AY 2019-20 ONWARDS

Course Structure and Curriculum

Master of Technology in Electrical Engineering

(Specialization: Control and Instrumentation)

DEPARTMENT OF ELECTRICAL ENGINEERING

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA,

BURLA – 768018

CONTENTS

VISION

To be recognized as a centre of excellence in education and research in the field of Electrical Engineering by producing innovative, creative and ethical Electrical Engineering professionals for socio-economic development of society in order to meet the global challenges.

MISSION

Electrical Engineering Department of VSSUT Burla strives to impart quality education to the students with enhancement of their skills to make them globally competitive through:

M1. Maintaining state of the art research facilities to provide enabling environment to create, analyze, apply and disseminate knowledge.

M2. Fortifying collaboration with world class R&D organizations, educational institutions, industry and alumni for excellence in teaching, research and consultancy practices to fulfil 'Make in India' policy of the Government.

M3. Providing the students with academic environment of excellence, leadership, ethical guidelines and lifelong learning needed for a long productive career.

PROGRAM EDUCATIONAL OBJECTIVES

The program educational objectives of M.Tech. in Electrical Engineering (Control and Instrumentation) program of VSSUT Burla are to prepare its graduates:

1. To acquire competency in analysis, design, modeling, programming and optimization skills to meet industrial challenges for solving real life problems and undertake research in broad area of control and instrumentation.
2. To excel in their professional career/entrepreneurial skill/research and higher studies and lead in the conception, design and implementation of new products, processes, services and systems according to the prevailing socio-economic context.
3. To augment the specialized workforce in the domain of control and instrumentation systems in private, government and public sector industries, educational institutions and state-of-the-art research laboratories.

PEO-MISSION MATRIX

	M1	M2	M3
PEO1	**3**	**1**	**1**
PEO2	**1**	**3**	**2**
PEO3	**2**	**3**	**3**

PROGRAM OUTCOMES of M.Tech. (CIE)

PO1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4	An ability to create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex problems in control and instrumentation systems with an understanding of the limitations.
PO5	An ability to understand of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research involving control and instrumentation engineering in order to achieve common goals.
PO6	Demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis to further the learning of themselves as well as others.

Program Specific Outcomes for M.Tech. (CIE)

PSO1	Ability of design, modeling and analysis of control and instrumentation systems components using the latest available tools.
PSO2	Develop suitable techniques and cutting-edge control and instrumentation system hardware and software for efficient monitoring and control of engineering systems.

COURSE STRUCTURE

Semester I

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-1	MEECI101	Advanced Control Systems	3	0	0	3
2	Core-2	MEECI102	Instrumentation and Sensor Technology	3	0	0	3
3	PE-1		PE-1	3	0	0	3
4	PE-2		PE-2	3	0	0	3
5	Common		Research Methodology & IPR	2	0	0	3
6	Lab-1	MEECI103	Instrumentation and Sensors Lab	0	0	6	4
8	Audit -1		Audit -1				
Total Credits							19

Semester II

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-3	MEECI201	Adaptive Control	3	0	0	3
2	Core-4	MEECI202	Non-linear Control Systems	3	0	0	3
3	PE-3		PE-3	3	0	0	3
4	PE-4		PE-4	3	0	0	3
5	Common		Minor project & Seminar	0	0	4	2
6	Lab-2	MEECI203	Control Lab	0	0	6	4
8	Audit -2		Audit -2				
Total Credits							18

Semester III

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	PE-5		PE-5	3	0	0	3
2	OE-1		OE-1	3	0	0	3
3	Minor Project		Dissertation (Phase-I)	0	0	20	10
Total Credits							16

Semester IV

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Major Project		Dissertation (Phase-II)	0	0	32	16
Total Credits							16

GRAND TOTAL CREDITS: 19+18+16+16= 69

Program Electives

First Semester			
Program Elective-I		**ProgramElective-II**	
MCIPE101	Biomedical Instrumentation	MCIPE105	Microprocessors & Microcontrollers
MCIPE102	Random Processes in Control and Estimation	MCIPE106	Optimization in Control
MCIPE103	Renewable Power and Control	MCIPE107	Robust and Optimal Control
MCIPE104	Control of Power Electronic Converters	MCIPE108	Power Plant Instrumentation and Control
Second Semester			
Program Elective-III		**Program Elective-IV**	
MCIPE201	Industrial Process Control and Automation	MCIPE205	Advanced Digital Signal Processing
MCIPE202	Networked and Multi-agent Control Systems	MCIPE206	Machine Learning and AI
MCIPE203	Cyber Physical Systems	MCIPE207	Computer Vision
MCIPE204	Wireless Sensor Networks	MCIPE208	Electric and Hybrid Vehicles
Third Semester			
Program Elective-V		**Open Electives**	
MCIPE301	CAD of Instrumentation system	MCIOE301	SCADA system and applications
MCIPE302	Machine Learning and AI	MCIOE302	Operations Research
MCIPE303	Robotics and Automation	MCIOE303	Guidance, Navigation and Control
MCIPE304	Mechatronics	MCIOE304	Autonomous Vehicles

Audit course 1 & 2

Sl.No.	Course Code	Subject Name
1.	BCAC1001	English for Research Paper Writing
2.	BCAC1002	Disaster Management
3.	BCAC1003	Sanskrit for Technical Knowledge
4.	BCAC1004	Value Education
5.	BCAC2001	Constitution of India
6.	BCAC2002	Pedagogy Studies
7.	BCAC2003	Stress Management by Yoga
8.	BCAC2004	Personality Development through Life Enlightenment Skills.

First Semester

Program Core Courses

Instrumentation and Sensor Technology

MODULE-I(7 hours)

Measurement and Instrumentation: General concepts of Measurement, Instruments and Instrumentation, static and dynamic characteristics, error probability density function, least squares calibration curves, calibration of measuring instruments. Introduction to Sensor, Actuator, Transducer, Inverse Transducer, Smart / Intelligent Sensors: Analog and Digital type Signal conditioning. Classification of transducers.

MODULE-II(8 hours)

Conventional and Smart Transducers: Working principle and design of conventional sensors and smart sensors to measure physical parameters like Temperature, Pressure, Level and Flow. LVDT, Strain Gauge, Proximity sensors: Capacitive and Inductive type probes/ pickups. Vibration Transducer, Seismic measurement: displacement, velocity & Acceleration pickups, Piezo-resistive and Piezoelectric transducers; Moisture and/or Humidity sensors, Gas Sensors. Case studies.

MODULE-III(8 hours)

Signal Conditioning Devices: 1-arm, 2-arm and/or 4-arm active bridges; Resistive deflection bridges, Reactive deflection bridges; OPAMP based: Instrumentation amplifier, Charge amplifier & Impedance converters, V/I converter and I/V converter, Integrator & Differentiator; Filters; A/D and D/A conversions: sampling, quantization, encoding, converters.

MODULE-IV(8 hours)

MEMS and NEMS Technology: Methods, and technologies of synthesis, modeling, analysis, simulation, control, prototyping, and fabrication of MEMS and NEMS. Development of NEMS and MEMS architectures, physical representations, structural synthesis, and optimization. Applications of MEMS and NEMS sensors and actuators. Case studies.

MODULE-V(8 hours)

Communication Links and Safety Measures: Introduction to transmitters, two wire and four wire transmitters, Smart Transmitters and Indicators. A.C. carrier and Digital carrier systems. Balanced and unbalanced type transmission. Introduction to Wired and Wireless Sensor Networks; Use of Industrial IoT (IIOT). Introduction to EMC, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding.

Books:

1. John P. Bentley, "Principles of Measurement Systems", First edition, Pearson India, 2006.
2. Ernest O. Doebelin and Dhanesh N. Manik, "Doebelin's Measurement Systems, Sixth edition, McGraw-Hill India, 2013.
3. "Handbook on Smart sensor and MEMS – Intelligent devices and Microsystems for industrial applications", Edited by StoyanNihtianov and Antonio Luque, Woodhead Publishing Ltd., 2014.
4. Kim R. fowler, "Electronic Instrument Design – Architecture for the Life cycle", Oxford University Press, 11th India edition, 2012.

References books:

1. ManabendraBhuyan, "Intelligent Instrumentation – Principles and Applications", CRC Press, 2012.
2. James W. Dally, William F. Riley, and Kenneth G. McConnell, "Instrumentation for Engineering Measurements", Wiley student edition, Second edition, 2013.
3. S. E. Lyshevski. "MEMS and NEMS: Systems, Devices, and Structures (Nano- and Microscience, Engineering, Technology and Medicine), CRC Press, 2002.

Course Outcome:

Upon completion of the course, students will demonstrate the ability to:

CO1	Demonstrate knowledge of principles of measurement and instrumentation in commercial and industry environments;
CO2	Compile mechanical or smart sensor/actuator as per specifications, and to measure the specific physical parameters;
CO3	Express understanding of the most appropriate signal conditioning (SC) devices and design of analog or digital SC circuits;
CO4	Inherit the MEMS and NEMS technologies to design smart/ intelligent devices for the purpose of measurement, and
CO5	Express need of communication links and safety measures as per industry standards and practices.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Advanced Control Systems

MODULE-I

Linearization of nonlinear systems, SISO Control Analysis and Design Analysis of SISO Control Loops, Classical PID Control, Synthesis of SISO Controllers.

