## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

## ANNA UNIVERSITY, CHENNAI – 25

### VISION OF THE DEPARTMENT

The vision of Anna University is to be a world class institution by producing professionals with high technical knowledge, professional skills and ethical values, and remain as a preferred partner to the industry and community for their economic and social development through excellence in teaching, research and consultancy. Anna University shall be recognized as a point of reference, a catalyst, a facilitator, a trend setter and a leader in technical education.

### MISSION OF THE DEPARTMENT

To produce full fledged Electrical and Electronics Engineers to cater to the needs of the modern industries and be useful for building the nation.



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**ANNAUNIVERSITY, CHENNAI**
**UNIVERSITYDEPARTMENTS**
**REGULATIONS-2019**
**CHOICE BASED CREDIT SYSTEM**
**M.E.CONTROL AND INSTRUMENTATION ENGINEERING**

**Programme specific outcomes**

After the completion of two-year Master of Engineering degree program in Control and Instrumentation (C&I) the student will have the following program specific outcomes.

1. Students will have the specialized training in classical as well as modern to pics in the broad field of system analysis and control.
2. Studentswillbeabletoderivemathematicalmodelsofthevariousphysicalsystemsto analyze their feasibility for the real time implementation.
3. It eventually enabling graduates to analyze, design, operates and integrates physical systems.
4. It also enables graduates to specialize in sensor synthesis, controller design and implementation.
5. Students are able to find control and instrumentation solution for power engineering, process stations and industries.

**1.PROGRAMME EDUCATIONAL OBJECTIVES(PEOs):**

| | |
|---|---|
| I. | To prepare students, for having career in teaching Institutions/research organizations/industriesthatmeet,theneedsof,nationalandinternationalinterest |
| II. | To develop among students, the ability to analyse systems, develop controllers and work with automation systems. |
| III. | To prepare students, to work in inter disciplinary groups. |
| IV. | Toprovidestudents,goodfoundationinmathematical,scientific,engineering Fundamentals and artificial intelligence. |
| V. | To provide the students with knowledge to be involved with the technology advancements and future developments in process industries and automation systems. |
| VI. | To promote student awareness, for life-long learning and introduce them to professional ethics and code of practice. |



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**2. PROGRAMME OUTCOME (POs):**

**On successful completion of the programme,**

| PO | Graduate Attribute | Programme Outcome |
|---|---|---|
| 1. | Problem analysis | Ability to solve linear algebraic and differential equations, Determine optimal solutions, apply statistical techniques |
| 2. | System analysis | Capability to analyse and interpret linear and non-linear systems |
| 3. | Design of controllers | Able to design controllers to meet the given specifications for linear single and multiple input-outputsystems |
| 4. | Technical development | Ability to review, prepare and present technical developments |
| 5. | Software packages | Skill to work on professional software packages for system analysis and design problems |
| 6. | Modern tool usage | To develop software packages for design problems in well- known professional platforms. |
| 7. | Hardware analysis& design | To analyse and design control and instrumentation hardware |
| 8. | Study of transducers | Competency to reproduce scientific principle of transducers and their principles |
| 9. | System design and automation | To design and conduct experiments on control system design |
| 10. | Ethics | To Interact industry, business and society in a professional and ethical manner |
| 11. | Communication Skills | Proficiency in oral and written Communications. |
| 12. | Project development | To develop a research for an industrial problem or develop an innovative and usable product of societal interest. |

**PEO/PO Mapping:**

| Program Educational Objective | Program Outcome | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| 1. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| 2. | | ✓ | ✓ | | | | | | ✓ | | | |
| 3. | | | | | ✓ | ✓ | | | | | ✓ | |

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| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4. | | | | | | | | ✓ | | | | |
| 5 | | | | | | | | | | | | |
| 6. | | | | | ✓ | | | ✓ | | ✓ | ✓ | |

**Mapping of Course**
**Outcome and Programme Outcome**

| | | Course Name | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 1 | SEM 1 | Control System Design | ✓ | ✓ | ✓ | | ✓ | ✓ ✓ | | ✓ ✓ | | | | |
| | | Instrumentation System Design | | ✓ | ✓ | | | ✓ | | ✓ | | | | |
| | | Intelligent Controllers | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | |
| | | MEMS Design: Sensors And Actuators. | | ✓ | ✓ | | | | | | | | | |
| | | Program Elective I | | | | | | | | | | | | |
| | | Research Methodology and IPR | | | | | | | | | | | | |
| | | Audit Course I (one from list of Audit courses) | | | | | | | | | | ✓ | | |
| | | Control System Design Lab | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | |
| | | Intelligent Controllers Lab | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | |
| | SEM 2 | Machine Learning | | | ✓ | | ✓ | ✓ | | | | | | |
| | | Non Linear Control | | | | | | | | | | | | ✓ |
| | | Industrial Automation Systems | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ |
| | | Program Elective II | | | | | | | | | | | | |

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| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Program Elective III | | | | | | | | | | | | |
| | | Audit Course II | | | | | | | | | | ✓ | | |
| | | Virtual Instrumentation Lab | | | | | ✓ | ✓ | ✓ | | ✓ | | | |
| | | (one from List of Audit courses) | | | | | | | | | | | | |
| YEAR2 | SEM 3 | Program Elective IV Program Elective V | | | | | | | | | | | | |
| | | Open Elective (one from list of 6 courses) | | | | | | | | | | ✓ | | |
| | | Project Phase I | | | | | | | | | | | ✓ | ✓ |
| | SEM 4 | Project Phase II | | | | | | | | | | | ✓ | ✓ |





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**M.E.CONTROL AND INSTRUMENTATION ENGINEERING**
**CURRICULUM AND SYLLABUS I TO IV SEMESTERS**

**SEMESTER I**

| S.No | CODE NO. | COURSETITLE | CATE GORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | CO5101 | Instrumentation System Design | PCC | 3 | 1 | 0 | 4 | 4 |
| 2. | CO5151 | Control System Design | PCC | 4 | 0 | 0 | 4 | 4 |
| 3. | CO5152 | Intelligent Controllers | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | CO5153 | MEMS Design: Sensors and Actuators | PCC | 3 | 0 | 0 | 3 | 3 |
| 5. | | Program Elective I | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | RM5151 | Research Methodology and IPR | RMC | 2 | 0 | 0 | 2 | 2 |
| 7. | | Audit Course I (one from list of Audit courses) | AC | 2 | 0 | 0 | 2 | 0 |
| **PRACTICALS** | | | | | | | | |
| 8. | CO5111 | Control System Design Lab | PCC | 0 | 0 | 4 | 4 | 2 |
| 9. | CO5112 | Intelligent Controllers Lab | PCC | 0 | 0 | 4 | 4 | 2 |
| | | **TOTAL** | | **20** | **1** | **8** | **29** | **23** |

*Audit Course is optional

**SEMESTER II**

| S.No | CODE NO. | COURSETITLE | CATE GORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | CO5251 | Machine Learning | PCC | 3 | 1 | 0 | 4 | 4 |
| 2. | CO5201 | Non Linear control | PCC | 3 | 0 | 2 | 5 | 4 |
| 3. | CO5202 | Industrial Automation Systems | PCC | 4 | 0 | 0 | 4 | 4 |
| 4. | | Program Elective II | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | | Program Elective III | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | | Audit Course II (one from list of Audit courses) | AC | 2 | 0 | 0 | 2 | 0 |
| **PRACTICALS** | | | | | | | | |
| 7 | CO5211 | Virtual Instrumentation Lab | PCC | 0 | 0 | 4 | 4 | 2 |
| | | **TOTAL** | | **18** | **1** | **6** | **25** | **20** |

*Audit Course is optional

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## SEMESTER III

| S.No | CODE NO. | COURSETITLE | CATE GORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | | Program Elective IV | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | | Program Elective V | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | | Open Elective<br>(one from list of 6 courses) | OEC | 3 | 0 | 0 | 3 | 3 |
| **PRACTICALS** | | | | | | | | |
| 4 | CO5311 | Project Phase I | EEC | 0 | 0 | 12 | 12 | 6 |
| | | **TOTAL** | | **9** | **0** | **12** | **21** | **15** |

## SEMESTER IV

| S.No | CODE NO. | COURSE TITLE | CATE GORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **PRACTICALS** | | | | | | | | |
| 1. | CO5411 | Project Phase II | EEC | 0 | 0 | 24 | 24 | 12 |
| | | **TOTAL** | | **0** | **0** | **24** | **24** | **12** |

**TOTAL NO.OF CREDITS:70**

## PROGRAM ELECTIVE COURSE (PEC) LIST (Group–I)

| S.No | CODE NO. | COURSETITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1 | CO5071 | Advanced Non-linear Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 2 | CO5072 | Control of Electrical Drives | PEC | 3 | 0 | 0 | 3 | 3 |
| 3 | CO5073 | Optimal Control and Filtering | PEC | 3 | 0 | 0 | 3 | 3 |
| 4 | CO5074 | System Identification and Adaptive Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 5 | CO5075 | System Theory | PEC | 3 | 0 | 0 | 3 | 3 |
| 6 | CO5001 | Multi Sensor Data Fusion | PEC | 3 | 0 | 0 | 3 | 3 |
| 7 | CO5002 | Robotics and Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 8 | CO5003 | Robust Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 9 | CO5004 | Dynamics and Control of Industrial Process | PEC | 3 | 0 | 0 | 3 | 3 |

## PROGRAMEL ELCTIVE COURSE(PEC) LIST (Group–II)

| S.No | CODE NO. | COURSETITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1 | ET5074 | Digital Instrumentation | PEC | 3 | 0 | 0 | 3 | 3 |
| 2 | ET5072 | Automotive Embedded System | PEC | 3 | 0 | 0 | 3 | 3 |
| 3 | ET5075 | Embedded Networking and Automation of Electrical System | PEC | 3 | 0 | 0 | 3 | 3 |
| 4 | ET5251 | VLSI Design and Architecture | PEC | 4 | 0 | 0 | 4 | 4 |
| 5 | ET5071 | Advanced Digital Signal Processing | PEC | 3 | 0 | 0 | 3 | 3 |
| 6 | ET5073 | Cryptography and Network Security | PEC | 3 | 0 | 0 | 3 | 3 |
| 7 | ET5077 | Nano Electronics | PEC | 3 | 0 | 0 | 3 | 3 |
| 8 | HV5151 | Electromagnetic Field Computation and Modelling | PEC | 3 | 0 | 0 | 3 | 3 |
| 9 | PS5075 | Smart Grid | PEC | 3 | 0 | 0 | 3 | 3 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | PS5076 | Wind Energy Conversion System | PEC | 3 | 0 | 0 | 3 | 3 |
| 11 | PW5252 | Optimization Techniques for Energy Management | PEC | 3 | 1 | 0 | 4 | 4 |
| 12 | PW5077 | Renewable Energy Technology | PEC | 3 | 0 | 0 | 3 | 3 |
| 13 | PW5071 | Electric Vehicles and Power Management | PEC | 3 | 0 | 0 | 3 | 3 |
| 14 | PW5075 | Grid Integration of Renewable Energy Sources | PEC | 3 | 0 | 0 | 3 | 3 |
| 15 | PW5079 | Waste Management and Energy Recovery Techniques | PEC | 3 | 0 | 0 | 3 | 3 |
| 16 | PW5078 | SCADA System and Applications Management | PEC | 3 | 0 | 0 | 3 | 3 |
| 17 | PW5072 | Energy Efficient Buildings | PEC | 3 | 0 | 0 | 3 | 3 |
| 18 | PW5074 | Energy Storage Technologies | PEC | 3 | 0 | 0 | 3 | 3 |
| 19 | PE5152 | Analysis of Power Converters | PCC | 3 | 1 | 0 | 4 | 4 |
| 20 | PE5151 | Analysis of Electrical Machines | PCC | 3 | 1 | 0 | 4 | 4 |
| 21 | PE5251 | Special Electrical Machines | PCC | 3 | 0 | 0 | 3 | 3 |
| 22 | PE5071 | Microcontroller Based System Design | PEC | 3 | 3 | 0 | 0 | 3 |

## PROGRAM CORE COURSES(PCC) LIST

| S.No | CODE NO. | COURSETITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | CO5101 | Instrumentation System Design | PCC | 3 | 1 | 0 | 4 | 4 |
| | CO5151 | Control System Design | PCC | 4 | 0 | 0 | 4 | 4 |
| 2. | CO5152 | Intelligent Controllers | PCC | 3 | 0 | 0 | 3 | 3 |
| 3. | CO5153 | MEMS Design: Sensors and | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | CO5111 | Control System Design Lab | PCC | 0 | 0 | 4 | 4 | 2 |
| 5. | CO5112 | Intelligent Controllers Lab | PCC | 0 | 0 | 4 | 4 | 2 |
| 6. | CO5251 | Machine Learning | PCC | 3 | 1 | 0 | 4 | 4 |
| 7. | CO5201 | Non Linear Control | PCC | 3 | 0 | 2 | 5 | 4 |
| 8. | CO5202 | Industrial Automation Systems | PCC | 4 | 0 | 0 | 4 | 4 |
| 9. | CO5211 | Virtual Instrumentation Lab | PCC | 0 | 0 | 4 | 4 | 2 |

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## RESEARCH METHODOLOGY AND IPR (RMC)

| S.No | CODE NO. | COURSETITLE | PERIODS PER WEEK | | | CREDITS | SEMEST ER |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| 1. | RM5151 | Research Methodology and IPR | 2 | 0 | 0 | 2 | 1 |
| | **Total** | | | | | 2 | |

## OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

| S.NO | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | OE5091 | Business Data Analytics | 3 | 0 | 0 | 3 | 3 |
| 2. | OE5092 | Industrial Safety | 3 | 0 | 0 | 3 | 3 |
| 3. | OE5093 | Operations Research | 3 | 0 | 0 | 3 | 3 |
| 4. | OE5094 | Cost Management of Engineering Projects | 3 | 0 | 0 | 3 | 3 |
| 5. | OE5095 | Composite Materials | 3 | 0 | 0 | 3 | 3 |
| 6. | OE5096 | Waste to Energy | 3 | 0 | 0 | 3 | 3 |

## AUDIT COURSES (AC)

**Registration for any of these courses is optional to students**

| SL. NO | COURSE CODE | COURSETITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | AX5091 | English for Research Paper Writing | 2 | 0 | 0 | 0 | 1/2 |
| 2. | AX5092 | Disaster Management | 2 | 0 | 0 | 0 | |
| 3. | AX5093 | Sanskrit for Technical Knowledge | 2 | 0 | 0 | 0 | |
| 4. | AX5094 | Value Education | 2 | 0 | 0 | 0 | |
| 5. | AX5095 | Constitution of India | 2 | 0 | 0 | 0 | |
| 6. | AX5096 | Pedagogy Studies | 2 | 0 | 0 | 0 | |
| 7. | AX5097 | Stress Management by Yoga | 2 | 0 | 0 | 0 | |
| 8. | AX5098 | Personality Development Through Life Enlightenment Skills | 2 | 0 | 0 | 0 | |
| 9. | AX5099 | Unnat Bharat Abhiyan | 2 | 0 | 0 | 0 | |
| **Total Credits** | | | | | | **0** | |

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## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

| S.No | CODE NO. | COURSETITLE | PERIODSPER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| 1. | CO5311 | Project Phase I | 0 | 0 | 12 | 6 | 3 |
| 2. | CO5411 | Project Phase II | 0 | 0 | 24 | 12 | 4 |
| | **Total** | | | | | 18 | |

## SUMMARY

| | Programme: M.E. Control &Instrumentation | | | | | |
|---|---|---|---|---|---|---|
| | Subject Area | Credits per Semeste | | | | Credits Total |
| | | I | II | III | IV | |
| 1. | PCC | 18 | 14 | 00 | 00 | 32 |
| 2. | PEC | 03 | 06 | 06 | 00 | 15 |
| 3. | RMC | 02 | 00 | 00 | 00 | 02 |
| 4. | OEC | 00 | 00 | 03 | 00 | 03 |
| 5. | AC | 00 | 00 | 00 | 00 | 00 |
| 6. | EEC | 00 | 00 | 06 | 12 | 18 |
| 7. | Non Credit/Audit Course | ✓ | ✓ | 00 | 00 | |
| | **Total Credit** | **23** | **20** | **15** | **12** | **70** |





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**CO5101 INSTRUMENTATION SYSTEM DESIGN LT P C**
**3 1 0 4**

**COURSE OBJECTIVES**

To educate the students

- To understand the physical principles of sensors and transducers.
- To impart the knowledge on signal conditioning and communication protocols.

