplating. Etching techniques - Dry and wet etching, electrochemical etching. Micromachining - Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology	10
3	MEMS Sensors - Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors. Micro Actuator - Design of Actuators, Actuations using thermal forces, shape memory Alloys, piezoelectric crystals, Electrostatic forces (Parallel plate, Comb drive actuators), Micromechanical pumps	9

4	Nanoelectronics and Quantum Mechanics - Atomic Structures and Quantum Mechanics Basics of Molecular and Nanostructure Dynamics - Schrodinger Equation and Wave function Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Molecular Wires and Molecular Circuits	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic principles of MEMS and Nano structures	**K2**
CO2	Understand the fabrication technology of MEMS structures	**K2**
CO3	Design MEMS sensors and actuators	**K3**
CO4	Illustrate the technology of nanoelectronics and quantum dynamics.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2								3
CO2	3	3	3	2								3
CO3	3	3	3	2								3
CO4	3	3	3	2								3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	MEMS and NEMS: Systems, Devices, and Structures	Sergey Edward Lyshevski	CRC Press	1/e, 2002
2	Fundamentals of Micro fabrication	Mark Madou	CRC Press, Newyork	1/e, 1997

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	VLSI Technology	Chang C Y and Sze S. M.	McGraw-Hill, New York	1/e, 2000
2	Microsensors: Principles and Applications	Julian W Gardner	John Wiley and sons	1/e, 1994
3	Microsystem design	Stephen D. Senturia,	Springer(India)	2/e, 2006
4	Foundations of MEMS	Chang Liu	Pearson	2/e, 2012
5	MEMS and Microsystems Design and Manufacture	Tai-Ran Hsu,	TMH	1/e, 2002
6	Principles of Quantum Mechanics	A M Dirac	Oxford University Presss	1/e, 1978

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117105082
2	https://nptel.ac.in/courses/117105082
3	https://nptel.ac.in/courses/117105082
4	https://nptel.ac.in/courses/117105082

SEMESTER S8

WAVELETS AND MULTIRATE ANALYSIS

Course Code	PEAET866	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PBECT504 Digital Signal Processing	Course Type	Theory

Course Objectives:

1. To have sufficient understanding of multirate operations and design of filter banks for signal processing applications.
2. To familiarize with wavelet transform of signals, construction of wavelets, filter bank implementation and practical applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Multirate Systems and Filter banks** Introduction to multirate signal processing and its applications. Multirate system fundamentals - Basic multi-rate operations - up sampling and down sampling, Time domain and Frequency domain analysis, Need for anti aliasing and anti imaging filters. Noble identities. Fractional sampling rate alteration. Type 1 and Type 2 Polyphase decomposition, Efficient structures for decimation and interpolation filters. Introduction to Digital Filter Banks, Efficient implementation, Two Channel Quadrature Mirror Filterbank (QMF), Perfect Reconstruction.	9
2	**Time - Frequency analysis of signals and Wavelet Transform** Time - frequency analysis of signals - Spectral analysis of signals, Spectral leakage by windowing effect, Time and frequency localization of signals, the Uncertainty Principle and its implications. Short Time Fourier transform – Continuous time and discrete time STFT, Filter bank implementation of STFT. Continuous wavelet transform – Concept of wavelets, CWT for signal	9