MODULE-II

Fundamental Limitations in SISO Control, Model error Limitations, Structural Limitations, Frequency Domain design limitations, Architectural Issues in SISO Control.

MODULE-III

Internal Model Principle, Feed forward and Cascade Control, Anti-wind-up scheme, SISO controller Parameterizations, Control Design Based on Optimization, Synthesis via state space methods.

MODULE-IV

Digital Computer Control, Models for sampled Data Systems, Sample Data Design, Internal Model Principle for Digital Control, Models for hybrid Control, Systems, Analysis of Inter sample behaviour.

MODULE-V

MIMO Control Essentials, Analysis of MIMO Control Loops, Exploiting SISO Techniques in MIMO Control, MIMO Control Design: Design via Optimal control techniques, MIMO Controller Parameterizations, Decoupling.

Books:

1. Graham C. Goodwin, Stefan F.Graebe, Mario E.Salgado, "*Control System Design*", PHI-2002.
2. M. Athans and P. Falb, "*Optimal control*", MGH
3. K. Astrom, and B.wittenmark, "*Computer Control Systems: Theory and design*", Prentice Hall

Course Outcomes:

Upon completion of the course, students will be able to:

CO1	Analyze and design different SISO control loops.
CO2	Evaluate limitations and architectural Issues in SISO control.
CO3	Synthesize control models based on internal model principle, optimization and state space models.
CO4	Develop digital control and hybrid control models.
CO5	Analyze MIMO control loops and design MIMO control structure based on optimization and parameterization.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Program Elective-I

Biomedical Instrumentation

MODULE-I

Introduction to the physiology of cardiac, nervous and muscular and respiratory systems, Transducers and Electrodes : Different types of transducers and their selection for Biomedical applications, Electrode theory, Different types of electrode Hydrogen Calomel, Ag-Agcl, Ph, Po2 Pco2 electrodes, selection criteria of electrodes.

MODULE-II

Cardiovascular measurement: The heart and other cardio vascular systems, Measurement of Blood pressure, Blood flow, Cardiac output and cardiac rate, Electrocardiography, Phonocardiography, Ballistocardiograph, Plethysmography, Magnet-Cardiograph, Cardiac pace-maker, Computer applications.

MODULE-III

Measurement of electrical Activities in Muscles and Brain: Electromyography, Electroencephalograph and their interpretation. Respiratory system measurement: Respiratory mechanism, Measurement of gas volume, flow rate carbon dioxide & oxygen concentration in inhaled air, Respiratory controller.

MODULE-IV

Instrumentation for clinical laboratory: Measurement of pH value of blood. ESR Measurement, Hemoglobin Measurement, oxygen & carbon dioxide concentration in blood, GSR Measurement, Polarographic Measurement, computer application.

MODULE-V

Medical Imaging: Ultra sound Imaging, Radiography, MRI, Electrical tomography & applications, Biotelemetry: Transmission and reception aspects of biological signals via long distances, Aspects of patient care monitoring.

Books:

Textbook:

[1]. Khandpur R S–Hand book on Biomedical instrumentation, TMH, New Delhi1991.

[2]. Astor B R–Introduction to Biomedical instrumentation & measurement, McMillan.

Reference book:

1. Webster J S –Medical instrumentation-Application & Design.
2. Cromwell L–Biomedical instrumentation, PHI

3. Mandeep Singh-Introduction to Biomedical Instrumentation, 2nd Edition, PHI

4. Andrew G. Webb-Principles of Biomedical Instrumentation, Cambridge University Press

Course Outcomes:

Upon completion of the course, students will be able to:

CO1	Evaluate anatomy, physiology, and medical terminology appropriate for the role in the health care field. The students understand the basic concept of transducer, electrode and its various types.
CO2	Define the principle and basic function of cardiovascular system in humans.
CO3	Demonstrate of the concept of various measurement techniques of electrical activities in muscles and brain and respiratory mechanism of the human body
CO4	Demonstrate the applicability of different measuring techniques of blood pressure and various computer applications in the field of hematology.
CO5	Express the medical imaging and biotelemetry concept.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Random Processes in Control and Estimation

Module-I (6 hours)

Introduction to Probability: Sets and set operations, probability space, conditional probability and Bayes theorem, combinatorial probability and sampling models.
Random Variables: Discrete random variables, probability mass function, probability distribution function, Joint distributions, functions of one and two random variables, moments of random variables conditional distribution. Important probability distributions in control theory.

Module-II (8hours)

Sequence of Random Variables and Convergence: Random sequences, Almost sure (a.s.) convergence and strong law of large numbers convergence in mean square sense with examples from parameter estimation convergence in probability with examples convergence in distribution central limit theorem.Markov, Cheby-shev and Chernoff bounds, cetection and estimation.

Module-III (8 hours)

Random Processes: Random processes, stationary processes, mean and covariance functions, ergodicity, linear filtering of random processes, power spectral density, examples of random processes: white noise process and white noise sequence, Gaussian process, Poisson process, Markov process.

Module-IV (10 hours)

Introduction to time series, nature of time series data, time series statistical models, measures of dependence, stationary time series, estimation of correlation. Classical regression, exploratory data analysis, smoothing. Basics of R Programming.
ARIMA Models: Autoregressive Moving Average Models, difference equations, autocorrelation and partial autocorrelation. Forecasting, estimation. Building ARIMA models.

Module-V (7 hours)

Spectral Analysis and Filtering: Cyclical behavior and periodicity. Spectral Density. Periodogram and Discrete Fourier Transform, Nonparametric and parametric spectral estimation, Multiple series and cross-spectra. Linear filters. Lagged regression models. Signal extraction and Optimal filtering.

Recommended Books

[1]. A Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochas- tic Processes, McGraw Hill

[2]. H. Stark and J. W. Woods, Probability and Random Processes with applications to Signal Processing, Pearson Education

[3]. Robert H. Shumway, David S. Stoffer. "Time Series Analysis and its Applications", Fourth Edition.,Springer

References

[1]. S. Ross, Stochastic Processes, Wiley

[2]. W. Feller, An Introduction to Probability Theory, Wiley

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate the axiomatic formulation of modern Probability Theory and think of random variables as an intrinsic need for the analysis of random phenomena.
CO2	Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits.
CO3	Apply the concept of random processes and determine covariance and spectral density of stationary random processes.
CO4	Express the characteristics of time series and build time domain models.
CO5	Perform spectral analysis and optimal filtering.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Renewable Power and Control

MODULE-1 (8 HOURS)

Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and Nonconventional), Energy needs of India, and Energy Consumption Patterns. Worldwide Potentials of these sources. Energy efficiency and Energy security. Energy and its environmental impacts, Distributed generation.

Solar Radiation and its Measurement: Introduction, Solar Constant, Solar Radiation at the Earth's Surface, Solar Radiation Geometry, Solar Radiation Measurements, Solar Radiation Data, Estimation of Average Solar Radiation, Solar Radiation on Tilted Surfaces.

MODUL-II (8 HOURS)

Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications.

Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing and economics. Peak power operation. Standalone and grid interactive systems.

MODUL-III (8 HOURS)

Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating. Choice of generation, turbine rating, electrical load matching, variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

MODUL-IV (8 HOURS)

Energy storage and hybrid system configurations: Energy storage, Battery types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Flywheel-energy relations, components, benefits over battery. Fuel Cell energy storage systems.

MODUL-V (7 HOURS)

Grid Integration: Stand alone systems, Concept of Micro-Grid and its components, Hybrid systems -hybrid with diesel, with fuel cell, solar-wind, wind hydro systems, Electric and Hybrid Electric vehicles, Hydrogen-Powered-Electric Vehicles.

TEXT BOOKS

[1]. R.Ramesh, Renewable energy technologies ,Narosa publication.
[2]. G.D.Rai, Non-Conventional Sources of Energy, Khanna Publishers

REFERENCE BOOKS

1].Mittal, Non-Conventional energy Systems, Wheelers Publication
2]. S. Rao Parulkar,Energy Technology, Khanna Publication.
3]. B. H. Khan, Non-Conventional Energy Resources, Tata McGrawHill, 2009.

Course Outcomes:

Upon completion of the course, the students will:

CO1	Express the idea about energy scenario.
CO2	Define different types of solar energy systems.
CO3	Design and control wind energy systems.
CO4	Design and control of energy storage and hybrid systems.
CO5	Design grid integration of renewable energy system and demonstrate concept of microgrids.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Control of Power Electronic Converters

Module-I (8 hours)

Power Electronic Devices: Diodes, Transistors, Thyristors, MOSFET and IGBT – operating principle, Static, dynamic and thermal characteristics, Data sheet ratings, gate drive circuits.

Module-II(8hours)

Single phase half controlled and fully controlled AC/DC bridge converter with R, R-L, R-L-E (motor) loads: operation (both rectifier and inverter modes) , waveforms ,harmonics (output voltage/current and input current) assuming continuous conduction, input current (ac) displacement, distortion and power factor, effect of input line inductance assuming constant current dc load, closed form expression of output dc current with general R-L-E load, discontinuous conduction mode of operation.

Module-III (8 hours)

Three phase half controlled and fully controlled AC/DC bridge converter assuming constant dc current load : operation in rectifier and inverter modes, waveforms, output voltage and input current harmonics, input power factor and effect of input line inductance, series and parallel operation of converters, power factor improvement, 12 pulse/18 pulse operation, transformer connection, dual converters.