**UNIT I PHYSICAL PRINCIPLES AND ELEMENTS OF SENSORS 12**

Principles: Resistive – Inductive – Capacitive - Magnetic sensing - Piezoelectric effects - Light - Temperature based sensing, Elements: Mechanical, Thermal, Electrical elements

**UNIT II SENSORS AND TRANSDUCERS 12**

Potentio metric Sensors – Gravitational Sensors – Capacitive Sensors – Inductive and Magnetic Sensors – Optical Sensors – Ultrasonic Sensors – Radar Sensors – Thickness and Level Sensors - Capacitive Accelerometer – Gyroscopes - optoelectronic sensors – Smart Sensors and applications

**UNIT III SIGNAL CONDITIONING AND INTERFACE 12**

Sensor linearization - Processing of Analog Measurement signals – Digital processing of measurement signals – wide area measuring systems – Sensors with built-in interface – Computer measuring systems and simulation studies

**UNIT IV COMMUNICATION PROTOCOLS 12**

Introduction-Evolution of signal standard – HART communication protocol – Communication modes – Networks – commands – applications OSI models - Field bus:- architecture, standard, Field bus topology, Interoperability and Interchange ability Profibus:- Introduction, protocol stack, communication model, Communication objects,– Foundation field bus & Profibus- Comparison of CANBUS,LINBUS,MODBUS,INDUSTRIAL ETHERNET.

**UNIT V SMART SENSORS 12**

Definition – Integrated smart sensors - Interface electronics - Design, sensing elements and parasitic effects, ADC, Accuracy and Dynamic range - Universal Sensor Interface – converters - front end circuits DAQ – Design - Digital conversion techniques - Microcontrollers and digital signal processors for smart sensors – selection - Timer, Analog comparator, ADC and DAC modules –IEEE 1451.0 Standard for smart sensor interface.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

**At the end of this course, the students will demonstrate the ability**

CO1 : To understand the basic elements of sensors
CO2 : To apply the principles of transducer to different applications
CO3 : To design a signal conditioning circuits for various applications
CO4 : To understand the importance of communication buses in applied automation Engineering.
CO5 : To design and develop customized smart sensors.

| CO | Program Outcomes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| **CO** 1 | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | | ✓ |
| **CO** 2 | ✓ | ✓ | ✓ | | | | | | ✓ | | | |
| **CO** 3 | | ✓ | | | | | | | | | | |
| **CO** 4 | ✓ | | ✓ | | | ✓ | | ✓ | | | | ✓ |
| **CO** 5 | ✓ | | | ✓ | | | ✓ | | ✓ | | | |

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**REFERENCES:**


1. Ernest O Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 5thEdition, Tata Mc-Graw Hill, 2011.
2. Ifan G. Hughes and Thomas P.A. Hase, Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press, 2010.
3. Handbook on “Practical Design Techniques for Sensor Signal Conditioning" published by Analog Devices, Vern vice hall.
4. Patrick H.Garrett “High Performance Instrumentation And Automation” CRC Press, Taylor & Francis Group, 2005
5. Gerard C.M. Meijer, Smart Sensor Systems, John Wiley and Sons, 2008
6. Ernest O. Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 5th Edition, Tata Mc-Graw Hill, 2011.


| CO5151 | CONTROL SYSTEM DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 4 |

**COURSE OBJECTIVES**

To educate the students on

- Analysis and design of controllers for linear systems defined in transfer function and state space from.
- Application of optimal control and filtering concepts for linear systems continuous and discrete domain.

**UNIT I ANALYSIS OF LINEAR SYSTEMS 12**

Review of system models –Transfer function and state space form– Time and Frequency Response – stability- Discretization –Need for Discretization –Sample and Hold devices – Effect of sampling on transfer function and state models – Analysis – Test for controllability and Observability.

**UNIT II DESIGN OF SISO SYSTEM 12**

Design Specifications –In continuous domain – Limitations – Controller Structure – Multiple degrees of freedom – PID controllers and Lag-lead compensators- Design – Discretization and direct discrete design - Design in continuous and discrete domain

**UNIT III STATE SPACE DESIGN 12**

Pole assignment design – State and Output Feedback – observers – Estimated State Feedback – Design Examples (Continuous and Discrete).

**UNIT IV OPTIMAL CONTROL 12**

Introduction: Classical control and optimization, formulation of optimal control problem, Typical performance measures – Linear quadratic regulator problem – solution – Application examples.

**UNIT V OPTIMAL FILTERING 12**

Filtering – Linear system and estimation – System noise smoothing and prediction – Kalman Filter –Recursive estimation.

**TOTAL: 60 PERIODS**

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**COURSE OUTCOMES:**

**Ability to**

CO1 Analyse controllers for linear systems defined in transfer function and state space forms.

CO2 Design controllers for linear systems defined in transfer function and state space forms.

CO3 Apply state space forms to continuous and discrete systems.

CO4 Apply optimal control to linear systems in continuous and discrete systems

CO5 Apply filtering concepts to linear systems in continuous and discrete systems.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| CO4 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |

**TEXT BOOKS:**


1. M.Gopal, "Digital Control and State Variable Methods", 4th edition, McGraw Hill India, 2012
2. K. Ogata, 'Modern Control Engineering', 5th Edition, Pearson, 2012.
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.
4. Kirk D.E., 'Optimal Control Theory – An introduction',Prentice hall, N.J., 1970.
5. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
6. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.


**REFERENCES:**


1. M.Gopal, Modern Control System Theory, 3rd edition, New Age International Publishers, 2014.
2. William S Levine, "Control System Fundamentals," The Control Handbook, CRC Press, Taylor and Francis Group, 2011.
3. AshishTewari, 'Modern Control Design with Matlab and Simulink', John Wiley, New Delhi, 2002.
4. T. Glad and L. Ljung, "Control Theory –Multivariable and Non-Linear Methods", Taylor & Francis, 2002.

**CO5152** **INTELLIGENT CONTROLLERS** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**

To educate the students on

- Design of ANN and fuzzy set theory.
- Analysis and implementation of ANN and Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
- Impart the knowledge of various optimization techniques and hybrid schemes with the ANFIS tool box.

**UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC** **9**

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron – Limitations – Multi Layer Perceptron – Back propagation algorithm (BPA); Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

**UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL** **9**

Generation of training data - optimal architecture – Model validation- Control of non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller –Case study - Familiarization of Neural Network Control Tool Box.

**UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL** **9**

Modeling of nonlinear systems using fuzzy models(Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification- Adaptive fuzz y systems-Case study-Familiarization of Fuzzy Logic Tool Box.

**UNIT IV GENETIC ALGORITHM** **9**

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

**UNIT V HYBRID CONTROL SCHEMES** **9**

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization - Case study– Familiarization of ANFIS Tool Box.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

**Ability to**

CO1 :Understand the basic architectures of NN and Fuzzy sets
CO2 :Design and implement ANN architectures, algorithms and know their limitations.
CO3 :Identify and work with different operations on the fuzzy sets.
CO4 :Develop ANN and fuzzy logic based models and control schemes for non-linear systems.
CO5 : Understand and explore hybrid control schemes and PSO

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| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | ✓ | ✓ | ✓ | | | ✓ | | | | | | ✓ |
| CO5 | ✓ | ✓ | ✓ | | | ✓ | | | | | | ✓ |

**REFERENCES:**


1. LaureneV.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.
5. George J.Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Prentice Hall, First Edition, 1995.


**CO5153 MEMS DESIGN:SENSORS AND ACTUATORS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To analyse the properties of materials, microstructure and fabrication methods.
- To design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling.
- To understand the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices

**UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONEPTS 9**

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis- torsional deflections-Intrinsic stress- resonant frequency and quality factor.

**UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9**

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

**UNIT III THERMAL SENSING AND ACTUATION 9**

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

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**UNIT IV PIEZOELECTRIC SENSING AND ACTUATION** **9**

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials Applications.

**UNIT V CASE STUDIES** **9**

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**:

**At the end of this course, the students will demonstrate the ability**

CO1 :To analyse the learning process to design of micro sensors, embedded sensors & actuators

CO2 :To analyse the electrostatic sensors and actuators through MEMS and NEMS devices

CO3 :To analyse the thermal sensors and actuators through MEMS and NEMS devices

CO4 :To analyse the piezoelectric sensors and actuators through MEMS and NEMS

CO5 : Design of piezoresistive sensors for biomedical and micro fluidic applications

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| CO1 | ✓ | ✓ | ✓ | | | | | | ✓ | | | ✓ |
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| CO4 | ✓ | ✓ | | ✓ | | ✓ | | | | | | ✓ |
| CO5 | ✓ | ✓ | | ✓ | | | ✓ | | | | | |

**REFERENCES**


1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of micro fabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Source book”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.




**RM5151** **RESEARCH METHODOLOGY AND IPR** **LT P C**
**2 0 0 2**

**COURSE OBJECTIVES:**

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

**UNIT I RESEARCH PROBLEM FORMULATION** **6**

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis,

interpretation, necessary instrumentations

**UNIT II LITERATURE REVIEW 6**

Effective literature studies approaches, analysis, plagiarism, and research ethics.

**UNIT III TECHNICALWRITING /PRESENTATION 6**

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

**UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.
Traditional knowledge Case Studies, IPR and IITs.

**TOTAL: 30 PERIODS**

**COURCE OUTCOMES:**

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | ✓ | | | | ✓ | | | | | | | |
| CO5 | ✓ | | | | | ✓ | | | | | | ✓ |

**REFERENCES:**


1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010


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**CO5111** **CONTROL SYSTEM DESIGN LAB** **LT P C**
**0 0 4 2**

**COURSE OBJECTIVES**

To educate the students

- Model, simulate and analyze physical systems in analog and digital platforms
- Design and implement simple controllers in standard forms.

**LIST OF EXPERIMENTS**

1. Analog simulation of linear systems
2. Digital simulation of linear and non-linear systems
3. Modelling and analysis of physical systems
4. Tuning methods of PID controller
5. Design of Lag-Lead compensators
6. Design of state feedback and optimal controller
7. Design of optimal estimator
8. Real time simulation of physical systems
9. Hardware in loop simulation of closed loop system
10. Design a closed loop controller for a physical system

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

**At the end of this course, the students will demonstrate the ability**

CO1 :Develop hardware in loop simulation of closed loop control system

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | ✓ | | | | | | | | ✓ | ✓ | ✓ |

**CO5112** **INTELLIGENT CONTROLLERS LAB** **LT P C**
**0 0 4 2**

**COURSE OBJECTIVES**

- To familiarize the students with optimization techniques and Intelligent Controllers.
- To implement different algorithms and Intelligent Controllers for various Process.
- To analyse the system performances for different controllers.

**LIST OF EXPERIMENTS**

1. To implement adaline and madaline with bipolar inputs and outputs using NN toolbox.
2. To implement back propagation for a given input pattern using NN toolbox.
3. To implement discrete hopfield network and test for given input pattern using NN toolbox.
4. To implement fuzzy set operation and properties using FUZZY toolbox.
5. To perform max-min composition of two matrices obtained from Cartesian product using ‘m file’ in MATLAB.
6. Write a program to verify the various laws associated with fuzzy set using FUZZY toolbox.
7. Write a matlab program for maximizing f(x) =x2 using GA, where x is ranges from 0 to 31 (Perform only 5 iterations). Find the function and ‘x’ value.
8. Design FLC for a FOPDT process using FUZZY toolbox.
9. Design a Neuro model for an inverted pendulum using NN toolbox.
10. Design Fuzzy model for an inverted pendulum using FUZZY toolbox.

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**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

CO1 :Ability to understand and use NN & FUZZY tool box using Software Packages.
CO2 :Ability to acquire knowledge on Identification of system & to work on simple application using MATLAB software.

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO2 | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ |

**CO5251 MACHINE LEARNING LT P C**
**3 1 0 4**

**COURSE OBJECTIVES**

To educate the students

- On several fundamental concepts and methods for machine learning.
- And get acquaint with basic learning algorithms and techniques and their applications.
- Acquire knowledge in processing, analyzing and handling data sets.
- Demonstrate typical applications of various clustering based learning algorithms

**UNIT 1 INTRODUCTION TO MACHINE LEARNING 12**

Objectives of machine learning – Human learning/ Machine learning – Types of Machinelearning:- Supervised Learning – Unsupervised learning – Reinforcement Learning –Evolutionary Learning - Regression – Classification – The Machine Learning Process:- DataCollection and Preparation – Feature Selection – Algorithm Choice – Parameter and Model Selection – Training – Evaluation.

**UNIT II DATA PREPROCESSING 12**

Data quality – Data preprocessing: - Data Cleaning:– Handling missing data and noisy data –Data integration:- Redundancy and correlation analysis – Data Reduction:- Dimensionalityreduction (Linear Discriminant Analysis – Principal Components Analysis – Factor Analysis –Independent Components Analysis) – Numerosity Reduction - Data Compression - Data Normalization and Data Discretization.