	analysis, Condition of admissibility and its implications, Inverse Continuous Wavelet Transform, Properties of CWT.	
3	**Discrete Wavelet Transform and filter bank implementation** Discrete Wavelet Transform – Concept of DWT, Time frequency tiling of DWT and comparison to STFT. Haar Scaling and Wavelet functions, Function Spaces, Refinement relation, Wavelet decomposition of signals. Designing orthogonal wavelet systems- Relation of DWT to filter banks for signal decomposition and reconstruction Multi resolution Analysis (MRA) - Concept of MRA and relating it to filter banks. Computation of DWT using Mallat Algorithm and Lifting Scheme.	**9**
4	**Wavelet Transform applications** Wavelet Transform applications in image processing – Wavelet Transform of images, Wavelet Transform based Image compression, EZW Coding. Applications of Wavelet Transform in image denoising, edge detection and object detection. Wavelet Transform applications in audio processing - Application of wavelets in audio compression, Wavelet based audio coding.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24 marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concepts and interconnection of multirate systems to identify the efficient realization of filter banks using polyphase decomposition and multirate identities.	**K3**
CO2	Explain the principles of Short Time Fourier Transform and Wavelet Transform, taking into consideration the time frequency analysis of signals.	**K3**
CO3	Illustrate filter bank implementation of wavelet transform to be used in multi resolution analysis for signal processing applications	**K3**
CO4	Examine the use of wavelet transforms for applications involving image and audio processing.	**K4**
CO5	Understand the concepts and interconnection of multirate systems to identify the efficient realization of filter banks using polyphase decomposition and multirate identities.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2						3
CO2	3	3	3	2	2	2						3
CO3	3	3	3	2	2	2						3
CO4	3	3	3	2	2	2						3
CO5	3	3	3	2	2	2						3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Multirate Systems and Filter Banks	P. Vaidyanathan	Pearson Education	1/e 2006
2	Insight Into Wavelets: From Theory to Practice	K.P. Soman, K.I. Ramachandran, N.G. Resmi	Prentice Hall	3/e 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal Processing: A computer based approach	Sanjith K Mitra	Tata-McGraw Hill	4/e 2013
2	Digital Signal Processing. Principles, Algorithms and Applications	John G. Proakis, Dimitris G. Manolakis.	Pearson Education	4/e 2007
3	Wavelets and Filter banks	Gilbert Strang and Truong Q. Nguyen	Wellesley- Cambridge Press	2/e 1996
4	Wavelet Transforms: Introduction to Theory and Applications	Raghuveer M. Rao, Ajit S. Bopardikar	Prentice Hall	1/e 1998
5	Wavelets and sub band coding,	M. Vetterli & J. Kovacevic	Prentice Hall	1/e 1995

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/106/108106136/
2	https://nptel.ac.in/courses/117101001
3	https://nptel.ac.in/courses/117101001
4	https://nptel.ac.in/courses/117101001

SEMESTER S8

DEEP LEARNING

Course Code	PEAET865	CIE Marks	40
Teaching Hours/Week (L:T:P:R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To provide foundational knowledge of advanced neural network architectures like CNNs, RNNs, and generative models.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to ANN and CNN** Overview of biological neuron, concept of Perceptrons, Multi-Layer Perceptrons (MLPs) Activation functions - Sigmoid Relu and Softmax. Loss functions-Mean Squared Error, Cross Entropy Convolutional Neural Networks - Convolution operation. CNN Architecture - convolutional layers, kernels, padding, pooling layers, fully connected layers.	9
2	Training CNNs - Back-propagation and initialization Optimization algorithms - SGD, Adam Hyper parameter optimization-Learning rate Regularization methods - L1, L2 regularization, dropout, Data Augmentation, Early stopping, batch normalization Introduction to Transfer learning.	9
3	**Sequence Models** Recurrent Neural Networks (RNN) - cell structure and architecture. Training RNN - back propagation through time, vanishing and exploding gradients. Architecture of Long Short-Term Memory (LSTM) Architecture of Gated Recurrent Units (GRU)	9

4	(Detailed mathematical treatment not required for this module) **Introduction to Generative Models** GANs - adversarial training. Discriminator, Generator. Introduction to Transformer models – architecture, word embedding, position encoding, attention, basics of training transformer models. Basics of Large language model - GPT	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Evaluation Methods:

1: Practical Experiments Using Design and Analysis Tools (10 marks)

Students will perform specific experiments using tools like TensorFlow, PyTorch, or Keras. Each experiment will focus on implementing and analyzing different types of neural network architectures and techniques.

2: Course Project (10 marks)

Comprehensive project involving design, implementation, and analysis of neural network models. Project phases: Proposal, Design, Implementation, Testing, Final Report, Presentation, and Viva Voce.

Sample Experiments:

Experiment 1: Building a Convolutional Neural Network (CNN)

- **Objective**: Design and train a CNN for image classification.
- **Tools**: TensorFlow/Keras or PyTorch.
- **Steps**:
  - Implement a CNN with convolutional layers, pooling layers, and fully connected layers.
  - Train the model on a dataset like CIFAR-10.
  - Analyze the model's performance using evaluation metrics like accuracy and loss curves.