Module-IV: (8 hours)

DC-DC choppers: basic voltage commutated thyristor chopper analysis , Separately excited DC motor drive using DC-DC choppers made of gate controlled devices, four quadrant operation, dynamic and regenerative braking of series DC motor using choppers; Basic DC-DC converters: buck, boost buck-boost and Cuk converter, operation, waveforms.

Module-V(7 hours)

DC-AC inverters using gate controlled devices: single phase and three phase square wave inverters, operation waveforms and harmonics in pole voltage, load phase voltage and line voltage, output voltage control in single phase square wave inverter using chopper control and phase shift, harmonic analysis, operating principles of single phase and three phase PWM inverters, modulation techniques, SPWM, Selective Harmonic Elimination PWM and delta modulation, harmonic spectrum and comparison among different PWM techniques. Variable frequency operation of three phase induction motors: Steady state analysis, Torque-speed, current, speed and slip frequency –speed characteristics and operating limits with constant volts/Hz and constant air gap flux operation, implementation using PWM.

Text Books

1. N. Mohan, T.M. Undeland& W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley &Sons , New York, 2003.
2. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2002

Reference Books:

1. M.H. Rashid, Power Electronics, Circuits, Devices, and Applications, Pearson, 2003
2. B. K. Bose, Modern Power Electronics and A.C. Drives, PHI, 2002

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate operation principle, characteristics rating of various power electronic devices such as transistor, MOSFET, IGBT etc
CO2	Perform single phase AC/DC bridge converter operation, output and input (voltage and current) waveform analysis.
CO3	Analyze three phase AC/DC bridge converter operation, output and input (voltage and current) waveform analysis.
CO4	Analyze DC-DC converter: buck, boost buck-boost and Cuk converter, operation, waveforms.
CO5	Construct DC-AC inverters, its operation and waveform analysis.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Program Elective-II

Power Plant Instrumentation and Control

Module-I (6 hours)

Overview of power generation – hydro, thermal, nuclear, solar and wind power – Importance of instrumentation in power generation, introduction and comparison of thermal Power plant, Hydro Electric Power Plant, Nuclear Power Plant, Solar Power Plant. Monte Carlo Method of finding accuracy of calculated results, Impacts of Degradation on Overall Plant Performance- Steam Turbine impacts, Heat recovery Steam Generator impacts, Condenser impacts, Cooling tower impacts.

Thermal power plant: Unit overview, air and fuel path, boiler instrumentation: Combustion control, air to fuel ratio control, 3-element drum level control, steam temperature and pressure control, oxygen/CO2 in flue gases, furnace draft, boiler interlocks, Start-up and shut-down procedures Boiler load calculation, boiler efficiency calculation, Boiler safety standard.

Module-II (8hours)

Turbine Instrumentation and control: Hydraulically controlled speed governing and turbine steam inlet control valve actuation system. Condenser vacuum control- gland steam exhaust pressure control speed, vibration, shell temperature monitoring-lubricating oil temperature control hydrogen generator. Start-up and shut-down, thermal stress control, condition monitoring and power distribution instrumentation, Synchronous, Induction generators cooling system.

Gas turbine performance- Correction curves (Baseload performance): Effect of Inlet temperature, inlet humidity, atmospheric pressure, inlet pressure loss, exit pressure loss and steam or water ejection. Steam Turbine Performance- Thermal performance, Rankine cycle ST heat balance analysis and performance curves.

Module-III (8 hours)

Hydro and Nuclear Power Plants: Hydro Power Plant: Overview on units, Types of water turbine. Regulation of speed and voltage. Surge tank level control. Nuclear Power Plant: Overview on units, Concept of energy generated from atomic fission. Block diagram of an Atomic power station. Types of coolants. Control of chain reaction. Radio activity and safety measures. Layout of control rooms, Criterion for selection of Instrumentation system / DCS system for nuclear and hydro power plant.

Nuclear Power Plant Instrumentation: Piping and instrumentation diagram of different types of nuclear power plant, radiation detection instruments, nuclear reactor control system and allied instrumentation.

Computer controlled processes: PLC based control of different types of processes such as liquid level system and flow control, open-and-closed chamber pressure control, temperature control, different types of heat exchangers, control of pressurized gases.

Module-IV (10 hours)

Non-conventional Energy Sources: Concept of power generation from non-conventional sources of energy like wind power, Solar Power and Tidal waves. Photovoltaic cells, Hydrogen cells. Power generation using incinerators and bagasse fired boilers, Criterion for selection of Instrumentation system for wind and solar and tidal wave plant.

Module-V (7 hours)
Physical Ladder Diagram and Programmable Ladder Diagram. Different Modules of the System Architecture of PLC. Case Studies: Design of boiler automation using DCS and PLC, frost free refrigerator / freezer system; composite discrete / continuous control; conveyor system; oven system; elevator system; uniformly heated liquid control system, and hydro-phonic system.
Advances in Automation: Programmable Automation Controllers. NI my-DAQ, my-RIO, c-RIO, and ELVIS. Role of Internet of Things and Cyber Physical System in Industry Automation, MQTT protocol.

Books:

1. "Power Plant Performance Monitoring", Rodney R. Gay, Tech Books International Publication.
2. "Handbook on Modern Power Station Practice", Instrumentation and Control, Vol. 06, British Electricity International, Elsevier, 2012.
3. Curtis D. Johnson, "Process Control and Industrial Technology", Pearson India, 8th ed., 2012.

Reference books:

1. "Instrument Engineer's Handbook – Process Control", B. Liptak, CRC Press.
2. Peter D. Harriot, "Process Control", Tata McGraw-Hill, New Delhi, 2009.
3. John W. Webbs, "Programmable Logic Controllers – Principals and Applications", Fifth Edition, Pearson India /PHI (Old edition), 2012.

Course Outcomes:
Upon completion of this course, students will demonstrate the ability to:

CO1	Demonstrate knowledge of different principles& importance of instrumentation and control for power generation applications using automation;
CO2	Develop the required instrumentation and final elements to ensure the operation of thermal power plants;
CO3	Develop required instrumentation and control to ensure the operation of hydro and nuclear power plants;
CO4	Develop automation systems to operate various renewable sources and/or hybrid sources of energy, and
CO5	Demonstrate appropriate automation platform for the control of plant dynamics and well-tuned control loops, field instrumentations.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Optimization in Control

Module –I (9 hours)

Unconstrained Optimization and Efficient Algorithms, e.g. steepest or gradient descent methods.

Constrained Optimization with Lagrange Multipliers (First-Order Necessary Conditions) and Second-Order Conditions.

Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variational problem Extrema of functions and functional with conditions – Variational approach to optimal control system.

Module –II (8 hours)

Linear Quadratic Optimal Control System: Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case.

Module -III(8 hours)

Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems – Hamilton-Jacobi-Bellman Equation – LQR system using H-J-B equation.

Module -IV(6 hours)

Global search algorithms: simulated annealing, GA, particle swarm optimizer, Application in control problems.

Module –V(8 hours)

Concept of paretooptimality , Conventional approaches for MOOP, Multi objective GA ,Fitness assignment ,Sharing function , Multi objective PSO(Dynamic neighbourhood PSO, Vector evaluated PSO) ,Application in control problem.

TEXT BOOKS:

[1]DesineniSubbaram Naidu, “Optimal Control Systems”, CRC Press, 2009.

[2]Kalyanmoy Deb, "Multi Objective Optimization using Evolutionary Algorithms", Wiley India Pvt ltd, 2010.

[3] J. Nocedal and S. Wright, Numerical Optimization, 2nd ed., Springer-Verlag, NewYork 2006.

REFERENCE BOOKS:

[1]J. E. Dennis and R. B. Schnabel, Numerical Methods for Unconstrained Optimization, SIAM, Philadelphia 1996.

[2]D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, New York 1989.

[3]Kirk D E, "Optimal Control Theory: An Introduction", Prentice Hall, New Jersey, 2008.

COURSE OUTCOMES:

Upon completion of the subject the students will demonstrate the ability to:

CO1	Solve unconstrained and constrained optimization problems.
CO2	Formulate and solve Linear Quadratic Optimal Control problem.
CO3	Apply dynamic programming for control optimization.
CO4	Apply evolutionary and swarm algorithms for optimization in control problems.
CO5	Solve multi objective optimization control problems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Microprocessors & Microcontrollers

MODULE-I (9 Hours)
Review of 8-bit microprocessor and 16-bit microprocessor, overview of the instruction set, Assembly language programming, Interrupt structure, interfacing memory and IO devices. Memory organizations, Standard peripherals and their interfacing (sw and hw aspects), color graphic terminals and ASCII keyboards, mouse, floppy and hard disc drive, other storage media (optical disks, Digital Audio Tapes etc.)

MODULE-II (9 Hours)
Data transfer techniques-Asynchronous and synchronous, Serial and parallel interface standards. Communication media and adapters, Modems and their interfacing, Bus structures and standard basic concepts, Example of a bus standard (PC-VME bus), Salient features of other processors (80286386486 and 680206803068040).

Module III (6 Hours)
Microcontrollers and digital signal processors. IO processors and arithmetic coprocessors. Logic design for microprocessor-based systems-design of state.

MODULE-IV (6 Hours)
Introduction to Microcontrollers, Motorola 68HC11, Intel 8051, Intel 8096, Registers, Memories, I/O Ports, Serial Communications, Timers, Interrupts.

MODULE-V (9 Hours)
Instructions in Microcontrollers, Interfaces, Introduction to Development of a Microcontroller Based System, Concept of a Programmable Logic Controller, Features and parts in a PLC unit.