**UNIT III SUPERVISED LEARNING 12**

Linearly separable and nonlinearly separable populations – Multi Layer Perceptron –Back propagation Learning Algorithm – Radial Basis Function Network – Support VectorMachines: - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm – Multi
Class Classification – Support Vector Regression.

**UNIT IV CLUSTERING AND UNSUPERVISED LEARNING 12**

Introduction – Clustering:- Partitioning Methods:- K-means algorithm - Hierarchical clustering –Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering - Self Organizing Map (SOM) - SOM algorithm.

**UNIT V BAYESIAN LEARNING 12**

Probability based clustering – The Expectation Maximization Algorithm – Bayesian Classification – Bayesian Networks – Learning Bayesian Networks – Hidden Markov Models.

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**TOTAL:60PERIODS**



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**COURSE OUTCOMES:**

**At the end of this course, the students will demonstrate the ability**

CO1 :To understand the basic theory underlying machine learning.
CO2 :A range of machine learning algorithms along with their strengths and weaknesses.
CO3 :To formulate machine learning problems corresponding to different applications.
CO4 :To apply machine learning algorithms to solve problems of moderate complexity.
CO5 : To read current research papers and understand the issues raised by current research.

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | ✓ | ✓ | | | | ✓ | | | | | | ✓ |
| CO5 | ✓ | ✓ | | ✓ | | | | | | | | ✓ |

**REFERENCES:**


1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2011.
2. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 2011
3. Jiawei Han, MichelineKamber, Jian Pei, Data Mining: Concepts and Techniques: Concepts and Techniques, Elsevier, 2011.
4. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification,Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2005.


**CO5201** **NON LINEAR CONTROL** **L T P C**
**3 0 2 4**

**COURSE OBJECTIVES**

To educate the students on

- Analysis of control non-linearilities in physical systems
- Stability analysis using construction of Lyapunov functions
- Design controllers for non-linear systems using feedback linearization and sliding mode control theory

**UNIT I PHASE PLANE ANALYSIS** **12**

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

**UNIT II DESCRIBING FUNCTION** **12**

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. Analysis using computer simulations

**UNIT III LYAPUNOV THEORY** **12**

Nonlinear Systems and Equilibrium Points - Concepts of Stability - Linearization and LocalStability - Lyapunov's Direct Method - Lyapunov Functions – construction - - Control Design based on Lyapunov's Direct Method. Analysis using computer simulations

**UNIT IV FEEDBACK LINEARIZATION** **12**

Feedback Linearization and the Canonical Form - Mathematical Tools - 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. Analysis using computer simulations

**UNIT V SLIDING MODE CONTROL** **12**

Sliding Surfaces - Continuous approximations of Switching Control laws - The Modeling / Performance Trade-Offs- MIMO Systems. Analysis using computer simulations

**TOTAL: P=30 +L=45 75 PERIODS**

**COURSE OUTCOMES:**

**Ability to**

CO1 :Analyse system performance in the presence of control non-linearity
CO2 :Analyse system performance using describing function method
CO3 :Analyse non-linear system performance by constructing Lyapunov function
CO4 :Analyse and Design robust controllers for non-linear systems for parameter variations but with stable zero-dynamics.
CO5 : Implement controllers for MIMO systems using computer simulations

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| CO4 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ |

**REFERENCES:**


1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006
3. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
4. S H Zak, "Systems and control", Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods", Taylor & Francis, 2002.
6. G. J. Thaler, "Automatic control systems", Jaico publishers, 2006.


**LIST OF EXPERIMENTS**

1. Construction of phase portraits for linear systems
2. Effect of saturation non-linearity on system Performance.

3. Effect of dead zone non-linearity on system Performance
4. Effect of hysterisis non-linearity on system Performance
5. Effect of back-lash non-linearity on system Performance
6. Analysis and performance enhancement of systems with construction of phase portraits.
7. Analysis and performance enhancement of systems with Describing functions.
8. Controller design with feedback Linearization and determine the limitations.
9. Design and performance evaluation of sliding mode controllers.
10. Design of controllers for MIMO systems.

**CO5202 INDUSTRIAL AUTOMATION SYSTEMS** **L T P C**
**4 0 0 4**

**COURSE OBJECTIVES:**

To educate the fundamental and programming concepts of conventional electronic instrumentation and virtual instrumentation in the areas of:

- Electronic instruments
- Computer based instruments
- Virtual instrumentation programming
- Latest industrial PLCs and SCADA

**UNIT I ELECTRONIC INSTRUMENTATION** **12**

Circuit and element measurement instruments – Semiconductor test instruments – Network Analyzers – Logic Analyzers – Protocol Analyzers – Impedance considerations – Electrical Grounding

**UNIT II INSTRUMENTS IN SYSTEMS** **12**

Introduction to instruments in systems – Switches in automated test systems – Instrument System elements – Computer controlled instrument systems

**UNIT III INTRODUCTION TO VIRTUAL INSTRUMENTATION** **12**

Evolution and challenges of Virtual Instrumentation (VI) – Architecture – Programming – Distributed Virtual Instrumentation – Virtual instruments Vs. Traditional instruments – Virtual Instrumentation for engineering processes.

**UNIT IV SOFTWARE PROGRAMMING IN VIRTUAL INSTRUMENTATION** **12**

Programming Techniques – Front Panel and Block diagram – Data flow programming – G programming concepts – Creating and saving VIs – Wiring, Editing and Debugging of Vis – Creating Sub Vis – Control structures – Nodes – Arrays – Cluster controls and indicators – Error handling – String controls – File I/O VIs and functions.

**UNIT V PLC AND SCADA BASED INSTRUMENTATION** **12**

Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – Communication Networks for PLC. PLC based control of processes SCADA:- Remote terminal units, Master station, Communication architectures and Open SCADA protocols.

**TOTAL :60 PERIODS**

**COURSE OUTCOMES:**

In the end of the course the students will be:

CO1 :able to gain the knowledge on various types of analyzers.
CO2 :able to analyse Computer controlled instrument systems
CO3 :able to understand Virtual Instrumentation for engineering processes.
CO4 :able to gain the knowledge on various types of sensors & sensor technologies, signal conditioning for interface applications and PC based instrumentation.
CO5 : able to acquire a detailed knowledge on data acquisition system interface with systems

| CO | Program Outcome | | | | | | | | | | | |
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| CO 2 | ✓ | ✓ | | ✓ | | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| CO 3 | | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ | |
| CO 4 | | | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ | |
| CO 5 | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | | ✓ | | ✓ |

**TEXT BOOKS:**


1. Clyde F Coombs, Jr., Electronic Instrument Handbook, Mc.Graw Hill Inc., 2018 Edition
2. Labview based Advanced Instrumentation systems, S. Sumathi& P. Surekha, Springer Publications, 2018 Edition
3. Dag H. Hanssen, Programmable Logic Controllers, A Practical Approach to IEC 61131-3 using CODESYS, John Wiley & Sons Ltd., 2015
4. David Bailey & Edwin Wright,"Practical SCADA for Industry'', Elsevier 2010.


**REFERENCES:**


1. Handbook on "Practical Design Techniques for Sensor signal Conditioning" published by Analog Devices, Vernvice hall.
2. The Software Environment and Programming of PLCs – Version-2, An NPTEL Courseware, EE IIT Kharagpur.
3. SrinivasMedida, Pocket Guide on Industrial Automation for Engineers and Technicians, IDC Technologies


**CO5211** **VIRTUAL INSTRUMENTATION LAB** **L T P C**
**0 0 4 2**

**COURSE OBJECTIVES**

To educate the students

- To understand the concepts and configuration of Instrumentation bus protocols
- To gain adequate knowledge on applying various instrumentation simulation software packages.

**LIST OF EXPERIMENTS**

1. Configuration of simulation of instrumentation bus protocols.
2. Configuration of simulation of RS232 and SPI interface protocols.
3. Simulation of process control loop using PLC with GUI.
4. Simulation of signal conditioning and processing circuits using circuit design packages.
5. Configuration of analog and digital data acquisition systems.
6. Development of GUI application for PID control.
7. Simulation of transfer function models using Virtual Instrumentation packages.
8. Simulation of state space models using virtual Instrumentation packages.
9. Development of GUI application to mimic closed loop performance of physical systems.
10. Demonstration of discretization blocks in the virtual instrumentation package.

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11. Ladder logic programming using PLC simulator software packages.
12. Simulation of SCADA based control of physical system.
13. Simulation of state diagram based application using virtual instrumentation package.
14. Simulation of virtual instrumentation tool for EMI, EMC and Noise cancellation
15. Mini Project

**TOTAL :60PERIODS**

**COURSE OUTCOMES:**

**At the end of this course, the students will demonstrate the ability**

CO1 :To interface processors with physical systems for control and automation purposes.
CO2 :To get hands on experience on various instrumentation protocols.

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO2 | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ |

**CO5071 ADVANCED NON-LINEAR CONTROL LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

To educate the students on

- Theory of perturbation
- Gain scheduling and feedback linearization
- input-output stability and passivity
- theory and design of back stepping controllers.

**UNIT I PERTURBATION THEORY 9**

Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises

**UNIT II SINGULAR PERTURBATIONS 9**

Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises

**UNIT III GAIN SCHEDULING AND FEEDBACK LINEARIZATION 9**

Control problem – stabilization via linearization – integral control via linearization – gain scheduling – Input output linearization – Full state linearization – state feedback control – tracking- exercises

**UNIT IV INPUT-OUTPUT STABILITY 9**

L stability – L stability of state models – $L_2$ gain – feedback system: small gain theorem – exercises – Passivity – State models - $L_2$ and Lyapunov stability

**UNIT V BAKSTEPPING CONTROL ALGORITHMS 9**

Passivity based control – High gain observers – stabilization – Regulation via integral control - exercises

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

CO1 :Understanding different types of perturbation models.
CO2 :Analysis of Stability of various perturbation models.
CO3 :Apply gain schedule all kind of perturbation systems.

CO4 :Apply L stability and lyapunov stability conditions for systems
CO5 : Apply Bakstepping control algorithms.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ |

**REFERENCES**


1. Hasan Khalil," Nonlinear systems and control", 3rd ed, PHI,
2. Slotine, J A E Slotine and W Li, "Applied Nonlinear control",1991, PHI
3. S.H. Zak," Systems and control", Oxford University Press


**CO5072 CONTROL OF ELECTRICAL DRIVES LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To introduce the PWM converters and their analysis.
- To educate on modeling of dc motor, drives and control techniques
- To educate on dynamic modeling of Induction motor drive.
- To educate on the V/f and vector control of Induction motor.
- To educate on generation of firing pulses and control algorithms in embedded platforms.

**UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9**

Power electronic switches-state space representation of switching converters-Fixed frequency PWM-variable frequency PWM- space vector PWM- Hysteresis current control-dynamic analysis of switching converters-PWM modulator model.

**UNIT II CONTROL OF DC DRIVES 9**

Modelling of DC machines-block diagram/transfer function-phase control-1phase/3phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit-closed loop control-speed control-current control-cascade control –constant torque/power operation-comparison of chopper/converter fed drives- techniques-merits/demits.

**UNIT III ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE 9**

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip characteristics-steady state performance- Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model.

**UNIT IV CONTROL OF INDUCTION MOTOR DRIVE 9**

VSI fed induction motor drives- waveforms for 1-phase, 3-phase Non-PWM and PWM VSI fed induction motor drives -principles of V/F control- principle of vector control-direct vector control- space vector modulation- indirect vector control .

**UNIT V EMBEDDED CONTROL OF DRIVES** **9**

Generation of firing pulses- generation of PWM pulses using embedded processors-IC control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller- vector control using embedded processors.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

CO1 :understand Power Electronic Converter Switches and different PWM approach.
CO2 : design and analyze converter and chopper driven dc drives.
CO3 :analyze converter and chopper driven dc drives.
CO4 : understand conventional control techniques of Induction motor drive.
CO5 : understand V/f Control using PIC Micro Controller and Vector control using Embedded processor.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO2 | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| CO4 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ |

**REFERENCES**


1. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” Prentice Hall of India, 2002.
2. Thyristor control of Electric drives, Vedam Subrahmanyam, Tata McGraw Hill, 1988
3. Ion Boldea & S.A.Nasar “ELECTRIC DRIVES”, CRC Press, 2006
4. Simon Ang, Alejandro Oliva “POWER SWITCHING CONVERTERS”, CRC Press, 2005
5. Buxbaum, A. Schierau, and K.Staughen, “A design of control systems for DC Drives”, Springer- Verlag, Berlin,1990.




**CO5073 OPTIMAL CONTROL AND FILTERING** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To educate on formulation of optimal control problems and introduce the minimum principle.
- To educate on Linear Quadratic tracking problems- in continuous and discrete domain.
- To introduce the numerical techniques used for solving optimal control problems
- To educate on the concepts of filtering in the presence of noise.
- To educate on the theory and design of Kalman filter.

**UNIT I INTRODUCTION** **9**

Statement of optimal control problem – Problem formulation and forms of optimal Control– Selection of performance measures. Necessary conditions for optimal control – Pontryagin’s minimum principle – State inequality constraints – Minimum time problem.

**UNIT II LINEAR QUADRATIC TRACKING PROBLEMS 9**

Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

**UNIT III NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9**

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method - solution of Ricatti equation by negative exponential and interactive Methods

**UNIT IV FILTERING AND ESTIMATION 9**

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimationLeast square estimation – Recursive estimation.

**UNIT V KALMAN FILTER AND PROPERTIES 9**

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

Ability to

CO1 :Understand the concept of Optimal Control problem.

CO2 :Identify, Formulate and measure the performance of Optimal Control.

CO3 :understand the Linear Quadratic Tracking Problems and implement dynamic programming application for discrete and continuous systems.

CO4 : Solve Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method.

CO5 : Understand Filtering problem their properties, linear estimator property of Kalman Filter and Time invariance and asymptotic stability of filters.

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

**REFERENCES**:


1. KiRk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.


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**CO5074 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To introduce various model structures for system identification.
- To impart knowledge on parametric and non-parametric identification
- To introduce non-linear identification techniques.
- To introduce the concept of adaptation techniques and control.
- To illustrate the identification and adaptive control techniques through case studies.

**UNIT I MODELS FOR INDENTIFICATION 9**

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models'.

**UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9**

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

**UNIT III NON-LINEAR IDENTIFICATION 9**

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

**UNIT IV ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9**

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

**UNIT V CASE STUDIES 9**

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

Ability to

CO1 :model LTI system and to analyse the Non-linear state-space model of a black box.
CO2 :analyse frequency, spectral, correlation and transient response of a system.
CO3 :Identify the Open & closed Loop of a Non-linear system by Neural network and Fuzzy Logic controller.
CO4 :Realize different tuning parameters for adaptive control and adaptive technique.
CO5 : Apply different control techniques to various applications

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| **CO5** | | ✓ | ✓ | ✓ | ✓ | | | | | | | |

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**REFERENCES**
1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall 'International (UK) Ltd,1989.
3. Astrom and Wittenmark," Adaptive Control ", PHI
4. William S. Levine, " Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

**CO5075** **SYSTEM THEORY** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To educate on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations.
- To illustrate the role of controllability and observability.
- To educate on stability analysis of systems using Lyapunov's theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

**UNIT I STATE VARIABLE REPRESENTATION 9**

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

**UNIT II SOLUTION OF STATE EQUATIONS 9**

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

**UNIT III CONTROLLABILITY AND OBSERVABILITY 9**

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

**UNIT IV STABILTY 9**

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

**UNIT V MODAL CONTROL 9**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems – The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

CO1 :To understand the concept of State-State equation for Dynamic Systems and the uniqueness of state model.
CO2 :To understand the concept of the uniqueness of state model.
CO3 :Analyse Controllability and Observability for Time varying and Time invariant case
CO4 :Analyse the linear systems in state space

CO5 :Design controllers in state space

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| CO5 | ✓ | ✓ | ✓ | ✓ | | | | | | | | |

**REFERENCES:**


1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.


**CO5001 MULTI SENSOR DATA FUSION L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To educate on sensor data inference hierarchy and fusion models.
- To educate on the algorithms used for data fusion.
- To educate on Kalman filter and its application to decision identity fusion.
- To educate on advanced filtering and sensor fusion concepts.
- To introduce various high performance data structures.

**UNIT I MULTISENSOR DATA FUSION INTRODUCTION 9**

sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

**UNIT II ALGORITHMS FOR DATA FUSION 9**

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

**UNIT III ESTIMATION: 9**

Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters. Decision level identify fusion. Knowledge based approaches.

**UNIT IV ADVANCED FILTERING 9**

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

**UNIT V HIGH PERFORMANCE DATA STRUCTURES: 9**

Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems within dependability bounds. Implementing data fusion system.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

CO1 :Ability to explain and use multiple sensor data in data fusion model.
CO2 :Capable to use algorithms for data fusion.
CO3 :Ability to estimate using kalman filter.
CO4 :Ability to estimate using advance filtering such as data, extended information filtering.
CO5 : Ability to handle various high performance data structures.

| CO | Program Outcome | | | | | | | | | | | |
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| **CO4** | ✓ | | ✓ | | | ✓ | | ✓ | | | | ✓ |
| **CO5** | ✓ | | | ✓ | | | ✓ | | ✓ | | | |

**REFERENCES:**


1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 1992.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press, 1982.
4. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company, 1987.


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**CO5002** **ROBOTICS AND CONTROL** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To introduce robot terminologies and robotic sensors
- To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning techniques
- To educate on robot dynamics
- To introduce robot control techniques

**UNIT I INTRODUCTION AND TERMINOLOGIES 9**

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates-Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-social issues

**UNIT II KINEMATICS 9**

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics-solution and programming-degeneracy and dexterity

**UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9**

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian- Robot Path planning

**UNIT IV DYNAMIC MODELLING 9**

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton- Euler formulation – Inverse dynamics

**UNIT V ROBOT CONTROL SYSTEM 9**

- Linear control schemes- joint actuators- decentralized PID control- computed torque control – force control- hybrid position force control- Impedance/ Torque control

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

Ability to

CO1 :understand the components and basic terminology of Robotics
CO2 :understand kinematic relations and dynamic model of robots
CO3 :understand differential motion, path planning and dynamic model of robots
CO4 :develop kinematic and dynamic models for two degrees of freedom
CO5 : apply control techniques for robot position and force control.

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| **CO1** | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| **CO2** | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | | | |
| **CO3** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| **CO4** | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| **CO5** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ |

Attested

**REFERENCES**

1. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata MacGraw Hill, Fourth edition.



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2. Saeed B. Niku ,"Introduction to Robotics ", Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach", Prentice Hall of India, 2003.

**CO5003** **ROBUST CONTROL** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To introduce norms, random spaces and robustness measures
- To educate on $H_2$ optimal control and estimation techniques.
- To educate on Hinfinity optimal control techniques
- To educate on the LMI approach of Hinfinity control.
- To educate on synthesis techniques for robust controllers and illustrate through case studies.

**UNIT I INTRODUCTION** **9**

Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions – structured and unstructured uncertainty- robustness.

**UNIT II $H_2$ OPTIMAL CONTROL** **9**

Linear Quadratic Controllers – Characterization of $H_2$ optimal controllers – $H_2$ optimal estimation- Kalman Bucy Filter – LQG Controller.

**UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH** **9**

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation.

**UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH** **9**

Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints

**UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES** **9**

Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant-Robust Control of Distillation Column.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES**

Ability to

CO1 :Understand the structured and unstructured uncertainty of robustness.
CO2 :Design an H2 optimal controller and to implement kalman Bucy filter.
CO3 :Design an H-Infinity optimal control using Riccati and LMI Approach.
CO4 :synthesis of Robust Controller and application of small gain theorem.
CO5 : Implement robust Controllerfor CSTR and Distillation Column.

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| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| CO4 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ |

**REFERENCES**


1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”,Springer International Edition, 2010.
2. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.
4. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H-infinity Methods”, Springer, 2000.
5. M. J. Grimble, “Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems”, John Wiley and Sons Ltd., Publication, 2006.


**CO5004 DYNAMICS AND CONTROL OF INDUSTRIAL PROCESS LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To give an overview of the features associated with Industrial Type PID Controller such as reset windup, bumpless auto-manual transfer, proportional kick and derivative kick.
- Design and analysis of various PID tuning methods
- To elaborate different types of control schemes such as cascade control, feed- forward control etc.
- To educate on multi variable systems and multi loop control
- To education various industrial processes

**UNIT I PROCESS DYNAMICS & CONTROL 9**

Need for process control – Hierarchical decomposition of Control Functions - Continuous and batch processes – P&ID diagram - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems - Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller.

**UNIT II PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL 9**

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning - Process reaction curve method- Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method – optimization methods – Auto tuning.

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**UNIT III ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL & MODEL BASED CONTROL SCHEMES** **9**

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control –override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller– Single Loop Dynamic Matrix Control – Generalized Predictive Control.

**UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL** **9**

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System - - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller - Decoupling Control.

**UNIT V CASE STUDIES** **9**

Introduction to Multivariable control – Multivariable PID Controller –Predictive PID Control - Control Schemes for Distillation Column, CSTR, Four-tank system and pH .

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1 :Ability to Apply knowledge of mathematics, science, and engineering to the build and analyze models for flow, level, and thermal processes.

CO2 : Ability to determine the advanced Features supported by the Industrial Type PID Controller.

CO3 :Ability to Design, tune and implement SISO P/PI/PID Controllers to achieve desired Performance for various processes.

CO4 :Ability to Analyze Multivariable Systems and Design Multi-variable and Multi-loop Control Schemes for various processes namely four-tank system, pH process, bio-reactor,distillation column.

CO5 : Ability to Identify, formulate, and solve problems in the process control domain.

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| CO4 | ✓ | ✓ | | ✓ | | ✓ | | | | | | ✓ |
| CO5 | ✓ | ✓ | | ✓ | | | ✓ | | | | | |

**REFERENCES**


1 B.Wayne Bequette, “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 2004.

2 George Stephanopolus, "Chemical Process Control", Prentice Hall India, 2006

3 Chidambarm. M, “ Computer control of processes”, Narosa Publications, Reprint 2006.chennai.

4 Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III “Process Dynamics and Control”, John Wiley and Sons, 3rd Edition, 2010.

5 Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.

6 Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2001.


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**ET5074** **DIGITAL INSTRUMENTATION** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To expose the students to the fundamentals of wired embedded networking techniques.
- To expose the students to the fundamentals of wireless embedded networking
- To study on design of automation tools to model instrumentation
- To introduce design wireless networking for monitoring grid
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

**UNIT I DIGITAL METER INFRASTRUCTURE 9**

Building blocks of automated instruments -Calibration, Overview of A/D converter- Data acquisition – Sampling , Errors–-Signal conditioners -–Counters – Modes of operation- Frequency, Period, Time interval measurements, autorange setting, Prescaler- Heterodyne converter for frequency measurement- Single and Multi channel Data Acquisition systems- Digital Modulation -serial wired Instrument bus protocols- RS 232C, RS 485 and USB standards –digital display.

**UNIT II DIGITAL METERING OF PROCESS 9**

Introduction – sensors and Digital Meters for vibration, temperature, pressure measurement of system- Multichannel DSO -Data loggers -meter data analytics -PC based process measurements -Digital Signal Sources- automating meter with Data analysis & display control.

**UNIT III METERING WITH VIRTUAL INSTRUMENTATION 9**

VI-Introduction, Block diagram and Architecture –VI for testing Real time process– Graphical programming using GUI – ADC/DAC – Digital I/O – Counter , Timer-I/O GUI-VI for Intelligent metering and control – Software and hardware of I/O communication blocks-peripheral interface

**UNIT IV METERING BASED ON WIRELESS NETWORK 9**

Wireless sensor networks-Introduction– performance of Zigbee sensor network for metering – challenges in wireless Meters- IoT in metering-Design challenges in IoT, - overview on ANSI ,IEC smart metering standards as case study.

**UNIT V AUTOMATED METERING OF ELECTRICAL SYSTEMS 9**

Digital meters and Instrumentation for electrical measurements- metering to test electrical components - meters for Smart grid management-AMI needs in smart grid- Meter data management -communication enabled metering.

**NOTE :** Miniproject / Discussions/ Practice on Workbench : on Digital meter ,Control of Relays/ Solenoids, DC/ STEPPER motor, Battery,Display Interface; modeling process metering and control /designing of Digital meter with wired /wireless communication interface suites / Virtual Laboratory tools.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

**At the end of this course, the students will demonstrate the ability in**

CO1: The concepts of Time and frequency analysis of Signal Transforms based on signal types.
CO2: The fundamentals of Time-Frequency Transforms are introduced
CO3: Analyze the quality and properties of speech based on DSP
CO4: Study through comparison on commercial available DSProcessors
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

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| CO4 | | ✓ | ✓ | | | | | | | | | ✓ |
| CO5 | | ✓ | | | ✓ | | | | | | | ✓ |

**REFERENCES:**


1. Lars Torsten Berger, Krzysztof Iniewski, Smart Grid-Applications, Communications and Security, Wiley, 2015.
2. Stuart Borlase,"Smart Grids Infrastructure,Technology and Solutions",CRC Press,2013.
3. Mathivanan, "PC based Instrumentation Concepts and practice", Prentice-Hall India, 2009
4. Jovitha Jerome,"Virtual Instrumentation using LabView,PHI 2010.
5. A.J. Bouwens, "Digital Instrumentation" , TATA McGraw-Hill Edition, 1998.
6. Ernest O Doebelin and Dhanesh N Manik, "Measurement Systems Application and Design", 5thEdition, Tata Mc-Graw Hill, 2011.
7. Cory L.Clark,"Labview Digital Signal Processing & Digital Communication,TMcH,2005.
8. Patrick H.Garrett "High Performance Instrumentation And Automation" CRC Press, Taylor & Francis Group, 2005
9. Joseph J. Carr, "Elements of Electronic Instrumentation and Measurement", Pearson Education, 2003.
10. Krzysztof Iniewski,"Smart Grid Infrastructure and Networking",Tata MGH ed,2012
11. Mark Ciampa,Jorge Olenewa,"Wireless Communications",Cengage Learning,IndiaEditio2007
12. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey,1997


**ET5072 AUTOMOTIVE EMBEDDED SYSTEM L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To expose the students to the fundamentals and building of Electronic Engine Control systems.
- To teach on functional components and circuits for vehicles
- To discuss on programmable controllers for vehicles management systems
- To teach logics of automation & commercial techniques for vehicle communication
- To introduce the embedded systems concepts for E-vehicle system development.

**UNIT I BASIC OF ELECTRONIC ENGINE CONTROL SYSTEMS 9**

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Automotive microcontrollers- Electronic control Unit- Hardware & software selection and requirements for Automotive applications – open source ECU- RTOS - Concept for Engine management-Standards; Introduction to AUTOSAR and Introduction to Society SAE- Functional safety ISO 26262- Simulation and modeling of automotive system components.

**UNIT II SENSORS AND ACTUATORS FOR AUTOMOTIVES 9**

Review of sensors- sensors interface to the ECU, conventional sensors and actuators, Modern sensor and actuators - LIDAR sensor- smart sensors- MEMS/NEMS sensors and actuators for automotive applications.

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**UNIT III VEHICLE MANAGEMENT SYSTEMS 9**

Electronic Engine Control-engine mapping, air/fuel ratio spark timing control strategy, fuel control, electronic ignition- Adaptive cruise control - speed control-anti-locking braking system-electronic suspension - electronic steering , Automatic wiper control- body control system ; Vehicle system schematic for interfacing with EMS, ECU. Energy Management system for electric vehicles- Battery management system , power management system-electrically assisted power steering system- Adaptive lighting system- Safety and Collision Avoidance.

**UNIT IV ONBOARD DIAGONSTICS AND TELEMATICS 9**

On board diagnosis of vehicles -System diagnostic standards and regulation requirements Vehicle communication protocols Bluetooth, CAN, LIN, FLEXRAY, MOST, KWP2000 and recent trends in vehicle communications- Navigation- Connected Cars technology – Tracking- Security for data communication- dashboard display and Virtual Instrumentation, multimedia electronics- Role of IOT in Automotive systems

**UNIT V ELECTRIC VEHICLES 9**

Electric vehicles –Components- Plug in Electrical vehicle- Charging station – Aggregators- Fuel cells/Solar powered vehicles- Autonomous vehicles.