Experiment 2: Visualizing Feature Maps and Weight Distributions

- **Objective***:* Visualize the internal workings of a neural network.

- ***Tools**:* TensorFlow/Keras or PyTorch, Matplotlib.
- **Steps:**
  - Train a CNN on a simple dataset.
  - Visualize the feature maps after each convolutional layer.
  - Use t-SNE for feature visualization and analyze the distribution of weights.

Experiment 3: Transfer Learning and Fine-Tuning

- **Objective***:* Use a pre-trained model for a new task.
- **Tools***:* TensorFlow/Keras or PyTorch.
- **Steps:**
  - Use a pre-trained model like VGG or ResNet.
  - Fine-tune the model on a new dataset.
  - Analyze the performance improvement compared to training from scratch.

Experiment 4: Exploring Recurrent Neural Networks

- **Objective***:* Implement an RNN to predict time-series data(eg. Word prediction).
- **Tools***:* TensorFlow/Keras or PyTorch.
- **Steps:**
  - Build an RNN model with LSTM or GRU cells..
  - Train the model on a time-series dataset
  - Visualize and interpret the model's predictions.

Sample Project Topics:

1 Designing a Real-Time Object Detection System Using YOLO

2 Development of a Neural Network for Sentiment Analysis on Social Media

3 Implementing a GAN for Image-to-Image Translation

4 Building a Speech Recognition System Using RNNs and LSTMs

5 Creating a Transfer Learning Model for Medical Image Classification

Criteria for Evaluation: Lab Experiments (10 marks)

Understanding of Concepts (3 marks)

- Demonstrates a thorough understanding of the theoretical concepts related to the experiments.
- Correctly explains the purpose and expected outcomes.

Implementation and Accuracy (3 marks)

- Correctly implements the neural network models using appropriate tools.
- Ensures the design functions as expected with minimal errors.

Analysis and Problem-Solving (2 marks)

- Effectively analyzes the model performance and identifies issues.
- Demonstrates problem-solving skills in addressing challenges encountered during experiments.

Documentation and Reporting (1 mark)

- Provides detailed documentation of the experimental setup, process, and outcomes.
- Includes visualizations, code snippets, and analysis of results.

Presentation and Communication (1 mark)

- Clearly presents the experiments and their results.
- Able to answer questions and explain design choices.

Course Project (10 marks)

Project Proposal and Planning (2 marks)

- Submits a well-defined project proposal outlining objectives, methodology, and expected outcomes.
- Demonstrates thorough planning and a clear timeline for the project.

Design and Implementation (3 marks)

- Implements the project design accurately using appropriate tools and techniques.
- The design is functional and meets the project objectives.

Innovation and Creativity (2 marks)

- Introduces innovative ideas or unique approaches in the design and implementation.
- Demonstrates creativity in solving problems or optimizing designs.

Analysis and Testing (2 marks)

- Effectively analyzes the project design to identify and address any issues.
- Conducts thorough testing to verify the functionality and performance of the model.

Final Report and Presentation (1 mark)

- Submits a comprehensive final report detailing the project, including objectives, design, methodology, analysis, and results.
- Clearly presents the project and its outcomes, and effectively communicates the key points.

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. • Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Illustrate the basic concepts of neural networks	**K2**
CO2	Train CNN models and Solve real world problems	**K6**
CO3	Create solutions for real world problems using Sequence models	**K6**
CO4	Understand the concepts of GAN	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3		3							3
CO2	3	3	3	2	3							3
CO3	3	3	3	2	3							3
CO4	3	3	3	2	3							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Learning Deep Learning	Magnus Ekman	Addison -Wesley	2022
2	Hands-on Machine learning with Sc-kit Learn Keras and Tensorflow	Aurelien Geron	Oreilly	2nd Edition 2019
3	Dive Deep into Machine Learning	Astan Zhang and Zachary and Alexander semola	Cambridge University Press	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Deep Learning.	Ian Goodfellow. Yoshua Bengio and Aaron Courville.	MIT Press	2016.
2	Neural Networks and Deep Learning: A Textbook..	Charu C. Aggarwal.	Springer	. 2019
3	Generative Deep Learning	David Foster	OReilly	2022
4	Build a Large Language Model	Sebastian Raschka	Manning	2023
5	Deep Learning with Python second Edition	Francois chollet	Manning	2021