TEXT BOOKS:

1. John. F. Wakerly: Microcomputer Architecture and Programming, John Wiley and Sons.

2. Ramesh S. Gaonker: Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing (India).

3. Yu-Cheng Liu and Glenn A. Gibson: Microcomputer systems: The 8086/8088 Family Architecture, Programming and Design, Prentice Hall of India.

4. Raj Kamal: The Concepts and Features of Microcontrollers, Wheeler Publishing.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Write memory organization of 16 bit microprocessor; interrupt structure and interfacing of standard peripheral devices.
CO2	Analyze the various types of data transfer technique in communication media, adapter and modem by using standard interfaces and buses.
CO3	Define the architecture and features of Intel 8096 and Motorola 68HC11microcontroller.
CO4	Realize the role of microcontroller based system and programmable logic controller.
CO5	Implement the design of microprocessor/microcontroller-based systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Robust and Optimal Control

MODULE-I (8 hours)

Overview and Preliminaries: Overview on robust control, basics from matrix algebra, norms of signals and systems ($\boldsymbol{L_2}$, $\boldsymbol{H_2}$, $\boldsymbol{L_\infty}$, $\boldsymbol{H_\infty}$), robust performance and limitations due to physical constraints, Small-gain theorem, structured and unstructured uncertainty, robust stability for structured uncertainty (M-Δ structure).

MODULE-II (8 hours)

H∞ Control: Generalized H-infinity controller synthesis problem, full information control, mixed sensitivity design, H-infinity loop shaping design: four-block problem, loop shaping concept, choice of weighting filters, Mu analysis and synthesis.

MODULE-III (8 hours)

Introduction, static and dynamic optimization, parameter optimization. Calculus of variations: problems of Lagrange, Mayer and Bolza, Euler-Language equation and transversality conditions, Lagrange multipliers, Pontryagins maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem.

MODULE-IV (8 hours)

Linear regulator problem: matrix Riccati equation and its solution, tracking problem, computational methods in optimal control, Different techniques for solution of algebraic Riccati equation, Stability and robustness properties of LQR design. Linear quadratic Gaussian design, loop transfer recovery design

MODULE-V(7 hours)

Dynamic programming: principle of optimality, principle of optimality, Computation of Optimal Control using Dynamic Programming, Bellman's principle of optimality, Hamilton-Jacobi-Bellman Equation,

TEXT BOOKS

1. SigurdSkogestad, Ian Postlethwaite, Multivariable Feedback Control: Analysis and Design, Wiley publication.
2. Donald E. Kirk, Optimal Control Theory, Prentice-Hall, New Jersey.

REFERENCE BOOKS

1. B.C.Kuo, F. Golnaraghi, "Automatic Control Systems", John Willey & Sons.
2. Frank L. Lewis, Optimal control, John Wiley & Sons.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Evaluate uncertainty of a system for robust design.
CO2	Implement an H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it.
CO3	Express the requirement of optimality.
CO4	Construct the designing and tuning LQR, LQG controllers.
CO5	Analyze and synthesize optimal feedback laws using the Hamilton-Jacobi-Bellman equation

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Instrumentation and Sensors Lab

List of Experiments

1. Study of a two-phase AC servomotor and measurement of its transfer functions parameters.
2. Study of a linear system simulator.
3. Measurement of unknown resistance, inductance and capacitance using bridges.
4. To plot the displacement- voltage characteristics of the LVDT.
5. Study of synchro -transmitter and receiver.
6. Study of various temperature sensors: RTD, Thermistor, and Thermocouple and its comparison with soft temperature sensors.
7. Study of moisture sensors for various applications.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Express the basic principles AC servomechanisms.
CO2	Demonstrate the linear system simulation.
CO3	Demonstrate the principles of synchros and displacement transducers.
CO4	Implement various types of temperature sensors based on application's need.
CO5	Design a moisture sensor.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**3**	**3**	**3**	**3**	**3**

Second Semester

Program Core Courses

Adaptive Control

MODULE-I (10 hours)

System Identification: Introduction, dynamic systems, models, system identification Procedure, Simulation and Prediction, Non-parametric time and frequency domain methods. Linear dynamic system Identification: Overview, excitation signals, general model structure, time series models, models with output feedback, models without output feedback. Convergence and consistency.

MODULE-II (10 hours)

Parameter estimation methods, minimizing prediction errors, linear regressions and Least squares method, Instrumental, variable method, prediction error method. Recursive algorithms. Closed-loop Identification.

MODULE-III (9 hours)

Adaptive Control: Close loop and open loop adaptive control. Self-tuning controller. Auto tuning for PID controllers: Relay feedback, pattern recognition, correlation technique.

MODULE-IV (4 hours)

Adaptive Smith predictor control: Auto-tuning and self-tuning Smith predictor.

MODULE-V (6 hours)

Adaptive advanced control: Pole placement control, minimum variance control, generalized predictive control.

TEXT BOOKS:

1. Ljung .L, System Identification: Theory for the user, Prentice Hall, Englewood Cliffs, 1987.

2. Astrom .K, Adaptive Control, Second Edition, Pearson Education Asia Pte Ltd, 2002.

REFERENCE BOOKS:

1. Chang C. Hong, Tong H. Lee and Weng K. Ho, Adaptive Control, ISA press, Research Triangle Park, 1993.

2. Nelles. O, Nonlinear System Identification, Springer Verlag, Berlin, 2001.

COURSE OUTCOMES:

Upon completion of the subject the students will demonstrate the ability to:

CO1	Solve unconstrained and constrained optimization problems.
CO2	Formulate and solve Linear Quadratic Optimal Control problem.
CO3	Construct dynamic programming for control optimization.
CO4	Demonstrate evolutionary and swarm algorithms for optimization in control problems.
CO5	Solve multi objective optimization control problems .

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Non-linear Control

SYLLABUS

MODULE-I (10 hours)

Introduction to nonlinear system behavior

Phase plane analysis: Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits-Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of Limit Cycles.

Describing function: fundamentals, definitions, assumptions, computing describing functions, common nonlinearities and its describing functions, Nyquist criterion and its extension, existence of limit cycles, stability of limit cycles.

MODULE-II (8 hours)

Lyapunov theory: Nonlinear Systems and Equilibrium Points, Concepts of Stability, Linearization and Local Stability, Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions, Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method, Krasovski's Method, Variable Gradient Method, Control Design based on Lyapunov's Direct Method.

MODULE-III (7 hours)

Advanced stability theory: Concepts of stability for Non-autonomous systems, Lyapunov analysis of non autonomous systems, instability theorems, Existence of Lyapunov functions, Barbalat's Lemma and stability analysis

Feedback linearization: Feedback Linearization and the Canonical Form, Concept of Lie derivative and Lie Bracket.

MODULE-IV (7 hours)

Input-State, Linearization of SISO Systems, Input-Output Linearization of SISO Systems, Generating a Linear Input-Output Relation, Normal Forms, The Zero-Dynamics, Stabilization and Tracking, Inverse Dynamics and Non-Minimum-Phase Systems, Feedback Linearization of MIMO Systems, Zero Dynamics and Control Design.

MODULE-V (7 hours)

Sliding mode control: Sliding Surfaces, Continuous approximations of Switching Control laws, The Modeling/Performance Trade-Offs-MIMO Systems.

Books:

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. H. K. Khalil, Nonlinear systems and control, Prentice Hall Inc.

Reference Books:

1. P.Albertos, A. Sala, Multivariable Control System, Springer, 2004.

2. S. H. Zak, Systems and control, Oxford University Press, 2003.
3. Torkel Glad and Lennart Ljung, Control Theory – Multivariable and Nonlinear Methods, Taylor & Francis, 2002.
4. M. Vidyasagar, Nonlinear systems analysis, SIAM, 2002.

Course Outcomes:

Upon completion of the course, students will be able to:

CO1	Comprehensively distinguish different nonlinear systems and analysis methods.
CO2	Apply the stability analysis to any nonlinear system.
CO3	Analyze the stability, hard nonlinearity, nonlinear behavior and apply control specific to different type of nonlinear system.
CO4	Apply the concepts of mathematical tools to evaluate analysis methods and compare for control of nonlinear systems.
CO5	Develop stable and robust control by design and modification of sliding mode controller for SISO and MIMO nonlinear systems.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Program Elective-III

Industrial Process Control and Automation

MODULE-I(7 hours)

Introduction to process dynamics, its type and classifications. Process Characteristics: process lag and self-regulation. Control system parameters. Control actions and controller tuning: Basic control actions-on/off mode, multi position mode, floating control mode; Analog and Discrete Control modes: P, P+I, P+I+D, pneumatic and electronic controllers, pneumatic vs hydraulic control, controller tuning.

MODULE-II(8 hours)

Introduction to PLC, PAC, DCS and SCADA. IEDs, RTUs, HMI, Smart Sensors and Actuators. IEEE 802.11 / 15 Standards, IEEE 1451.5 Std. Communication Networks for PLC. The Instrument Lists of PLC and HMI. Sequential and Programmable controllers, System Architecture, Programming languages of PLC, Relay logic and Ladder logic, Ladder Diagram Elements.

MODULE-III(9 hours)

Computer controlled processes: PLC based control of different types of processes such as liquid level system and flow control, open-and-closed chamber pressure control, temperature control, different types of heat exchangers, control of pressurized gases.