**NOTE:** Miniproject/Discussions/Practice on Workbench/AUTOSAR/ Vehicle simulators / modeling packages on the basics of interfacing sensors, actuators specific to automobile-microcontrollers/ special automobile-microcontrollers for i/o port communication applicable to vehicles

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: The learning process delivers insight into the significance of the role of embedded system for automotive applications.
CO2: Understanding the need, selection of sensors and actuators and interfacing with ECU
CO3: Applying the Embedded concepts for vehicle management and control systems.
CO4: Understanding the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| CO2 | ✓ | ✓ | | ✓ | ✓ | | | | | | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| CO4 | | ✓ | ✓ | | | | | | | | | |
| CO5 | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | |

**REFERENCES:**


1. William B. Ribbens ,"Understanding Automotive Electronics", Elseiver,2012
2. Ali Emedi, Mehrded ehsani, John M Miller , "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 2004.
3. L.Vlacic,M.Parent,F.Harahima,"Intelligent Vehicl Technologies",SAE International,2001.
4. Jack Erjavec,Jeff Arias,"Alternate Fuel Technology-Electric ,Hybrid& Fuel Cell Vehicles",Cengage ,2012

5. Electronic Engine Control technology – Ronald K Jurgen Chilton's guide to Fuel Injection – Ford
6. Automotive Electricals / Electronics System and Components, Tom Denton, 3rd Edition, 2004.
7. Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1 edition, March 30, 2000 .
8. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 4th Edition, 2004.
9. Automotive Hand Book, Robert Bosch, Bently Publishers, 1997.
10. Jurgen, R., Automotive Electronics Hand Book.

**ET5075 EMBEDDED NETWORKING AND AUTOMATION OF ELECTRICAL SYSTEM** **L T P C 3 0 0 3**

**COURSE OBJECTIVES:**

- To discuss the fundamentals building blocks of a digital instrument .
- Introduce wired, WSN for configuring metering network
- Discuss requirements for grid automation using meters.
- To discuss networking configuration to develop PAN.
- To discuss the functions of digital instrument Power quality monitoing .

**UNIT I BUILDING SYSTEM AUTOMATION** **9**

Sensor Types & Characteristics: Sensing Voltage, Current, flux, Torque, Position, Proximity, Accelerometer - Data acquisition system- Signal conditioning circuit design- Uc Based & PC based data acquisition – uC for automation and protection of electrical appliances –processor based digital controllers for switching Actuators: Stepper motors, Relays –System automation with multi channel Instrumentation and interface .

**UNIT II EMBEDDED NETWORKING OF INSTRUMENT CLUSTER** **9**

Embedded Networking: Introduction – Cluster of Instruments in System- Comparison of bus protocols – RS 232C- embedded ethernet - MOD bus and CAN bus, LIN BUS- Introduction to WSN-– Commercially available sensor nodes-Zigbee protocol -Network Topology Energy efficient MAC protocols –SMAC –Data Centric routing Applications of sensor networks-Database perspective on sensor networks- IoT Applications .

**UNIT III AUTOMATION OF SUBSTATION** **9**

Substation automation- Distribution SCADA system principles -role of PMU,RTU, IEDs, BUS for smart Substation automation- Introduction to Role of IEC 61850,IEEEC37.118 std- Interoperability and IEC 61850-challenges of Substations in Smart Grid - challenges of Energy Storage and Distribution Systems monitoring- Communication Challenges in monitoring electric utility asset .

.

**UNIT IV METERING OF SMART GRID** **9**

Characteristics of Smart Grid- Generation by Renewable Energy Sources based on solar grid-Challenges in Smart Grid and Microgrids- electrical measurements with AMI -Smart meters for EV plug in electric vehicles power management -Home Area Netmetering and Demand side Energy Management applications.

**UNIT V SMART METERS FOR PQ MONITORING** **9**

Power Quality issues of Grid connected Renewable Energy Sources -Smart meters for Power Quality monitoring and Control - Power Quality issues -Surges – Flicker - Interharmonics - Transients – Power Quality Benchmarking – Power Quality Meters- Meter data management In Smart Grid-, communication enabled Power Quality metering

NOTE : Mini project/ Discussions/Exercise on Workbench /simulators: on the basics interface of sensors,actuators to microcontrollers,role of virtual Instrumentation software packages simulators/ special microcontrollers for i/o port communication etc

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: The criteria of choice of sensors, components to build meters.
CO2: The demand for BUS communication protocols are introduced
CO3: Analyze the need and standards in Substation automation
CO4: Deployment of PAN for metering networked commercial applications
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded networked communications

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| **CO2** | | ✓ | ✓ | | | | | | | | | |
| **CO3** | | ✓ | ✓ | | | | | | | | | |
| **CO4** | | ✓ | ✓ | | | | | | | | | |
| **CO5** | | ✓ | | | ✓ | | | | | | | |

**REFERRENCES:**


1. Control and automation of electrical power distribution systems, James Northcote-Green, Robert Wilson, CRC, Taylor and Francis, 2006
2. Krzysztof Iniewski,"Smart Grid ,Infrastructure & Networking",TMcGH,2012
3. Robert Faludi,"Building Wireless Sensor Networks,O'Reilly,2011
4. Mohammad Ilyas And Imad Mahgoub, 'Handbook of sensor Networks: Compact wireless and wired sensing systems', CRC Press,2005
5. Shih-Lin Wu,Yu-Chee Tseng,{"Wireless Ad Hoc Networking,PAN,LAN,SAN,Aurebach Pub,2012
6. Sanjay Gupta, **"Virtual Instrumentation, LABVIEW"**, TMH, New Delhi, 2003
7. Ernest O. Doeblin and Dhanesh N Manik, " **Measrement Systems – Application and Design"**, 5th Edn, TMH, 2007.
8. Bhaskar Krishnamachari, 'Networking wireless sensors', Cambridge press 2005


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**ET5251** **VLSI DESIGN AND ARCHITECTURE** **LT P C**
**4 0 0 4**

**COURSE OBJECTIVES:**

- To understand the basic concepts of VLSI and CMOS design.
- To introduce the IC fabrication methods
- To study the architectures of various RPLDs.
- To introduce the basics of analog VLSI design and its importance.
- To learn about the programming of Programmable device using Hardware description Language.

**UNIT I CMOS DESIGN** **12**

Review of switching devices and logics- MOSFET Scaling- MOS Transistor Model-CMOS inverter-determination of pull up / pull down ratios, Nano MOSFET- CMOS based combinational logic & sequential design- Dynamic CMOS & clocking –Transmission Gates- BiCMOS- Low power VLSI.

**UNIT II IC FABRICATION** **12**

Overview of IC Fabrication -NMOS, PMOS, CMOS, SOI ,BiCMOS fabrication- Stick Diagrams, Design Rules and Layout - recent trends in IC fabrication.

**UNIT III PROGRAMMABLE LOGIC DEVICES AND ASIC DESIGN** **12**

Programming techniques- Architecture of CPLD and FPGA – advanced FPGA devices- ASIC physical design– Logic Implementation with PLDs.

**UNIT IV ANALOG VLSI DESIGN** **12**

Introduction to analog VLSI- Design of CMOS 2stage-3 stage Op-Amp –High Speed and High frequency op-amps-Super MOS- Analog primitive cells-realization of neural networks- Introduction to FPAA**.**

**UNIT V HDL PROGRAMMING** **12**

Overview of digital design with HDL, structural, data flow and behavioural modeling- logic synthesis-simulation-Combinational and Sequential logic design examples, Ripple carry Adders, Carry Look ahead adders, Multiplier, ALU, Test Bench.

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

CO1: The learning process delivers insight into developing CMOS design techniques and development of low power VLSI logic circuits.
CO2: Insight into IC fabrication methods.
CO3: Improved skill set in RPLD/SOC usage for real time applications.
CO4: Design and development of reprogrammable analog devices and its usage for embedded applications.
CO5: Understating and usage of HDL computational processes with improved design strategies.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | |
| **CO2** | ✓ | | | ✓ | ✓ | | | | | | | |
| **CO3** | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | | | |
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| **CO5** | | | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | |

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**TEXTBOOKS:**


1. M.J.S Smith, “Application Specific integrated circuits”,Addition Wesley Longman Inc.1997.
2. Kamran Eshraghian,Douglas A.pucknell and Sholeh Eshraghian,”Essentials of VLSI circuits and system”, Prentice Hall India,2005.
3. Wayne Wolf, “ Modern VLSI design “ Prentice Hall India,2006.
4. Mohamed Ismail ,Terri Fiez, “Analog VLSI Signal and information Processing”, McGraw Hill International Editions,1994.
5. Samir Palnitkar, “Veri Log HDL, A Design guide to Digital and Synthesis” 2nd Ed,Pearson,2005.
6. Debprasad Das, VLSI Design, Oxford University Press, 2010.
7. Zainalatsedin Navabi, ‘VHDL Analysis and Modelling of Digital Systems’, 2n Edition, Tata McGraw Hill, 1998.


**ET5071 ADVANCED DIGITAL SIGNAL PROCESSING LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To expose the fundamentals of digital signal processing in frequency domain& its application
- To teach the fundamentals of digital signal processing in time-frequency domain& its application
- To teach the fundamentals of audio signal processing & its application
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

**UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 6**

Introduction to Digital Signal Processing System- Discrete Time Sequences- Time-Invariant & Time-variant Systems, Decimation and Interpolation- The Sampling Process - Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)- Basics of Digital Filters- FIR Filters, IIR Filters -adaptive filter based on LMS.

**UNIT II WAVELET TRANSFORM 9**

Introduction to continuous wavelet transform- discrete wavelet transform -orthogonal wavelet decomposition- Multiresolution Analysis-Wavelet function-DWT,bases,orthogonal Basis-Scaling function, Wavelet coefficients- Multirate signal processing and their relationship to filter banks- Digital filtering interpolation(i) Decomposition filters, (ii) reconstruction, the signal- Example MRA- Haar & Daubechies wavelet.

**UNIT III AUDIO SIGNAL PROCESSING 12**

Introduction to Speech and Audio Processing - Speech Signal Processing- Pitch-period estimation, all-pole and all-zero filters- convolution - autoregressive model, autocorrelation estimation, General structure of speech coders; Requirements of speech codecs –quality, LPC model of speech production- LPC encoders and decoders-Power spectral density, periodogram ,Spectral measures of audio signal.

**UNIT IV ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 12**

Introduction, catogorisation of DSP Processors-one case example Architecture Processor for Fixed Point (Blackfin), Floating Point & Speech Processor- Basics of Architecture – study of functional variations of Computational building blocks(with comparison onto their MAC, Bus Architecture ,I/O interface, application).

**UNIT V IMPLEMENTATION OF DSP BASED SYSTEMS 6**

Introduction- Interfacing processor- Memory Interface-I/O Interface-Mapping of DSP algorithm onto hardware -Design of Filter-FFT Algorithm- Application with DSP based Interfacing- Power Meter; DSP as motor control

**NOTE:** Discussions/Miniproject/Practice on Workbench : Signal analysis transforms,Filter design concepts with simulation tools as Matlab /Labview/ VLSI/CCS/other suites to understand the commercial DSP processor technology and practice in programming.

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**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: The concepts of Time and frequency analysis of Signal Transforms based on signal types.
CO2: The fundamentals of Time-Frequency Transforms are introduced
CO3: Analyze the quality and properties of speech based on DSP
CO4: Study features through comparison on commercial available DSProcessors
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in signal processing for embedded systems design.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| **CO2** | | ✓ | ✓ | | | | | | | | | |
| **CO3** | | ✓ | ✓ | | | | | | | | | |
| **CO4** | | ✓ | ✓ | | | | | | | | | |
| **CO5** | | ✓ | | | ✓ | | | | | | | |

**REFERENCES:**


1. John G. Proaks, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education 2002.
2. Vinay K.Ingle,John G.Proakis,”DSP-A Matlab Based Approach”,Cengage Learning,2010
3. Taan S.Elali,”Discrete Systems and Digital Signal Processing with Matlab”,CRC Press2009.
4. Sen M.Kuo and Woon-Seng S.Gan, Digital Signal Processors-Architectures, implementation and applications”, Pearson Education 2008.
5. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India,2004.
6. Ashok Ambardar,”Digital Signal Processing: A Modern Introduction”,Thomson India edition, 2007.
7. Lars Wanhammer, “DSP Integrated Circuits”, Academic press, 1999,NewYork.
8. Raghuveer M.Rao and Ajit S. Bapardikar, Wavelet transforms- Introduction to theory and applications, Pearson Education, 2000.
9. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
10. Ifeachor E. C., Jervis B. W ,”Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002
11. B Venkataramani and M Bhaskar **“**Digital Signal Processors**”**, TMH, 2nd, 2010
12. “Digital Speech” by A.M.Kondoz, Second Edition (Wiley Students_ Edition), 2004.


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**ET5073** **CRYPTOGRAPHY AND NETWORK SECURITY** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To expose the students to the fundamentals of data security.
- To teach the fundamentals of mathematical aspects in creating Encryption keys
- To teach the fundamentals of Security in data& wireless communication.
- To teach the fundamentals of Secured system operation.
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

**UNIT I SYMMETRIC CIPHERS** **9**

Overview – classical Encryption Techniques – Block Ciphers and the Data Encryption standard – Introduction to Finite Fields–Advanced Encryption standard–Contemporary, Symmetric Ciphers – Confidentiality using Symmetric Encryption.

**UNIT II PUBLIC-KEY ENCRYPTION AND HASH FUNCTIONS** **9**

Introduction to Number Theory – Public-Key Cryptography and RSA – Key Management – Diffie-Hellman Key Exchange – Elliptic Curve Cryptography – Message Authentication and Hash Functions – Hash Algorithms – Digital Signatures and Authentication Protocols.

**UNIT III NETWORK SECURITY PRACTICE** **9**

Authentication Applications – Kerberos – X.509 Authentication Service – Electronic mail Security – Pretty Good Privacy – S/MIME – IP Security architecture – Authentication Header – Encapsulating Security Payload – Key Management.

**UNIT IV SYSTEM SECURITY** **9**

Intruders – Intrusion Detection – Password Management – Malicious Software – Firewalls – Firewall Design Principles – Trusted Systems.

**UNIT V WIRELESS SECURITY** **9**

Introduction to Wireless LAN Security Standards – Wireless LAN Security Factors and Issues.

**NOTE:** Discussions/Exercice/Practice on Workbench : on the basics /numerical design aspects of encryption, decryption keys/password creation etc

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Understanding the significance of security for communication
Co2: Delivers Insight of security mechanism and architecture.
CO3: Applying the security algorithms for real time applications.
CO4: The learning process delivers insight onto role of security aspects during data transfer and communication systems like electrical grid
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems and secured systm design.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | | ✓ | ✓ | ✓ | | ✓ | | | | | | |
| **CO2** | | | | ✓ | ✓ | | | | | | | |
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| **CO5** | | | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | |

**REFERENCES:**


1. William Stallings, "Cryptography And Network Security – Principles And Practices", Pearson Education, 3rd Edition, 2003.
2. Atul Kahate, "Cryptography and Network Security", Tata McGraw Hill, 2003.
3. Bruce Schneier, "Applied Cryptography", John Wiley and Sons Inc, 2001.
4. Stewart S. Miller, "Wi-Fi Security", McGraw Hill, 2003.
5. Charles B. Pfleeger, Shari Lawrence Pfleeger, "Security In Computing", 3rd Edition, Pearson Education, 2003.
6. Mai, "Modern Cryptography: Theory and Practice", First Edition, Pearson Education, 2003.