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.cse.iitm.ac.in/~miteshk/CS6910.html
2	https://cs231n.github.io/
3	https://wiki.pathmind.com/lstm http://colah.github.io/posts/2015-08-Understanding-LSTMs/
4	https://jalammar.github.io/illustrated-transformer/ Jay Almar

SEMESTER S8

MECHATRONICS

Course Code	**PEAET895**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	-	**Course Type**	Theory

Course Objectives:

1. To provide a deep understanding of mechatronics concepts, systems and its components.
2. To familiarize various actuation systems for mechatronics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Mechatronics** Definition and scope of Mechatronics, Key elements of a mechatronic system - sensors, actuators, controllers, and interfaces. Multi disciplinary nature of Mechatronics, Comparison between traditional design and mechatronics approach, applications of mechatronics in industry (robotics, automotive, aerospace, consumer electronics). **Sensors (Basic working only) –**Position, displacement, and proximity sensors (encoders, potentiometers, LVDTs, IR sensors), acoustic emission sensors, vibration sensors and tactile sensors, flow sensors.	9
2	**Electrical Actuators and Control Systems** Types of actuators (basics only) - Electromechanical, hydraulic, pneumatic, and piezoelectric. Overview of Relays and solenoids. Electric motors (working only) - DC, stepper, and servo motors Motor control techniques - PWM control, H-bridge circuits, motor drivers. Selection criteria for actuators and drive systems in mechatronic design. Overview of Proportional, Integral, and Derivative (PID) control, Example practical implementation of control algorithms on mechatronic systems	9

3	**Actuation Systems** Hydraulic and Pneumatic actuation systems (basics only) - Introduction, reciprocating cylinders, Rotary actuators – gear, vane and lobe. Comparison between electrical, pneumatic and hydraulic actuators. Mechanical power transmission systems –spur gears, bevel gear, planetary gear, Belts and chains. Direction control valve, pressure control valves, solenoid valve.	**9**
4	**Mechatronic Design and Modern Trends** Design considerations for mechatronic systems (cost, reliability, scalability). Case studies (Basic overview only) - Examples of mechatronic system (robotic arm, Robotic vision system, autonomous vehicle, Auto focus camera, automatic car park barrier system, Assembly line automation in manufacturing). Introduction to smart sensors and actuators, Basics of Mechatronics in Industry 4.0, Overview of Soft robotics and human-machine interfaces	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyze): 20 marks

- **Each student should Design and hardware/software implementation of a project involving electronic control of mechanical parts.**
- Computational tools such as MATLAB or Octave can be utilized for simulation and analysis.

Evaluation Parameters

Project Proposal and Planning

- Submits a well-defined project proposal outlining objectives, methodology, and expected outcomes.
- Demonstrates thorough planning and a clear timeline for the project.

Design and Implementation

- Implements the project design accurately using appropriate tools and techniques.
- The design is functional and meets the project objectives.

Innovation and Creativity

- Introduces innovative ideas or unique approaches in the design and implementation.
- Demonstrates creativity in solving problems or optimizing designs.

Analysis and Testing

- Effectively analyzes the project design to identify and address any issues.
- Conducts thorough testing to verify the functionality and performance of the model.

Final Report and Presentation

- Submits a comprehensive final report detailing the project, including objectives, design, methodology, analysis, and results.
- Clearly presents the project and its outcomes, and effectively communicates the key points.

Sample project topics:

1. Robotic Arm
2. Automated Sorting System
3. Self-Balancing Robot
4. Inverted Pendulum with 2 DOF

The project deliverables consist of the following components:

- Detailed design specifications
- Identification and resolution of technical challenges
- Designed and developed algorithms
- Implementation results and performance evaluations
- Comprehensive project report, incorporating methodology, results, challenges, and recommendations.