MODULE-IV(9 hours)

Discrete State Process Control: Physical Ladder Diagram and Programmable Ladder Diagram. Different Modules of the System Architecture of PLC. Case Studies: frost free refrigerator / freezer system; composite discrete / continuous control; conveyor system; oven system; elevator system; uniformly heated liquid control system, and hydro-phonic system.

MODULE-V(6 hours)

Advances in Automation: Programmable Automation Controllers. NI my-DAQ, my-RIO, c-RIO, and ELVIS. Role of Internet of Things and Cyber Physical System in Industry Automation, MQTT protocol.

Books:

1. Peter D. Harriot, "Process Control", Tata McGraw-Hill, New Delhi, 2009.
2. Curtis D. Johnson, "Process Control and Industrial Technology", Pearson India, 8th ed., 2012.
3. Liptak, "Process Control: Instruments Engineer's Handbook", Butterwirth Heinemann, 1995.

Reference books:

1. Norman A Anderson, Instrumentation for Process Measurement and Control, CRC Press, 2008.
2. B. Wayne Bequette, "Process Control – Modeling, Design, and Simulation", Pearson India, 2015.
3. John W. Webbs, "Programmable Logic Controllers – Principals and Applications", Fifth Edition, Pearson India /PHI (Old edition), 2012.

Course Outcomes:

Upon completion of this course, students will demonstrate the ability to:

CO1	Describe the basic principles and importance of process control applications using automation;
CO2	Express the required instrumentation, knowledge of the P&ID, the Instrumentation Lists, and final elements to ensure that well-tuned control is achieved;
CO3	Create computer control mechanism of various processes
CO4	Design, install, operate, control and maintain different process and automated applications using PLCs/PACs. Further, PLC / PAC algorithm using Ladder Logic Diagram or equivalent languages while handling a plant process;
CO5	Apply knowledge on advances in use of automation platform such as PACs and IoT while handling a plant process.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Networked and Multi-agent Control Systems

Module-I (7 hours)

Network Models: graphs, random graphs, random geometric graphs, state-dependent graphs, switching networks.

Module-II (8 hours)

Decentralized Control: limited computational, communications, and controls resources in networked control systems.

Module-III (8 hours)

Multi-Agent Robotics: formation control, sensor and actuation models.

MODULE-IV (8 hours)

Mobile Sensor Networks: coverage control, voronoi-based cooperation strategies.

MODULE-V (8 hours)

LANdroids: mobile communications networks, connectivity maintenance.

TEXT BOOKS

[1]. M. Mesbahi and M. Egerstedt, "*Graph Theoretic Methods in Multiagent Networks"*, Princeton University Press, 2010.

[2]. F. Bullo, J. Cortes, and S. Martinez, "*Distributed Control of Robotic Networks*", Princeton, 2009.

REFERENCE BOOKS

[1]. C. Godsil and G. Royle, "*Algebraic Graph Theory*", Springer, 2001.

[2]. *Networked Embedded Sensing and Control,* edited by P. J. Antsaklis and P. Tabuada, Springer 2006.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define the basic concept of Network Models.
CO2	Implement differentDecentralized Control
CO3	Express the concept ofMulti-Agent Robotics.
CO4	Development of fundamental behindMobile Sensor Networks.
CO5	Express the concept of LANdroids.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Cyber Physical Systems

Module-I (8 hours)

Cyber physical system: Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications, Building Automation, Medical CPS.

CPS - Platform components:CPS HW platforms - Processors, Sensors, Actuators, CPS Network –WirelessHart, CAN, Automotive Ethernet, CPS Sw stack – RTOS, Scheduling Real Time control tasks.

Module-II (8 hours)

CPS implementation: From features to software components, Mapping software components to ECUs, CPS Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion, Control, Bus and Network Scheduling using Truetime.

Module-III (8 hours)

Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis (Basic introduction and examples, Timed and Hybrid Automata, Formal Analysis: Flowpipe construction, reachability analysis), Analysis of CPS Software, Hybrid Automata Modelling (Flowpipe construction using SpaceX and Phaver tools), CPS SW Verification: Frama-C, CBMC.

MODULE-IV (7 hours)

Secure Deployment of CPS: Attack models (Secure Task mapping and Partitioning, State estimation for attack detection, Automotive Case study: Vehicle ABS hacking, Power Distribution Case study: Attacks on SmartGrids).

MODULE-V (8 hours)

CPS Case studies and Tutorials: Automotive:SW controllers for ABS, ACC, Lane Departure Warning, Suspension Control, Healthcare: Artificial Pancreas/Infusion, Pump/PacemakerGreen Buildings: automated lighting, AC control.

TEXT BOOKS

1. "Introduction to Embedded Systems – A Cyber–Physical Systems Approach" - E. A. Lee, SanjitSeshia

2. “Principles of Cyber-Physical Systems” - Rajeev Alur

Course Outcomes:

Upon completion of the course, the students will:

CO1	Define the basic concept of Cyber-Physical System (CPS) and its platform component.
CO2	Construct differentCPS implementation.
CO3	Implement Formal Methods for Safety Assurance of Cyber-Physical Systems.
CO4	Plan the concept of Secure Deployment of CPS.
CO5	Develop the logic of CPS Case studies.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Wireless Sensor Networks

MODULE-I(5 hours)

Limitations of Wired Network Protocols; Benefits of Wireless Network Protocols/ Wireless Sensor Networks (WSNs); Introduction to IEEE 802.xx Standards: specifications of bandwidth, SNR, range of measurement of physical parameters. Communication Networks for industry, home appliances, office automation and biomedical applications.

MODULE-II(10 hours)

Wireless LAN (WLAN): Direct Sequence Spread Spectrum (DSSS) technique, Frequency Hoping Spread Spectrum (FHSS) technique. Wi-Fi (IEEE 802.11); Bluetooth (IEEE 802.15.1), WRAN (IEEE 802.15.1), and Wireless HART (IEEE 802.15.1/ ISA 100.11a); Zigbee (IEEE 802.15.4); WiMAX (IEEE 802.16e); MBWA (IEEE 802.20).

MODULE-III(7 hours)

Advances in WSN: IEEE 1451.5 Standard: IEEE 1451.2 - transducer to microprocessor communication protocol and TEDS (transducer Electronic Data Sheet) formats; IEEE 1451.3 - digital communication and TEDS format for distributed multi-drop system; IEEE 1451.4 - mixed mode communication protocols and TEDS format; IEEE 1451.5 – wireless communication protocols and TEDS formats; IEEE 1451.6: high speed CAN open-band transducer network interface for intrinsically safe and non-intrinsically sate applications; IEEE 1451.7 – transducer to radio frequency identification (RFID) system communication protocols and TEDS formats.

MODULE-IV(9 hours)

Real-life Applications - Sensors interconnection with wireless sensor nodes: Xbee based modules can be used as it is mesh capable; Bluetooth 2.0 enabled hardware. Centralized gateways: Collect data from various sensor nodes; Pre-processing of data; Sending data to the cloud for further processing. Mesh compatible protocols: communicate over long distance; Consume low power, MQTT protocol, IPv6, Zigbee (IEEE 802.15.4), Bluetooth.

MODULE-V(9 hours)

Optimization of sensor networks using IoT enabled sensors: Sensor Placement Optimization; Coverage and connectivity; Energy Consumption optimization, and Fault

Tolerance. IoT System architecture: Physical Layer - Sensor and actuators with embedded processing units; Communication Layer, and Application Layer; Enabling IEEE 1451.5 protocol with IoT.

Books:

1. Christian Poellabauer and WaltenegusDargie, Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley, 2010.
2. KazemSohraby, Wireless Sensor Networks, Springer, edited by TaiebZnati, 2005.

Reference books:

1. Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005.
2.

Course Outcomes:

CO1	Identify the limitations of wired network protocols, benefits of wireless network protocols/ wireless sensor networks (WSNs), and their applications;
CO2	Express the concept of existing WSN schemes and standards;
CO3	Able to interface and appreciate WSN technology with TEDS;
CO4	Implement sensors interconnection with wireless sensor nodes and further developments in this direction.
CO5	Apply the advances in WSNs technologies and use of optimized sensor networks and IoT enabled sensors.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Program Elective-IV

Advanced Digital Signal Processing

Module-I (8 hours)

Multirate Digital Signal Processing: Introduction, Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by rational factor I/D, Filter Design and Implementation for sampling-rate, Multistage implementation of sampling rate conversion, Sampling rate conversion of Band pass signal, Application of multi rate signal processing: design of phase shifters, Implementation of narrowband low pass filters. Implementation of Digital filter banks. Filter Bank and Sub-band Filters and its applications.

Module-II (8 hours)

Linear prediction and Optimum Linear Filters: Innovations Representation of a stationary random process, Forward and Backward Linear Prediction, Solution of the normal equations, Properties of the linear prediction-error filters, AR lattice and ARMA lattice- ladder filters, Wiener filter for filtering and Prediction: FIR Wiener Filter, Orthogonality Principle in linear mean square estimation.

Module-III (8 hours)

Power Spectrum Estimation: Estimation of spectra from finite-duration observation of signals, Non parametric method for power spectrum estimation: Bartlett method, Blackman and Turkey method, parametric method for power estimation: Yuke Walker method, Burg method, MA model and ARMA model.