**ET5073** **NANO ELECTRONICS** **LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To introduce the properties of electron and its implication for electronics
- To teach the importance and the issues of Nanoscale CMOS technology.
- To introduce the characteristics and applications of Nano electronic devices, methods and techniques.
- To teach the circuits and architectural features of nano memory devices.
- To introduce the various fabrication techniques for nano electronic devices.

**UNIT I INTRODUCTION** **9**

Overview of nanotechnology – Implication on science, engineering and technology- Particles-, waves, Wave mechanics, schrodinger equation- Electron transport in semiconductors and nanostructures, Nano materials and its properties- Electrical and Electronics Applications of Nanotechnology.

**UNIT II NANOSCALE CMOS** **9**

Survey of modern electronics and trends towards nano electronics CMOS scaling, challenges and limits, static power, device variability, interconnect - CNT-FET, FinFET, FerroFET - Surround gate FET nanoscale CMOS circuit design and analysis

**UNIT III NANOELECTRONIC DEVICES** **9**

Resonant-tunneling diodes- Resonant Tunneling Transistor-Single-electron transfer devices-Potential effect transistors- Nano Photonic Devices-Molecular electronic devices -Nano-electromechanical system devices-Recent development.

**UNIT IV NANOELECTRONIC COMPUTATION AND MEMORIES** **9**

Quantum-dot cellular automata –Spintronics- Memristor- Nano tube for memories- Nano RAM-Nanoscale DRAM, SRAM, Tunnel magnetoresistance-Giant magnetoresistance- design and applications.

**UNIT V FABRICATION TECHNIQUES** **9**

Clean room standards-Microfabrication –Synthesis of nao materials-nanofabrication- E-beam lithography- X-ray and ion-beam lithography- nanoimprint lithography- Scanning probe lithography-Nano-characterization techniques.

**NOTE:** Class room discussions and tutorials can include the following guidelines for improved teaching /learning process :Discussions/Practice on Workbench : on modelling of nano/micro analog &digital devices.

Attested

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:** After the completion of this course the student will be able to:



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CO1: Understand the properties of electron and the significance of of nanotechnology.
CO2: Concept of nanoscale CMOS devices and its various issues.
CO3: Apply the concept of nanotechnology and understand the significance of nano electronic devices.
CO4: Understand the nano configurations of computational processors and memories with improved design strategies.
CO5: Learn and understand the nano fabrication techniques.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | | ✓ | | | ✓ | | | | | | ✓ |
| **CO2** | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | | |
| **CO3** | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| **CO4** | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| **CO5** | ✓ | | ✓ | | | ✓ | | ✓ | | | | |

**REFERENCES :**


1. Hagelstein, Peter L., Stephen D. Senturia, and Terry P. Orlando, "Introduction to Applied Quantum and Statistical Physics.", New York, NY: Wiley, 2004.
2. Rainer Waser, "Nanoelectronics and Information Technology", Wiley 2005
3. Michael A. Nielsen and Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2000.
4. Adrian Ionesu and Kaustav Banerjee eds. " Emerging Nanoelectronics: Life with and after CMOS" , Vol I, II, and III, Kluwer Academic, 2005.
5. Kiyoo Itoh Masashi Horiguchi ,Hitoshi Tanaka, Ultra Low voltage nano scale memories. Spl Indian Edition, Springer.
6. George W. Hanson, Fundamental of nanoelectronics, Pearson education.


**HV5151 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING** **LT P C 3 0 0 3**

**COURSE OBJECTIVES:**

- To refresh the fundamentals of Electromagnetic Field Theory
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart knowledge in fundamentals of FEM
- To compute and analyze the field quantities using FEM
- To formulate, solve, analyze and optimize the design of electrical components

**UNIT I INTRODUCTION** **9**

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation

**UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS** **9**

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method

**UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9**

Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems

**UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES 9**

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance

**UNIT V DESIGN APPLICATIONS 9**

Design of Insulators –Magnetic actuators – Transformers – Rotating machines.

**L=45: T=0, TOTAL = 45 PERIODS**

**COURSE OUTCOMES:**

CO1 Ability to understand the field theory concepts
CO2 Ability to formulate and compute Electromagnetic Fields from Maxwell's equations.
CO3 Ability to formulate FEM problems from the fundamental concepts
CO4 Ability to compute the respective field using FEM ( post processing)
CO5 Ability to check and optimize the design of electrical power equipment

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO1 | ✓ | | | | | | | | | | | |
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| CO3 | | | ✓ | | ✓ | | | | | | | |
| CO4 | | | | | ✓ | | | | | | | |
| CO5 | | | ✓ | | ✓ | | | | | | | |

**REFERENCES**


1. Matthew. N.O. Sadiku, S.V. Kulkarni, "Elements of Electromagnetics", Sixth Edition, Oxford University Press, Asian Edition 2015.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A.Bastos, "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983


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**PS5075** **SMART GRID**

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**COURSE OBJECTIVES**

Students will be able to:

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understanding the problems associated with integration of distributed generation & its solution through smart grid.
- To familiarize the high performance computing for Smart Gridapplications

**UNIT I INTRODUCTION TO SMART GRID 9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

**UNIT II SMART GRID TECHNOLOGIES (Transmission) 9**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

**UNIT III SMART GRID TECHNOLOGIES (Distribution) 9**

DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric Vehicles (PHEV).

**UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

**UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9**

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Computing algorithms for Smart grid, IOT, Cyber Security for Smart Grid.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

Students will be able to:

CO1 :Understand on the concepts of Smart Grid and its present developments.

CO2 :Analyze about different Smart Grid transmission technologies.

CO3 :Analyze about different Smart Grid distribution technologies.

CO4 :Acquire knowledge about different smart meters and advancedmetering infrastructure.

CO5 : Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | | | | ✓ | ✓ | ✓ | | | | | |
| CO2 | ✓ | | | | ✓ | ✓ | ✓ | | | | | |
| CO3 | ✓ | | | | ✓ | ✓ | ✓ | | | | | |
| CO4 | ✓ | | | | ✓ | ✓ | ✓ | | | | | |
| CO5 | ✓ | | | | ✓ | ✓ | ✓ | | | ✓ | | |

**REFERENCES**


1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”,CRC Press 2016.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”,Wiley.
3. Vehbi C. Gungor, DilanSahin, TaskinKocak, Salih Ergut, Concettina Buccella, Carlo Cecati ,and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies andStandards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey” , IEEE Transaction on Smart Grid


**PS5076 WIND ENERGY CONVERSION SYSTEM LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To learn about the basic concepts of wind energy conversion system
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of Variable speed wind energy conversion systems.
- To analyze the grid integration issues.

**UNITI INTRODUCTION 9**

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

**UNIT II WINDTURBINES 9**

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum powerextraction.

**UNIT III FIXEDSPEEDSYSTEMS 9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

Attested



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**UNIT IV VARIABLESPEED SYSTEMS** **9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

**UNIT V GRIDCONNECTED SYSTEMS** **9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modelling issue.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

Students will be able to:

CO1: Attain knowledge on the basic concepts of Wind energy conversion system.
CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine
CO3: Develop more understanding on the design of Fixed speed system
CO4: Study about the need of Variable speed system and its modelling.
CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | | | | | | | | | | | |
| **CO2** | ✓ | | ✓ | | ✓ | | | | | | | |
| **CO3** | ✓ | | ✓ | | | | | | | | | |
| **CO4** | ✓ | | ✓ | | ✓ | | | | | | | |
| **CO5** | ✓ | ✓ | ✓ | ✓ | | | | | | | | |

**REFERENCES**


1. L.L.Freris “Wind Energy conversion Systems”, Prentice Hall,1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,”Wind Electrical Sytems”,Oxford University Press,2010.
3. Ion Boldea, “Variable speed generators”, Taylor & Francis group,2006.
4. E.W.Golding “The generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge,1976.
5. N. Jenkins,” Wind Energy Technology” John Wiley &Sons,1997
6. S.Heir “Grid Integration of WECS”, Wiley1998.

**PW5252 OPTIMIZATION TECHNIQUES FOR ENERGY MANAGEMENT L T P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To understand the probability concepts.
- To provide knowledge on the demand analysis and forecasting techniques
- To emphasis the optimization for energy management.
- To provide knowledge about the selection of optimization techniques for real time problems and to analyze the solutions.
- To analyze and comprehend the various operating modes of different configurations at different applications.

**UNIT I PROBABILITY THEORY 12**

The nature of random variables: populations and samples, parameters and statistics. Probability concepts; properties of random variables, probability distribution functions.

**UNIT II DEMAND ANALYSIS AND FORECASTING 12**

Drivers of energy demand, Sectoral energy demand: domestic, commercial, industrial, agricultural. Projections for future demands.

**UNIT III INTRODUCTION TO OPTIMIZATION 12**

Problem formulation: decision variables, objective function, maxima, minima, constraints. Analysis techniques: simulation, optimization, stochastic optimization. Multiobjective optimization - non-inferior solutions, trade off analysis, weighted and constraints method.

**UNIT IV LINEAR PROGRAMMING AND APPLICATION 12**

Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis. Power system planning using optimization techniques, case study.

**UNIT V DYNAMIC PROGRAMMING AND APPLICATION 12**

Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming. Optimal energy resource, technology mix in micro and macro level energy planning exercises. Power generation expansion planning, case study.

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

CO1: Ability to define and use optimization techniques and concepts.
CO2: Understand the concept of optimization methods for energy system planning
CO3: Able to define an optimization problem and exploring the solution by applying optimization methods and interpreting results.
CO4: Excel the selection of optimization techniques for real time problems and to analyze the solutions.
CO5: Analyze the various operating modes of different configurations in different applications.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO3 | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| CO5 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |

Attested



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**REFERENCES**


1. Taha, H. A.,'Operations Research—An Introduction', Prentice Hall of India, New Delhi,2007.
2. Vohra, N. D.,'Quantitative Techniques in Management, III Edition', Tata McGraw-Hill Education, 2006.
3. Rardin, R. L.,'Optimization in operations research: Upper Saddle River', NJ: Prentice Hall, 1998.
4. Dhillon, J. S., and Kothari, D. P,'Power system optimization',Prentice Hall of India Private Limited, 2010.


**PW5077 RENEWABLE ENERGY TECHNOLOGY LT P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To Provide knowledge about various renewable energy technologies
- To enable students to understand and design a PV system.
- To provide knowledge about wind energy system.
- To Provide knowledge about various possible hybrid energy systems
- To gain knowledge about application of various renewable energy technologies

**UNIT I INTRODUCTION 9**

Primary energy sources, renewable vs. non-renewable primary energy sources, renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.

**UNITII SOLAR ENERGY 9**

Solar Radiation and its measurements, Solar Thermal Energy Conversion from plate Solar Collectors, Concentrating Collectors and its Types , Efficiency and performance of collectors, Applications of Solar Thermal Energy use of low and medium, high temperature and recent advances in industry and buildings. Direct Solar Electricity Conversion from Photovoltaic, types of solar cells and its application of battery charger, domestic lighting, street lighting, and water pumping, power generation schemes. Recent Advances in PV Applications: Building Integrated PV, Grid Connected PV Systems, Hybrid Systems and Solar Cars, Solar Energy Storage system and their economic aspects.

**UNIT III WIND ENERGY 9**

Wind energy principles, wind site and its resource assessment, wind assessment, Factors influencing wind, wind turbine components, wind energy conversion systems (WECS), Classification of WECS devices, wind electric generating and control systems, characteristics and applications. Hybrid systems - safety and environmental aspects, economic aspects.

**UNIT IV BIO-ENERGY 9**

Energy from biomass, Principle of biomass conversion technologies/process and their classification, Bio gas generation, types of biogas plants, selection of site for biogas plant, classification of biogas plants, Advantage and disadvantages of biogas generation, thermal gasification of biomass, biomass gasifies, Application of biomass and biogas plants and their economics.

**UNIT V OTHER TYPES OF ENERGY 9**

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles utilization, setting of OTEC

plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Attained knowledge about various renewable energy technologies
CO2: Ability to understand and design a PV system.
CO3: Understand the concept of various wind energy system.
CO4: Gained knowledge about various possible hybrid energy systems
CO5: Attained knowledge about various application of renewable energy technologies

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO2** | ✓ | | ✓ | | | | | | | | | |
| **CO3** | ✓ | | ✓ | | | | | | | | | |
| **CO4** | ✓ | | ✓ | | | | | | | | | |
| **CO5** | | | ✓ | | | | | | | | | |

**REFERENCES**


1. Twidell & Wier,'Renewable Energy Resources' CRC Press( Taylor & Francis).
2. Tiwari and Ghosal/ Narosa,'Renewable energy resources'.
3. D.P.Kothari,K.C.Singhal,'Renewable energy sources and emerging technologies', P.H.I.
4. D.S.Chauhan, S.K. Srivastava, 'Non – Conventional Energy Resources', New Age Publishers, 2006.
5. B.H.Khan, 'Non – Conventional Energy Resources', Tata Mc Graw Hill, 2006.


**PW5071 ELECTRIC VEHICLES AND POWER MANAGEMENT L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To provide knowledge about electric vehicle architecture and power train components.
- To know the concepts of dynamics of electrical vehicles
- To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs)
- To understand the concept of energy storage systems.
- To provide knowledge about different energy sources and energy management in HEVs.

**UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9**

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

**UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9**

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

**UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9**

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

**UNIT IV ENERGY STORAGE SYSTEMS 9**

**Battery:** Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. **Alternate sources:** Fuel cells, Ultra capacitors, Fly wheels.

**UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT 9**

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode - energy management of HEV's.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Learned the electric vehicle architecture and power train components.
CO2: Acquired the concepts of dynamics of electrical vehicles
CO3: Able to understand the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs).
CO4: Ability to design and select energy storage systems.
CO5: Acquired the knowledge of different energy sources and energy management in HEVs.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| CO5 | ✓ | | ✓ | | | | | | | | ✓ | |

**REFERENCES:**

1. Iqbal Husain, 'Electric and Hybrid Electric Vehicles', CRC Press, 2011.
2. Wei Liu, 'Hybrid Electric Vehicle System Modeling and Control', Second Edition, WILEY, 2017.
3. James Larminie and John Lowry, 'Electric Vehicle Technology Explained', Second Edition, 2012.