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand mechatronics systems and its components	**K2**
CO2	Familiarise sensors and electrical actuators for mechatronics	**K2**
CO3	Apply concepts hydraulic, pneumatic and mechanical actuation systems for designing mechatronic equipments	**K4**
CO4	Design mechatronic systems for various applications	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3		2							3
CO2	3	2	3		2							3
CO3	3	2	3		2							3
CO4	3	2	3		2				3	3	3	3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Mechatronics	Musa Jouaneh	Cengage Learning	1st Edition, 2013
2	Mechatronics: A multidisciplinary approach	William Bolton	Pearson	4th Edition, 2014
3	Introduction to Mechatronics and Measurement Systems	David G. Alciatore and Michael B. Histand	McGraw Hill	4th Edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	William Bolton	Pearson	6th Edition, 2019
2	Mechatronics: Principles and Applications	Godfrey Onwubolu	Elsevier	1st Edition, 2005
3	Mechatronics: Integrated Mechanical Electronic Systems	K.P. Ramachandran, G.K. Vijayaraghavan and M.S.Balasundaram	Wiley	1st Edition, 2008
4	Mechatronics	Dan Necsulescu	Pearson	1st Edition, 2002
5	Mechatronics : Principles, Concepts and Applications	Nitaigour Premchand Mahalik	McGraw Hill	1st Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107298/
2	https://archive.nptel.ac.in/courses/112/107/112107298/
3	https://archive.nptel.ac.in/courses/112/107/112107298/
4	https://archive.nptel.ac.in/courses/112/107/112107298/

SEMESTER S8

INTRODUCTION TO MECHATRONICS

Course Code	OEAET831	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To provide a deep understanding of mechatronics concepts, systems and its components.
2. To familiarize various actuation systems for mechatronics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Mechatronics** Definition and scope of Mechatronics, Key elements of a mechatronic system - sensors, actuators, controllers, and interfaces. Multi disciplinary nature of Mechatronics, Comparison between traditional design and mechatronics approach, applications of mechatronics in industry (robotics, automotive, aerospace, consumer electronics). **Sensors (Basic working only) –**Position, displacement, and proximity sensors (encoders, potentiometers, LVDTs, IR sensors), acoustic emission sensors, vibration sensors and tactile sensors, flow sensors.	9
2	**Electrical Actuators and Control Systems** Types of actuators (basics only) - Electromechanical, hydraulic, pneumatic, and piezoelectric. Overview of Relays and solenoids. Electric motors (working only) - DC, stepper, and servo motors Motor control techniques - PWM control, H-bridge circuits, motor drivers. Selection criteria for actuators and drive systems in mechatronic design. Overview of Proportional, Integral, and Derivative (PID) control, Example	9

	practical implementation of control algorithms on mechatronic systems	
3	**Actuation Systems** Hydraulic and Pneumatic actuation systems (basics only) - Introduction, reciprocating cylinders, Rotary actuators – gear, vane and lobe. Comparison between electrical, pneumatic and hydraulic actuators. Mechanical power transmission systems –spur gears, bevel gear, planetary gear, Belts and chains. Direction control valve, pressure control valves, solenoid valve.	**9**
4	**Mechatronic Design and Modern Trends** Design considerations for mechatronic systems (cost, reliability, scalability). Case studies (Basic overview only) - Examples of mechatronic system (robotic arm, Robotic vision system, autonomous vehicle, Auto focus camera, automatic car park barrier system, Assembly line automation in manufacturing). Introduction to smart sensors and actuators, Basics of Mechatronics in Industry 4.0, Overview of Soft robotics and human-machine interfaces	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand mechatronics systems and its components	K2
CO2	Familiarise sensors and electrical actuators for mechatronics	K2
CO3	Apply concepts hydraulic, pneumatic and mechanical actuation systems for designing mechatronic equipments	K4
CO4	Design mechatronic systems for various applications	K4

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3		2							3
CO2	3	2	3		2							3
CO3	3	2	3		2							3
CO4	3	2	3		2							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Mechatronics	Musa Jouaneh	Cengage Learning	1st Edition, 2013
2	Mechatronics: A multidisciplinary approach	William Bolton	Pearson	4th Edition, 2014
3	Introduction to Mechatronics and Measurement Systems	David G. Alciatore and Michael B. Histand	McGraw Hill	4th Edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	William Bolton	Pearson	6th Edition, 2019
2	Mechatronics: Principles and Applications	Godfrey Onwubolu	Elsevier	1st Edition, 2005
3	Mechatronics: Integrated Mechanical Electronic Systems	K.P. Ramachandran, G.K. Vijayaraghavan and M.S.Balasundaram	Wiley	1st Edition, 2008
4	Mechatronics	Dan Necsulescu	Pearson	1st Edition, 2002
5	Mechatronics : Principles, Concepts and Applications	Nitaigour Premchand Mahalik	McGraw Hill	1st Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107298/
2	https://archive.nptel.ac.in/courses/112/107/112107298/
3	https://archive.nptel.ac.in/courses/112/107/112107298/
4	https://archive.nptel.ac.in/courses/112/107/112107298/