MODULE-IV (7 hours)

Adaptive Signal Processing: Basics of Wiener filtering, Widrow-Hopf Equation, Least mean square algorithm, Recursive least square algorithm, variants of LMS algorithm: FX-LMS, Fast LMS, N-LMS, PN-LMS.

MODULE-V (8 hours)

Design of Adaptive FIR & IIR filters, Application of adaptive signal processing: Adaptive linear combiner, System identification, Channel equalization, adaptive noise cancellation, adaptive line enhancer.

TEXT BOOKS

[1]. John G. Proakis, and Dimitris G. Manolakis, “Digital Signal Processing” (third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997

[2]. Alan V. Oppenheim, Ronald W. Schafer, “Discrete-Time Signal Processing”, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997

REFERENCE BOOKS

[1] A. Nagoor Kani, “Digital Signal Processing”, Second edition, Mc Graw Hill.

[2]. Sanjit K Mitra, “A computer-based approach”, Tata Mc Grow-Hill edition .1998

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Develop the basic of Multirate Digital Signal Processing.
CO2	Construct Linear prediction and Optimum Linear Filters.
CO3	Evaluate Power Spectrum Estimation.
CO4	Analyse the Adaptive Signal Processing.
CO5	Design and implement Adaptive FIR & IIR filters.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Machine Learning and AI

MODULE-I (10 HOURS)

Principles of AI and Search Techniques: Introduction to AI, AI Problems, Planning, Production System, State Space Representation, Branches and Application of AI

Heuristic Search: Hill Climbing, Simulated Annealing, Depth First Search, Breadth First Search, Greedy Method, Best First Search, A* Algorithm, Problem Reduction: AND-OR graph, AO* Algorithm, Adversary Search: MINIMAX Algorithm, Alpha-Beta Cut-off algorithm.

MODULE-II (10 HOURS)

Knowledge and Reasoning: Knowledge Management, Types of Knowledge, Knowledge Representation, First Order Logic: Basic Predicate Representation, Conversion of WFF to Clause Form, Resolution and its Problem,

Reasoning: Types of Reasoning, Non-Monotonic Inference Method and Reasoning, Truth Maintenance System, Rule Based Reasoning, Reasoning with Fuzzy Logic

MODULE-III (10 HOURS)

Machine Learning (ML): Introduction to ML, Problems in ML, Learning System, Application of ML, Clustering: k-Means Clustering, Fuzzy and Hierarchical Clustering, Reinforcement Learning: Markov Decision Problem, Q-learning, Temporal Difference Learning, Statistical Learning: Hidden Markov Models, Linear, Quadratic Classifier, Decision Trees, Bayesian Networks

MODULE-IV (6 HOURS)

Artificial Neural Network: ANN, Types of Network, Perceptron, RBF Network, Supervised Learning: Support Vector Machines, Inductive Logic Programming, Case-Based Reasoning, Ensemble Classifier, Nearest Neighbourhood, Fuzzy Network, RBF, Unsupervised Learning: Self Organising Maps, Adaptive Resonance Theory, Deep Learning

MODULE-V (3 HOURS)

Expert System: Characteristic and Components Expert System, Expert System Development, Application of Expert System

TEXT BOOKS

[1]. E. Rich and K. Knight, *Artificial Intelligence*, Tata McGraw Hill.

[2]. Tom Mitchell, *Machine Learning*, McGraw Hill , 1997, ISBN 0-07-042807-7

REFERENCE BOOKS

[1]. S. Russel and P. Norvig, *Artificial Intelligence: a Modern Approach*, Pearson

[2]. Zsolt Nagy, Artificial Intelligence and Machine Learning Fundamentals

Course Outcomes:

Upon successful completion of this course, students will be able to:

CO1	Demonstrate the principles, advantages, problem of AI and implement in real field with different algorithms.
CO2	Solve problems using AI Knowledge and Reasoning.
CO3	Explain the principles, advantages, problems of ML and applications of ML.
CO4	Implement Artificial Neural Network and the different learning algorithm and deep learning.
CO5	Express the characteristics, components and development of Expert System.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Computer Vision

Syllabus:

Module I (9 Hours)

Brief overview of digital image fundamentals, image enhancement, image restoration. Color Image Processing:Color fundamentals, Color models, Pseudo-color image processing, Basics of full-color image processing, Color transformations, smoothing and sharpening, Color segmentation.

Module II (9 Hours)

Wavelets and Multi-resolution processing: Introduction, multi-resolution expansions, wavelet transforms in one dimension, fast wavelet transform wavelet transforms in two dimensions, wavelet packets.

Image compression:Fundamentals, image compression models, error-free compression, lossy compression, image compression standards.

Module III (6 Hours)

Morphological Image Processing: Binary morphology-Dilation and erosion, opening and closing, edge detection, hit-miss, thinning, thickening, skeletons and pruning, gray-level morphology.

Module IV (6 Hours)

Image segmentation:Detection of discontinuities, edge linking and boundary detection, thresholding, region based segmentation by morphological watersheds.

Module V (9 Hours)

Representation and Description:Representation, boundary descriptors, regional descriptors, relational descriptors. Object Recognition:Patterns and pattern classes, recognition based on decision-theoretic methods, structural methods.

Text Books:

1. Digital image processing by R. C. Gonzalez and R. E. Woods, Pearson Education.
2. Fundamentals of electronic Image processing by Arthur R. weeks. Jr.-PHI.

Reference Books:

1. Digital Image Processing and Analysis by B. Chanda and D. DuttMajumdar, PHI.

Course Outcomes:

Upon successful completion of this course, students will demonstrate the ability to:

CO1	Analyse general terminology of digital image processing;
CO2	Examine various types of images, wavelet transformations and compression techniques;
CO3	Evaluate the methodologies for image segmentation, restoration, etc;
CO4	Implement image process and analysis algorithms;
CO5	Apply image processing algorithms in practical applications.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Electric and Hybrid Vehicles

Module-I (5 hours)

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Architectures of HEVs, series and parallel HEVs, complex HEVs.

Module-II (10 hours)

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Module-III (10 hours)

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

Module-IV (7 hours)

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter,

current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Electric Machines and Drives in HEVs: Induction motor drives, Field oriented control of induction machies; Permanent magnet motor drives; Switched reluctance motors; Doubly salient permanent magnet machines. Case studies.

Module-V (7 hours)

Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies

Recommended Books

[1]. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

[2]. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

[3]. Mi Chris, Masrur A., and Gao D.W., " Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives".

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define the requirements and architecture of EVs and HEVs.
CO2	Develop drive trains mechanism used in EVs and HEVs.
CO3	Design electric propulsion unit and storage systems for EVs and HEVs.
CO4	Design drive systems for EVs and HEVs.
CO5	Demonstrate different communication systems used in EVs and HEVs.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Control Laboratory

List of Experiments

1. Designing of ladder logic for elevator system using PLC.
2. Designing of ladder logic for level control system using PLC.
3. Designing of ladder logic for microwave oven system using PLC.
4. Designing of ladder logic for Dual hooper control/conveyor belt using PLC.
5. Designing of ladder logic for uniform distribution of temperature through stirring mechanism using PLC/PAC.
6. Experiments of DC position control system.
7. Perform an experiment to obtain speed-torque characteristic of DC motor control system.
8. Experiment of AC servo system.
9. Perform the experiment to tune PID controller through Ziegler-Nichols tuning for 1^{st} order and 2^{nd} order system and verify the theoretical response with the experimental response.
10. Design a lead/lag controller and verify the theoretical response with the experimental response.
11. Perform an experiment to obtain gains of discrete PID controller and verify the theoretical response with the experimental response.
12. Tuning of PID controller for moving cart system.

Course Outcomes:
Upon completion of the course, students will be able to:

CO1	Demonstrate the basic principles & importance of ladder logic and its application to various plants.
CO2	Express the servo problem and able to find out the transfer function of a system experimentally.
CO3	Develop PID controller logic for any given system.
CO4	Design a compensator network for any given system.
CO5	Design and implement the PID controller for any practical system

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**3**	**3**	**3**	**3**	**3**

Minor Project and Seminar

Course description:

As a part of the curriculum, this is a sessional course, in which the students are trained in basic tools and presentation skills.

Upon completion of the course, the students will demonstrate the ability to:

CO1	Identify and analyze engineering problems and research problem.
CO2	Utilize technical resources for problem solving.
CO3	Develop skills to use modern engineering tools, software and equipment.
CO4	Write technical reports and demonstrate the findings in terms of oral presentations.
CO5	Develop confidence plan for future work .

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**3**	**3**	**3**	**3**	**3**

Third Semester

Program Elective-V

CAD of Instrumentation Systems

Module I

Data acquisition: Sampling Concepts: Sampling and Reconstruction, Shanon's Sampling Theorem, Aliasing, Oversampling. Characteristics of DAC and ADC, Comparison of Different types of ADCs.

Functional blocks of a typical PC based DAQ system: Analog input, PGA, sample timing, Multichannel Analog Input, multiplexing, sequential sampling, simultaneous sampling, clocked sampling, external sampling, multi rate sampling, Analog Output, Digital I/O, Timing I/O.

Triggering data acquisition, Data transfer methods

Module II

Hardware Organisation of PC**:** Functional units of Mother Board and their inter communication.

Interrupts: Interrupts in the PC and PC-XT systems, interrupts in PC-AT systems.

DMA Channels: Basic DMA operation, DMA channels in PC and PC-XT systems, DMA channels in PC and PC-AT systems. System Control Chips, Peripheral Control Chips.