**PW5075 GRID INTEGRATION OF RENEWABLE ENERGY SOURCES LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To study about the integration of various renewable energy sources into the grid.
- To analyse various grid issues due to renewable energy sources.
- To analyse the dynamics of network due to wind farm
- To provide knowledge about power system stabilizers.
- To provide knowledge about grid connected and standalone PV system

Attested

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**UNIT I INTRODUCTION** **9**

Introduction to renewable energy grid integration - Concept of mini/micro grids and Smart grids - Different types of grid interfaces - Issues related to grid integration of small and large scale of synchronous generator based - induction generator based and converter based sources together - Network voltage management - Power quality management (voltage dips, harmonics, flickers, and reactive power control) - Frequency management - Influence of WECS on system transient response - Interconnection standards and grid code requirements for integration.

**UNIT II NETWORK INFLUENCE OF GENERATION TYPE** **9**

starting – Network voltage management – Thermal/Active power management – Network power quality management – Transient system performance – Fault level issues – Protection.

**UNIT III INFLUENCE OF WIND FARMS ON NETWORK DYNAMIC PERFORMANCE** **9**

Dynamic Stability and its Assessment – Dynamic characteristics of Synchronous Generation - A Synchronizing power and Damping power model of a Synchronous Generator – Influence of Automatic Voltage Regulator on Damping – Influence on Damping of Generator Operating Conditions – Influence of Turbine Governor on Generator Operation – Transient Stability – Voltage Stability – Influence of Generation Type on Network Dynamic Stability – Dynamic Interaction of Wind Farms with the Network – influence of Wind Generation on Network Transient Performance.

**UNIT IV POWER SYSTEM STABILIZERS AND NETWORK DAMPING CAPABILITY OF WIND** **9**

A Power System Stabilizer for a Synchronous Generator - A Power System Stabilizer for a DFIG - A Power System Stabilizer for a FRC Wind Farm.

**UNIT V STAND ALONE AND GRID CONNECTED PV SYSTEM** **9**

Solar modules – storage systems – Basics of batteries – Batteries for PV Systems – Charge Controllers – MPPT and Inverters – Power Conditioning and Regulation – protection – Types of Solar PV systems - standalone PV systems design – sizing – PV systems in buildings – design issues for central power stations – safety – Economic aspect – efficiency and performance – International PV programs

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Know about the integration of various renewable energy sources into the grid.
CO2: Able to analyze various grid issues due to renewable energy sources.
CO3: Able to analyze the dynamics of network due to windfarm
CO4: Know about power system stabilizers.
CO5: Able to design the grid connected and standalone PV system.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | | | | | | | | | | | |
| **CO2** | | ✓ | | | | | | | | | | |
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| **CO4** | | ✓ | | | | | | | | | | |
| **CO5** | | | ✓ | | | | | | | | | |

**REFERENCES**


1. Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, 'Applied Photovoltaics', Earthscan, UK, 2007.
2. Joshua Earnest, 'Wind power technology', II Edition, PHI, 2015.

3. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright and Mike Hughes, 'WIND GENERATIONModelling and Control', A John Wiley and Sons, Ltd., Publication, 2009.
4. Brenden Fox, Damian Flynn and Leslie Bryans, 'Wind Power Integration Connection and system operational aspects', Published by The Institute of Engineering and Technology, London, United Kingdom, 2007.
5. Frank S. Barnes & Jonah G.Levine, 'Large Energy Storage Systems Handbook', CRC Press, 2011.
6. S.P. Sukhatme, 'Solar Energy', Tata McGraw Hill, 1987.
7. Chetan Singh Solanki, 'Solar Photovoltaic Technology and Systems' – A Manual for Technicians, Trainees and Engineers, PHI, 2014.

**PW5079 WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES LT P C 3 0 0 3**

**COURSE OBJECTIVES:**

- To provide information on various methods of waste management.
- To Impart Knowledge about separation techniques & Transformation Technologies.
- To detail on the recent technologies of waste disposal
- To familiarize students with recent energy generation techniques.
- To make student realize on the importance of healthy environment.

**UNIT I CHARACTERISTICS AND PERSPECTIVES 9**

Sources – Types – Composition – Generation – Estimation Techniques – Characterization –Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle/ Recovery Facilities.

**UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES 9**

Separation & Processing: Size Reduction – Separation through Density Variation, Magnetic / Electric Field: Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies.

**UNIT III WASTE DISPOSAL 9**

Disposal Option & Selection Criteria - Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation - Waste Disposal: A Case Study of Bangalore

**UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION 9**

Physical Transformation: Component Separation & Volume Reduction: Chemical Transformation– Combustion/Gasification/ Pyrolysi: Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion.

**UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING 9**

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling: Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes.

Hazardous Waste Management: Generation, Storage & Collection, Transfer & Transport, Processing, Disposal-Hazardous Waste Treatment: Physical & Chemical Treatment, Thermal Treatment, Biological Treatment - Pollution Prevention and Waste Minimization- Hazardous Wastes Management in India.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Acquired basic knowledge about the Methods of Waste Management.
CO2: Understand the concept of Segregation & Transformation Techniques.
CO3: Learned the technologies that are available for effective waste disposal along with pros

/ cons.

CO4: Ability to develop various Energy generation Techniques.

CO5: Able to predict the waste related problems (Hazardous Waste, Pharma Waste, Biomedical Waste etc).

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO4** | | | | | | | | | | | | |
| **CO5** | | ✓ | | ✓ | | ✓ | ✓ | | | | | ✓ |

**REFERENCES**


1. George Polimveros, 'Energy Cogeneration Hand book', Industrial Press Inc, New York 1982.
2. Howard S. Peavy etal, 'Environmental Engineering', McGraw Hill International Edition, 1985.
3. LaGrega, M., et al., 'Hazardous Waste Management', McGraw-Hill, c. 1200 pp., 2nd edition.,2001.
4. Manoj Datta, 'Waste Disposal in Engineered Landfills', Narosa Publishing House, 1997.
5. Parker Colin and Roberts, 'Energy from Waste – An Evaluation of Conversion Technologies',Elsevier Applied Science, London, 1985.
6. Stanley E. Manahan, 'Hazardous Waste Chemistry, Toxicology and Treatment', Lewis Publishers, Chelsea, Michigan, 1990.
7. Tchobanoglous, Theisen and Vigil, 'Integrated Solid Waste Management', 2d Ed. Mc-GrawHill, New York, 1993.
8. Freeman, M. H.1988. 'Standard Handbook of Hazardous Waste Treatment and Disposal', Mc-Graw-Hill Book Company, New York.
9. Tchobanoglous, G., Theisen, H. and Eliassan, R. 'Solid WastesEngineering Principles and Management Issues', McGraw-Hill Book Company, New York, 1977.




**PW5078 SCADA SYSTEM AND APPLICATIONS MANAGEMENT L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the basic concepts and components of SCADA
- To introduce the SCADA communication protocols
- To apply the SCADA technology to power systems for automation
- To provide knowledge about SCADA based energy management centre.
- To emphasis the role of SCADA monitoring and control concepts.

**UNIT I INTRODUCTION TO SCADA 9**

SCADA overview, general features, SCADA architecture, SCADA Applications, Benefits, Remote Terminal Unit (RTU), Human- Machine Interface Units (HMI), Display Monitors/Data Logger Systems, Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA Control systems and Control panels

Attested

**UNIT II SCADA COMMUNICATION 9**

SCADA Communication requirements, Communication protocols: Past, Present and Future, Structure of a SCADA Communications Protocol, Comparison of various communication protocols, IEC61850 based communication architecture, Communication media like Fiber optic, PLCC etc. Interface provisions and communication extensions, synchronization with NCC, DCC, IOT, Cyber cell, Redundancy of Network.

**UNIT III SCADA IN POWER SYSTEM AUTOMATION 9**

Applications in Generation, Transmission and Distribution sector, Substation SCADA system Functional description, System specification, System selection such as Substation configuration, IEC61850 ring configuration, SAS cubicle concepts, gateway interoperability list, signal naming concept. System Installation, Testing and Commissioning,

**CASE STUDIES**:SCADA Design for 66/11KV and 132/66/11KV or 132/66 KV any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations

**UNIT IV ENERGY MANAGEMENT CENTRE 9**

Functions, production control and load management, economic despatch, distributed centres and power pool management, energy management system and its role.

**UNIT V SCADA MONITORING AND CONTROL 9**

Online monitoring the event and alarm system, trends and reports, Blocking list, Event disturbance recording. Control function: Station control, bay control, breaker control and disconnector control.

**TOTAL: 45 PERIODS**

**COURE OUTCOMES:**

CO1: Students will learn the SCADA system components and its significance.
CO2: Students will understand the need and advantages of communication protocols for SCADA
CO3: Students will get implementation knowledge about the application of SCADA to Power System.
CO4: Students will get exposure to the best operating mechanism for Energy centre based on SCADA concepts
CO5: Students will understand the need and importance of monitoring and control logic for SCADA based power systems.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO1 | ✓ | | | | ✓ | | | | | | | ✓ |
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| CO4 | | ✓ | ✓ | | ✓ | | | | ✓ | | | ✓ |
| CO5 | ✓ | | ✓ | | | | | | | | | |

**REFERENCES:**


1. Stuart A. Boyer, 'SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications,USA,2004.
2. Gordon Clarke, Deon Reynders, 'Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems', Newnes Publications, Oxford, UK,2004.
3. William T. Shaw, 'Cybersecurity for SCADA systems', PennWell Books, 2006.
4. David Bailey, Edwin Wright, 'Practical SCADA for industry', Newnes, 2003.
5. Michael Wiebe, 'A guide to utility automation: AMR, SCADA, and IT systems for electric Power', PennWell, 1999.

6. Dieter K. Hammer, Lonnie R. Welch, Dieter K. Hammer, 'Engineering of Distributed Control Systems', Nova Science Publishers, USA, 1st Edition, 2001.

**PW5072 ENERGY EFFICIENT BUILDINGS LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the different climate zones and modelling methods
- To understand about the principle of energy conscious building design.
- To understand about the concept of passive solar heating and efficient technologies in electrical system.
- To provide knowledge about the energy conservation techniques in buildings.
- To provide knowledge about energy efficient technologies.

**UNIT I CLIMATE AND SHELTER 9**

Historic buildings – Modern architecture – Examples from different climate zones –Thermal comfort – Solar geometry and shading – Energy modeling techniques– Integrative Modeling methods and building simulation.

**UNIT II PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN 9**

Energy conservation in buildings – Day lighting – Solar based Water heating - Advances in thermal insulation – Heat gain/loss through building components - Solar architecture.

**UNIT III PASSIVE SOLAR HEATING 9**

Basics of Passive solar – Mechanical Systems – South Facing Glass – Thermal mass – Orientation – site planning for solar access - Direct gain – thermal storage wall – Sunspace –Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Design guidelines and natural cooling guidelines.

**UNIT IV ENERGY CONSERVATION IN BUILDING 9**

Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles – ECBC applicability – Building Envelope – Comfort system and controls – Lighting – Electrical Power and Renewable Energy.

**UNIT V EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9**

Maximum demand controllers, automatic power factor controllers, energy efficient motors, and soft starters – Energy efficient Lighting and Transformers.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Able to understand the different climate zones and modelling methods
CO2: Able to design energy conscious building design.
CO3: Able to understand about the concept of passive solar heating and efficient technologies in electrical system.
CO4: Able to gain knowledge about the energy conservation techniques in buildings.
CO5: Know about different energy efficient technologies.

Attested

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

**REFERENCES**


1. Joseph Clarke, 'Energy Simulation in Building Design', II Edition, Butterworth, 2001.
2. J. K. Nayak and J. A. Prajapati, 'Handbook on Energy Conscious Buildings', Solar Energy Centre, MNES, May 2006.
3. 'Energy conservation Building Codes – 2017', Bureau of Energy Efficiency.
4. 'Passive Solar Building - Design Strategies', Guidelines for home passive solar industries council, National Renewable Energy Laboratory and Charles Elay Associates.
5. J. Douglas Batcomb, 'Passive Solar Building',The MIT Press, 1992.
6. Thomas H.Kuehn, James W. Ramsey and J. L. Threlkeld, 'Thermal Environmental Engineering', 3rd Edition Prentice Hall, 1970.


**PW5074 ENERGY STORAGE TECHNOLOGIES L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the various types of energy storage Technologies.
- To analyze thermal storage system.
- To analyze different battery storage technologies
- To analyze the thermodynamics of Fuel Cell
- To study the various applications of energy storage systems.

**UNIT I INTRODUCTION 9**

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

**UNIT II THERMAL STORAGE SYSTEM 9**

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

**UNIT III ELECTRICAL ENERGY STORAGE 9**

Fundamental concept of batteries – measuring of battery performance, charging and is charging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, ickel – Cadmium, Zinc Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

**UNIT IV FUEL CELL 9**

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantages and disadvantages –Fuel Cell Thermodynamics.

**UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9**

Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Gained knowledge of various storage technologies.
CO2: Able to design a thermal storage system.
CO3: Ability to model battery storage system.
CO4: Learned to analyze the thermodynamics of fuel cell.
CO5: Gained Knowledge of various applications of storage technologies and perform the selection based on techno-economic view point.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | ✓ | ✓ | | | | | | | | | | |
| **CO2** | | | ✓ | | | | | | | | | |
| **CO3** | | | ✓ | | | | | | | | | |
| **CO4** | | | ✓ | | | | | | | | | |
| **CO5** | ✓ | | ✓ | | | | | | | | | |

**REFERENCES**


1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', JohnWiley & Sons 2002.
2. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
3. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2012.
5. Schmidt.F.W. and Willmott.A.J., 'Thermal Storage and Regeneration', Hemisphere Publishing Corporation, 1981.


**PE5152 ANALYSIS OF POWER CONVERTERS LT P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To provide required skills to formulate and design inverters for generic load and for machine loads.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters

**UNIT I SINGLE PHASE AC-DC CONVERTER 12**

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

**UNIT II THREE PHASE AC-DC CONVERTER 12**

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and overlap-12 pulse converter

**UNIT III SINGLE PHASE INVERTERS 12**

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS-VSR operation

**UNIT IV THREE PHASE INVERTERS 12**

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application to drive system – Current source inverters.

**UNIT V MODERN INVERTERS 12**

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters - Filters.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

CO1 Ability to acquire and apply knowledge of mathematics in power converter analysis
CO2 Ability to model, analyze and understand power electronic systems and equipment
CO3 Ability to formulate, design and simulate phase controlled rectifiers for generic load and for machine loads
CO4 Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads
CO5 Ability for device selection and calculation of performance parameters of power converters under various operating modes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| **CO2** | ✓ | ✓ | ✓ | | ✓ | | | | | | | ✓ |
| **CO3** | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | |
| **CO4** | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | |
| **CO5** | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | ✓ |

**TEXT BOOKS:**


1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, fourth Edition, New Delhi, 2014.
2. Jai P. Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal.K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan, T.M.Undeland and W.P.Robbins, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press-1998.