SEMESTER S8

INDUSTRY 4.0

Course Code	OEAET832	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To familiarize Industrial IoT and Industry 4.0
2. To understand various enabling technologies and trends in Industry 4.0

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Industry 4.0** Overview and evolution of Industry 4.0, Key aspects and components of Industry 4.0. Industrial IoT (IIoT) – Introduction, IIoT reference architecture, overview of three tier topology of IIoT (edge tier, platform tier and enterprise tier) Basics of cyber physical systems (CPS), CPS and IIoT, Applications of IIoT Industrial Internet Systems (IIS) – Fundamentals, elements of IIS (analytics, intelligent machines and connected people). Applications of Industry 4.0.	9
2	**Enabling Technologies in Industry 4.0.** Smart factories – Introduction, characteristics of smart factories, benefits, smart factories versus traditional factories. Industrial sensing – Smart sensors, enhanced sensors (virtual sensors, self-calibration, self-testing, self-learning), introduction to tool condition monitoring.	10

	Introduction to customized and modular robotic systems (basics only), Additive Manufacturing (AM) - Introduction, The general AM process chain, advantages and limitations of AM. Advantages of 3D printing technology for Industry 4.0	
3	**Big Data and AI in Industry 4.0** Big Data – Introduction, characteristics of big data, big data sources, big data acquisition and storage, necessity of big data analytics (basics only). Machine learning and artificial intelligence for industry 4.0 (overview only), applications of ML in industries. Blockchain for Industry 4.0 – Introduction, challenges for blockchain implementation.	**9**
4	**Recent Trends** Data Security (basics only) – types of cyber security threats, Need for security in IIoT (software security, network security, mobile device security) Introduction to Cloud Computing for Industry 4.0 (Overview and advantages only). Introduction to Smart supply chain management - Advantages of IIoT in inventory management. Introduction to Industry 5.0. Case study (application and benefits of IIoT only) – Manufacturing industry and Automotive industry.	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Illustrate the fundamentals of Industrial IoT and Industry 4.0	K2
CO2	Understand the enabling technologies for Industry 4.0	K2
CO3	Apply machine learning and big data for Industry 4.0	K3
CO4	Explain the cloud computing and security issues.	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**3**		**3**							**3**
CO2	**3**	**2**	**3**		**3**							**3**
CO3	**3**	**2**	**3**		**3**							**3**
CO4	**3**	**2**	**3**		**3**							**3**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industry 4.0: Concepts, Processes and Systems	Ravi Kant and Hema Gurung	CRC Press	1st Edition, 2024
2	Introduction to Industrial Internet of Things and Industry 4.0	Sudip Misra, Chandana Roy, Anadarup Mukherjee	CRC Press	1st Edition, 2021
3	Industry 4.0: The Industrial Internet of Things	Alasdair Gilchrist	APress	1st Edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industrial IoT Application Architecture and Use Cases	Suresh, Malarvizhi Nandagopal, Pethuru Raj, E. A. Neeba, Jenn Wei Lin	CRC Press	1st Edition, 2020
2	Hands On Industrial Internet of Things	Giacomo Veneri and Antonio Capasso	Packt	1st Edition, 2018
3	Industrial Internet of Things: Technologies and Research Directions	Anand Sharma, Sunil Kumar Jangir, Manish Kumar, Dilip Kumar Choubey, Tarun Shrivastava, S. Balamurugan	CRC Press	1st Edition, 2022
4	5G-Enabled Industrial IoT Networks	Amitava Ghosh, Rapeepat Ratasuk, Peter Rost, Simone Redana	Artech House	1st Edition, 2022
5	IoT Product Design and Development: Best Practices for Industrial, Consumer, and Business Applications	Ahmad Fattahi	Wiley	1st Edition, 2023
6	Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance	R. Anandan, S. Gopalakrishnan, Souvik Pal and Noor Zaman	Wiley	1st Edition, 2022
7	Technology for People: Industry 5.0 = Industry 4.0 + Society 5.0	Mune Moğol Sever	Literaturk Academia	1st Edition, 2024