Expansion Buses: ISA bus, EISA bus, PCI bus, AGP.

I/O ports: parallel port, serial port, mouse port, keyboard port, USB port.

Module III

Interfacing to PC: 8-bit ISA bus: Pins and signals, bus cycles, interfacing to 8-bit ISA bus, interrupt handling, using DMA channels, Design of expansion boards, case study.

16-bit ISA bus: Signals, interrupt handling, DMA channels, Bus cycles, interfacing to 16-bit ISA bus

EISA bus: structure of EISA bus, bus arbitration, interrupt handling, signals, Bus cycles, DMA, EISA system configuration, interfacing to EISA bus.

PCI Bus: PCI system, PCI signals and their functions, PCI addressing and bus commands, Bus arbitration, Bus transactions, PCI read cycle, PCI write cycle, PCI interrupt handling.

Module IV

Parallel Port (PP) and Serial Port Interfacing Techniques: Standard Parallel Port (SPP): Registers,pins and signals, Handshaking, Bi- directional function, Interfacing to SPP, ADC interface by interrupt, ADC interface by polling. Enhanced Parallel Port (EPP): pins and signals, Handshaking, Programming

Enhanced Capabilities Port (ECP): pins and signals, Registers, Handshaking

Universal Asynchronous Receiver/ Transmitter: Internal blocks of PC16550D, Registers of PC16550D, Functions of the UART registers, System Resources for Serial Port, Serial port programming, Interfacing to PC serial Port.

Module V

Plug-in Data Acquisition and Control Boards: Plug-in Boards: Basic rules of plug-in DAQ board design. ADC Board: specifications of a typical ADC board, circuit diagram, Bus buffering and address decoding block, ADC block, Analog input stage, Bit definitions of I/O registers, Programming the ADC board.

DAC Board: Specifications of DAC board, Circuit diagram,I/O map of the DAC board,Programming the DAC board.Digital I/O Board: Specifications of digital I/O board, Circuit diagram, I/O map of digital I/O board, Programming the digital I/O board.Timing I/O Board: Specifications of timing I/O board, Circuit diagram, I/O map of timing I/O board, Programming the timing I/O board.

Text Books

1. N. Mathivanan: PC Based Instrumentation Concepts and Practice, PHI Learning Pvt. Ltd., 2009.

2. Michel H. Toolay: PC Based Instrumentation and Control, 3rd Edition, CRC Press, 2005.

Reference Books

1. Computer Interfacing: A Practical Guide to Data Acquisition and Control by Rigby WH and T Dalby 1995; Prentice Hall Inc. Englewood Cliffs, NJ 232 pp. ISBN 0 – 13 288374 – 0

2. Tom Shanley, Don Anderson: PCI System Architecture, 3rd Edition, Adison Wesley Pub. Co., 1999.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Use personal computers as instrument controllers and develop simple computer programs to assist in or automate the collection and analysis of experimental data.
CO2	Develop the basics concepts and programming of Plug-in Data Acquisition and Control Boards.
CO3	Interface instruments and collect data by PC parallel and serial ports.
CO4	Design instrumentation devices.
CO5	Develop the theory of installation and commissioning the data communications links to ensure they run fault-free.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Machine Learning and AI

MODULE-I (10 HOURS)

Principles of AI and Search Techniques: Introduction to AI, AI Problems, Planning, Production System, State Space Representation, Branches and Application of AI

Heuristic Search: Hill Climbing, Simulated Annealing, Depth First Search, Breadth First Search, Greedy Method, Best First Search, A* Algorithm, Problem Reduction: AND-OR graph, AO* Algorithm, Adversary Search: MINIMAX Algorithm, Alpha-Beta Cut-off algorithm.

MODULE-II (10 HOURS)

Knowledge and Reasoning: Knowledge Management, Types of Knowledge, Knowledge Representation, First Order Logic: Basic Predicate Representation, Conversion of WFF to Clause Form, Resolution and its Problem,

Reasoning: Types of Reasoning, Non-Monotonic Inference Method and Reasoning, Truth Maintenance System, Rule Based Reasoning, Reasoning with Fuzzy Logic

MODULE-III (10 HOURS)

Machine Learning (ML): Introduction to ML, Problems in ML, Learning System, Application of ML, Clustering: k-Means Clustering, Fuzzy and Hierarchical Clustering, Reinforcement Learning: Markov Decision Problem, Q-learning, Temporal Difference Learning, Statistical Learning: Hidden Markov Models, Linear, Quadratic Classifier, Decision Trees, Bayesian Networks

MODULE-IV (6 HOURS)

Artificial Neural Network: ANN, Types of Network, Perceptron, RBF Network, Supervised Learning: Support Vector Machines, Inductive Logic Programming, Case-Based Reasoning, Ensemble Classifier, Nearest Neighbourhood, Fuzzy Network, RBF, Unsupervised Learning: Self Organising Maps, Adaptive Resonance Theory, Deep Learning

MODULE-V (3 HOURS)

Expert System: Characteristic and Components Expert System, Expert System Development, Application of Expert System

TEXT BOOKS

[1]. E. Rich and K. Knight, *Artificial Intelligence*, Tata McGraw Hill.

[2]. Tom Mitchell, *Machine Learning*, McGraw Hill , 1997, ISBN 0-07-042807-7

REFERENCE BOOKS

[1]. S. Russel and P. Norvig, *Artificial Intelligence: a Modern Approach*, Pearson

[2]. Zsolt Nagy, Artificial Intelligence and Machine Learning Fundamentals

Course Outcomes:

Upon successful completion of this course, students will be able to

CO1	Demonstrate principles, advantages, problem of AI and implement in real field with different algorithms.
CO2	Solve problems using AI Knowledge and Reasoning.
CO3	Explain the principles, advantages, problems of ML and applications of ML.
CO4	Implement Artificial Neural Network and the different learning algorithm and deep learning.
CO5	Express the characteristics, components and development of Expert System.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Robotics and Automation

MODULE I (7 hours)

Introduction, Types of Robot–Technology-Robot classifications and Specifications-Design and control issues- Various manipulators – Sensors - work cell - Programming languages.

MODULE II (8 hours)

Mathematical representation of Robots - Position and orientation – Homogeneous transformation Various joints- Representation using the DenavitHattenberg parameters - Degrees of Freedom-Direct Kinematics-Inverse kinematics- SCARA robots- Solvability – Solution Methods-Closed form solution.

MODULE III (8 hours)

Linear and angular Velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse - Wrist and arm singularity - Static analysis - Force and moment Balance.

MODULE IV (8 hours)

Path Planning: 9 Definition-Joint Space Technique-Use of p-degree Polynomial-Cubic Polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.

MODULE V DYNAMICS AND CONTROL (8 hours)

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler Formulation-Dynamic model – Manipulator control Problem-Linear control schemes-PID control Scheme-Force control of robotic manipulator.

TEXT BOOKS:

1. R. K. Mittal and I. J. Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2. J. J. Craig, “Introduction to Robotics Mechanics and Control”, Third edition, Pearson Education, 2009.

REFERENCES:

1. A. Ghoshal, "Robotics-Fundamental Concepts and Analysis", Oxford University Press, Sixth impression, 2010.
2. R. D. Klafter, T. A. Chimielewski and M. Negin, "Robotic Engineering–An Integrated Approach", Prentice Hall of India, New Delhi, 1994.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define basic concept of robotics.
CO2	To analyze Instrumentation systems and their applications to various.
CO3	Develop differential motion add statics in robotics
CO4	Construct various path planning techniques.
CO5	Implement different dynamics and control in robotics industries.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Mechatronics

Module I (8 hours)

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products,and design. Comparison between Traditional and Mechatronics approach.

Module II (8 hours)

Review of fundamentals of electronics. Data conversion devices, sensors,microsensors, transducers, signal processing devices, relays, contactors and timers.Microprocessors controllers and PLCs.

Module III (8 hours)

Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams,systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfersystems.

Module IV (8 hours)

Hydraulic systems: flow, pressure and direction control valves, actuators, andsupporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics:production, distribution and conditioning of compressed air, system components and graphicrepresentations, design of systems. Description

Module V (7 hours)

Description of PID controllers. CNC machines and part programming. IndustrialRobotics.

Texts:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar . II, Machine design for mobile and industrial applications, SAE, 1994.
3. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall, 1996.
4. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005
5. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate the concept of mechatronics.
CO2	Develop fundamentals of electronics involved in mechatronics.
CO3	Demonstrate applications of mechatronics in drives.
CO4	Implement mechatronics in hydraulic system.
CO5	Implement mechatronics in industrial robotics.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Open Electives

SCADA System and Applications

Module-1 (8 hours)

Introduction to SCADA Data acquisition systems- Evolution of SCADA, Communication technologies-. Monitoring and supervisory functions- SCADA applications in Utility Automation, Industries.

Module-2 (8 hours)

SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module-3 (8 hours)

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850-SCADA

Module-4 (8 hours)

Communication:Various industrial communication technologies -wired and wireless methods and fiber optics-Open standard communication protocols

Module-5 (8 hours)

SCADA Applications: Utility applications- Transmission and Distribution sector - operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation. Simulation Exercises

Books

1. Stuart A Boyer. SCADA-Supervisoiy Control and Data Acquisition', Instrument Society of America Publications. USA. 1999.