**REFERENCES:**


1. P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co,First Edition, New Delhi, 1998.
2. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Bin Wu, Mehdi Narimani, "High-power Converters and AC Drives", Wiley, 2nd Edition, 2017.


| PE5151 | ANALYSIS OF ELECTRICAL MACHINES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**COURSE OBJECTIVES:**

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

**UNIT I PRINCIPLES OF ELECTRO MAGNETIC ENERGY CONVERSION 12**

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf– determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

**UNIT II DC MACHINES 12**

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – electrical and mechanical time constants - Time domain block diagrams –transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

**UNIT III REFERENCE FRAME THEORY 12**

Historical background of Clarke and Park transformations – power invariance and phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

**UNIT IV INDUCTION MACHINES 12**

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque

variations – modeling of multiphase machines - digital computer simulation of three phase induction machines.

**UNIT V SYNCHRONOUS MACHINES 12**

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – digital computer simulation of synchronous machines.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

CO1 Ability to optimally design magnetics required in power supplies and drive systems.
CO2 Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.
CO3 Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.
CO4 Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance
CO5 Ability to verify the results of the dynamic operation of electrical machine systems

| CO | PO | | | | | | | | | | | |
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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| 2 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | |
| 3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | |
| 4 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | |
| 5 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | |

**TEXT BOOKS:**

1. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. R Ramanujam,"Modelling and Analysis of Electrical Machines", I.K International Publishing Pvt. Ltd., New Delhi, 2018

**REFERENCES:**

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition,199

**PE5251 SPECIAL ELECTRICAL MACHINES LT P C 3 0 0 3**

**COURSE OBJECTIVES:**

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.

- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

**UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9**

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control.

**UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9**

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

**UNIT III SWITCHED RELUCTANCE MOTORS 9**

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

**UNIT IV STEPPER MOTORS 9**

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non- linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

**UNIT V OTHER SPECIAL MACHINES 9**

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

CO1 Ability to model and analyze power electronic systems and equipment using computational software.

CO2 Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.

CO3 Ability to analyse the dynamic performance of special electrical machines

CO4 Ability to understand the operation and characteristics of other special electrical machines.

CO5 Ability to design and conduct experiments towards research.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO2** | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | | |
| **CO3** | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | | |
| **CO4** | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | | |
| **CO5** | ✓ | ✓ | | | | | | | | | | |

**TEXT BOOKS:**


1. T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’, Claredon press, London,1989.
2. R.Krishnan, ‘Switched Reluctance motor drives’, CRC press,2001.
3. T.Kenjo, ‘Stepping motors and their microprocessor controls’, Oxford University press, New Delhi,2000.


**REFERENCES:**


1. T.Kenjo and S.Nagamori, ‘Permanent magnet and Brushless DC motors’, Clarendon press, London,1988.
2. R.Krishnan, ‘Electric motor drives’, Prentice hall of India,2002.
3. D.P.Kothari and I.J.Nagrath, ‘ Electric machines’, Tata McGraw hill publishing company, New Delhi, Third Edition,2004.
4. Irving L.Kosow, “Electric Machinery and Transformers” Pearson Education, Second Edition,2007.


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**PE5071 MICROCONTROLLER BASED SYSTEM DESIGN**

| L | T | P | C |
|---|---|---|---|
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**COURSE OBJECTIVES:**

- To get Introduced to the fundamentals of microcontroller based system design.
- To learn I/O and other built in features available in microcontroller.
- To know Microcontroller based system design, applications.
- To learn I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired for improved employability skills

**UNIT I 8051 ARCHITECTURE 9**

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

**UNIT II 8051 PROGRAMMING 9**

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – LCD digital clock/thermometer. Introduction to IDE based assembler programming.

**UNIT III PIC MICROCONTROLLER 9**

Architecture – memory organization – addressing modes – instruction set – PIC progrmming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.

**UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 9**

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPRO Memories.

**UNIT V SYSTEM DESIGN –CASE STUDY 9**

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Standalone Data Acquisition System.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1 Ability to understand the features of microcontroller 8051
CO2 Ability to write programs using 8051 assemble language, utilizing its build in features
CO3 Ability to understand the features of PIC microcontroller.
CO3 Ability to use the peripherals builtin the PIC microcontroller through programming
CO4 Ability to grasp the interfacing concepts involving in the design of microcontroller based systems.

| | O1 | O2 | O3 | O4 | O5 | O6 | O7 | O8 | O9 | O10 | O11 | O12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O1 | ✓ | | | | ✓ | ✓ | | | ✓ | | ✓ | |
| O2 | ✓ | | | | ✓ | ✓ | | | ✓ | | ✓ | ✓ |
| O3 | ✓ | | | | ✓ | ✓ | | | ✓ | | ✓ | |

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| **O4** | ✓ | | | | ✓ | ✓ | | | ✓ | | | ✓ |
| **O5** | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ |

**TEXTBOOKS:**

1. Kenneth J Ayala, "The 8051 Microcontroller", Thomson press, 2007
2. Muhammad Ali Mazidi, RolinD.Mckinlay, Danny Causey ' PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008

**REFERENCES:**


1. Rajkamal, "Microcontrollers Architecture, Programming, Interfacing & System Design, Pearson, 2012.
2. MykePredko, "Programming and customizing the 8051 microcontroller", Tata McGraw Hill 2001
3. Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi," The AVR Microcontroller and Embedded Systems' Using Assembly & C, PearsonEducation,2014
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems' Prentice Hall,2005.
5. John Iovine, 'PIC Microcontroller Project Book ', McGraw Hill 2000


## OPEN ELECTIVE COURSES (OEC)

**OE5091 BUSINESS DATA ANALYTICS L T P C**
**3 0 0 3**

**OBJECTIVES:**

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

**UNIT I OVERVIEW OF BUSINESS ANALYTICS 9**

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

**Suggested Activities:**

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

**Suggested Evaluation Methods:**

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

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**UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9**

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

**Suggested Activities:**

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

**Suggested Evaluation Methods:**

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

**UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9**

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

**Suggested Activities:**

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

**Suggested Evaluation Methods:**

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

**UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9**

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

**Suggested Activities:**

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

**Suggested Evaluation Methods:**

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

**UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9**

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Attested

**Suggested Activities:**

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in Map Reduce involving numerical methods for analytics.

**Suggested Evaluation Methods:**

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

**TOTAL: 45 PERIODS**

**OUTCOMES**:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

**REFERENCES:**


1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.


| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 1 | 2 | 3 | 1 |
| **CO2** | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO3** | 1 | 1 | 2 | 3 | 3 | 1 |
| **CO4** | 2 | 2 | 1 | 2 | 1 | 1 |
| **CO5** | 1 | 1 | 2 | 2 | 1 | 1 |
| **CO6** | 1 | 1 | 1 | 3 | 2 | 1 |

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**OE5092** **INDUSTRIAL SAFETY** **LT P C**
**3 0 0 3**

**OBJECTIVES:**

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

**UNIT I INTRODUCTION 9**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9**

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT IV FAULT TRACING 9**

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9**

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**TOTAL: 45 PERIODS**

**OUTCOMES:**

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

Attested

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

**REFERENCES:**


1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008


**OE5093 OPERATIONS RESEARCH LT P C**
**3 0 0 3**

**OBJECTIVES:**

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

**UNIT I LINEAR PROGRAMMING 9**

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

**UNIT II ADVANCES IN LINEAR PROGRAMMING 9**

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

**UNIT III NETWORK ANALYSIS – I 9**

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

**UNIT IV NETWORK ANALYSIS – II 9**

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

**UNIT V NETWORK ANALYSIS – III 9**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

**TOTAL: 45 PERIODS**

Attested



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**OUTCOMES:**

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| **CO1** | ✓ | | | | | | | | | | | |
| **CO2** | ✓ | | | | | | | | | | | |
| **CO3** | ✓ | ✓ | ✓ | | | | | | | | | |
| **CO4** | ✓ | ✓ | ✓ | | | | | | | | | |
| **CO5** | ✓ | ✓ | ✓ | | | | | | | | | |

**REFERENCES**:


1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008


**OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C**
**3 0 0 3**

**OBJECTIVES:**

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

**UNIT I INTRODUCTION TO COSTING CONCEPTS 9**

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

**UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

**UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9**

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

**UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9**

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

**UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9**

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

**TOTAL: 45 PERIODS**

**OUTCOMES**

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | ✓ | ✓ |
| **CO2** | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | ✓ | ✓ |
| **CO3** | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | ✓ |
| **CO4** | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | | ✓ | ✓ |
| **CO5** | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | ✓ |

**REFERENCES:**


1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007




**OE5095 COMPOSITE MATERIALS LT P C**
**3 0 0 3**

**OBJECTIVES:**

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

**UNIT I INTRODUCTION 9**

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT II REINFORCEMENTS 9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

**UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9**

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

**UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

**UNIT V STRENGTH 9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | ✓ | ✓ | ✓ | | | | | | | | |
| **CO2** | | ✓✓ | ✓ | ✓ | ✓ | | | | | | ✓ | |
| **CO3** | | | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | |
| **CO4** | | | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | |
| **CO5** | | | | ✓ | ✓ | | ✓ | | | | | |

**REFERENCES:**


1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.


Attested

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**OE5096** **WASTE TO ENERGY** **LT P C**
**3 0 0 3**

**OBJECTIVES:**

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

**UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9**

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**UNITII BIOMASS PYROLYSIS 9**

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**UNITIII BIOMASS GASIFICATION 9**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**UNITIV BIOMASS COMBUSTION 9**

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**UNITV BIO ENERGY 9**

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | ✓ | | ✓ | | | | | | | | | ✓ |
| **CO2** | ✓ | | ✓ | | | | | | | | | ✓ |
| **CO3** | ✓ | ✓ | ✓ | | ✓ | | | | | | | ✓ |
| **CO4** | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | | | ✓ |
| **CO5** | ✓ | ✓ | ✓ | | ✓ | | | | | | | ✓ |

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**REFERENCES:**


1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.


## AUDIT COURSES (AC)

**AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C**
**2 0 0 0**

**OBJECTIVES**

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

**UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

**UNIT II PRESENTATION SKILLS 6**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

**UNIT III TITLE WRITING SKILLS 6**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

**UNIT IV RESULT WRITING SKILLS 6**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

**UNIT V VERIFICATION SKILLS 6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

**TOTAL: 30 PERIODS**

**OUTCOMES**

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title

CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | ✓ | | ✓ |
| **CO2** | | | | | | | | | | ✓ | | ✓ |
| **CO3** | | | | | | | | | | ✓ | | ✓ |
| **CO4** | | | | | | | | | | ✓ | | ✓ |
| **CO5** | | | | | | | | | | ✓ | | ✓ |

**REFERENCES**


1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.


**AX5092 DISASTER MANAGEMENT L T P C**
**2 0 0 0**

**OBJECTIVES**

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

**UNIT I INTRODUCTION 6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

**UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

**UNIT III DISASTER PRONE AREAS IN INDIA 6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

**UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

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**UNIT V RISK ASSESSMENT 6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

**TOTAL : 30 PERIODS**

**OUTCOMES**

CO1: Ability to summarize basics of disaster

CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO5: Ability to develop the strengths and weaknesses of disaster management approaches

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | | | | | | | | | | | |
| CO2 | ✓ | | | | | | | | | | | |
| CO3 | ✓ | ✓ | ✓ | | | | | | | | | |
| CO4 | ✓ | ✓ | ✓ | | | | | | | | | |
| CO5 | ✓ | ✓ | ✓ | | | | | | | | | |

**REFERENCES**


1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.




**AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C**
**2 0 0 0**

**OBJECTIVES**

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

**UNIT I ALPHABETS 6**

Alphabets in Sanskrit

**UNIT II TENSES AND SENTENCES 6**

Past/Present/Future Tense - Simple Sentences

**UNIT III ORDER AND ROOTS** **6**

Order - Introduction of roots

**UNIT IV SANSKRIT LITERATURE** **6**

Technical information about Sanskrit Literature

**UNIT V TECHNICAL CONCEPTS OF ENGINEERING** **6**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

**TOTAL: 30 PERIODS**

**OUTCOMES**

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | ✓ | | ✓ |
| CO2 | | | | | | | | | | ✓ | | ✓ |
| CO3 | | | | | | | | | | | | ✓ |
| CO4 | | | | | | | | | | | | ✓ |
| CO5 | | | | | | | | | | | | ✓ |

**REFERENCES**


1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.


**AX5094 VALUE EDUCATION** **L T P C**

**2 0 0 0**

**OBJECTIVES**

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

**UNIT I**

Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

**UNIT II**

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

**UNIT III**

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for

truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

**UNIT IV**

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

**TOTAL: 30 PERIODS**

**OUTCOMES**

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

**Suggested reading**

1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University, Press, New Delhi

**AX5095** **CONSTITUTION OF INDIA** **L T P C**
**2 0 0 0**

**OBJECTIVES**

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

**UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:**

History, Drafting Committee, (Composition & Working)

**UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:**

Preamble, Salient Features

**UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:**

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

**UNIT IV ORGANS OF GOVERNANCE:**

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

**UNIT V LOCAL ADMINISTRATION:**

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

**UNIT VI ELECTION COMMISSION:**

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

**TOTAL: 30 PERIODS**

**OUTCOMES**

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

**Suggested reading**

1. The Constitution of India,1950(Bare Act),Government Publication.

Attested



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2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**AX5096** **PEDAGOGY STUDIES** **L T P C**
**2 0 0 0**

**OBJECTIVES**

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

**UNIT I INTRODUCTION AND METHODOLOGY:**

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

**UNIT II THEMATIC OVERVIEW**

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

**UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES**

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

**UNIT IV PROFESSIONAL DEVELOPMENT**

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

**UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS**

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

**TOTAL: 30 PERIODS**

**OUTCOMES**

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?

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- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

**Suggested reading**


1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**AX5097 STRESS MANAGEMENT BY YOGA L T P C**
**2 0 0 0**

**OBJECTIVES**

- To achieve overall health of body and mind
- To overcome stress

**UNIT I**

Definitions of Eight parts of yoga.(Ashtanga)

**UNIT II**

Yam and Niyam - Do's and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

**UNIT III**

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

**TOTAL: 30 PERIODS**

**OUTCOMES**

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

**SUGGESTED READING**


1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

| AX5098 | PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS | L T P C 2 0 0 0 |
|---|---|---|

**OBJECTIVES**

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

**UNIT I**

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

**UNIT II**

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

**UNIT III**

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 - Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

**TOTAL: 30 PERIODS**

**OUTCOMES**

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

**Suggested reading**


1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.