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105195
2	https://nptel.ac.in/courses/106105195
3	https://nptel.ac.in/courses/106105195
4	https://nptel.ac.in/courses/106105195

SEMESTER S8

VIRTUAL INSTRUMENTATION

Course Code	**OEAET833**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	-	**Course Type**	Theory

Course Objectives:

1. To understand the architecture and components of a virtual instrument.
2. To design simple virtual instruments.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Virtual Instrumentation** Introduction and definition of Virtual Instrumentation (VI), block diagram and architecture of a virtual instrument, Virtual instruments versus traditional instruments, advantages of VI. Overview of Virtual Instrumentation in the Engineering Process – Design, Test and Control, Virtual Instruments Beyond the Personal Computer. Overview of graphical programming for VI. Software tools used in VI (Features and advantages only) – LabView, MATLAB/Scilab, Python Introduction to Smart Instruments (Basic concepts only)	**9**
2	**Introduction to LabVIEW** Introduction to Graphical system design using LabVIEW, Advantages of LabVIEW, Key elements in LabVIEW(Overview only) - Front Panel and Block Diagram. Concept of Virtual Instruments (VIs) and SubVIs, Steps involved in Developing Virtual Instruments using LabVIEW, Real time data acquisition - analog and digital Input/Output operations in LabVIEW, Basic concept of clusters in LabVIEW, Simple design examples using LabVIEW	**9**

	(Data Logging, Monitoring, Control Systems), Introduction to LabVIEW Realtime, LabVIEW FPGA and LabVIEW Embedded.	
3	**Data Acquisition Systems (DAQ)** Introduction to data acquisition on PC, Components of a Data Acquisition System, Analog vs. Digital signals, Sampling fundamentals and sampling theorem, Basics of ADC and DAC, Overview and need of Signal Conditioning (Amplification and Filtering), Interfacing sensors with data acquisition systems, Calibration, Resolution, Data acquisition interface requirements.	**9**
4	**Common Instrument Interfaces** Overview of Instrument control using VISA (Virtual Instrument Software Architecture), Basics of 4-20mA current loop. Serial versus parallel data transfer, concept of baud rate, overview of RS-232. GPIB – Introduction, types of messages, overview of physical bus structure, advantages, Overview of IEEE 488.2, Basics of Standard Commands for Programmable Instruments (SCPI). USB – Introduction, need for USB, overview of USB data format, advantages. Overview of MOD Bus.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the architecture and components of a virtual instrument.	**K2**
CO2	Design simple virtual instruments.	**K6**
CO3	Familiarize data acquisition techniques to design virtual instruments	**K3**
CO4	Illustrate various instrument interface protocols	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**3**		**3**							**3**
CO2	**3**	**2**	**3**		**3**							**3**
CO3	**3**	**2**	**3**		**3**							**3**
CO4	**3**	**2**	**3**		**3**							**3**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Virtual Instrumentation Using Labview	Jovitha Jerome	Prentice Hall	1st Edition, 2010
2	Labview Based Advanced Instrumentation	S Sumathi, P. Surekha	Springer	1st Edition, 2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Learning with LabVIEW	Robert Bishop	Pearson	2nd Edition, 2020
2	Real World Instrumentation with Python	J. M. Hughes	O'Reilly	1st Edition, 2010
3	LabVIEW for Everyone: Graphical Programming Made Easy and Fun	Jeffrey Travis and Jim Kring	Prentice Hall	3rd Edition, 2006
4	LabVIEW Graphical Programming	Gary W. Jhonson and Richard Jennings	McGraw Hill	4th Edition, 2006
5	PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control	Kevin James	Newnes	1st Edition, 2000
6	Virtual Instrumentation Using LabVIEW	Sanjay Gupta and Joseph John	McGraw Hill	2nd Edition, 2010

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/ZHNlKyYzrPE?si=Q0XfJfrI_mKsVEl-
2	https://youtu.be/ZHNlKyYzrPE?si=Q0XfJfrI_mKsVEl-
3	https://nptel.ac.in/courses/108105062
4	https://nptel.ac.in/courses/108105062