2. Gordan Clarke, Deon RzynAzvs,Practical Modern SCADA Protocols: DNP3, 60870J and Related Systems', Newnes Publications, Oxford, UK,2004

Course Outcomes:
Upon completion of the course, students will be able to:

CO1	Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications
CO2	Define SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA serve
CO3	Develop concept of SCADA architecture, various advantages and disadvantages of each system
CO4	Define single unified standard architecture IEC 61850
CO5	Implement SCADA in transmission and distribution sector, industries etc

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Operations Research

Module-I (8 hours)

Statement of an optimization problem, classical optimization techniques: single variable optimization, unconstrained and constrained multivariable optimization problems, Karush-Kuhn-Tucker (KKT) conditions, convex programming problem.

Linear programming problem, simplex algorithm, duality, transportation model and its variants. Linear programming solvers in MATLAB, SCILAB and OCTAVE.

Module-II (8 hours)

Nonlinear programming algorithms: direct search method, gradient method, separable programming, quadratic programming, chance constrained programming. Non-linear programming solvers in MATLAB, SCILAB and OCTAVE.

Module-III (8 hours)

Overview of the geometric programming problem. Dynamic programming: multi-stage decision process, computational procedure. Integer programming: solution using cutting-plane method, branch-and-bound method. Mixed-integer programming problems.

Module-IV (8 hours)

Stochastic processes: review of basic probability, empirical distributions, Monte carlo simulation. generation of discrete and continuous random variables, joint distribution and copula. Decision making under certainty, risk and uncertainty, game theory. Markov chains.

Module-V (7 hours)

Multiobjective optimization: pareto optimality, selection using fuzzy membership, weighting method, utility function method, global criterion method, goal programming method. Concept of heuristic and meta-heuristic methods, Derivative free optimization, Genetic algorithms, neural networks, swarm optimization techniques.

Books

1. S.S.Rao, "Engineering Optimization", 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007
2. H.A. Taha, Operations Research, An Introduction, PHI, 2008

Course Outcomes:
Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate classical optimization and linear programming techniques
CO2	Solve nonlinear programming problems.
CO3	Solve dynamic programming and integer programming problems.
CO4	Apply stochastic processes and tools for solving decision making problems
CO5	Apply multi-objective optimization and evolutionary programming techniques

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Guidance, Navigation and Control

Course Objectives:

- To develop mathematical models that characterize aerospace vehicle dynamics.
- To understand the guidance law in aerospace.
- To know the navigation system used in aerospace.
- To be able todesign PID controller for aerospace vehicle system
- Able to usethe linear techniques to synthesize navigation, guidance, and control algorithms for aerospace vehicles.

MODULE-I Introduction to radars; Radar equation. Block Diagram and Operation; Radar Frequencies. Application of Radars; Range performance of radars. Minimum detectable signal ; Noise effects. Continuous wave and Frequency modulated radars; Doppler effect. CW-radar; Isolation between transmitter and receiver. Radial velocity; CW radar applications; Frequency modulated CW radars.

MODULE-II MIT and Pulse Doppler radars; Description of operation, Guided missiles; Classifications; Description of tactical missiles. Guidance phases during flight; Categories of Homing and command guidance. The kinematic equations. Missile Guidance laws; Classification of guidance laws; Classical guidance laws; Modern guidance laws.

MODULE-III Aircraft Navigation; Kinds of navigation - Position Fixing and Dead-reckoning systems. LORAN; DECCA; OMEGA. Very High Frequency Omni-Directional Range (VOR). Celestial navigation and GPS based navigation; Inertial Navigation Systems. Integrated navigation systems

MODULE-IV Control Systems-Classical linear time invariant control systems. Transfer function representations; stability; time domain characteristics. PID controller design for aerospace systems.

MODULE-V Frequency domain characteristics; Root Locus. Nyquist and Bode plots and their application to controller design for aerospace systems

TEXT BOOKS

3. M .I. Skolnik: Introduction to Radar Systems, Tata McGraw-Hill, 2007.
4. M. Kayton and W. Fried: Avionics Navigation System, Wiley Interscience, 1997.
5. N.S. Nise: Control Systems Engineering, Wiley-India, 2004.

REFERENCE BOOKS

1. P. Zarchan: Tactical and Strategic Missile Guidance, AIAA, 2007.
2. B. Friedland: Control System Design, Dover, 2005.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Develop mathematical models that characterize aerospace vehicle dynamics.
CO2	Construct different guidance law in aerospace.
CO3	Define the navigation system used in aerospace.
CO4	Able to design PID controller for aerospace vehicle system
CO5	Construct linear techniques to synthesize navigation, guidance, and control algorithms for aerospace vehicles.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Autonomous Vehicles

Module-I (8 hours)

Introduction to Automated, Connected, and Intelligent Vehicles • Introduction to the Concept of Automotive Electronics • Automotive Electronics Overview • History & Evolution • Infotainment, Body, Chassis, and Powertrain Electronics • Advanced Driver Assistance Electronic Systems

Connected and Autonomous Vehicle Technology • Basic Control System Theory applied to Automobiles • Overview of the Operation of ECUs • Basic Cyber-Physical System Theory and Autonomous Vehicles • Role of Surroundings Sensing Systems and Autonomy • Role of Wireless Data Networks and Autonomy

Sensor Technology for Advanced Driver Assistance Systems • Basics of Radar Technology and Systems • Ultrasonic Sonar Systems • Lidar Sensor Technology and Systems • Camera Technology • Night Vision Technology • Other Sensors • Use of Sensor Data Fusion • Integration of Sensor Data to On-Board Control Systems

Module-II (8 hours)

Overview of Wireless Technology • Wireless System Block Diagram and Overview of Components • Transmission Systems – Modulation/Encoding • Receiver System Concepts – Demodulation/Decoding • Signal Propagation Physics • Basic Transmission Line and Antenna Theory. Wireless System Standards and Standards Organizations • Role of Standards

Wireless Networking and Applications to Vehicle Autonomy • Basics of Computer Networking – the Internet of Things • Wireless Networking Fundamentals • Integration of Wireless Networking and On-Board Vehicle Networks • Review of On-Board Networks – Use & Function

Module-III (8 hours)

Connected Car Technology • Connectivity Fundamentals • Navigation and Other Applications • Vehicle-to-Vehicle Technology and Applications • Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications • Wireless Security Overview

Advanced Driver Assistance System Technology • Basics of Theory of Operation • Applications – Legacy • Applications – New • Applications - Future • Integration of ADAS Technology into Vehicle Electronics • System Examples • Role of Sensor Data Fusion

Connected Car Display Technology • Center Console Technology • Gauge Cluster Technology • Heads-Up Display Technology • Warning Technology – Driver Notification

Module-IV (8 hours)

Impaired Driver Technology • Driver Impairment Sensor Technology • Sensor Technology for Driver Impairment Detection • Transfer of Control Technology

Vehicle Prognostics Technology • Monitoring of Vehicle Components • Basic Maintenance • End-of-Life Predictions • Advanced Driver Assistance System Sensor Alignment and Calibration

Autonomous Vehicles • Driverless Car Technology • Moral, Legal, Roadblock Issues • Technical Issues • Security Issues.

Module-V (7 hours)

Present Advanced Driver Assistance System Technology Examples • Toyota, Nissan, Honda, Hyundai • Volkswagen, BMW, Daimler • Fiat Chrysler Automobiles • Ford, General Motors

Troubleshooting and Maintenance of Advanced Driver Assistance

Systems • Failure Modes – Self Calibration • Sensor Testing and Calibration • Redundant Systems • Standard Manufacturing Principles

Non-Passenger Car Advanced Driver Assistance Systems and Autonomous Operation • Uber/Lyft – Disruptive Technology • Trucking • Farming • Mining • Shipping & Rail • Military

Books

1. G. Mullett, Wireless Telecommunications Systems and Networks, Thomson – Delmar Learning, ISBN#1-4018-8659-0, 2006
2. G. Mullett, Basic Telecommunications : The Physical Layer, Thomson – Delmar Learning, ISBN#1-4018-4339-5, 2003

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define basics components of Autonomous Vehicles.
CO2	Express the concept of wireless networks in Autonomous Vehicles.
CO3	Construct vehicle to vehicle communication technology
CO4	Implement driverless car technology
CO5	Demonstrate driver assistant systems

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**2**	**1**
CO4	**3**	**1**	**3**	**3**	**2**	**1**
CO5	**3**	**1**	**3**	**3**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Dissertation (Phase-I)

Course description:

As a part of the curriculum, this is a sessional course, in which the students are trained to perform literature review and formulate a research problem.

Upon completion of the course, the students will demonstrate the ability to:

CO1	Evaluate published literature and express the research gaps.
CO2	Construct a research problem.
CO3	Compile modern engineering tools, software and equipment and develop research methodology.
CO4	Write technical documents and give oral presentations related to the work completed.
CO5	Develop confidence for detailed analysis of the selected problem.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**3**	**3**	**3**	**3**	**3**

Dissertation (Phase-II)

Course description:

As a part of the curriculum, this is a sessional course, in which the students are trained to analyze a research problem and develop the solution.

Upon completion of the course, the students will demonstrate the ability to:

CO1	Apply selected solution methodology to produce solutions to the chosen problem.
CO2	Analyze the output and demonstrate its validity.
CO3	Organize the results and compile the conclusions.
CO4	Write technical report and express the findings in oral presentations.
CO5	Develop confidence for identifying future scope and ability for life-long learning.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**3**	**3**	**3**	**3**	**3**